Economic Inquiry

DETERMINANTS OF REVENUE IN SPORTS LEAGUES: AN EMPIRICAL ASSESSMENT

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This study investigates determinants of revenue in North America's four major professional sports leagues. Revenue is positively associated with on-field success in baseball (MLB), basketball (NBA), and hockey (NHL), but not in football (NFL). The returns to success are not diminishing as commonly assumed, which casts doubt on the uncertainty of outcome hypothesis, and differences across leagues are consistent with revenue sharing arrangements. Estimates indicate a strong negative but diminishing relationship between stadium age and revenue. Teams in larger markets generate more revenue than smaller markets, but the returns to success do not differ according to market size. (*JEL* Z21)

I. INTRODUCTION

In his seminal article, "The Peculiar Economics of Professional Sports," Walter Neale (1964) examines several unique features of North American professional sports leagues, such as the need for competitors and the inevitable evolution of teams into single-cartel leagues, and he proposes justifications for common institutional features and implications of their structure. A large literature on the "peculiar economics" of sports leagues has developed to examine these and other relevant factors that affect the success of sports leagues, such as competitive balance, the financial worth of players, and economic benefits of sports stadiums and events to communities.

In recent years, the professional sports industry has increased in popularity. In the decade spanning from 2006 to 2015, revenues of North America's top-four professional sports leagues expanded from \$17.7 to \$30.5 billion. The average annual growth rate of 5.62% was nearly three times larger than the growth rate of the U.S. economy (1.93%) over this same period. Although there is a large literature on the economics of sports, few economists have examined the economic determinants of this successful economic sector empirically. Much analysis in this rich literature focuses on specific aspects of sports using foundational theoretical assumptions of the sports marketplace developed during the mid-20th century.

This analysis seeks to further a broad understanding of the economics of modern professional sports leagues through empirical examination of North America's four "major" sports leagues to aid the understanding of the economics of sports leagues that is largely driven by theoretical analysis. The findings contribute to several strands of related literatures summarized below.

A. *The Returns to Winning*

A common assumption in economic studies of sports leagues is that profit-maximizing owners seek to increase revenue generation through on-field success through winning. Within this literature, researchers have assumed that the revenue returns (R) to winning (W) are positive ($\frac{\partial R}{\partial W} > 0$), with additional wins generating positive returns but at a diminishing rate ($\frac{\partial^2 R}{\partial W^2} < 0$). These assumptions are proposed in two seminal studies

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ABBREVIATIONS

CMA: Census Metropolitan Area
MLB: Major League Baseball
MRP: Marginal Revenue Product
MSA: Metropolitan Statistical Area
NBA: National Basketball Association
NFL: National Football League
NHL: National Hockey League
UOH: Uncertainty of Outcome Hypothesis

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of the economics of professional sports and have continued to be employed in subsequent studies.

Rottenberg (1956, 254), who provides the first economic analysis of the professional labor market for baseball players, notes the positive returns to success of sports teams, but places emphasis on the diminishing returns to winning due to the erosion of competitive balance within the league.

> At first sight, it may appear that the high-revenue teams will contract all the stars, leaving the others only the dregs of the supply; that the distribution of players among teams will become very unequal; that contests will become less uncertain; and that consumer interest will flag and attendance fall off. On closer examination, however, it can be seen that this process will be checked by the law of diminishing returns, operating concurrently with each team's strategic avoidance of diseconomies of scale.

Through anecdotal examples of dampening fan interest for the dominant 1950s New York Yankees teams and the 1961 San Diego Chargers, Neale (1964) implies that the returns to winning are diminishing, consistent with Rottenberg (1956). Following the lead of these seminal works, other economists studying sports leagues have used these assumptions in their models (e.g., Fort and Quirk 1995), and will likely continue to do so in future studies given that these assumptions remain largely unchallenged.

Within the sports economics literature, the posited positive relationship between the fan interest and competitiveness of games is referred to as the uncertainty of outcome hypothesis (UOH). If the uncertainty of contests is an important determinant of consumer demand for sports, then greater similarity of playing strengths across teams in a league, known as competitive balance, should increase team revenue. However, empirical evidence indicates that, at best, league competitive balance, which is a measure of outcome uncertainty, has little impact on fan demand (Berri, Schmidt, and Brook 2007). An emerging literature on the consumer demand for both home-team success and upsets also calls this foundational assumption into question by demonstrating that fan interest can increase even as win uncertainty decreases (Coates, Humphreys, and Zhou 2014).

Despite the importance of these assumptions in analyses of the economics of sports leagues, the relationship between on-field success and revenue in professional sports has faced little empirical scrutiny. In baseball, Solow and Krautmann (2007) report finding diminishing returns to wins from 1996 to 2001; however, Bradbury (2007) and Bradbury (2010) identify increasing returns using data from the mid-2000s. I am not aware of any similar analysis of North American sports leagues. Thus, empirical support for diminishing returns is mixed despite its assumed importance.

B. Market Size

El-Hodiri and Quirk (1971) demonstrate that a league with teams located in cities with unequal revenue may result in competitive imbalance, as revenues flow to wealthier cities and franchises that use their revenue advantage to build superior teams. Two common sources for revenue generation are the size and wealth of the population supporting the team. Markets with larger populations and wealthier fans present greater revenue-generating opportunities for clubs. It is common for studies of the consumer demand for sports to include variables to control for market potential such as population size and income per capita (e.g., Berri, Leeds, and von Allmen 2015; Coates and Humphreys 2005; Scully 1974) and find a positive impact of market size on revenue.

Burger and Walters (2003) further estimate the impact of market size on demand through winning and posit that larger markets additionally benefit from their size through the increased returns to winning according to the population size. Teams in larger markets not only experience more general interest from fans, but the larger fanbase creates an opportunity for more bandwagon fans whose demand is positively associated with winning. This effect has not been examined outside of baseball, and it is in need of further and updated study.

C. The Novelty Effect of New Stadiums

A consistent finding in the empirical analysis of spectator demand is that there is a short-term boost in attendance and revenue following the introduction of a new stadium, sometimes referred to as the "novelty" or "honeymoon" effect. This observation is consistent with increased attendance and interest in newer stadiums that offer novel and improved amenities. This boost in attendance and revenue tends to dissipate gradually before evaporating within 10 years of a stadium opening.

Clapp and Hakes (2005) identify positive attendance effects that diminish with time from new stadiums in Major League Baseball (MLB). Leadley and Zygmont (2005) identify a positive attendance effect in the National Basketball

Association (NBA), and Leadley and Zygmont (2006) identify a similar attendance effect in the National Hockey League (NHL). Coates and Humphreys (2005) identify attendance effects in MLB and NBA, but do not identify an effect in the National Football League (NFL). Depken (2006) and Poitras and Hadley (2006) find a positive effect of new stadiums on revenue in MLB. The novelty effect has not been examined since the mid-2000s and is in need of undated analysis. In addition, novelty effects on revenue have not been examined outside of baseball.

D. *Summary of Findings*

This paper seeks to address the gaps in these literatures using the experience of North America's four major leagues of professional sports teams during the past decade. The results update past findings with more recent data as well as generate the first estimates of hypothesized relationships.

With one exception, NFL, the estimates identify positive returns to on-field success, but the results indicate that the returns are increasing and not diminishing as commonly assumed. For all leagues, market size plays an important role in determining team revenue. Larger populations are associated with higher revenue, relative to smaller populations, but do not experience additional greater returns to winning. The wealth of communities and intracity competition from teams that share markets have differing effects across leagues. The estimates indicate a strong revenue boost from new stadiums that diminishes over a decade, consistent with past studies of the novelty effect in baseball, basketball, and hockey. In addition, the novelty effect is similarly observed in football. In total, the findings serve as a foundation for further analyses of professional sports leagues.

Section II presents the empirical strategy for estimating determinants of revenue in sports leagues. Section III presents the empirical results for each league separately and offers interleague comparisons. Section IV discusses the implications of the findings for the economic study of sports leagues. Section V concludes the paper with a summary of the findings.

II. EMPIRICAL MODEL

North America's four major sports leagues are quite similar in their organization—they are natural monopoly cartel sellers of a major-league sport, monopsony employers in a bilateral monopoly relationship with a labor union, and have a similar number of teams spread throughout North America's largest population centers. They differ in terms of average revenue, revenue-sharing rules that generate differing incentives to win, frequency of play (ranging from weekly to almost-daily), season of operation, geographic concentration, and typical stadium size. In order to measure the impact of potential explanatory factors on team revenue, I employ a basic empirical model that can be applied to teams in all sports to generate league-specific estimates. The generalized model (expressed in Equation (1)) is based on factors previously identified as theoretically important for generating revenue, estimating total team revenue as a function of team performance, market size, stadium age, and team performance.

(1)

$$\text{Revenue}_{it} = \alpha + \lambda\mathbf{Performance}_{it} + \mu\mathbf{Market}_{it} + \gamma\mathbf{Stadium}_{it} + \chi\mathbf{X}_{it} + \tau\mathbf{T}_{it} + \varepsilon_{it} + \nu_{i}.$$

Revenue is the total revenue generated by franchise i in year t estimated by *Forbes* in its annual financial valuations of sports franchises from 2006 to 2015, excluding the 2011–2012 NBA and 2012–2013 NHL seasons, which were shortened or canceled by lockouts, respectively.[1] All dollar values are converted to 2015 dollars for each league.[2]

Performance is a vector of variables that measure team success as it relates to on-field performance. Following Bradbury (2010), rather

1. Berri, Leeds, and von Allmen (2015) and Bradbury (2010) also use *Forbes* (Various years, Various leagues) revenue data, which were compiled with information provided by team officials, bankers, consultants, and other knowledgeable officials under the continuous direction of Michael Ozanian. Poitras and Hadley (2006) and Depken (2006) use data from *Financial World*, which compiled revenue data prior to *Forbes*, also under the direction of Michael Ozanian using similar methods. The web addresses listed in the references link to the most recent yearly estimates, but the publisher has changed the web location of its estimates over time and replaced previous estimates. Estimates for previous seasons were culled from internet searches of cached pages using the Internet Archive: Wayback Machine (https://archive.org/web/). It is assumed that each team will set prices for attendance, media rights, sponsorship, and so on to maximize financial returns.

2. A simple inflation adjustment is inappropriate, because all leagues' revenues have grown faster than the economy's price level over time. A league-specific deflator based on annual revenue is used to adjust teams' annual revenues to their 2015 league equivalent so that estimated financial impacts of the independent variables over time are consistent.

than use winning directly, I use the score differential between runs, points, or goals scored and allowed to proxy winning. This measure of regular-season success has several advantages over raw win totals or winning percentage while being highly correlated with winning—the correlation (r) between score differential and winning in leagues ranges from 0.92 to 0.96. First, wins are discrete, and reflect a large range of team quality as it is likely to be perceived by fans; thus, when making comparisons across leagues with different lengths of seasons, changes in wins do not reflect the differences in team quality in the same manner. For example, nine and ten wins in the NFL are equivalent to winning 91 and 101 games in MLB in terms of winning percentage. In the former league, such teams are considered marginally to moderately better than average, while in the latter, the teams are considered to range from good to exceptional. Using score differential to proxy for winning also allows for distinguishing quality among teams with a similar number of wins at a more granular level. Wins, especially in close games, are a product of luck as well as talent. Bad (good) teams that receive a few wins (losses) in close games mean that wins may not reflect the quality of the team on the field as well as score differential. All wins are not equal, but a team that wins all its games by one point is likely to be worse than a team that wins the same number of games by ten points. Thus, score differential allows for a more precise estimate of team quality as it is likely perceived by fans than winning. Finally, the differing frequency of ties across leagues complicates the value of winning when comparing the estimates across leagues. As a precaution, I also estimated specifications that included wins instead of score differential for all leagues (not reported), and the estimated relationships between winning and revenue are not meaningfully different from regression estimates using score differential as they relate to the implications reported in this paper.

Preliminary analysis of the relationship between on-field success and revenue using univariate fractional polynomial regression estimation, which does not presuppose a functional form of the relationship, indicated potential nonlinear relationships for the leagues. For the multivariate regression analysis, score-differential estimates were generated using linear and quadratic functional forms. The inclusion of higher-order polynomials did not improve the fit of the models, as measured by R^2. In addition, Scully (1989) suggests on-field success likely affects revenue generation in the future as well as the present, because fans purchase season-tickets and premium broadcast packages based on recent past performance as a proxy of the quality of the upcoming team. Therefore, the previous season's run differential is always included as an independent variable.

Postseason playoffs are a common feature to all North American sports leagues and represent an opportunity for increased revenue from postseason revenue and increased consumer demand. Playoff revenue is also allocated to teams according to separate complex revenue sharing formulas for allocating this additional revenue among players, franchises, and the league central offices. Thus, an indicator variable that records whether or not the team made the playoffs is also included. Although postseason participation is determined strongly by on-field performance as measured by score differential this variable captures any additional value fans may place on reaching the playoffs. Because the strong correlation between winning and postseason participation produces multicollinearity, I also report estimates that exclude playoff participation.[3]

Market is a vector of factors that may influence revenue through the market size of the home team. It is expected that larger populations are associated with greater revenue due to the larger number of potential customers. The primary measure of market size is the metropolitan population of the city that hosts the team. Estimates of U.S. cities are metropolitan statistical area (MSA) estimates reported by the United States Census Bureau, and Canadian city estimates are census metropolitan area (CMA) estimates reported by Statistics Canada. In an attempt to identify market-size impacts on winning, I include an interaction term of population times score differential, similar to Burger and Walters (2003), in some specifications. To control for the presence of multiple teams in a metropolitan area, which might dilute a market-size effect, I include an indicator variable denoting the presence of multiple teams in the metropolitan area. Income per capita proxies the affluence of markets served by teams which may affect market revenue potential. If sports are a normal good, then differences

3. The additional impact of playoff performance (e.g., number of games won, rounds advanced, seeding, etc.) warrants further study; however, differences in playoff structure across leagues and changes in playoff formats within leagues require specific scrutiny beyond the scope of this analysis.

in wealth across cities may affect team revenue.[4] Three of the sports leagues include one or more teams in Canada—the NHL includes seven Canadian teams—therefore, I include a Canada indicator variable to estimate the impact of this potential influence.

Stadium is a vector of variables that measure stadium attributes that may attract spectators. Previous estimates of the impact of stadium age on fan attendance have found a novelty effect from new stadiums that boosts attendance for between 5 and 10 years, because fans are attracted to updated amenities and a new experience (e.g., Clapp and Hakes 2005; Coates and Humphreys 2005; Leadley and Zygmont 2006). I include the reciprocal of stadium age to quantify the impact of the novelty effect on fans. When conducting preliminary analysis, I estimated alternate models that included indicator variables and logged and quadratic transformations of stadium age to identify any novelty effects and their duration. I determined that transforming stadium age to its reciprocal generally provided the best fit (as measured R^2) of the impact stadium age on revenue for all leagues.[5] This functional form is also theoretically consistent with a short-term novelty effect that diminishes before leveling off. It is also possible that stadium age affects financial returns from revenue generated through on-field success. If new stadiums attract more novelty-focused spectators who are less interested in home team performance than typical consumers, then crowds may lessen the social pressure on referees/umpires to influence calls in favor of the home team (see Buraimo, Simmons, and Maciaszczyk 2012; Pettersson-Lidbom and Priks 2010). I include an interaction term of the reciprocal of stadium age times score differential in some specifications in an attempt to identify this impact. In addition, baseball and football are played in both indoor and outdoor stadiums, which allow teams to shield the fans from potentially unfavorable weather; therefore, for the NFL and MLB, I include an indicator variable that denotes that a team plays in a stadium with a dome or retractable roof.

In addition, some teams appear to be able to attract revenue for undefinable and unique reasons that are not explainable by other included factors. For example, the famed New York Yankees of MLB and the Dallas Cowboys of the NFL (sometimes referred to as "America's team") may possess revenue advantages that need to be accounted for when estimating team revenue. **X** is a vector of franchise indicator variables that account for the impact of franchises that were consistently exceptional at generating revenue during the sample. **T** is a vector of year effects to capture overall nonlocal fluctuations in revenue that affect all teams in a league during the year of analysis, such as league-wide national broadcast rights and sponsorship deals. ϵ is a standard error term and ν is a franchise-specific error term.

For all leagues, a Breusch and Pagan (1980) test for random effects rejected pooled ordinary least squares as an estimator, indicating that a panel data estimator is needed. A Hausman (1978) specification test rejects the random-effects estimator as appropriate for all leagues except MLB. Random- and fixed-effects estimates are presented for all leagues as a robustness check and to examine factors that remain constant for teams over time. A Woolridge (2002) test identified the presence of first-order serial correlation in the data for all leagues; therefore, I estimate Equation (1) using the Baltagi and Wu (1999) random- and fixed-effects estimators that adjust for serial correlation in panel data.

III. EMPIRICAL ESTIMATES

Table 1 lists the summary statistics by sports league. The regression estimates for each sports league are discussed in separate subsections below, and a subsection comparing the results from all leagues concludes the section.

A. *MLB*

Table 2 reports the empirical estimates of the revenue returns in MLB. Models 1–6 report the random effects estimates, and models 7–8 report fixed-effects estimates for robustness. The estimates reveal a strong positive and increasing relationship between on-field success and revenue. Both regular-season performance and postseason

4. Income per capita by MSA is available from the Bureau of Economic Analysis for the United States. Income data by Canadian CMAs is reported only at the median family level and is not available consistently over the sample; therefore, Canadian observations are excluded when income per capita is estimated.

5. Estimates using the log of stadium age were similar to the reported reciprocal estimates but provided a worse overall fit. Various combinations of indicator variables measuring age by year (e.g., first year, second year, etc.) or age groups (e.g., first 3 years, first 5 years, etc.) and quadratic estimates generated much worse fits and/or statistically insignificant coefficients.

TABLE 1
Summary Statistics

		MLB	NBA	NFL	NHL
Revenue (in millions)	Mean	279.65	195.58	380.19	136.69
	SD	70.69	51.31	65.37	35.59
Score differential	Mean	0	0	0	0
	SD	98.80	387.02	104.39	35.77
Postseason	Observations = 1	88	144	120	160
	Observations = 0	212	126	200	140
Stadium age	Mean	23.35	16.73	18.93	17.66
	SD	24.77	9.95	14.35	10.36
Stadium roof	Observations = 1	68	NA	87	NA
	Observations = 0	232		233.00	
Population	Mean	5,941,649	5,359,448	4,533,448	5,718,501
	SD	4,646,447	4,863,076	4,336,950	5,538,583
Multiple teams in MSA	Observations = 1	80	36	40	45
	Observations = 0	220	234	280	245
Income per capita	Mean	51,537	49,078	50,212	51,279
	SD	8,689	8,605	8,817	8,242
Canada	Observations = 1	10	9	0	58
	Observations = 0	290	261	320	212

participation are associated with higher revenue.

Larger markets are associated with greater revenue; however, the interaction of population and score differential is not correlated with revenue. The reported estimate (5) that includes the interaction term excludes the postseason indicator and other potential irrelevant explanatory variables to maximize the identification of any interaction effect, and other nonreported specifications failed to find an interaction effect between population and score differential. While financial returns are greater for franchises in larger markets, this does not translate into higher returns to on-field success in larger markets. Market size and winning both affect revenue, but they do so independently. The estimates in this study contradict the interpretation of Burger and Walters (2003), which estimates the impact of winning and market size in baseball using an interaction term of population and winning. However, in Burger and Walters (2003), the interaction term is statistically significant only when its components are excluded from the model, which makes interpretation of the coefficient impossible. The full specification estimates reported in that study do not produce statistically significant estimates of the interaction term. Therefore, the previous results do not provide strong evidence of returns to winning differing with market size, which is consistent with the findings of this analysis. The other demographic factors of income per capita, playing in Canada, and having multiple teams in the metropolitan area are not associated with revenue.

The reciprocal of stadium age is strongly associated with revenue, indicating the existence of a novelty effect that diminishes over time. This effect is further addressed in comparison to other sports leagues below. The interaction between run differential and stadium age is insignificant (not reported). Having a dome or retractable roof is not correlated with revenue.

When investigating the particular effects of individual teams, the estimates indicate that New York Yankees benefit from a unique revenue effect. This is not surprising given the storied history of the franchise, which for much of its history was the league's most dominant club, winning 27 World Series Championships. During the decade of analysis, the Yankees led MLB in revenue every year by an average of 37% more than the next-highest revenue-generating franchise, and the top revenue-generating clubs immediately below the Yankees differed throughout the sample. The regression estimates confirm the uniqueness of the Yankees, with a revenue effect of over $170 million and the indicator variable improving the fit of the model.

B. NBA

Table 3 reports the empirical estimates for the NBA, with the fixed effects (1–3) estimates preceding the random effects estimates (4–8). Although the squared term of the quadratic estimate of score differential is not statistically significant for the fixed-effects estimates, its *p* value

TABLE 2
Determinants of Revenue in MLB (2006−2015)

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Score differential	0.049	0.054	0.049	0.050	0.061	0.066	0.045	0.063
	(0.014)**	(0.014)**	(0.013)**	(0.014)**	(0.020)**	(0.011)**	(0.014)**	(0.011)**
Score differential^2	1.657E-04	2.049E-04	1.646E-04	1.682E-04	2.128E-04	2.213E-04	1.726E-04	2.323E-04
	(8.370E-05)*	(8.693E-05)*	(8.295E-05)*	(8.313E-05)*	(8.378E-05)*	(7.822E-05)**	(8.309E-05)*	(7.871E-05)**
Score differential (t−1)	0.047	0.050	0.047	0.047	0.046	0.045	0.041	0.040
	(0.011)**	(0.011)**	(0.011)**	(0.011)**	(0.011)**	(0.011)**	(0.011)**	(0.012)**
Postseason	5.181	5.057	5.136	5.115			5.504	
	(2.538)*	(2.563)*	(2.513)*	(2.519)*			(2.512)*	
Population	3.640E-06	4.050E-06	5.430E-06	8.830E-06	5.430E-06	5.470E-06	−2.119E-05	−2.091E-05
	(2.360E-06)	(2.290E-06)	(1.720E-06)**	(1.720E-06)**	(1.720E-06)**	(1.720E-06)**	(1.443E-05)	(1.476E-05)
Population × Score differential					8.270E-10			
					(2.88E-09)			
Income per capita		9.406E-04						
		(6.772E-04)						
Canada	−12.721							
	(37.638)							
Multiple teams in MSA	20.608	10.050						
	(22.357)	(22.706)						
Stadium age	47.738	47.490	47.660	48.281	49.038	48.748	47.370	48.473
	(7.147)**	(7.189)**	(7.093)**	(7.114)**	(7.237)**	(7.078)**	(7.615)**	(7.613)**
Stadium roof	−13.660	−12.479						
	(9.163)	(9.157)						
New York Yankees	179.502	172.717	173.405		172.509	172.858		
	(43.937)**	(42.555)**	(44.847)**		(44.901)**	(44.948)**		
Fixed effects	No	No	No	No	No	No	Yes	Yes
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.69	0.71	0.67	0.53	0.67	0.67	0.31	0.29
Observations	300	290	300	300	300	300	270	270

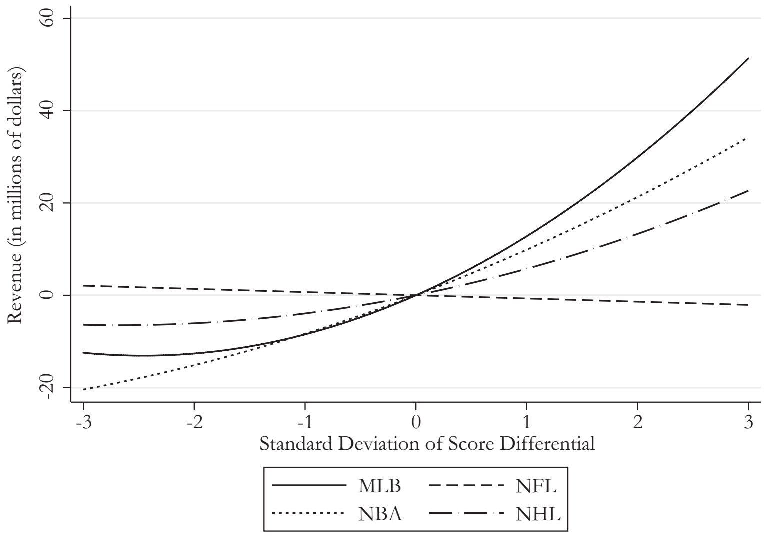
Notes: Standard errors in parentheses. Overall R^2 reported for random effects, within R^2 reported for fixed effects. Constant not reported.
$^*p < .05$; $^{**}p < .01$.

TABLE 3
Determinants of Revenue in NBA (2006–2015)

	1	2	3	4	5	6	7	8
Score differential	0.007	0.014	0.014	0.015	0.015	0.013	0.019	0.019
	(0.004)	(0.003)**	(0.005)**	(0.004)**	(0.004)**	(0.004)**	(0.003)**	(0.005)**
Score differential^2	5.120E-06	5.470E-06	5.570E-06	1.178E-05	1.144E-05	1.080E-05	1.133E-05	1.169E-05
	(5.620E-06)	(5.660E-06)	(5.81E-06)	(5.710E-06)*	(5.61E-06)*	(5.630E-06)	(5.590E-06)*	(5.750E-06)*
Score differential (t−1)	0.011	0.011	0.011	0.016	0.016	0.015	0.016	0.016
	(0.003)**	(0.003)**	(0.003)**	(0.003)**	(0.003)**	(0.003)**	(0.003)**	(0.003)**
Postseason	7.055			5.339	4.753	5.159		
	(2.899)*			(2.933)	(2.850)	(2.853)		
Population	1.078E-05	1.143E-05	1.154E-05	7.720E-06	7.740E-06	7.100E-06	7.860E-06	7.920E-06
	(2.900E-06)**	(2.930E-06)**	(3.070E-06)**	(1.620E-06)**	(1.490-E06)**	(2.280E-06)**	(1.460E-06)**	(1.450E-06)**
Population × Score differential			−4.410E-11					1.090E-10
			(6.61E-10)					(0.000)
Income per capita				−7.610E-05				
				(3.965E-04)				
Canada					−2.158			
					(18.615)			
Multiple teams in MSA				−104.027	−104.886	−15.334	−106.053	−106.532
				(23.608)**	(23.026)**	(33.459)	(22.559)**	(22.507)**
Stadium age	42.680	43.392	43.868	54.734	54.845	55.392	54.622	54.915
	(12.937)**	(13.057)**	(13.184)**	(11.979)**	(11.830)**	(11.966)**	(11.837)**	(11.988)**
Los Angeles Lakers				170.328	170.916		171.616	171.675
				(22.614)**	(22.602)**		(22.458)**	(22.419)**
New York Knicks				156.676	156.083		154.919	154.825
				(22.677)**	(22.663)**		(22.513)**	(22.440)**
Fixed effects	Yes	Yes	Yes	No	No	No	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.57	0.56	0.56	0.77	0.77	0.43	0.77	0.77
Observations	240	240	240	261	270	270	270	270

Notes: Standard errors in parentheses. Overall R^2 reported for random effects, within R^2 reported for fixed effects. Constant not reported.
$^*p < .05$; $^{**}p < .01$.

FIGURE 1
Returns to On-Field Performance by League



(.06) approaches the standard threshold of statistical significance. Given the strong correlation between the several included measures of on-field success (point differential, point differential squared, lag of point differential, playoffs, and in the interaction term), it is possible that multicollinearity is raising the standard errors of the estimates and thus limiting their precision. In addition, the squared term is statistically significant in most of the random-effects estimates. Therefore, I report the quadratic estimates of all regression models in an effort to identify any diminishing returns to winning. The shape of the quadratic estimates over the range of performance and revenues of NBA teams reveals a near-linear estimate that is similar to linear estimates, which are not reported (see Figure 1). Postseason performance is also associated with an increase in revenue of approximately $7 million.

Population is positively correlated with team revenue, but the interaction between population and score differential does not indicate increased returns to winning in larger markets. The stadium age coefficient indicates a diminishing novelty effect from new stadiums similar to the effect estimated for MLB. The coefficient estimate of the interaction term of stadium age and score differential was negative and statistically significant; however, investigation of the marginal effects of stadium age on point differential identified the effect to be relevant only during a stadium's first year, which applies to two observations (less than 1% of the sample). Furthermore, the effect was positive for older stadiums, and estimates along the spectrum of stadium ages are small, even when statistically significant. Therefore, I exclude the interaction term from the reported models.

The random-effects estimates indicate that while per capita income and being located in Canada are not associated with financial returns, there is a significant revenue decline associated with playing in a market with multiple teams. This effect is prevalent in only two markets (Los Angeles and New York) and primarily affects the Los Angeles Clippers and the New Jersey/Brooklyn Nets. The Los Angeles Lakers and New York Knicks have strong unique revenue effects, as these two teams are consistently the top-two revenue-generating NBA teams during the sample, which somewhat offset substitution effects from their cross-town competitors.

C. NHL

Table 5 reports the estimated revenue effects on NHL franchises. The returns to regular-season success are positive; however, like the NBA, the coefficient for the squared term is statistically significant only for the random effects estimates. I report the quadratic specifications to identify any diminishing returns to winning. Linear estimates produce a similar relationship and the curvature estimated by the quadratic function is slight (see Figure 1). The previous season's performance is consistently positive, but it is not statistically significant in the fixed-effects estimates.

The coefficients for population generally are not statistically significant and the estimated effect is much smaller than in other leagues: a one standard deviation increase in population is associated with approximately $2 million more in revenue. This finding is consistent with Poplawski and O'Hara (2014), which finds small markets to be viable hosts for NHL franchises, which the authors hypothesize may be the product of the league's revenue sharing system. The interaction between score differential and population is also small and statistically insignificant.

The stadium age coefficients indicate a diminishing novelty effect that is strong and similar to other leagues. Although the magnitude of the effect is large, the novelty effect is the smallest among the leagues included in this analysis. The interaction between goal differential and stadium age is insignificant (not reported).

The random-effects estimates indicate positive revenue effects from playing in Canada, where the sport is more popular than in the United States. Combined with the small impact of population, this highlights the importance of a market's taste for hockey in determining revenue. The top-three revenue-generating teams during the sample—Montreal Canadiens, New York Rangers, and Toronto Maple Leafs—all experience unique revenue effects. Income per capita is positively associated with revenue; however, the samples that include income exclude Canadian teams.

D. NFL

Table 5 reports the empirical estimates for the NFL. No measure of on-field success is associated with revenue among NFL teams. Neither current nor previous score differential, nor appearing in the postseason, are associated with revenue. In terms of the market, both population and income per capita are positively associated with revenue: a one million increase in population is associated with approximately $40 million increase in revenue, and every $1,000 increase in per capita income is associated with approximately $2 million more in revenue. The interaction of population and score differential was not associated with any statistically significant change in revenue (specification not reported), nor should it be expected, given the lack of correlation between on-field success and revenue. Having multiple teams in the same market is associated with lower team revenue, indicating that teams in the same area serve as substitutes. The reciprocal of stadium age is positively associated with revenue, indicating a strong novelty effect. The coefficient estimate of the interaction between stadium age and score differential is negative and statistically significant; however, analysis of the marginal effects indicates that the impact was relevant to teams with stadiums 4 years old or less, which applies to less than 10% of the sample—similar to the findings in the NBA. In addition, the point differential was insignificant for older stadiums, the coefficient estimate was sensitive to the inclusion of dome (see below), and the estimates were of a small magnitude. Therefore, I exclude the interaction term from the reported models.

A peculiarity of the NFL market is the uniquely high revenues generated for three particular teams. The Dallas Cowboys, New England Patriots, and Washington Redskins were the top-three revenue generators every year during the decade analysis by a substantial amount—2.8 standard deviations above the rest of the league's average. Including indicator variables for these teams substantially improves the fit of the random-effects estimates as well as changes the values of the included coefficients. These changes also reveal some weaknesses of the fixed-effects estimator. For example, the impact of having a stadium roof is substantially dampened when the three team indicators are included in the model. This occurs because Dallas is the only team in the sample that changed from an outdoor stadium to a retractable-roof stadium during the examined period, and this move was associated with a 50% increase in revenue. In the fixed-effect estimation, this is the only within-team change and thus it heavily influences the stadium roof coefficient. When Dallas is excluded from the estimation (6), the estimated impact of a roof is negative. Thus, the strong revenue effect of a roof on revenue estimated via fixed effects should be interpreted cautiously, and it is unclear what effect a stadium roof might have on revenue in football.

E. General Observations

Interleague comparisons of the raw nonlinear coefficient estimates are difficult. Table 6 reports abridged regression estimates, reporting the main variables of interest, using the standard deviation in scoring differential to enable normalized comparisons across leagues and provide a general summary of the results presented in Tables 2–5.[6] I also present the nonlinear estimates graphically to ease their interpretation.

Figure 1 maps the regression-estimated relationships between performance and revenue. Each function is estimated using the value of the current score differential and the discounted present value of score differential in the previous year, based on the average revenue growth of the league.[7] The estimates reveal a positive and statistically significant relationship between team performance and revenue for all leagues, except the NFL. The positive coefficients of the squared terms indicate increasing returns to winning for MLB in all estimated models, while for the NBA and NHL the squared term was statistically significant when estimated using random effects. The lower *p* values in the fixed-effects models are unsurprising due to the strong collinearity of the several included measures of on-field success. Estimating a quadratic relationship is needed for identifying diminishing or increasing returns to winning.[8]

The graph highlights the distinct differences in the returns to winning across leagues in terms of relative shape and magnitude. Among sports leagues, MLB experiences the strongest returns to winning, and the returns to winning are increasing at an increasing rate. The NBA and NHL also exhibit increasing returns to winning, but the curvature of the relationship is slight and the impact of winning on revenue is less than in MLB. The returns to winning in the NFL are slightly negative but flat as indicated by the insignificance of the coefficient estimates.

As expected, there is a positive relationship between market size and revenue in all leagues, though the effect differs considerably across leagues, with market size having the strongest effect in the NFL, while the effect in the NHL is weak. A one million person increase in metropolitan area population is associated with increased revenue by $40 million in the NFL, $10 million in the NBA, $4 million in MLB, but only $400,000 in the NHL. The impact of population on revenues in the NFL is 100 times larger than the impact on the NHL, ten times larger than MLB, and four times larger than the NBA. Estimates of an interaction term of score differential and population were not statistically significant for any league. I also estimated several additional specifications (not reported) intended to observe any interactive effect between winning and market size (e.g., including the squared score differential using random- and fixed-effects estimators) and the coefficients were never statistically significant. Therefore, while winning and market size both positively impact revenue, I was unable to identify a synergistic effect between winning and market size. This does not mean that there are not specific market effects on winning, only that they have yet to be identified if they exist.

Although the returns to winning do not differ according to market size, the estimates indicate that the returns to winning can differ across teams, due to the nonlinear impact of wins. This means that teams may value similar players differently according to each team's in-season performance. The same marginal player will be worth more to a team with more wins than a team with fewer wins, as the returns to winning are steeper in the former market. Better teams ought to be willing to spend more on free agents and give up more developing players to other teams in trades. This is consistent with the observed behavior of better teams acquiring players from weaker teams in return for long-run prospects during mid-season trades, when performance quality is known. The increasing returns may be explained by increasing fan demand from a bandwagon effect as well as the growing expected share of postseason revenue.

The increasing returns to winning is consistent with Bradbury (2007) and Bradbury (2010), which also find a similar nonlinear impact in baseball; however, the estimates do not find support for the disincentive for winning at lower levels identified in Bradbury (2010) as the "loss trap." The estimates reported here do not produce a loss trap, indicating that there are not positive returns to losing along any part of the win-revenue function; thus, the disincentive effects

6. The normalized estimates are generated from regression specifications that replace raw score differential with the standard deviation of score differential. The functions were generated using the following model specifications for each league from Tables 2–5: MLB (6), NBA (2), NHL (2), and NFL (2). The specifications exclude the postseason indicator variable because of the strong correlation between score differential and postseason participation, which is a function of winning.

7. Average annual revenue growth during the sample by league: MLB (5.7%), NBA (5.1%), NFL (7.1%), and NHL (5.3%).

8. Estimates that exclude the lag of score differential produces similar estimates.

TABLE 4
Determinants of Revenue in NFL (2006–2015)

	1	2	3	4	5	6	7
Score differential	−0.006	−0.007	−4.172E-04	−0.001	−0.001	−0.001	−0.004
	(0.010)	(0.008)	(0.012)	(0.012)	(0.013)	(0.009)	(0.011)
Score differential (t−1)	3.373E-05	1.821E-04	1.100E-06	4.550E-03	4.877E-03	1.097E-02	5.201E-03
	(0.008)	(0.008)	(0.008)	(0.010)	(0.011)	(0.008)	(0.011)
Postseason	−0.456			−1.285	−0.992	−0.971	
	(1.860)			(2.350)	(2.588)	(1.751)	
Population	4.152E-05	4.144E-05	4.084E-05	8.080E-06	3.970E-06	4.490E-06	3.980E-06
	(1.074E-05)**	(1.069E-05)**	(1.071E-05)**	(2.240E-06)**	(1.060E-06)**	(1.010E-06)**	(1.060E-06)**
Population × Score differential			−1.600E-09				
			(1.98E-09)				
Income per capita	0.002	0.002	0.002	0.003	0.001	0.001	0.001
	(7.310E-04)**	(7.296E-04)**	(7.305E-04)**	(6.985E-04)**	(5.758E-04)*	(4.713E-04)**	(5.747E-04)*
Multiple teams in MSA				−103.886	−47.901	−61.460	−47.954
				(32.720)**	(18.884)*	(16.966)**	(18.841)*
Stadium age	39.438	39.438	39.795	50.014	59.228	43.691	59.225
	(5.829)**	(5.822)**	(5.848)**	(6.883)**	(7.442)**	(5.345)**	(7.439)**
Stadium roof	164.614	164.417	164.674	95.952	15.753	−19.943	15.634
	(15.720)**	(15.633)**	(15.642)**	(12.067)**	(7.529)*	(7.844)*	(7.510)*
Dallas					212.945		212.983
					(19.883)**		(19.833)**
New England					118.050	106.120	117.902
					(22.112)**	(20.546)**	(22.057)**
Washington					129.054	117.035	128.909
					(22.206)**	(20.636)**	(22.152)**
Fixed effects	Yes	Yes	Yes	No	No	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.52	0.52	0.52	0.12	0.76	0.76	0.76
Observations	288	288	288	320	320	310	320

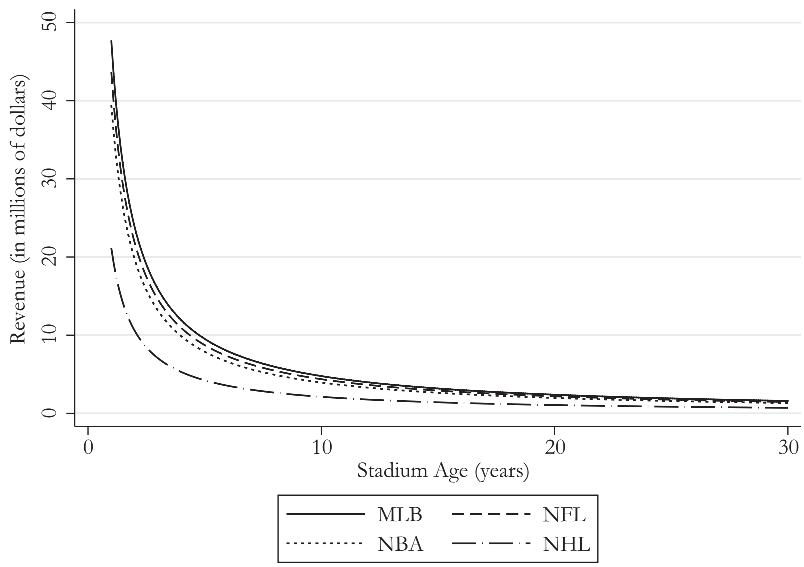
Notes: Standard errors in parentheses. Overall R^2 reported for random effects, within R^2 reported for fixed effects. Constant not reported.
$^*p < .05$; $^{**}p < .01$.

TABLE 5
Determinants of Revenue in NHL (2006–2015)

	1	2	3	4	5	6	7
Score differential	0.063	0.105	0.071	0.091	0.077	0.083	0.076
	(0.030)*	(0.024)**	(0.034)*	(0.028)**	(0.029)**	(0.028)**	(0.029)**
Score differential^2	6.242E-04	6.668E-04	5.948E-04	7.641E-04	5.017E-04	7.070E-04	4.963E-04
	(3.548E-04)	(3.59E-04)	(3.66E-04)	(3.55E-04)*	(3.580E-04)	{3.544E-04)*	(3.623E-04)
Score differential (t−1)	0.027	0.028	0.029	0.063	0.073	0.057	0.073
	(0.022)	(0.023)	(0.023)	(0.020)**	(0.021)**	(0.020)**	(0.021)**
Postseason	3.934			3.661	3.471	3.650	3.498
	(1.812)*			(1.841)*	(1.946)	(1.836)*	(1.968)
Population	4.100E-07	3.400E-07	3.000E-07	1.960E-06	1.310E-06	5.820E-06	2.730E-06
	(1.310−06)	(1.310E-06)	(1.300−006)	(1.180E-06)	(1.290E-06)	(1.620E-06)**	(1.570E-06)
Population × Score differential			6.390E-09				
			(4.47E-09)				
Income per capita					6.867E-04		8.644E-04
					(3.459E-04)*		(4.012E-04)*
Canada				18.069		41.149	
				(7.100)*		(8.814)**	
Multiple teams in MSA				−27.265	−22.887	−61.219	−25.057
				(16.382)	(17.722)	(23.372)**	(22.302)
Stadium age	21.141	21.230	19.942	19.818	18.608	19.067	17.794
	(5.688)**	(5.760)**	(5.846)**	(5.664)**	(5.883)**	(5.745)**	(5.951)**
Montreal Canadiens				61.732			
				(15.685)**			
New York Rangers				88.350	87.080		
				(16.312)**	(17.223)**		
Toronto Maple Leafs				86.269			
				(16.346)**			
Fixed effects	Yes	Yes	Yes	No	No	No	No
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.53	0.52	0.52	0.73	0.59	0.41	0.31
Observations	240	240	240	270	212	270	212

Notes: Standard errors in parentheses. Overall R^2 reported for random effects, within R^2 reported for fixed effects. Constant not reported.
$^*p < .05$; $^{**}p < .01$.

FIGURE 2
The Impact of Stadium Age on Revenue



from revenue sharing are limited to reducing the value of wins as teams lose more games. The flattening of the revenue functions with poor performance in MLB and the NHL also indicates that there is little disincentive to "tank" during a low-win season in order to improve a team's draft position to select future superior talent. Tanking appears to have a greater cost in the NBA.

In addition, postseason participation is associated with increased revenue in all leagues except the NFL, increasing revenue by $3.9 million in the NHL, $5 million in MLB, and $7 million in the NBA. Thus, there are additional returns to success from appearing in playoffs beyond the benefits of the added wins that put a team in the playoffs.

The estimates also identify the importance of new stadiums on team revenue during an unstudied time period, finding a novelty effect on revenue streams that are not dependent on higher attendance, such as sponsorship, naming rights, and attendance amenities (e.g., luxury boxes, premium seating, and associated restaurants). Figure 2 maps the estimated relationships between revenue and stadium age by sports league over a 30-year stadium lifespan, based on the regression estimates for each league. The estimates show strong returns to a new stadium that diminish over time, consistent with studies from earlier time periods, and nearly all the benefits are exhausted within a decade of opening.[9] Although Coates and Humphreys (2005) do not identify an attendance novelty effect in football, the analysis of revenue indicates that stadium age is an important determinant of revenue for NFL teams, which highlights the importance of revenue streams that depend on factors other than increased attendance. The results explain why professional sports teams consistently push for new stadiums well before they have exhausted their useful physical lifespan for hosting games.

The presence of multiple teams in markets is negatively related with revenue in the NFL and NBA, but not in MLB or the NHL. Income per capita is positively associated with revenue in the NFL and NBA. Canadian teams were not associated with revenue in MLB or the NBA—both leagues having one team in Toronto—but were associated with approximately $18 million more revenue in the NHL.

9. The initial higher revenues do not appear to reflect the endogeneity of high-revenue teams using excess revenue to build new stadiums. The mean revenue rank among teams in the year preceding the adoption of a new stadium during the period is as follows: MLB (15), NBA (24.5), NFL (20.4), and NHL (25). In addition, professional franchises typically receive significant public subsidies to construct new stadiums; therefore, the availability of funds for internal private financing is not a dominant factor in choosing to construct a new stadium.

All leagues have one-to-three teams who have unique revenue characteristics. These may result from enthusiastic fanbases to broad extralocal fandom. Regardless of the reason, excluding these explanatory factors from empirical specifications that estimate team revenue may result in omitted variable bias that correlates with demographic factors that also affect revenue generation and highlight the importance of fixed effects.

IV. IMPLICATIONS

A. Revenue Sharing

The most obvious implication from the empirical findings is the influence of differing revenue sharing arrangements on team revenue generation. Each league has unique structures and nuances that generate differing financial incentives, and each league has operated under multiple collective bargaining and revenue sharing agreements during the time period of analysis; however, the following general descriptions provide a guide to the range of revenue sharing agreements as they differ across leagues. The findings indicate that teams in leagues that rely more on revenue sharing experience lower returns to winning than in leagues with less revenue sharing.

The NFL operates largely as a syndicate, with all 32 teams sharing 50% to 75% of revenue equally, deriving much of its revenue from a league-wide national television contract that eschews local television broadcasting rights (Kaplan 2013). The NFL is also the only league that does not give teams control over their local broadcasting rights. In the NBA, teams share approximately 50% of total revenue, which is derived from both local and central sources (Lombardo 2012). The NHL uses a complicated formula from which distributions to low-revenue clubs are allocated from the top ten revenue-generating teams, 35% of playoff gate receipts, and centrally shared revenue (NHL/NHLPA 2013). MLB teams share approximately 34% of net local revenue, which includes local broadcasting revenue, and sharing all national broadcast contract revenue equally (MLB/MLBPA 2011). The varying sensitivity of team revenue to on-field success across leagues is consistent with winning mattering less where revenue is shared greatly (NFL) and winning mattering more where a larger share of revenue is generated and retained by each team (MLB).

MLB, NBA, and NHL teams can increase revenue by winning, and thus they benefit from devoting financial resources to facilitate winning. In the NFL, which shares the largest percentage of its revenues among the leagues, winning does not appear to provide any marginal financial gains. When more revenue is shared, owners have less financial incentive to improve team quality: and, the empirical estimates support this finding. An NFL owner may seek better players for pride or out of civic duty to fans, but devoting resources to improve team quality does not appear to produce financial gains similar to what can be expected in MLB, NBA, or NHL. Also, the NFL is governed by a hard salary cap which prevents investment in player labor to improve a team beyond a threshold.

B. Diminishing Returns, Uncertainty of Outcome, and Competitive Balance

The estimated relationship between on-field success and revenue also has implications for understanding the demand for professional sports. The marginal returns to winning are not diminishing—in fact, the returns to winning may be increasing—which contradicts a linchpin assumption often employed in economic models of sports leagues. The reasons for the expectations of diminishing returns hypothesized by Rottenberg (1956) and Neale (1964) are the result of uncertainty of outcome. As follow-up analysis, I estimated regressions that included two measures of competitive balance as explanatory variables in the regression models, and the estimates were not statistically significant for any league, which is consistent with the lack of diminishing returns.[10]

While it is possible for a league to be composed of a few teams that are so dominant that the outcome of the games/season is rarely in doubt, in practice, the actual dispersion of team quality has not been so great. Also, Coates, Humphreys, and Zhou (2014) survey the existing literature on UOH and find that the model's predictions are not widely supported by empirical evidence. Furthermore, the authors demonstrate that fan demand for sports as it relates to uncertainty of outcome is more complicated than fans valuing

10. The competitive balance measures employed were the ratio of the actual to the ideal standard deviations of winning percentages (Quirk and Fort 1992) and the ratio of the within-team standard deviation over the sample and within-season standard deviations in winning percentages (Humphreys 2002).

raw win uncertainty and, that under certain reasonable assumptions, demand can increase even as outcomes become more certain. When spectators have strong preferences for both home team wins (due to loss aversion) and upsets of superior teams, attendance will be highest when the home team's win probabilities are high or low; thus, attendance demand is U-shaped. The authors find support for U-shaped demand for attendance in MLB. Humphreys and Zhou (2015) find further support for U-shaped attendance demand in MLB, and Humphreys and Pérez (2017) identify a similar demand relationship in television viewership of Spanish football (soccer). The increasing financial returns to on-field success identified in this study are consistent with increasing spectator demand for winning associated with fan loss aversion that has been identified in these other recent studies.

While Solow and Krautmann (2007) report finding a diminishing value of wins needed for the UOH in MLB using data from 1996 to 2001, the results represent a short period for one league in the past and do not necessarily suggest diminishing returns.[11] Bradbury (2017) examines the returns to winning in MLB from 1990 through 2015 and finds some evidence of diminishing returns during the late-1990s; however, in all other periods, returns are positive and increasing. Thus, the relationship between winning and revenue in the late-1990s appears to be anomalous or a product of factors unique to that era and therefore not generally applicable outside of this time period.

Thus, there are good reasons to believe that the standard argument for the diminishing returns to winning due to fan preferences for uncertainty of outcome does not conform to the real world. The findings here cast further doubt on the UOH as it relates to league competitive balance as traditionally applied in the sports economics literature. Fans do not appear to be particularly sensitive to outcome uncertainty and continue to value additional wins from local teams; therefore, leagues are operating in a range where no team should be discouraged from improving itself too much for fear of deterring fans.

11. The reported estimated effects of winning on revenue are not statistically significant at the standard 5% level. Also, the empirical model includes interaction terms of population and income with winning without all the associated components as separate variables, rendering the coefficients indecipherable.

C. *Player Marginal Revenue Products (MRPs)*

The findings also have implications for how economists measure player MRPs. Beginning with Scully (1974), economists have tied athlete productivity to winning, and used this contribution to measure player value. While winning affects revenue for most sports leagues, revenue is also determined by the performance quality that is unrelated to winning. If one was to estimate the MRP of football players based on their contributions to winning as estimated in Table 4, their MRPs would be $0; yet, the average wage for an NFL player in 2015 was $2.1 million (Badenhausen 2016). After estimating the impact of winning on revenue using a specification like those reported in this paper, Berri, Leeds, and von Allmen (2015) similarly find that players are paid salaries above what their value from producing wins is estimated to be. Because of this finding, the authors declare standard measures of MRPs to be meaningless and posit that player wages are instead tied to bargaining power. However, economists should not be too quick to abandon the basic rationality assumption embodied in the MRP framework when valuing professional athletes. As Rottenberg (1956, 252) notes, "it is undoubtedly correct that the player will not be paid more than he is worth to the team, his worth being determined by that part of the team's revenue which is attributable to his capacity to attract patrons to the ball park, net of the price paid for his contract to another team or the cost of his development."

The absurdity of paying multimillion-dollar contracts to zero MRP workers (as the results would indicate) points to a potential misunderstanding of the information contained in the estimates, as they relate to the economic value of player quality. The problem is not with the decision-making of the teams, but with the interpretation of the estimates. Coefficients that estimate the returns to winning—via wins, winning percentage, score differential, and so on—provide information only about the value of performance *relative* to each other, but not about the value of absolute performance level of play to which all players contribute. Because winning reflects only relative performance differences across teams, not how good the talent of the league is overall, the coefficients do not account for the value that fans place on overall competition being played at a major-league level. This notion has not been sufficiently addressed within the sports economics literature.

TABLE 6
Summary Estimates of Major Determinants of Revenue in Sports Leagues (2006–2015)

	MLB	NBA	NFL	NHL
Score differential	6.474	5.183	−0.737	3.853
	(1.071)**	(1.149)**	(0.858)	(0.879)**
Score differential^2	2.159	0.766		0.903
	(0.763)**	(0.793)		(0.487)
Score differential (t−1)	4.450	4.124	0.019	1.039
	(1.105)**	(1.192)**	(0.874)	(0.836)
Population	5.470E-06	1.143E-05	4.144E-05	3.400E-07
	(1.72E-06)**	(2.93E-06)**	(1.069E-05)**	(1.31E-06)
Stadium age	48.748	43.392	39.438	21.230
	(7.078)**	(13.057)**	(5.822)**	(5.760)**
Fixed effects	No	Yes	Yes	Yes
Year effects	Yes	Yes	Yes	Yes
R^2	0.67	0.56	0.52	0.52
Observations	300	240	288	240

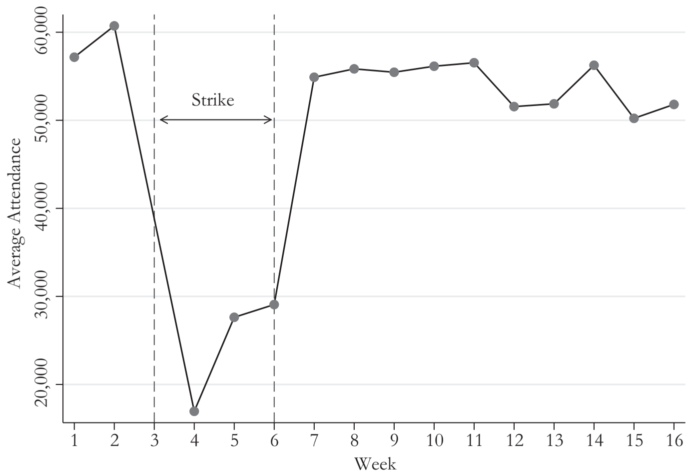
Notes: Standard errors in parentheses. Overall R^2 reported for random effects, within R^2 reported for fixed effects. Score differential estimates in standard deviations from average and report model specifications by league in Tables 2–5: MLB (6), NBA (2), NHL (2), and NFL (2).
*$p < .05$; **$p < .01$.

Sports fans do value winning and contribute more revenue to teams that win; however, fans also value the overall quality of performance in addition to winning. From amateur leagues to minor leagues to major leagues, the quality of performances increases with each level, and fans do not freely substitute between levels to accommodate a preference for winning—we do not expect baseball fans to transfer support from a losing MLB team to a successful minor-league team. The overall quality of the league itself is a strong determinant of fan interest, and that interest is not the result of an arbitrary declaration of a league being deemed a "major league" to which players contribute nothing. Rottenberg (1956, 256) explicitly states that preserving the overall quality of the league is vital to generating revenue in a league with 100% revenue sharing, which somewhat describes the NFL, "It will pay for all teams, taken together, to play well enough, on the average, so that revenue will not fall off faster than costs.…A rule of equal sharing of revenue leads to the equal distribution of mediocre players among teams and to consumer preference for recreational substitutes." As the league-wide talent-level diminishes from owners attempting to free ride on the talent level of other league members, fans will consume more recreational substitutes; therefore, the revenue contribution from superior talent requires adequate compensation. A league that offered salaries to players based solely on their marginal contributions to winning would be undervaluing its chief input and would open the door for entry by a rival league—something that has happened to the NFL three times in the past 60 years (American Football League, World Football League, and the United States Football League).

Measuring the added value of being a major-league player is difficult in North American professional sports leagues because teams operate as territorial monopolies; thus, there is no counterfactual lower tier to which attendance or revenue can be compared in the same geographic area. Minor leagues (baseball and hockey) and collegiate athletics (football and basketball) cover different geographic areas and are valued for reasons other than their high level of play (e.g., collegiate athletics serve as a focal point for loyal alumni). However, there was one instance in which the NFL fielded teams with nonmajor-league players, and its experience demonstrates the strong value that fans place on the absolute level of play.

In response to the 1987 NFL players strike, NFL owners heavily stocked their teams with "replacement players" to play regular-season games for 3 weeks. Rosters were composed of players from the next tier of quality, who were deemed as unqualified to play major-league football previously. Figure 3 maps the significant decline in attendance during the weeks with replacement players (weeks 4, 5, and 6) versus regular NFL players. On average, attendance dropped to 24,551 during the strike weeks from

FIGURE 3
NFL Weekly Attendance, 1987



54,873 during major-league player weeks—a 55% decline, which is statistically significant.[12]

Evidence of fan preferences for top-level talent is also observable in the differences in attendance and revenue following relegation and promotion in European professional soccer, where teams generally play for the same fans but against different levels of competition when transitioning between league tiers. Symanski (2015, 92) reports an average 16% difference in attendance between teams switching between Premier League and the second division in English soccer, and a further difference of 13% between the second and third division. Noll (2002) lists data for several English soccer clubs who were both relegated and promoted in the 1990s. The reported totals show an average 22% increase in attendance and 44% increase in revenue from promotion, and corresponding declines in attendance and revenue of 15% and 21% from relegation.

12. Attendance figures compiled from Carroll et al. (1999). Perhaps a portion of the attendance decline reflected union solidarity support among fans or general contempt for the strike. However, fans have largely not been supportive of players who are viewed as overpaid due to their relatively high salaries. Staudohar (1996, 75) reports that a survey of NFL fans at the time of the strike found fans supported the owners over the players by about a three-to-one margin. Schmidt and Berri (2004) note that despite often-expressed consumer "disgust" at labor strife, threats to cease consumption are not credible as fans quickly return to sports consumption following labor strife (consistent with data presented in Figure 3). Thus, the reduction in consumption likely reflected the quality of the on-field labor product.

The massive differences in attendance between major- and nonmajor-league competition highlight the importance of the overall quality of play for generating fan interest. Major leagues feature the top talent in their respective sports to raise the overall level of play that drives fan interest. Although this revenue is a product of a quality that impacts winning, that same quality has an impact on revenue that is separate from winning. A marginal major-league player may not add significant value to winning, but he does offer value in the form of being sufficiently capable of providing high-quality output. Thus, the MRP of any major-league player remains positive even when the returns to winning are zero. Therefore, it is wrong to estimate the full MRP of players solely from their contribution to winning as has been done traditionally in the economics literature.

If MRP estimates derived solely from the relative quality do not fully value players, then a method for incorporating the absolute quality value into the estimates is needed.[13] Equation (2) presents a hypothetical equation for estimating a player's MRP that includes his contribution to the absolute performance of the league (A) in addition to his relative contribution to winning (R).

$$\text{MRP} = \alpha(pA) + R, \tag{2}$$

13. Cyrenne (2001) presents a model where fans value absolute and relative quality of play.

where $0 < \alpha < 1$, and represents the contribution of the players' share of league value attributed to the absolute quality of play and reflects "consumer preferences for recreational substitutes." For example, if 55% of team revenue is generated by the league having major-league players (as measured by the 1987 NFL example above) then $\alpha = .55$.[14] Owner rents would then equal $1-\alpha$. If fans prefer the highest-quality league, and there is free entry into a competitive or contestable monopoly league market, then the credible threat of rival league entry will drive α toward 1. If fans are loyal to the incumbent natural monopoly league, or entry by rivals is otherwise restricted, then α will approach 0. p is the percentage of the contribution of any player to the absolute quality (A) of the league. For example, a pitcher who pitches 10% of his team's innings would contribute that same percentage of his team's major-league contribution to revenue. In sports where assignment of marginal contributions to players is difficult, such as the joint product provided by football players, the value may be assumed to be 1/nth of A, where n is the total number of players/positions in the league. Equation (2) is meant as a general guide, serving as a starting place for future research on MRP estimates of athletes, which should include a component to measure the contribution to absolute quality of play that has not been acknowledged.

V. CONCLUSION

Although theoretical aspects of sports leagues have been studied extensively by economists, empirical analysis has been scant and needs updating. The empirical analysis in this paper reveals conflicts with commonly employed theoretical assumptions and past empirical findings, confirms other theoretical aspects and past empirical analyses, and provides updated analysis that furthers our understanding of the modern sports industry.

Estimates from the past decade indicate that the returns to on-field success differ by sports leagues. The impacts range from no effect, in the NFL, to positive and increasing effects in the other sports leagues—with MLB experiencing the strongest returns to winning. The differing financial impacts to winning across sports leagues are consistent with league revenue-sharing structures determined through collective bargaining and related agreements. The returns to winning do not appear to differ according to market size, but market size does have a separate positive effect on revenue. The wealth of the host city has a positive effect in the NFL and NHL, and Canadian teams generate more revenue in the NHL than teams located in the United States. Additionally, some franchises experience unique revenue streams.

The results also confirm the importance of the novelty effect of new stadiums on revenue in all sports leagues. The returns to stadiums are highest when they are new and then diminish over a decade, which creates a strong incentive to replace stadiums even before they have exhausted their useful physical life. These results are consistent with past studies of attendance in most North American sports leagues; in addition, the estimates identify a novelty effect in the NFL that previously had not been observed in the economics literature.

The findings have several implications for our understanding of sports leagues and how economists should model and evaluate related aspects of professional sports. First, increased revenue sharing lowers the marginal value of winning, which is consistent with incentives created by contributing and withdrawing revenue to and from a common pool. Second, the estimates do not support the common assumption that there are diminishing returns to winning in professional sports leagues. This finding supports the critique of Coates, Humphreys, and Zhou (2014) that the UOH, as it is commonly used in the sports economics literature, does not conform with reality; thus, models based on these traditional assumptions need to be reformulated. Third, the findings imply that because players are paid positive salaries, even when their revenue contributions to winning are zero, player MRP estimates should value absolute player quality in addition to their relative quality as it contributes to winning.

14. Measuring α is more complicated than presented in than the 1987 strike example, and this example is used only for illustration.

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