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Market Success as a Criterion for Assessing Player Contributions in Sports Businesses via a Regression-Based Approach Using Adjusted Performance Measures and Quasi-Dummy Variables

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Abstract

Using winning percentage as a well-established proxy for market success, this article proposes a method for estimating the relative contributions of players to victories as an assessment of their worth—that is, their value to team owners or their greatness as judged by sports fans. Specifically, the proposed approach regresses winning percentage on adjusted measures of team performance (with the players of interest omitted) plus quasi-dummy variables coded to represent the participation rates of the relevant players. Though this approach lends itself to use across a wide variety of sports (professional or college football, basketball, hockey, baseball, and so on) and situations (such as season, league, and history of team), it is described primarily in the context of major league baseball and is illustrated by means of a specific empirical application to the case of the New York Yankees.

> Fans do not come to the park primarily to see hitting and pitching; rather, they come to see their team win.... The hypothesis is that fan support is affected by club wins (Scully, 1989, pp. 154–155).

> Nothing could be more obvious than this: that the fans simply want to win. If you win, the fans will be happy; if you don't, they won't. There's no second verse here (James, 1993, p. xx).

1. Introduction

Firms often face the problem of assessing the relative value of individual contributors to overall performance. For example, Fortune 500 companies must evaluate the worth of their CEOs as a basis for their often astronomical compensation packages. Similarly, film and theater companies must gauge the drawing power of individual actors and actresses. And sports franchises must assess the relative contributions of the various players on a given team. This article addresses such issues as they apply to sports in general and to the case of major league baseball in particular.

Specifically, the article focuses on winning percentage as a well-established proxy for market success in such professional or college sports as football, basketball, hockey, and baseball. It suggests that the contributions of players in enhancing team victories provide a clearly interpretable assessment of their economic value as viewed by owners and of their greatness as seen by fans. The article shows how specially designed regression analyses reminiscent of those sometimes used in conjoint analysis or in other familiar marketing-research procedures to determine the utilities or part worths of various product attributes or brand features can be adapted and deployed to measure the contributions of various players to the market success of their teams.

To preview briefly, the proposed approach borrows from conventional methods by regarding a team's winning percentage as a proxy for its market success and by regressing this criterion on two major types of explanatory variables—first, measures of team performance adjusted to indicate what that performance would have been without the participation of the relevant player; second, a set of quasi-dummy variables coded to reflect the degree to which each player of interest participated in the various units of observation (such as games or seasons, depending on the focus of the analysis).

This general approach is applicable across a wide variety of situations that interest sports managers and fans. For example, it could be used to address questions arising from a pay-for-play outlook on the problem of setting salaries. Further, it could be modified to provide insights into issues such as who should win the Heisman trophy in college football, who deserves election to the Basketball Hall of Fame in Springfield, who has earned the Cy Young Award, who ranks as the season's Most Valuable Player (MVP) in virtually any sport, or who is the greatest player of all time for his team, at his position, or in his league. However, to provide clarity and consistency, I shall focus primarily on the case of major league baseball. Further, to offer a detailed example, I shall describe a specific empirical illustration drawn from the history of the New York Yankees—a team that, whatever its current situation, has perhaps been known to more sports fans than any other professional franchise.

Clearly, I am not the first to raise questions about who is the most valuable or greatest player in a sport, league, team, or season. Indeed, this fundamental issue has proven so fascinating to sports writers that they have suggested a host of measures, formulas, indices, and other statistics to provide what each commentator regards as his own definitive answer (James, 1993; Gimbel, 1994; Siwoff et al., 1993). The problem, of course, is that these assessments do not usually agree and seldom point to unequivocal conclusions. Hence, we encounter endless debates on who deserves the Heisman Trophy (Moran, 1995), who has earned the MVP award (Chass, 1995b; Smith, 1995), who ranks as the best player at each position (Chass, 1995a), or who has met reasonable standards for election to the Hall of Fame (Anderson, 1995; Vecsey, 1996). In this connection, my key points are (1) that such debates should be resolved by placing measures of value or greatness on the same basis geared toward assessing a player's relative contribution to his team's winning percentage as a proxy for market success and (2) that the techniques for deriving such measures stem from straightforward modifications of conventional regression-based procedures commonly used in marketing research. In that light, I shall describe the overall application of the proposed approach to major league baseball in general and to a specific illustration based on the New York Yankees in particular.

2. The case of baseball

Recent traumatic events such as the 1994 baseball strike have dramatized the extent to which professional sports are businesses of entertainment as much as arenas of athletic competition (Fort, 1992; Quirk and Fort, 1992; Scully, 1989; Vernon, 1992). In that light, if one views a sports business through the eyes of the marketing strategist, one sees the market success of a team as a function of its product design. In this sense, one may examine the market-enhancing contribution of a baseball star in much the same way that a marketing researcher who performs conjoint analysis or some comparable analytic technique would inquire about the utility or part worth of a brand feature. In producing cola, one asks whether to include sugar or artificial sweetener. In producing baseball games, one asks whether to add a power-hitting first baseman or a hard-throwing relief pitcher. Further, we may extrapolate this perspective to raise fundamental questions about a player's economic value (to team owners) and greatness (to fans).

2.1. Economic value to team owners

Over twenty years ago, Scully (1974, 1989) introduced a recursive two-equation model for determining the economic value of a baseball player to his team—that is, the player's marginal revenue product (MRP) in contributing to team revenues by virtue of his on-field performance. Specifically, Scully showed (1) that team revenues depend on the team's winning percentage (as well as on the population of its market area) and (2) that winning percentage in turn depends on the team's offensive and defensive performance. Scully (1974, 1989) and Fort (Fort, 1992; Quirk and Fort, 1992) have measured the latter two variables by the team's slugging average and strikeouts-to-walks ratio, respectively. Other researchers have replaced the slugging average with such measures of batting performance as run production viewed as the sum of slugging average plus on-base percentage (Zimbalist, 1992, 1994); runs produced via scoring and RBIs (Burgess and Marburger, 1992); total bases gained from hits, walks, and steals (Scully, 1995); or offensive average defined as bases gained per trip to the plate (Johnson, 1992). Meanwhile, Zimbalist (1992, 1994) has shown that, as a measure of pitching performance, the strikeouts-to-walks ratio predicts less well than the earned run average (ERA), while Burgess and Marburger (1992) have used an inverse function of ERA as their measure of pitching effectiveness. Also, some researchers pursuing topics rather different from those investigated here (such as the determination of player salaries) have included additional measures of player performance (e.g., Hadley and Gustafson, 1991; Holbrook and Shultz, 1996). However, in view of the considerable multicollinearity that exists among various performance measures, virtually all researchers have agreed on the feasibility of adopting a highly parsimonious approach to explaining winning percentage via a model in which just one summary index represents each of the two key components, offensive production and defensive performance (Quirk and Fort, 1992, p. 369): "All previous attempts at widening the repertoire of performance variables have reached the same conclusion: the variables are so highly correlated that, once a few are included, more variables provide little additional explanation" (Fort, 1992, p. 138).

Based on the data available for purposes of the present study, I shall focus on slugging average (SA) and earned run average (ERA) as the two principal predictors of winning percentage (WP). However, the reader should keep in mind that I intend this demonstration primarily for illustrative purposes; that, in baseball, alternative analyses of other data bases might well benefit from exploring additional ways to operationalize the two measures of batting and pitching performance; and that, in other sports, analogous measures of offensive and defensive performance would be needed in order to conduct comparable investigations.

2.2. *Greatness to fans*

In addition to the managerially relevant implications of SA and ERA in contributing to WP as the hallmark of a team's market success, one also notes a considerable fascination among baseball fans concerning minor variations on the basic question "Who is the greatest player?" For example, pursuing what Fort (1992, p. 137) calls the "Bill James Model," some analysts have suggested complex formulas, arcane logic, or informed intuition for determining a player's relative worth—as when James (1993, p. xi) employs an admittedly impressionistic dollarmetric scale based on "purely subjective judgments" to assign, say, Barry Bonds a value of $100 and Don Mattingly a value of $34 or when Gimbel (1994) extends the Jamesian approach to derive a formula for run production average (RPA) that takes account of both offensive and defensive abilities as well as position, home stadium, and age to compute scores of, say, .223 for Bonds and .127 for Mattingly. Others have relied on more esoteric statistics such as batting average with two outs and runners in scoring position (Siwoff et al., 1993). Meanwhile, as noted earlier, still others have debated subtle issues involved in establishing criteria for admission to the Baseball Hall of Fame, for choosing the Most Valuable Player, or for comparing the performances of stars who have played the same position. Recall, for example, the extended controversies about whether Phil Rizzuto deserved election to Cooperstown or whether Cal Ripkin ranks above the standards set by other star shortstops.

The problem with most available indices on which such comparisons have been based is that they are not logically comparable among players from different eras, different leagues, different teams, different positions, or other different contexts. It makes no sense to compare the slugging averages of Lou Gehrig and Don Mattingly if these two batters played with balls of different liveliness, with different strike zones, and with pitching mounds of different heights located at different distances from home plate. It makes no sense to compare the earned run averages of Ron Guidry and Whitey Ford if only the former had to face the designated hitter. It makes no sense to compare Mike Stanley and Paul O'Neill if one wrecks his knees by squatting behind home plate or if the other damages his arm by crashing into the right-field fence. In short, it makes no sense to compare players from different eras, leagues, teams, or positions using virtually any of the standard indices that have been concocted by those who compile baseball statistics. Apparently, then, we are in need of an approach to assessing the comparative contributions of players in a way that makes more sense.

2.3. The proposed approach

One can, of course, debate the philosophical basis for assessing "worth," estimating "value," or evaluating "greatness" in a sport such as baseball. However, my position in this article is that the key criterion from the model of economic value with which we began and the greatness factor of relevance to crowds in the stands are essentially *the same*. When all is said and done, recalling the famous words of Coach Vince Lombardi, the purpose of the game is to win; economic value results from winning; and the greatest players are those that do the most to help their teams accomplish that objective (James, 1993; Porter, 1992; Scully, 1989). Hence—from the viewpoints of both the team owner and the fan—we arrive at the same conclusion: the worth of a player should be measured by the strength of his contribution to his team's winning percentage. A player's greatness to fans is *synonymous* with his value to owners in enhancing the team's chances for victory.

Accordingly, in contrast to other studies that have used questionably valid indices based on potentially incomparable performance statistics as their standards for judging a player's worth, this article proposes an approach to assessing value or greatness by measuring the relative strength of a player's contribution to winning percentage. In what follows, I shall explain the *method* briefly in a manner that can be applied by any researcher interested in raising this general type of issue (in baseball or, potentially, in other sports of interest) and shall then *illustrate* this approach by addressing a question pertinent to the case of the New York Yankees in particular (namely, "Who was the greatest Yankee of them all?").

3. Method and illustration

3.1. General approach

In general, the approach proposed here proceeds by means of straightforward OLS regression analysis.

Step 1 develops a model of winning percentage by regressing this dependent variable—across teams, across seasons, or even across games—on suitable measures of offensive and defensive performance *relative* to those for the relevant basis of comparison (say, the rest of the league). This emphasis on relativistic predictors (for example, team performance divided by average performance for the rest of the league) reduces problems of incomparability due to changes in the liveliness of the ball, the definition of the strike zone, the position of the pitching mound, and so on.

Step 2 computes *adjusted* relative measures of offense and defense for each unit of observation (team, season, game) *without* the performance of the player of interest by *subtracting* the contribution of that player from each relevant observation and by computing the relative performance of the team *without* the player of interest as a ratio of that for the appropriate basis of comparison (again, say, the rest of the league).

Step 3 represents each player of interest by a quasi-dummy playing-time variable coded to indicate the extent to which that particular player participated in the relevant unit of observation (team, season, game)—as indicated, for example, by that player's percentage of team at bats or percentage of innings pitched. This quasi-dummy variable will, of course, be zero for any unit of observation in which the player did not appear and between zero and some upper limit less than one for any team, season, or game in which the player did participate.

Step 4 regresses the relevant winning percentages on the adjusted relative performance scores plus the quasi-dummy playing-time variables representing extent of participation by the various players. The resulting regression coefficients are interpreted as indices of the players' incremental contributions to winning percentage. Where the bases for comparison are different—for example, batters versus pitchers—the ordinary regression coefficients should be replaced by standardized beta weights to adjust for different degrees of variation in the participation rates across the various categories of interest.

3.2. Specific illustration

3.2.1. Data. The present illustration draws on data published by *The Baseball Encyclopedia* (1993). This encyclopedia provides hitting, pitching, and winning statistics for all players and teams throughout the history of major league baseball. In particular, I followed the previous researchers mentioned earlier by selecting slugging average (SA) and earned run average (ERA) as the indices of batting and pitching performance of relevance to the explanation of winning percentage (WP) at the team level across seasons from 1903 through 1992.

3.2.2. Sample. For illustrative purposes, I focused on the American League New York team in general and on players for the Highlanders (1903–1912) and Yankees (1913–present) in particular who have either already been elected or who appear to be conceivably electable to the Baseball Hall of Fame. Specifically, the roster of Yankee or Highlander regulars and pitchers who currently reside in the Hall of Fame (with their years of activity on the team) include the following:

- *Regulars*: Frank Baker (1916–1922), Yogi Berra (1946–1963), Earle Combs (1924–1935), Bill Dickey (1928–1946), Joe Dimaggio (1936–1951), Lou Gehrig (1923–1939), Reggie Jackson (1977–1981), Willie Keeler (1903–1909), Tony Lazzeri (1926–1937), Mickey Mantle (1951–1968), Johnny Mize (1950–1953), Phil Rizzuto (1941–1956), Babe Ruth (1920–1934), Joe Sewell (1931–1933), and Enos Slaughter (1954, 1957–1959).
- *Pitchers*: Jack Chesbro (1903–1908), Whitey Ford (1950–1967), Lefty Gomez (1930–1942), Waite Hoyt (1921–1929), Catfish Hunter (1975–1979), Herb Pennock (1923–1933), and Red Ruffing (1931–1946).

To this list, I added several players of interest because of their distinguished careers—specifically, the regulars Roger Maris (1960–1966), Don Mattingly (1982–present), Lou Piniella (1974–1984), and Dave Winfield (1981–1988) plus the pitchers Goose Gossage (1978–1983), Ron Guidry (1975–1988), Sparky Lyle (1972–1978), and Dave Righetti

(1979–1990). Given this sample of players across the history of the team's experience, the relevant unit of observation was defined as the team's performance during a year in which a given player was at least partially active. With thirty players of interest, this criterion produced a sample size of N = 314.

3.2.3. Analysis. The detailed steps of the analysis serve to illustrate the general approach described earlier. Specifically, if $1B_i$, $2B_i$, $3B_i$, HR_i, AB_i, ER_i, and IP_i where $i = l, t$, or p represent singles, doubles, triples, home runs, at bats, earned runs, and innings pitched for the league, team, and player, respectively, then slugging or $S_i = 1B_i + 2 \times 2B_i + 3 \times 3B_i + 4 \times HR_i$, slugging average or $SA_i = S_i/AB_i$, and earned run average or $ERA_i = (9 \times ER_i)/IP_i$.

In *Step 1*, I defined the team's relative slugging average (RSA) and relative earned run average (RERA), respectively, as

$$RSA = SA_t/[(S_l - S_t)/(AB_l - AB_t)] \text{ and}$$

$$RERA = [ERA_t/9]/[(ER_l - ER_t)/(IP_l - IP_t)].$$

These measures provide relativistic assessments of the team's batting and pitching performances *compared with* those for the rest of the league. They thereby control for changes over time in such performance-relevant factors as the liveliness of the ball, the definition of the strike zone, or the position of the pitching mound. Using these relativistic measures, I checked to make sure that RSA and RERA provided an adequate explanation of winning percentage, as judged by R^2. As noted later, they did.

In *Step 2*, as mentioned previously, I *adjusted* the measures of RSA and RERA by subtracting the performance of the relevant player from their numerators. Formally, the team's adjusted measures—ARSA and ARERA—are given by

$$ARSA = [(S_t - S_p)/(AB_t - AB_p)]/[(S_l - S_t)/(AB_l - AB_t)] \text{ and}$$

$$ARERA = [(ER_t - ER_p)/(IP_t - IP_p)]/[(ER_l - ER_t)/(IP_l - IP_t)].$$

Clearly, these measures of ARSA and ARERA provide adjusted and relativistic estimates of how the team's slugging and earned run averages would have compared to those for the rest of the league *without* the participation of the player in question (for further justification, see Zimbalist, 1992, p. 118). Regressing winning percentage on ARSA and ARERA indicates the variance in WP explained on the assumption that the players of interest did *not* participate. The key question, of course, concerns the contributions estimated when accounting for the fact that the relevant players *did* participate to greater or lesser degrees in various years.

To address that question, in *Step 3*, I coded thirty quasi-dummy variables—one for every player—to represent that player's degree of participation or relative playing time in each unit of observation. Specifically, the quasi-dummy playing-time variables of interest were AB_p/AB_t and IP_p/IP_t for the relevant batters and pitchers, respectively (see Fort, 1992; Quirk and Fort, 1992). The average maximum participation rates were 0.11 for batters and

0.19 for pitchers. These feasible maximum playing times of roughly 10 and 20 percent for batters and pitchers, respectively, become important later when interpreting the effect sizes associated with the various findings.

Finally, in *Step 4*, I regressed WP on ARSA, ARERA, *and* the thirty quasi-dummy playing-time variables to determine the relative contribution of each player to the Yankees' overall winning percentage. Here, because the participation rates of batters and pitchers differ considerably, initial comparisons are made between the relevant standardized beta coefficients (β) before examining the effect sizes associated with maximum playing times for the different categories of players whose incremental contributions pass the test of statistical significance.

3.3. Results

As expected, the regression of WP on RSA and RERA produced a strong explanation of variance ($R^2 = 0.785$, $F_{2,311} = 568.6$, $p < 0.0001$) with highly significant contributions from both RSA ($\beta = 0.549$, $t_{311} = 20.0$, $p < 0.0001$) and RERA ($\beta = -0.553$, $t_{311} = -20.1$, $p < 0.0001$), respectively. This result indicates that, as found in the other aforementioned studies, the relative slugging and earned run averages provide measures of offensive and defensive performance that together explain a team's winning percentage. (This explanation was not improved by including a multiplicative RSA $\times$ RERA interaction term: $\beta = 0.015$, $t_{310} = 0.54, p > 0.50$.)

As one would also expect, when using the adjusted relative predictive measures ARSA and ARERA, explained variance in WP falls a bit ($R^2 = 0.746$, $F_{2,311} = 457.4$, $p < 0.0001$); but strongly significant contributions continue to appear for both ARSA ($\beta = 0.510$, $t_{311} = 17.3, p < 0.0001$) and ARERA ($\beta = -0.581$, $t_{311} = -19.7, p < 0.0001$). This drop in R^2 from 0.785 to 0.746 reflects the fact that we have intentionally *omitted* the contributions to winning percentage attributable to participation by the players of interest. (Again, the ARSA $\times$ ARERA interaction makes no significant contribution: $\beta = 0.043$, $t_{310} = 1.44, p = 0.15$.)

When including the player-specific quasi-dummy playing-time variables, explained variance returns to a level slightly higher than that prior to the adjustment of the relativistic scores ($R^2 = 0.793$, $F_{32,281} = 33.730, p < 0.0001$)—still with strongly significant contributions from ARSA ($\beta = 0.563$, $t_{281} = 15.3$, $p < 0.0001$) and ARERA ($\beta = -0.622$, $t_{281} = -18.1$, $p < 0.0001$). Further, the standardized beta weights (β) for the individual batters and pitchers, ranked in decreasing order of their relative magnitudes, appear in Table 1 and provide indices of the players' *comparative strengths of contributions* to the Yankees' winning percentage. These indices of contribution strengths (Table 1) suggest several findings of potential interest:

1. As one would expect, comparatively strong contributions appear for the names of such familiar Yankee heroes as Babe Ruth ($\beta = 0.150$), Lou Gehrig ($\beta = 0.110$), Joe Dimaggio ($\beta = 0.105$), and Mickey Mantle ($\beta = 0.098$).
2. However, strong contributions also appear for at least two players not normally regarded as household names. Specifically, Willie Keeler ranks second among all batters (β

Table 1. Regression of winning percentage (WP) on adjusted relative slugging average (ARSA), adjusted relative earned run average (ARERA), and Quasi-dummy playing-time variables representing participation by 19 batters and 11 pitchers.

Independent Variables	Standardized Beta (β)	t-Value	p-Level
ARSA	0.563	15.31	0.0001
ARERA	−0.622	−18.14	0.0001
Batters:			
Babe Ruth	0.150	4.64	0.0001
Willie Keeler	0.131	4.25	0.0001
Lou Gehrig	0.110	3.41	0.0007
Joe Dimaggio	0.105	3.27	0.001
Mickey Mantle	0.098	2.94	0.004
Don Mattingly	0.077	2.44	0.02
Roger Maris	0.070	2.36	0.02
Yogi Berra	0.067	2.03	0.04
Dave Winfield	0.065	2.14	0.03
Bill Dickey	0.057	1.72	0.09
Reggie Jackson	0.054	1.84	0.07
Frank Baker	0.043	1.46	n.s.
Lou Piniella	0.043	1.40	n.s.
Johnny Mize	0.040	1.41	n.s.
Joe Sewell	0.030	1.03	n.s.
Tony Lazzeri	0.023	0.72	n.s.
Phil Rizzuto	0.022	0.67	n.s.
Earle Combs	0.010	0.30	n.s.
Enos Slaughter	−0.003	−0.11	n.s.
Pitchers:			
Jack Chesbro	0.143	4.57	0.0001
Ron Guidry	0.074	2.38	0.02
Lefty Gomez	0.060	1.88	0.06
Goose Gossage	0.053	1.79	0.07
Whitey Ford	0.052	1.61	n.s.
Red Ruffing	0.048	1.46	n.s.
Dave Righetti	0.038	1.23	n.s.
Sparky Lyle	0.025	0.85	n.s.
Herb Pennock	0.020	0.62	n.s.
Waite Hoyt	0.017	0.55	n.s.
Catfish Hunter	0.009	0.30	n.s.

= 0.131), while Jack Chesbro leads all pitchers and ranks just slightly behind Babe Ruth overall (β = 0.143). (Both men played for the Yankees during the period from 1903 through 1912 when the American League New York team was known as the Highlanders.)

3. The indices of comparative strength suggest that certain players not currently in the Hall of Fame clearly deserve that honor (either now or when they become eligible). Among the batters, these include Don Mattingly (β = 0.077), Roger Maris (β = 0.070), and Dave Winfield (β = 0.065). Among the pitchers deserving election, we find Ron Guidry (β = 0.074) and Goose Gossage (β = 0.053).

4. The indices indicate that certain players in the Hall of Fame made smaller contributions than did others who may stand comparatively little chance of getting elected. For example, ten Hall of Fame batters—including Phil Rizzuto (β = 0.022), Reggie Jackson (β = 0.054), and Yogi Berra (β = 0.067)—contributed less than did Roger Maris (β = 0.070). Similarly, five Hall of Fame pitchers—including Catfish Hunter (β = 0.009) and Whitey Ford (β = 0.052)—contributed less than did Goose Gossage (β = 0.053).

Although the results reported thus far rely on beta coefficients that permit meaningful comparisons among players with different patterns of playing time (for example, batters versus pitchers), the reader might still wonder about the comparative *effect sizes* of the differing participation rates involved. These effect sizes depend on the ordinary regression coefficients, which indicate the increase in winning percentage that would theoretically occur if a player's participation rate were increased from zero to 100 percent. Unfortunately, a 100 percent participation rate is literally impossible for batters (who cannot, in principle, appear at the plate more frequently than every ninth time) and virtually impossible for pitchers (whose arms, in practice, would collapse if they pitched more often than, say, one out of every five games). Accordingly, in line with the data mentioned earlier, let us assume that 10 and 20 percent represent the maximum feasible participation rates for batters and pitchers, respectively. It therefore makes sense, (1) to multiply each batter's ordinary regression coefficient by 0.10 to determine the effect size of his incremental contribution to the team's winning percentage if he were to play full time, (2) to multiply each pitcher's coefficient by 0.20 to provide a similar estimate, (3) *only* to examine effects that are statistically significant at (say) $p < 0.05$ for batters or $p < 0.10$ for pitchers (based on the aforementioned pattern of findings in the data), and (4) *only* to compare batters with batters and pitchers with pitchers (because the equilibrating effects of the aforementioned standardization no longer apply). Such comparisons are ranked in decreasing order of incremental full-time contributions to winning percentage in Table 2.

These estimates of incremental contributions from full-time participation suggest that, when playing at full strength (interpreted as 0.10 for batters and 0.20 for pitchers), such batters as Berra, Winfield, Mattingly, Mantle, Gehrig, Dimaggio, Maris, Ruth, or Keeler could add anywhere from two to six points to the team's winning percentage; whereas such pitchers as Gomez, Guidry, Chesbro, or Gossage could increase the won-loss record by anywhere from three to eight percentage points. While continuing to document the preeminence of Ruth, Keeler, and Chesbro, these estimates also highlight the potentially underappreciated worth of Roger Maris and the more contemporary achievements of Goose Gossage, Ron Guidry, Don Mattingly, or Dave Winfield.

4. Conclusions

As in any study of this type, the findings just presented require qualification by various important limitations or restrictions. Specifically, we might find different relative orders of contribution strengths if we adopted a different basic model (such as one including the potential effect of an interaction between slugging and earned run average); if we analyzed

Table 2. Decreasing order of incremental full-time contributions to winning percentage.

Name	Incremental Contribution
Batters:	
Willie Keeler	0.062
Babe Ruth	0.052
Roger Maris	0.039
Joe Dimaggio	0.036
Lou Gehrig	0.034
Mickey Mantle	0.033
Don Mattingly	0.029
Dave Winfield	0.027
Yogi Berra	0.023
Pitchers:	
Goose Gossage	0.081
Jack Chesbro	0.058
Ron Guidry	0.036
Lefty Gomez	0.027

the data for various types of players considered separately (batters versus pitchers); if we looked at different sets of players (a random selection of Yankees rather than just Hall of Fame material or an even more restricted set of certifiable superstars); if we included years spent playing on other teams (Reggie Jackson and Catfish Hunter with Oakland); if we used different explanatory variables (total base production instead of slugging average); if we employed a different criterion of success (box-office receipts as opposed to winning percentage); or if we included more detailed measures of performance in batting (walks, stolen bases), fielding (assists, errors), and pitching (strikeouts, bases on balls). Some of these concerns can be addressed using the available data via various reanalyses of the estimated player contributions reported earlier. Toward this end, three alternative analyses were performed—(1) with the inclusion of a multiplicative ARSA $\times$ ARERA interaction term, (2) for batters and pitchers considered separately, and (3) for only those players with contributions statistically significant at $p < 0.05$ for batters or $p < 0.10$ for pitchers (as reported earlier). Suffice it to say that, as judged by the relevant beta weights, these alternative formulations produced relative contributions virtually indistinguishable from those presented in Table 1. As a rough index of the degrees of correspondence between the findings for the original and alternative formulations, the Spearman rank-order correlations between the original and alternative sets of beta weights were (1) 0.99, (2) 0.98, and (3) 0.89, respectively (the latter reflecting the clearly erroneous assumption that all omitted players contributed nothing). All this suggests that our findings concerning the relative contributions of the various players would not be affected by adopting reasonable alternative specifications of the regression model or the sample to which it is applied. Further, apart from such considerations of robustness, the main point of my empirical example rests on its value as an illustration. Readers interested in subtle variations on the model, the sample, or the operational definitions of key variables may use essentially the same analytic procedure to conduct their own empirical tests.

Subject to such potential limitations or restrictions, the present illustrative study appears to demonstrate the viability of the proposed approach. As mentioned earlier, this approach lends itself to the investigation of numerous interesting questions, both in baseball and in other professional or college sports. These include such issues as which player most deserves the MVP award, which players have performed best at various positions, who belongs in the Hall of Fame, or the relationship of incremental contributions to player salaries. In short, the proposed method can be applied wherever the researcher has access to some measure of market success and to predictive performance measures that can be partitioned into those attributable to the individuals of interest as opposed to those attributable to the various other participants. Clearly, sports teams and their players—as opposed, say, to *Fortune* 500 CEOs or movie stars—represent ubiquitous cases where such available data are likely to exist.

In the present illustration, I have addressed the question of "Who is the greatest Yankee of them all?" Perhaps few will be surprised to find out that the answer appears to be Babe Ruth ($\beta = 0.150$). However, many might not have anticipated that the closest runners up would be the Highlander pitcher Jack Chesbro ($\beta = 0.143$) and his outfielder team mate Willie Keeler ($\beta = 0.131$). And many might have neglected to nominate Don Mattingly (0.077), Roger Maris (0.070), Dave Winfield (0.065), Ron Guidry (0.074), or Goose Gossage (0.053) as among the greatest Yankees of all time.

When they write and rewrite the books on sports history, findings such as those reported here based on something resembling the proposed approach clearly deserve attention. Further, owners of sports teams and fans in the stands may find meaningful applications to gauging the value or greatness of those who play the game. If so, the explanation of market success via a regression-based approach using adjusted performance measures and quasi-dummy variables may help to assess the contributions of various players in ways on which sports teams and their fans can agree.

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