Multiple Equilibria and Unsustainable Runs in Major League Baseball: More Evidence

Rockerbie, Duane and Easton, Stephen

University of Lethbridge, Simon Fraser University

15 September 2021

Multiple Equilibria and Unsustainable Runs in Major League Baseball: More Evidence

Duane W. Rockerbie[a]

Stephen T. Easton[b]

[a] Corresponding Author. Department of Economics, University of Lethbridge. 4401 University Drive, Lethbridge, Alberta, Canada. T1K 3M4. Email: rockerbie@uleth.ca. Tel. 1-403-329-2517.

[b] Department of Economics, Simon Fraser University. 8888 University Drive, Burnaby, British Columbia, Canada. V5A 1S6. Email: easton@sfu.ca. Tel. 1-778-782-3565.

Multiple Equilibria and Unsustainable Runs in Major League Baseball: More Evidence

Abstract

Teams that operate in professional sports leagues often display a cyclical pattern in team winning percentages that are driven by the payroll choices of owners that are inconsistent with a single, stable equilibrium. Two explanations emerge: a stable equilibrium that is shifting over time due to shifts of the revenue or payroll function; or moving between two stable equilibriums. We employ the Bounds test for cointegration between relative team revenues and payrolls to detect multiple equilibria in a sample of Major League Baseball teams over the 1990-2018 seasons. The results suggest the possibility of multiple equilibria for five teams even after accounting for moves to new stadiums that shift the team revenue function.

JEL codes: Z20, Z23, L19

Key words: revenue, payroll, equilibrium, revenue sharing, baseball

1. INTRODUCTION

Armchair sports fans expect to experience the thrill of victory and the agony of defeat with their favorite team over a number of games, or perhaps even over a single season. Even very talented teams lose occasionally due to injuries, bad weather, poor calls by the umpire, or just bad luck. Over a long season, more talented teams tend to win more games, while lesser talented teams struggle to eek out victories. Educated sports fans understand the connection between talent and winning and that talent comes at a high cost that not all teams can afford. Nevertheless, the frustration and disappointment for the fans of losing teams is abated by the hope that there is always next season. But not always. Some professional leagues exhibit teams with winning percentages that remind one of the booms and busts of the stock market. Consistent middling or cellar-dwelling teams experience a change of thinking and "make a run" by quickly acquiring expensive talent and dramatically improving their winning percentage for several seasons. Ultimately the effort collapses, talent is traded or sold off, and the team returns to its inevitable mediocrity. Not all teams display this behavior, but for those that do, we use the term "unsustainable run" to describe their sudden rise to glory and ultimate fall to failure.

MLB is a particularly valid professional league to investigate unsustainable runs since it has no salary cap that short circuits the ability to acquire expensive talent quickly. Although the competitive balance tax[1] (sometimes called the luxury tax) provides some disincentive to ramp up the team payroll, it is only paid by the very few richest teams in MLB and is mostly viewed by them as a cost of doing business. The MLB revenue sharing plan could provide teams with some disincentive to make a run since a portion of the local team revenue (48%) is shared with all of the

[1] The competitive balance tax is paid as a percentage of the overage of the team payroll above a threshold level that is set in the league collective bargaining agreement. The threshold was $206 million for the 2019 season. Only the New York Yankees, Boston Red Sox and Chicago Cubs exceeded the threshold.

other 29 teams in the league, lowering the return to the team making a run. The National Football League (NFL), National Hockey League (NHL), National Basketball Association (NBA) and Major League Soccer (MLS) all utilize a salary cap system and extensive revenue sharing that reduces the incidence of unsustainable runs, although not eliminating them.[2]

Rockerbie and Easton (2013, 2010) construct a model of two-team professional sports league that can generate two equilibriums, regardless of whether the team owners are profit-maximizers or win-maximizers. Multiple equilibria can be the result of spillover effects on league revenue from talent acquisitions by individual teams. The result of the extensive revenue sharing of both local and national revenues is an upward-sloping section of the marginal revenue product schedule when team owners acquire more talent. The standard two-team league diagram is provided in Figure 1 with team winning percentage on the horizontal axis. Winning percentage for each team is determined by the Tullock function $w_i = t_i/(t_1 + t_2)$ where t is the stock of team talent. Three profit-maximizing equilibria are demonstrated with the middle equilibrium being unstable. Swings between the two stable equilibriums can occur due to a number of events, such as a change in team ownership, a change in management philosophy, an anticipation of higher or lower local and national revenues that does not materialize, or irrational exuberance. It could also be the case that factors that shift the marginal revenue product schedules give the appearance of an unsustainable run, but are merely the movement from a single, stable equilibrium to a new one. These could be the result of a new local or national media contract, a new stadium, or demographic shifts in the local metropolitan area.

[2] The NBA collective bargaining agreement contains many exemptions to the team salary cap that allow some teams to exceed the salary cap by a wide margin.

A small number of MLB teams appear to start, be in the middle of, or just ending, an unsustainable run every season. Their hopes of championship glory are always dashed by mounting financial losses, resulting in a return to mediocrity on the field. Profit-maximizing team owners should not behave this way, particularly if they are risk-averse. Ignoring a sudden change in an owner's utility function, economics predicts a rapid increase in payroll only when the local market size increases just as rapidly, but it cannot explain the inevitable plummet in payroll that follows. Some economists argue that team owners are win-maximizers that are satisfied to just break even financially, but this argument still cannot explain the downward swing in payroll that ends a run. Perhaps teams are subject to talent cycles – bringing talented players to the major league club in "lumps" and then trading or releasing them when they become too expensive to keep. Surely a profit-maximizing owner could understand the nature of these talent cycles and smooth them out with the careful drafting and development of young talent. Some teams are quite successful doing this and are consistent talent producers (Yankees, Dodgers, Red Sox, etc.), while others develop talented young players to trade or sell before they become expensive (Athletics, Mariners, Rays, Royals, etc.) so the major league club is consistently mediocre on the field, but at least consistent. Both types of club deal with smoothing talent cycles, just in different ways.

2. STATISTICAL EVIDENCE OF UNSUSTAINABLE RUNS

We provide suggestive evidence of unsustainable runs by performing a non-parametric runs test on the winning percentages of MLB clubs over the period 1962-2019.[3] The null hypothesis of the Wald-Wolfowitz runs test is that the winning percentages are generated by a random process. The critical cut-off winning percentage to identify a run is 0.499, as some clubs experienced

[3] These winning percentages are taken from http://www.baseball-reference.com/.

winning percentages of 0.5 at the end of a season necessitating excluding the observation. The results are summarized in Table 1.

Rejecting a random process for winning percentages based on the runs test does not identify what type of process is generating the winning percentages. To provide some further insight, we estimated a first-order autoregressive model for winning percentages that forced an intercept of 0.500. The estimated slope coefficient and Breusch-Godfrey F statistic value (for first-order serial correlation) appear in the last two columns of Table 1. The Breusch-Godfrey test suggests evidence of a higher-order autocorrelation process if its null hypothesis is rejected.

The results of the runs test suggest that there is a non-random pattern for club winning percentages, with the exceptions of the Anaheim Angels, Chicago Cubs, Colorado Rockies, Kansas City Royals, Miami Marlins, Minnesota Twins, Seattle Mariners, and Texas Rangers. Just what is the process generating unsustainable runs is suggested by the slope coefficient for the AR(1) model (with an intercept of 0.500), which is positive and statistically significant at 95% confidence for all MLB clubs, with the exception of the Arizona Diamondbacks. The results of the Breusch-Godfrey test suggest that a higher order autoregressive process is determining winning percentages for the Dodgers, Cardinals, Mariners, Rangers, and Red Sox. One can interpret these results as suggesting that almost all MLB clubs display cyclical behavior, but for those that fail the runs test, the cycles are short. The clubs that are most characterized by unsustainable runs in winning percentage could be the Atlanta Braves, Baltimore Orioles, Houston Astros, New York Mets, New York Yankees, and Tampa Bay Rays based on the magnitude of their AR(1) coefficient and runs test.

3. SOME THEORY

The standard two-team league models used in sports economics (Kesenne (2000, 2015)) cannot generate unsustainable runs. The league distribution of talent is optimal and constant unless there is a change in relative market sizes or some other unspecified exogenous variable. An unsustainable run would be a movement of one team away from its profit-maximizing equilibrium stock of talent and would quickly be corrected in the absence of constraints on player movement. League welfare would be reduced since the positive unsustainable run of one team affects all its opposing teams in a negative fashion and league profitability would fall. Unsustainable runs are frequent enough that they cannot just be a miscalculation by a team owner.

Rockerbie and Easton (2010, 2013) demonstrate that an unsustainable run cannot be the result of a two-team league model with a single equilibrium, regardless of whether the team owner is a profit-maximizer or a win-maximizer and regardless of revenue sharing and team salary caps. They argue that an unsustainable run can be the result of two equilibrium talent stocks, one low and one high, that result in corresponding low and high winning percentages.

The model relies on the presence of a variable returns to scale production technology at the league level. Although individual teams produce their output (wins) with decreasing returns to scale (arising from the diminishing marginal product of talent), league output in terms of revenue is produced with increasing returns to scale in talent. Spillover effects are generated when one team acquires talented players whose revenue contribution to the league outweighs their diminishing marginal revenue product for their own team. Since national revenues (broadcasting, media, apparel, etc.) are shared equally among all teams under the MLB revenue sharing system, the marginal revenue product schedule for a small market team could reach a minimum and then slope upward at a high stock of its own talent due to the revenue sharing arrangement that rewards its own talent stock with higher league revenues. This is less likely for large market teams since the national revenues received are a small percentage of their team total revenue. The S-shaped marginal revenue product schedule in Figure 1 may result in a low and high talent equilibrium for a small market team, the middle portion being unstable. What is not known is what factors incentivize a team owner to "run" from a low to high equilibrium, then back again. What the model does suggest is that the equilibrium at point B in Figure 1 could occur at a winning percentage close to 0.500 and that clubs would not stay at point B season after season.

A little algebra gives some insights into the connection between the team payroll and team revenue at a talent equilibrium. This is essential in order to motivate the time series methods that follow in the next section. Assume that, in a two-team league, the revenue of team 1 is given by $R_1 = R_1(w_1, X_1) = Aw_1X_i$ where w_1 is the team winning percentage and X_1 is a vector of shift variables that can be local or league wide and each is assumed to have the same marginal effect on revenue. The team owner chooses a stock of talent that "produces" a winning percentage from the Tullock function $w_1 = t_1/(t_1 + t_2)$. The concavity of the production function ensures that the revenue function displays diminishing marginal revenue in talent. The team owner establishes a monetary budget, B_1, to acquire costly talent. The exogenous marginal cost of talent (the wage rate per unit of talent) is z thus we have $zt_1 = B_1$.[4] The team owner maximizes profit with respect to the team talent stock when $dR_i/dt_i = z$. Stability of the equilibrium requires that $dR_i/dt_i < z$ with an increase in the team talent stock ($d^2R_i/dt_i^2 < 0$), or, with some manipulation, that the

[4] Differences in the marginal cost of talent among teams are a possibility, but not typically assumed in the literature since the entire league is thought of as a monopsony, not individual teams. However, the results that follow rely critically on this assumption. Rockerbie and Easton (2019) specify a relationship between the team budget and the team stock of talent that incorporates the openness of the league talent market. We abstract from that relationship here to keep the exposition simple.

elasticity of revenue with respect to talent is less than the share of the team payroll budget, zt_i, in total revenue $(t_i dR_i/R_i dt_i < zt_i/R_i)$.

The first-order condition from the maximization problem is

$$A(t_2/(t_1+t_2)^2)X_1 - z = 0 \tag{1}$$

The condition in (1) can be solved for the profit-maximizing talent stock and the resulting indirect budget and revenue functions, $B_1^* = zt_1^*$ and $R_1^* = Aw_1^*X_1$.

$$t_1^* = (AX_1t_2/z)^{0.5} - t_2 \tag{2}$$

Exogenous factors contained in X_1 shift the revenue and budget functions to move to a new profit-maximizing equilibrium, although the shifts may differ in magnitude. Nevertheless, team revenue and payroll (budget) move in the same direction in a stable and predictable way in reaction to exogenous shocks, whether anticipated or not. Changes in the marginal cost of talent shift the payroll function to move along the revenue function in the same direction to a new equilibrium. Team 1 will increase its talent stock and payroll in reaction to an increase in team 2's talent stock providing $t_2 < AX_1/2$. The important point is that team revenue and payroll should be strongly associated and not drift apart – that is they should be cointegrated in the language of time series analysis.

4. TIME-SERIES METHODS

Testing for the presence of multiple equilibria is difficult using structural regression models due to the identification problem. It could be the case that more than one equilibrium exists, but if there is no movement to the other equilibrium, it cannot be observed with sample data.[5] Therefore,

[5] Berthelemy (2006) applies a Hodrick-Prescott filter to real per capita GDP time-series data for a number of suspect countries in an attempt to identify multiple equilibrium growth rates with some success. Firms in the same market

tests for multiple equilibria have relied upon estimating the time-series properties of the variable(s) being considered, usually employing unit-root tests that incorporate known structural breaks. Davis and Weinstein (2002) test for the presence of multiple equilibria in the growth paths of Japanese cities subjected to bombing in World War II. The dropping of the atom bombs on Hiroshima and Nagasaki (and conventional allied bombing on other Japanese cities) introduced large, negative shocks to their growth paths. A rapid return to their pre-bombing growth paths suggests a temporary movement below a single, stable equilibrium, while a permanent change in their growth paths suggests a movement to a second equilibrium. The test requires holding constant control variables that could have shifted the growth paths of these cities to create a new, stable, single equilibrium. Davis and Weinstein (2002) employed a unit-root test and determined the shock to be temporary, thereby finding no evidence for multiple equilibria.

Bosker et al (2007) apply the time-series methods of Davis and Weinstein (2002) to German cities bombed during World War II to test for multiple equilibria, with an important innovation – the incorporation of spatial interdependence. Multiple equilibria can be generated when large spillover effects occur between cities (or teams in our case). Without the allowance for these effects, the Davis and Weinstein (2002) method will have difficulty identifying multiple equilibria. Bosker et (2007) do find evidence for two stable equilibrium growth paths for German cities on the basis of unit-root tests.

A single long-run equilibrium can be detected using cointegration methods. In our case, a run to a second equilibrium requires the rapid accumulation (or releasing) of talent to improve the team winning percentage. A hefty increase in team payroll could be followed by an increase in

clustering their outputs at different positions could be evidence of multiple equilibria. Sweeting (2009) tests this hypothesis for radio stations by noting if commercials are clustered at various times in the day and finds evidence in favor of multiple equilibria.

team revenue and a new, local profit maximum is reached. Team revenue and payroll then form a cointegrating regression model if both series are trend-stationary ((I(0)), that is, stationary in variance so that they do not drift apart over time. Stationarity is tested using the Ng-Perron (NP) test as it has higher power when facing small sample sizes. The NP test first de-trends the data using the method in Elliot, Rothenberg and Stock (1996) to remove any trend and drift components, then estimates a Dickey-Fuller (DF) regression of the form below (where the superscript d denotes de-trended data).

$$\Delta y_t^d = \beta y_{t-1}^d + e_t \tag{3}$$

The t-statistic for the coefficient of the lagged dependent variable is calculated using the Phillips and Perron (1988) method and compared to tabled values contained in Ng and Perron (2001). Rejection of the null hypothesis $H_0\!: \beta = 0$ suggests that the series is trend-stationary.

We chose to model relative team revenue as the dependent variable since team revenues are accumulated over a season while team payrolls are determined at the start of the season. Team owners likely base their payroll decisions on an expectation of the subsequent season revenue. If their expectations are correct on the average, our approach is appropriate. In addition, revenue and payroll should move in the same direction when affected by local (local media, demographics, income, stadium, etc.) and league wide shocks (national media, apparel, licensing contracts, changes to the revenue sharing plan, etc.) eliminating the need to include other control variables in the cointegrating regression and stripping the error term of these shocks that would normally require breakpoint methods.

We first conduct the NP test on relative team revenue and relative team payroll for each of the 28 MLB teams in our sample (1990-2018) to determine the order of stationarity.[6] Visual inspection of these series for each team strongly suggested that the trend component could be excluded and only the drift term included. A finding that team revenue and payroll are both I(0) is evidence in favor of a single, stable equilibrium association between the two and no further testing is required.

If the two time-series are both difference-stationary (I(1)), an Augmented Dickey-Fuller (ADF) test can be applied to the residuals of the cointegrating regression of relative team revenue and relative team payroll. Failing to reject a unit root suggests that the two time-series are not cointegrated and a long-run equilibrium does not exist. This finding, combined with graphical inspection of the team revenue and team payroll to detect runs, could be evidence in favor of two equilibriums. A number of teams displayed results suggesting that relative team revenue and relative team payroll are stationary of different orders.[7] Fortunately, the Bounds test of Pesaran, Shin and Smith (PSS, 2001) we use is not sensitive to the order of differencing of the variables as long as they are either I(0) or I(1). The method first estimates an ARDL model in the form of a VAR(p) model in (4) below that includes an error correction term below where y = relative team revenue, x = relative team payroll, t = time trend, and L is the lag-difference operator.

$$\varphi(L)(y_t - x_t - \alpha - \gamma t) \tag{4}$$

[6] Forbes estimates of annual revenue and opening day payrolls were obtained from Rod Fort's online database that can be found at https://sites.google.com/site/rodswebpages/codes. We chose to not deflate the data as team owners are thought to make their business decisions based on figures and ratio analysis from annual financial statements that report nominal figures. While it is true that time-series analysis for macroeconomic data typically focuses on the best estimates of real variables, decisions at the firm level rely on nominal firm financial data.

[7] This was the case for the Boston Red Sox, Chicago White Sox, Los Angeles Dodgers, Milwaukee Brewers, New York Yankees, Oakland Athletics, Seattle Mariners and Texas Rangers.

After estimation of (4), the Bounds test tests the restriction that the coefficient of the error correction term and those for the lagged independent variable (in levels and differences) are equal to zero. Rejection of the null hypothesis from an F-statistic is evidence in favor of a cointegrated association. Critical Bounds for the F-statistic at various levels of confidence are provided in PSS (2001).

Although failing to reject the null hypothesis in the Bounds test is not definitive evidence for more than one equilibrium, the combination of finding difference-stationary series and a lack of cointegration suggests that both relative team revenue and relative team payroll are dominated by permanent shocks that do not appear to return to a single equilibrium. Economic theory suggests that team payroll and revenue are connected by profit-maximization, thus permanent shocks that affect both variables should move them together to a new profit-maximizing position – potentially a second equilibrium

5. EMPIRICAL RESULTS

The Bounds test for cointegration does not require the separate computations of unit-root tests on team revenue and payroll, however we present them for analysis in Table 2 in addition to the Bounds test. We included an intercept but no trend variable in the NP unit-root test since relative team revenue and relative team payroll were not centered around zero (nor their first differences) and a discernible upward trend was not found in most cases. An exact p-value for the reported F-statistic from the Bounds test cannot be computed since its distribution is not well-known. Instead, it is compared to upper and lower critical values found in PSS (2001) and the decision is reported in Table 2.

The null hypothesis of a unit root in relative team revenue could not be rejected at 95% confidence using the NP test in 16 out of 28 teams. Shocks to relative team revenue have persistence for these teams while temporary shocks are characteristic of the others. A unit root in relative team payroll could not be rejected at 95% confidence in 20 of 28 teams. Shocks to relative team payrolls also have persistence, suggesting that these 20 team owners made very conscious policy shifts in relative team payroll, while the other teams that display trend-stationary shocks returned to the same payroll policy after brief spells of movement.

Although team revenue and payroll may share the same order of stationarity, their cointegrating regression may perform poorly if it is not properly specified. Stationarity of the same order is a necessary but not sufficient condition for a long-run association. Subsequently, the Bounds test was computed for each of the 28 teams. Eight teams failed the Bounds test at 95% confidence, five of which made runs to World Series appearances only to reduce their team payrolls significantly in subsequent seasons, while the other two made short-lived playoff runs.[8] Each of these teams displayed unit roots in relative team payroll, with the exception of the San Diego Padres. Our results suggest that these episodes were not merely a movement around a single stable equilibrium, but rather a movement to a second, albeit short-lived and lower profit, stable equilibrium.

Significant events could have shifted the team revenue function and marginal revenue, resulting in a profit-maximizing change in the team payroll to a new equilibrium team winning percentage, giving the illusion of two equilibria when in fact it is not the case. Testing for a

[8] World Series appearances followed by large payroll reductions included the Chicago Cubs (2016), Kansas City Royals (2015, 2014), Philadelphia Phillies (2009, 2008), San Diego Padres (1998), and San Francisco Giants (2010, 2002). The Baltimore Orioles (1997, 1996) and Texas Rangers (2016, 2011) made playoff runs and appeared in the American League Championship Series.

cointegrating association between relative team revenue and payroll incorporating a breakpoint at the event, if known, would reject the null hypothesis of no cointegration. The existence of a breakpoint in a time series reduces the power of standard unit root tests so that rejection of the null hypothesis of a unit root is less likely (Gregory and Hansen, 1996). In our case a unit root in relative team revenue and payroll could not be rejected for a majority of the MLB teams in our sample, suggesting that structural breaks could be a problem.

The new stadium effect likely shifted the revenue function for a short period, the so-called "honeymoon effect" noted by Coffin (1996) and Coates and Humphreys (2005), resulting in an increase in payroll to maximize profit. To hold this effect constant, we included a dummy variable for the first year of a new stadium and found the best fitting lag length up to a maximum of five seasons for the stadium effect in the ARDL model for relative team revenue.[9] This is consistent with the findings of Coates and Humphreys (2005) of a honeymoon of no more than five seasons following the move to a new stadium.[10] The Bounds test was computed for teams that rejected a cointegrating relationship between relative team revenue and payroll without accounting for the stadium effect.[11] These results appear in the last column in Table 2. Many teams displayed a cointegrated association despite moving into new stadiums at some point in the sample period, eliminating the need to perform further cointegration tests. Cointegration was rejected for the Chicago Cubs, Chicago White Sox, Cleveland Indians, Los Angeles Dodgers, Philadelphia Phillies, San Francisco Giants and Texas Rangers.

[9] Specifically, a dummy variable for a new stadium was applied to the intercept, trend interaction and interaction with relative payroll.
[10] In all cases, the lag length that maximized the Akaike Information Criterion (AIC) was less than five seasons, suggesting a relative short honeymoon effect on relative team revenue.
[11] A simple exposition of the Bounds test when including an intervention variable can be found in Nguyen and Ngoc (2020).

6. ANALYSIS

The cointegration test results in Table 2 deserve some graphical analysis for the teams who appear to be good candidates for unsustainable runs. We present only four for the sake of brevity, however all eight teams display similar behavior. These can be compared to a team that is representative of a cointegrated association between relative team revenue and payroll, the Oakland Athletics.

The Philadelphia Phillies suffered through a decade of mediocrity in the 1990's, only moving above a 0.500 winning percentage in 1993. Relative team revenue and payroll consistently fell below the MLB median in Figure 2, moving roughly in step with each other. The team was sold in 1997 to David Montgomery, however any change in management philosophy was not immediately apparent. The 2002 season saw a jump in relative team payroll that continued until the 2004 season where it peaked at 142.7%. Relative team revenue increased in step, but more slowly, hence the team experienced operating losses. The team moved to the new Citizens Bank Park for the 2004 season with little effect on revenue and payroll, both falling back to the MLB median by 2007, although the Phillies appeared in the World Series in 2008, more by luck than effort. Drastic payroll cuts move the relative team payroll to just 72.6% by 2018. The correlation coefficient for the 1990-2018 seasons is 0.611, but only 0.324 for the 2008-2018 seasons. Although the Phillies experienced success on the field for a short period (2005-12), the run to position C in Figure 1 was not sustainable from a profit standpoint and the team has slipped back to mediocrity since the 2011 season.

The Chicago White Sox enjoyed success on the field in the 1990's fueled by a large increase in relative payroll in Figure 3, peaking at 141% in 1997, and an increase in relative revenue to 153% in 1992, partly spurred by the move to the New Comiskey Park in 1994 (now U.S. Cellular

Field). The team made playoff appearances in 1993 and 2000, but in the end, these runs were not sustainable. Relative team revenue and payroll rapidly fell to just below the MLB median in 1998 and continued to decline to historical lows for the 1999 season. The White Sox won the World Series in the 2005 season, then quickly fell back to an also-ran team with relative team revenue falling well short of payroll. The correlation coefficient over the 1990-2018 seasons is just 0.273. An ownership change is not an explanation for the cyclical behavior as the club was owned by Jerry Reinsdorf over the entire sample period. The high and low equilibria model in Figure 1 is a good fit for the White Sox.

Relative revenue and payroll are only weakly associated for the Texas Rangers in Figure 4 with a correlation coefficient of 0.334. The Rangers are the best example for unsustainable runs among all 28 MLB teams sampled. The new Rangers Ballpark was opened for the 1994 season and relative revenue increased modestly for the two subsequent seasons, meandering back to the MLB median thereafter. The club was sold to Tom Hicks in 1998. Hicks began an aggressive increase in team payroll to turn the club into a winner, but the gamble did not pay off. Relative payroll increased dramatically, far outstripping the growth in relative revenue, resulting in financial losses that persisted until the 2004 season.[12] The team winning percentage cycled annually from good to bad most erratically, so much so, that it deserves display in Figure 5. Poor on-field performance did not hurt the bottom line from 2004 to 2011 as the Rangers were profitable The club was sold again in 2010 to a group of investors (Rangers Baseball Express) who increased relative payroll significantly starting in the 2011 season, but relative revenues did not keep pace.

[12] A large portion of the relative payroll increase was the MLB record $250 million 10-year contract paid to shortstop Alex Rodriguez.

The run ended in the 2018 season. The lack of cointegration suggested by the Bounds test in Table 2 is not surprising for the Rangers.

The Cleveland Indians signed John Hart as the new General Manager to begin the 1992 season. Hart built the team into a contender with a series of trades and free agent signings that increased the team payroll from a low of 27.5% of the MLB median payroll to a peak of 160% for the 1999 season in Figure 6. Revenue benefited from World Series appearances in 1995 and 1997 and the move into the new Jacobs Field (now Progressive Field) at the start of the 1994 season. The next four seasons saw team revenue rise in step with the team payroll, peaking at 175% of the league median revenue in the 1998 season. The team's performance fell off after the 1998 season resulting in a drop in payroll as the Hart shed expensive players and a drop in revenue. Team owner Richard Jacobs sold the club to Larry Dolan in 2001, who brought in a more conservative, cost-conscious management strategy. Since 2002, Cleveland's relative revenue and payroll have moved in close step with a correlation coefficient of 0.88, resulting in modest profitability. The Bounds test in Table 2 strongly suggests that relative team revenue and payroll are not cointegrated with persistent shocks impacting both.

Walter Haas purchased the Oakland Athletics from Charlie Finley in 1981 and immediately began to build a World Series contender, increasing the payroll and bringing in a new management team. The A's made a World Series appearance in 1989, but the team payroll dropped in subsequent seasons as did the team's on-field performance. Haas sold the team in 1995 and the team was sold again in 2005. Relatively turbulent ownership has not changed the team philosophy that recognizes the relatively small size of its local market and adopts a careful business plan that does not feature unsustainable runs. The team has displayed a very consistent association between relative team revenue and payroll in Figure 7, usually below the league median values. The correlation coefficient between relative team revenue and payroll is strong at 0.877 over the 1990-2018 sample period. This consistency is quite typical of MLB teams that share a cointegrating association between relative team revenue and payroll, although the A's have one of the smaller variances between the two.

7. CONCLUSIONS

This paper notes the rather odd cyclical pattern of winning and losing that is characteristic of many MLB teams. Other research has argued that cyclical variation of winning percentages and the odd disassociation between team revenues and payrolls is not consistent with profit maximization or win maximization and could be the result of multiple equilibria (Rockerbie and Easton, 2010, 2013). Economic development and macroeconomics research have also developed theoretical models where multiple equilibria can arise, but they have also demonstrated that empirically testing from multiple equilibria is difficult and inconclusive. Conclusive tests are not available, instead the researcher must rely upon indirect evidence.

Recent developments in the time series literature have provided methods to find additional evidence. Cointegration of relative team revenue and payroll (via the Bounds test) is suggestive of a long run association, lending support to a single, stable profit maximizing equilibrium that can shift over time due to changes in factors that shift the team revenue or payroll function, perhaps giving the illusion of multiple equilibria. We include an intervention variable for new stadiums that could provide the impetus for such shifts, but still find eight MLB teams that do not share a cointegrating association. A lack of cointegration is suggestive of multiple equilibria but is not definitive proof. However, the odd behaviors of relative team revenue and payroll for these teams cannot be explained by the standard profit maximizing (or win maximizing) team model, unless one resorts to irrational exuberance or some other owner objective as an explanation – poor ones at that. The upshot is that the large spillover effects from team talent acquisitions due to revenue sharing plans (both local and national revenues) that exist in professional sports leagues can create considerable instability in the profit maximizing decisions of team owners when multiple equilibria exist, generating the ebbs and flows in performance that are not characteristic of other industries.

REFERENCES

Berthelemy, J-C. “Convergence Clubs and Multiple Equilibria: How Did Emerging Economies Escape the Under-development Trap?” *Revue d’Economie du Developpement*, 14, 2006, 5-41.

Coates, D. and B. Humphreys. “Novelty Effects of New Facilities on Attendance at Professional Sporting Events.” *Contemporary Economic Policy*, 23(3), 2005, 436-55.

Coffin, D. “If You Build It, Will They Come? Attendance and New Stadium Construction” in J. Fizel, E. Gustafson, L. Hadley (Eds.), *Baseball Economics: Current Research*. Westport, Conn. and London: Greenwood, Praeger, 1996, 33-46.

Davis, D. and D. Weinstein. “Bones, Bombs and Break Points: The Geography of Economic Activity.” *American Economic Review*, 92(5), 2002, 1269-89.

Elliot, G., Rothenberg, T. and J. Stock. “Efficient Tests for an Autoregressive Unit Root.” *Econometrica*, 64(4), 1996, 813-36.

Gregory, A. and B. Hansen, B. “Residual-Based Tests for Cointegration in Models with Regime Shifts.” *Journal of Econometrics*, 70(1), 1996, 99-126.

Késenne, S. “Revenue Sharing and Competitive Balance in Professional Team Sports.” *Journal of Sports Economics*, 1(1), 2000, 56-65.

_________. “Revenue Sharing and Absolute League Quality: Talent Investment and Talent Allocation.” *Scottish Journal of Political Economy*, 62(1), 2015, 51-58.

Ng, S. and P. Perron, P. “Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power.” *Econometrica*, 69(6), 2001, 1519-54.

Nguyen, H. and B. Ngoc, B. “Energy Consumption – Economic Growth Nexus in Vietnam: An ARDL Approach with a Structural Break.” *Journal of Asian Finance, Economics and Business*, 7(1), 2020, 101-10.

Pesaran, M., Shin, Y. and R. Smith, R. "Bounds Testing Approaches to the Analysis of Level Relationships." *Journal of Applied Econometrics*, 16(3), 2001, 289-326.

Phillips, P. and P. Perron, P. "Testing for a Unit Root in Time Series Regression." *Biometrika*, 75(2), 1988, 335-46.

Rockerbie, D. and S. Easton. *The Run to the Pennant: A Multiple Equilibria Model of a Professional Sports League*. Springer-Verlag New York, 2013.

______________________. "The Ebbs and Flows of the Game: Multiple Equilibria in a Sports League Model." *Journal of Sports Economics*, 11(2), 2010, 172-85.

______________________. "Of Bricks and Bats: New Stadiums, Talent Supply and Team Performance in Major League Baseball." *Journal of Sports Economics*, 20(1), 2019, 3-24.

Sweeting, A. "The Strategic Timing Incentives of Commercial Radio Stations: An Empirical Analysis Using Multiple Equilibria." *Rand Journal of Economics*, 40(4), 2009, 710-42.

TABLE 1

Runs Test, AR(1) Slope and Breusch-Godfrey Test Results for MLB Club Winning Percentages, 1962-2019.

MLB Club	Seasons	Runs	Expected Runs	P-Value	AR(1) slope	B-G Test
Anaheim Angels	58	32	29.9	0.718	0.151	0.180
Atlanta Braves	58	17	37.3	0.001	0.729*	1.385
Arizona Diamondbacks	22	8	14.9	0.001	-0.005	1.371
Baltimore Orioles	58	13	36.3	0.001	0.653*	0.134
Boston Red Sox	58	14	48.0	0.001	0.452*	3.500*
Chicago Cubs	58	24	26.7	0.234	0.296*	0.265
Chicago White Sox	58	22	29.9	0.018	0.304*	0.692
Cincinnati Reds	58	20	35.2	0.012	0.429*	2.164
Cleveland Indians	58	18	26.7	0.009	0.423*	2.242
Colorado Rockies	27	11	10.6	0.577	0.434*	0.052
Detroit Tigers	58	18	35.2	0.001	0.538*	0.139
Houston Astros	58	22	36.3	0.003	0.620*	0.207
Kansas City Royals	51	21	24.5	0.161	0.581*	2.567
Los Angeles Dodgers	58	21	50.2	0.001	0.444*	4.721*
Miami Marlins	27	7	7.4	0.149	0.486*	0.197
Milwaukee Brewers[1]	50	16	30.9	0.001	0.530*	0.803
Minnesota Twins	58	27	32.0	0.093	0.366*	1.040
New York Mets	58	14	28.8	0.001	0.645*	0.043
New York Yankees	58	11	52.3	0.001	0.795*	0.172
Oakland Athletics[2]	58	14	34.1	0.001	0.578*	0.385
Philadelphia Phillies	58	14	32.0	0.001	0.602*	0.486
Pittsburgh Pirates	58	18	27.7	0.008	0.605*	0.159
San Diego Padres	52	17	18.1	0.241	0.489*	1.417
San Francisco Giants	58	18	38.4	0.001	0.337*	0.198
Seattle Mariners	43	18	16.0	0.771	0.405*	4.475*
St. Louis Cardinals	58	29	47.0	0.001	0.337*	3.972*
Tampa Bay Rays	22	4	9.55	0.001	0.697*	0.148
Texas Rangers[3]	58	25	25.6	0.435	0.438*	3.253*
Toronto Blue Jays	43	13	25.6	0.001	0.609*	0.335
Washington Nationals[4]	53	16	27.7	0.001	0.451*	1.353

[1]Relocated from Seattle in 1971.
[2]Relocated from Kansas City in 1967.
[3]Relocated from Washington in 1971.
[4]Relocated from Montreal in 2005.

TABLE 2.

Unit-Root tests and Bounds Test Results for MLB Club Relative Team Revenue and Payroll, 1990-2018.

MLB Club	Seasons	New stadium year	Relative revenue t-statistic[1]	Relative payroll t-statistic[1]	Bounds test F value[2]	Bounds test F-value (intervention)
Anaheim Angels	29	1999	-4.531	-5.762	12.182*	
Atlanta Braves	29	1997	-3.538	-3.583	5.708	31.887*
Arizona Diamondbacks	21		-1.590	-6.816	5.049	
Baltimore Orioles	29	1992	-4.210	-5.309	5.501	12.488*
Boston Red Sox	29		-14.441*	-2.738	14.314*	
Chicago Cubs	29		-4.254	-7.677	1.568	
Chicago White Sox	29	1991	-6.260	-10.675*	1.623	3.369
Cincinnati Reds	29	2000	-13.911*	-11.367*	40.573*	
Cleveland Indians	29	1994	-7.779	-6.113	7.932[a]	2.693
Colorado Rockies	26		-3.416	-3.355	6.928	
Detroit Tigers	29	2000	-6.962	-5.388	8.105[a]	6.252*
Houston Astros	29	2000	-7.060	-8.037	12.543*	
Kansas City Royals	29	2010	-2.297	-5.282	2.162	6.864*
Los Angeles Dodgers	29		-160.466*	-6.480	1.220	
Miami Marlins	26	2012	-8.564*	-11.199*	18.279*	
Milwaukee Brewers	29	2001	-42.901*	-7.528	111.241*	
Minnesota Twins	29	2010	-5.274	-7.142	15.645*	
New York Mets	29	2009	-20.044*	-18.734*	26.046*	
New York Yankees	29	2009	-23.399*	-2.582	24.654*	
Oakland Athletics	29	1995	-19.538*	-5.569	112.300*	
Philadelphia Phillies	29	2004	-3.576	-3.560	3.022	3.126
Pittsburgh Pirates	29	2001	-8.552*	-8.736*	34.230*	
San Diego Padres	29	2000	-9.322*	-10.384*	11.262*	
San Francisco Giants	29	2000	-2.780	-6.971	4.898	3.559
Seattle Mariners	29	1999	-2.964	-8.543*	5.942	9.888*
St. Louis Cardinals	29	2004	-23.986*	-14.430*	14.589*	
Tampa Bay Rays	21		-3.875	-7.675	20.041*	
Texas Rangers	29	1994	-9.625*	-7.887	6.711	4.835[a]

[1]An asterisk denotes rejection of the null hypothesis of a unit-root at 95% confidence.
[2]An asterisk denotes rejection of the null hypothesis on no cointegration at 95% confidence.
[a]Falls in the indeterminate region.

FIGURE 1

Multiple Equilibria in the Two-Team League Model with Spillover Effects

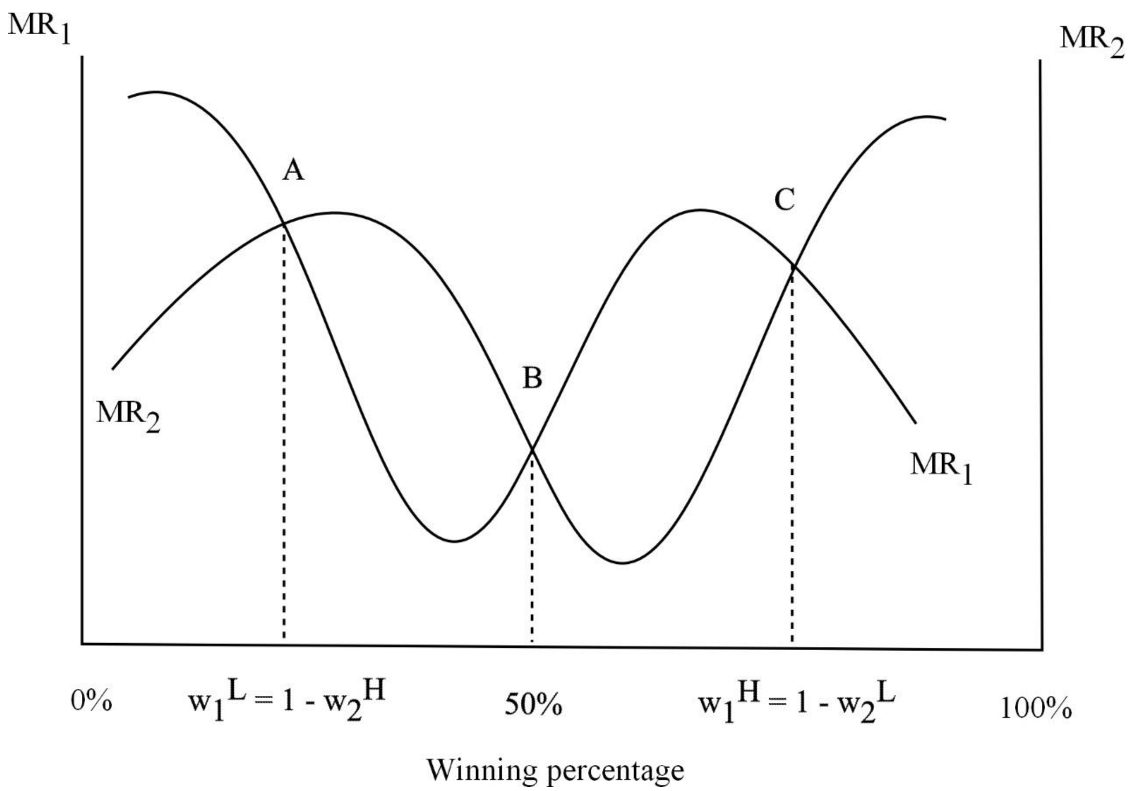
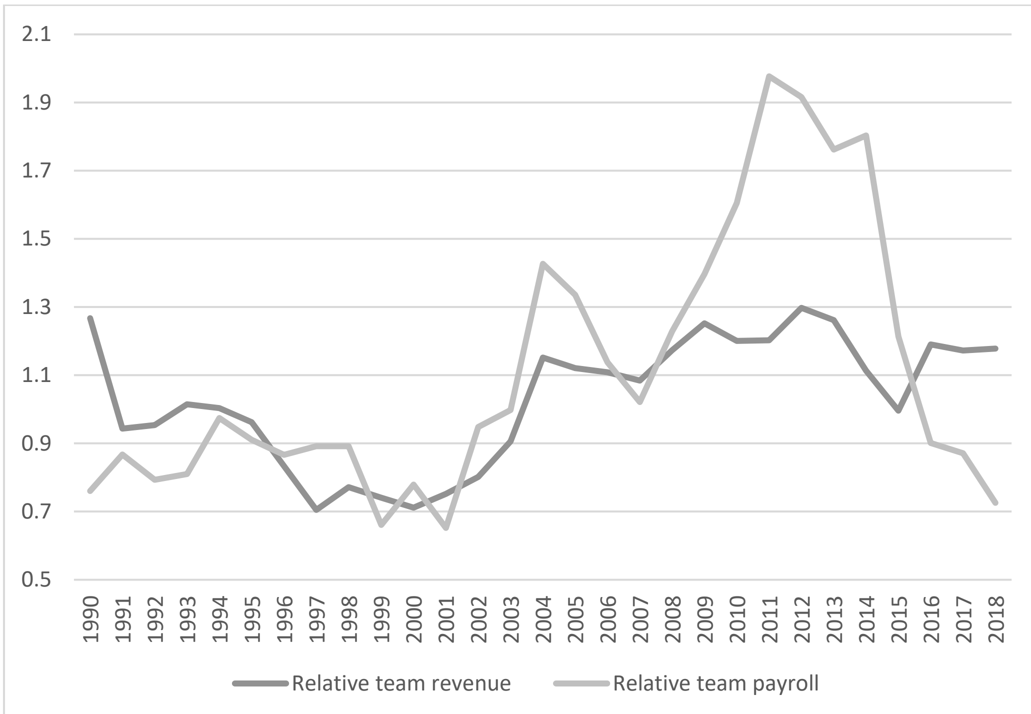


FIGURE 2

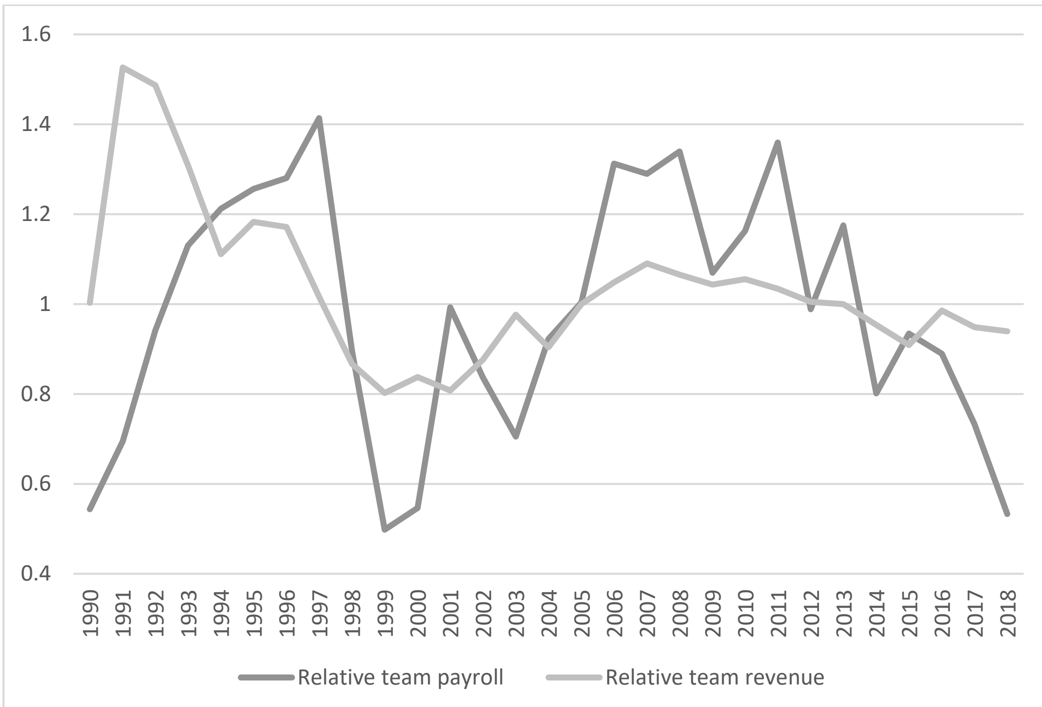
Philadelphia Phillies Relative Team Revenue and Payroll, 1990-2018.



Source: https://sites.google.com/site/rodswebpages/codes and author's calculations.

FIGURE 3

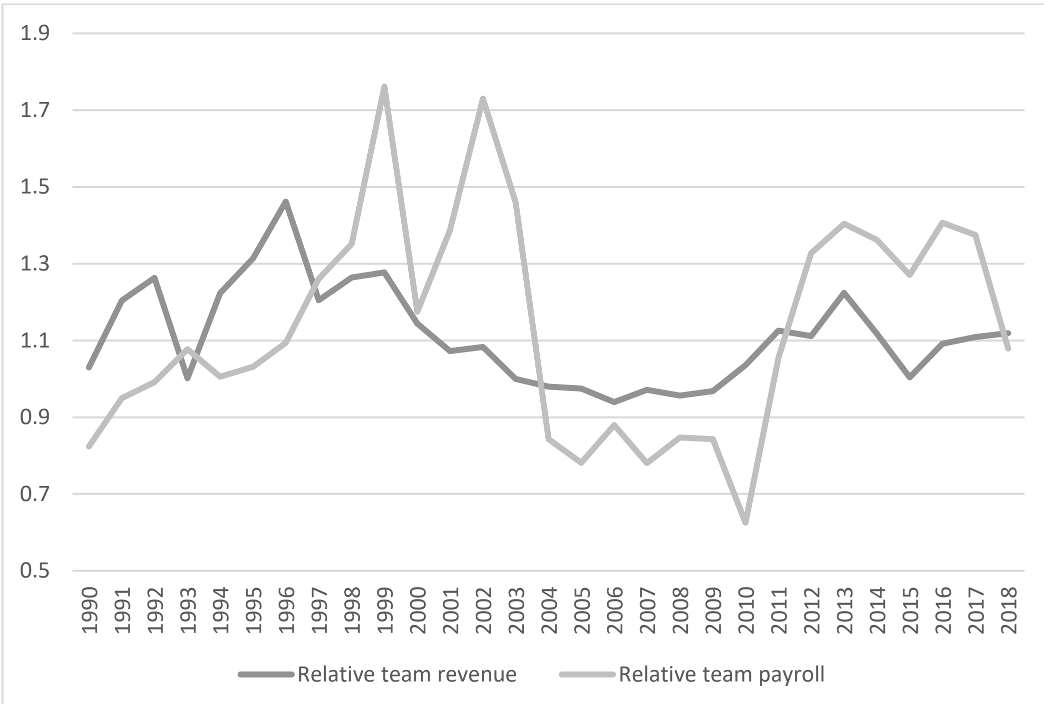
Chicago White Sox relative team revenue and payroll, 1990-2018.



Source: https://sites.google.com/site/rodswebpages/codes and author’s calculations.

FIGURE 4

Texas Rangers relative team revenue and payroll, 1990-2018.



Source: https://sites.google.com/site/rodswebpages/codes and author's calculations.

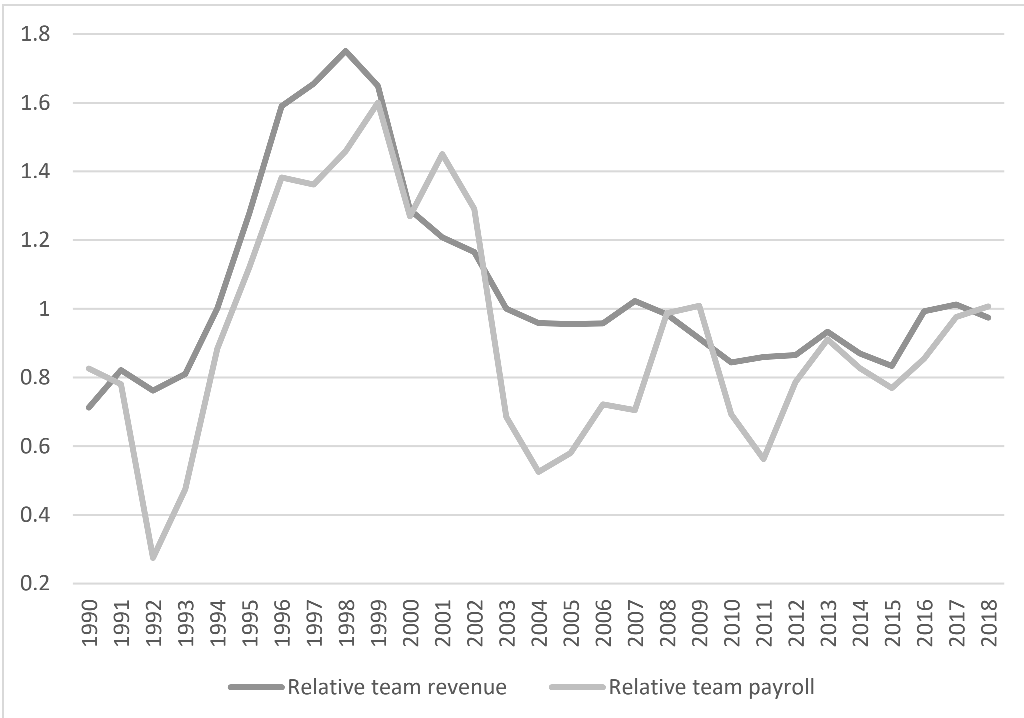
FIGURE 5

Texas Rangers winning percentage, 1990-2018.

Source: https://sites.google.com/site/rodswebpages/codes and author's calculations.

FIGURE 6

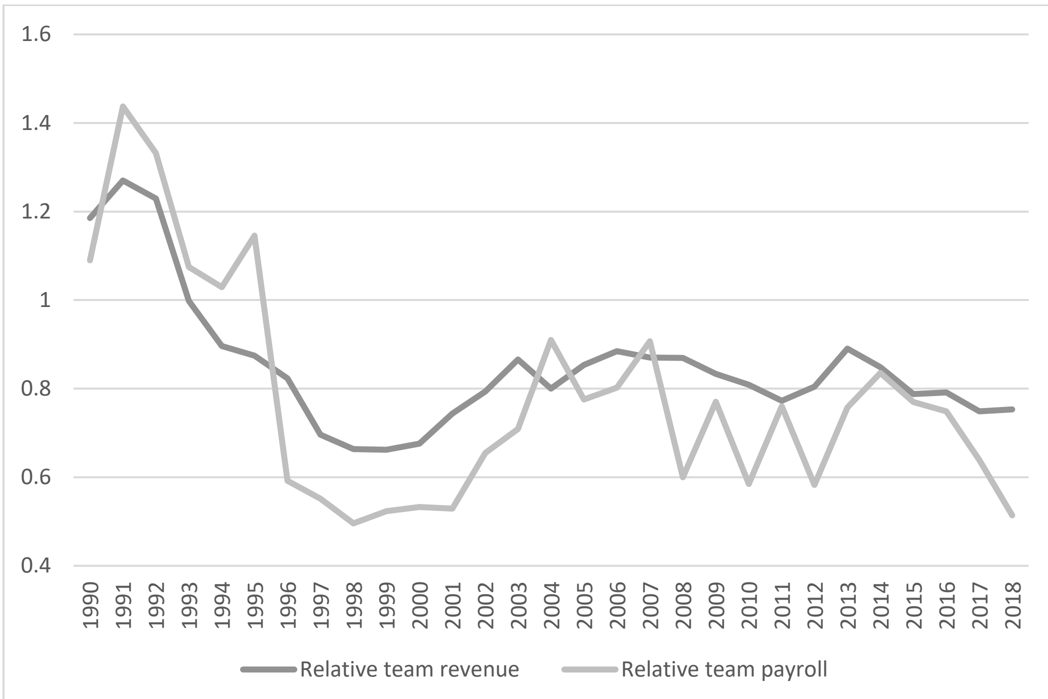
Cleveland Indians relative team revenue and payroll, 1990-2018.



Source: https://sites.google.com/site/rodswebpages/codes and author's calculations.

FIGURE 7

Oakland Athletics Relative Team Revenue and Payroll, 1990-2018.



Source: https://sites.google.com/site/rodswebpages/codes and author's calculations.