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“It isn’t really the stars that are expensive. It is the high cost of mediocrity.” Bill Veeck, owner at various times of the Cleveland Indians, St. Louis Browns and Chicago White Sox.

1. INTRODUCTION

The standard approach to explaining the rigidity of long-term labor contracts employs a risk-neutral employer offering such a contract to risk-averse workers who value stability in their wages. Early contributors were Baily (1974) and Azariadis (1975). Rudanko (2009) is a recent example. Labor productivity generally behaves pro-cyclically (Romer, 2012), consequently workers experience periods where their marginal revenue product (MRP) can fall above or below a normally contracted wage. Employers will then display pro-cyclical employment. Risk-averse workers will accept a long-term contract with employment stability in exchange for a wage below their MRP and risk-neutral employers are happy to agree to such contracts. This standard approach fails to take into account the possible options that a worker might have to move to a higher paying job during the contract. Yamaguchi (2010) estimates that this option value increased wages by 15% in the first five years of employment in a large sample of U.S. workers.

We explore how workers are paid in long-term contracts by focusing on an industry in which MRP’s can be estimated and compared to actual salaries: professional baseball players. Although a standard labor market demand-supply approach (Rosen and Sanderson, 2001) results in the MRP = salary profit-maximizing condition, the approach does not account for failures in the condition for specific players other than to resort to untested monopsony models or vague discussions of the bargaining power of players. Our results suggest that significant changes have occurred in the MRP = salary condition since the 1980’s. Contrary to the quotation at the start of our paper, we find that higher-priced free agents, defined as those paid above the league average salary for all players, tend to be overpaid (or their expected MRP overestimated) while other free agents are underpaid or paid appropriately. Berri *et al.* (2015) found that NBA players were overpaid over the 2001-11 sample period, resulting in negative surpluses for team owners. They suggest that the MRP rule works to some extent and that players earn part of the owner's surplus that arises from fixed revenues through a bargaining process. Krautmann and Solow (2018) found that most MLB free agents were overpaid using a different methodology to estimate player MRP's. These results contrast sharply with the belief that the player's market is a monopsony (Humphreys and Pyun, 2017, Leeds and Leeds, 2017). Krautmann, von Allmen and Berri (2009) found that players with low bargaining power tend to be underpaid in the National Football League, the National Basketball Association and MLB. Our empirical results in this paper agree, with a number of further insights, the most important being that free agents signing multi-year contracts are overpaid relative to those signing one-year contracts (contrary to the quote at the start of the paper). The remainder of the paper offers an explanation for this result.

Instead of relying on present value calculations alone, real options theory has become increasingly popular to model investment decisions by firms.[1] Present value calculations do not account for the flexibility provided by deferring, restarting, or altogether dropping investment project decisions. If this flexibility is valuable to decision makers, real options will have a positive value and may increase the likelihood of undertaking an investment project. We employ a simple real options approach to model the decisions by professional sports team owners and players to agree to multi-year player contracts. For the player, flexibility is the option to leave the team to move to another team at the end of any year excepting the final year of the contract. The player could move if available salary offers in mid contract are higher than the currently contracted salary. The team owner values flexibility if he or she can release the player from the contract at the end of any year, excepting the final year of the contract. He or she could do so if the expected revenue gained from keeping the player is less than the contracted salary owing. The positive value of real options may explain the puzzling empirical result that with respect to their MRP's, highly paid (and skilled) players are generally overpaid,[2] while lesser players are generally underpaid.

[1] A good reference is Copeland and Antikarov (2003).

[2] A recent example is the 10-year, $300 million contract signed by Manny Machado with the San Diego Padres in 2019, the third largest total value contract in MLB history. This contract effectively takes the now 26-year old Machado through the bulk of his remaining playing years, capturing the financial value of most of his remaining options, but not all. The contract includes an option for Machado to leave the team after five seasons.

2. ESTIMATING PLAYER SURPLUSES IN MLB

One of the important issues in the sports economics literature is whether players are paid according to what economic theory predicts: profit-maximizing firms pay a salary equal to a player's marginal revenue product (MRP). Scully (1974) tackled the problem decades ago during the last remnants of the reserve clause era in major league baseball (MLB). His method and results are well-known and his paper sparked a burgeoning literature on the subject. More recent contributions are illustrated by Scully (1989), Bruggink and Rose (1990), Fort (1992), Zimbalist (1992), MacDonald and Reynolds (1994), Leeds and Kowalewski (2001), Bradbury (2007), and Berri et al (2015). All of these papers utilize a two-equation regression model to estimate the appropriate salary given an individual player's production on the field and estimate a revenue function and a team production function. A player's estimated MRP is a simple derivative. The method places strains on the data, although it is not computationally burdensome. Krautmann (1999) developed a simpler, more direct approach that required fewer data and utilized only one regression equation. This method has become the method of choice over the last few years (Krautmann and Ciecka, 2009, Brown and Jepsen, 2009 to name a few), however it does not provide an estimate of a player's MRP, rather it is a method to predict a player's salary assuming that the MRP rule holds (see Bradbury, 2012 for a critique of the method).

All of these studies estimate MRP in an *ex ante* sense. That is, they attempt to estimate how a club owner forms an expectation of a player's future MRP based on past performance data. Utilizing the Scully method, this MRP expectation is then compared to the actual salary a player earns for a particular season to determine if this is how the expectation is formed. The method does not compare the salary earned[3] with the realization of the player's future MRP. Abstracting from player injuries, the ability to accurately forecast player MRPs is an *ex post* test of the MRP rule. An innovation in our paper is to

[3] This assumes the expectation the owner has formed plus any monopsony rent plus any additional surplus the player has been able to negotiate from the owner is part of the salary.

compare the negotiated salary for free agents with their subsequent MRP in the following seasons of the contract period.

Accurate and reliable financial data for MLB clubs is more available than it was in the 1980's and a consistent time-series of estimates has been provided by Financial World and Forbes magazine since 1990.[4] A lack of available data for other variables in the model prevents us from going as far back as 1990, but by starting in 2000 we have a longer sample period than has been used in previous studies. We also utilize average ticket prices in our revenue function. We estimate our winning percentage function using a logistic regression, rather than the standard linear probability model that has been used in the past. Finally, rather than estimate MRPs for every player, we estimate MRPs only for players who signed contracts with new clubs after free agency. In this way, we isolate the effect that the expectation of future performance has on the negotiated salary. We compare the newly negotiated annual salary of each free agent position player (excluding pitchers) to an estimate of the present value of the marginal revenue products over the lifetime of the new contract.

Our sample includes 678 free agents (excluding pitchers) who were signed to MLB contracts over the 2000-12 MLB seasons. The free agent market was more active in some seasons than others. Summary statistics of free agent activity by fielding position appear in Table 1. When a player played in multiple fielding positions during the season immediately following their free agent signing, the most frequently played position was used in the table.[5]

2.1 Revenue model

In our specification, the revenue function for a single club is given by:

$$R = \boldsymbol{X}^{\boldsymbol{\alpha}}(WP)^{\beta} \tag{1}$$

[4] These revenue data are not without their limitations. See Zimbalist (2010) for an in-depth analysis of salary and revenue data.
[5] The Designated Hitter (DH) position for American League teams was not used since most teams did not employ a full-time DH, rather they split time among several players at different fielding positions with the DH position.

where R = attendance revenue + television revenue + all other revenues
WP = season winning percentage
$\boldsymbol{X}$ = a vector of independent variables that affect revenue

Total revenue includes revenue that is specific to each club (attendance, local television, concessions, etc.) and revenue that is shared by all clubs (national television, apparel, etc.). Although some of these revenues might not be a function of local player talent directly (such as national television revenue), increases in these revenue sources can increase the MRP of talent by shifting the MRP schedule for each club. The vector $\boldsymbol{X}$ includes per capita income (total metropolitan income / metropolitan population) Y, a state unemployment rate U, a weighted average real ticket price P, a dummy variable, *NEWSTA*, taking on the value one for a period of five seasons after a new stadium is opened (Coffin, 1996, Clapp and Hakes, 2005, Coates and Humphreys, 2005), and three dummy variables (*TV1*, *TV2* and *TV3*) that take on the value one in each season during or after a new national television contract (2001, 2007 and 2012 respectively). Finally, team revenue, per capita income and the average ticket price were deflated by a state-side consumer price index (2000 = 100). A list of sources for all variables is contained in the appendix.

2.2 Winning percentage model

The function relating team winning percentage to player performance is given by the logistical function:

$$ln(WP/1 - WP) = \delta + \theta OPS + \mu(K/BB) + \pi ERA + \rho CONT + \omega OUT \qquad (2)$$

where OPS = team slugging percentage (total bases / total at bats) + team on base percentage
K/BB = team strikeout - walk ratio
ERA = earned run average (earned runs surrendered by a pitcher / innings pitched)

CONT = a dummy variable equal to one if a team finishes within five games of the wild card winner

OUT = a dummy variable equal to one if a team finishes twenty or more games behind the wild card winner

The independent variables *OPS*, *K/BB* and *ERA* are measures of hitting and pitching quality that have been justified by Scully (1974) and others. The independent variables *CONT* and *OUT* were also used by Scully (1974) and others as proxies for team morale or perhaps managerial ability. They represent a shift in the team production function based on factors other than player performance. We have retained their use to allow for comparison of our results to previous work.

The fact that winning percentage is bounded between zero and one justifies the use of the logistic function. The predictions for the marginal effect on winning percentage require estimation of the parameters and the choice of a baseline winning percentage ($\partial WP/\partial OPS = \hat{\theta} WP(1 - WP)$). Teams with a 0.500 winning percentage will show the largest marginal effect, holding player performance and team morale constant. We chose to use the fitted value for the current season's winning percentage for each team as the baseline winning percentage. This places each team on a logistic function at different positions with different marginal effects.

Taking the natural logarithm of (1), the calculation for MRP is straight-forward after (1) and (2) have been estimated. For a specific hitter denoted as player i playing on team j, MRP is given by (where AB are at-bats):

$$MRP_i = (\partial R_i/\partial WP_i)(\partial WP_i/\partial OPS_i)dOPS_{ij} = \hat{\beta}\hat{\theta}R_j WP_j\left(1 - WP_j\right)dOPS_{ij}$$

$$= \hat{\beta}\hat{\theta}R_j WP_j\left(1 - WP_j\right)OPS_{ij}\left(\frac{AB_i}{AB_j}\right) \qquad (3)$$

The contribution to the team OPS by a specific hitter is calculated using the hitters total at bats as a share of total team at bats multiplied by the hitters OPS for a season. If a hitter has an OPS of 0.750 and accounts for 10% of the team's total at bats, his contribution to the team OPS is 0.075.

We found that the estimates for gross MRP for pitchers were very unreliable when compared to actual salaries, so we do not report them. Pitchers can be divided into three categories: starters, middle relievers and relievers. Starting pitchers are paid far less per inning pitched than relief pitchers and this makes the results very hard to interpret. If the samples of free agents were evenly divided between starters and relievers, the differences might cancel out in the overall average gross MRP, however our sample years of free agents were typically heavily weighted towards starting pitchers or relief pitchers. Zimbalist (1992) also excluded gross MRP estimates for pitchers on similar grounds. We also discovered that a large proportion of free-agent pitchers spent a considerable amount of time on the 60-day disabled list in the first season of their new contract.[6] Consequently their net MRP was smaller than expected, but not due to their own performance or the mistake of the owner. These players were excluded from the sample.

2.3 Estimated revenue and production functions

The revenue function in (2) was estimated in natural log form using data collected from the 2000-2012 MLB seasons, providing a total pooled sample size of 364 observations per variable. The Montreal Expos and Washington Nationals were excluded from the sample. It was thought that the franchise move from Montreal to Washington for the 2005 season could distort the regression results. The Toronto Blue Jays were also excluded due to the effect of swings in the Canadian-U.S. Dollar exchange rate on the club's revenues measured in U.S. Dollars.

[6] Players who are assigned to the 60-day disabled list (DL) typically have serious injuries that require rehabilitation. They may not return to the major league roster before the 60-day period has expired, however they may be replaced on the team roster by another player. Clubs can apply for reimbursement of salary for players on the 60-day DL through insurance policies they purchase on their players, hence the player's MRP is zero whilst on the DL, but the club suffers no salary expense. Historical transactions for the 60-day DL can be found at the MLB website http://mlb.mlb.com/mlb/transactions/

Total revenue for each club was taken from Forbes magazine and includes revenue from all sources and is net of revenue sharing.[7] Team fixed effects were included to account for variations in team revenue not explained by the independent variables in (1). A weighted least squares method was used to account for heteroskedasticity across teams. The National League (NL) and American League (AL) used the same revenue sharing formula over our sample period, so we see little reason to include a league dummy variable in (1). After testing for and rejecting non-linearity, we report the linear regression results (t-ratios appear in parantheses) in Table 2. To test for robustness of the team revenue model, results are also reported for the 2000-08 and 2004-12 sub-samples.

The fixed effects estimates are omitted for the sake of brevity. The high significance of the F statistic and the very acceptable adjusted R^2 suggests that the linear model is appropriate in explaining variations in team revenue. All of the regression coefficients are statistically significant at 95% confidence with the exception of the state unemployment rate. The unemployment rate is a proxy for economic conditions and the results suggest that MLB team revenues are not sensitive (a-cyclical) to the business cycle. The team winning percentage has an elasticity estimate of 0.523 suggests that a ten percent increase in winning percentage (say from 0.5 to 0.55) raises team revenue by about 5.23%, suggesting that revenue is quite inelastic to winning percentage. Given that approximately 90% of teams in any given season fell within winning percentages of 0.4 and 0.6, large revenue swings due to team performance were not a frequent occurrence in MLB.

A new stadium had no significant effect on team revenue. This result is counter to the short-run effects on attendance found by Coffin (1996), Clapp and Hakes (2005), and Coates and Humphreys (2005). However, Rockerbie and Easton (2019) find the same result on team performance using a much longer sample period and a model that incorporates the availability of talent. Real per capita income had the largest positive effect on revenue with an estimated elasticity 0.873, while the average ticket price had

[7] Although it would not be difficult to reverse the effects of revenue sharing on team revenues using the revenue sharing formula for each season, it was left in place on the reasoning that each owner can more or less predict team revenues after revenue sharing fairly accurately and base their talent acquisition and payroll decisions on available revenues after sharing.

a positive effect on revenue that is inelastic (0.457), confirming that marginal revenue was less than the ticket price. Each new national television contract increased team revenue independently of the other variables, with percentage increases of 0.15, 0.29 and 0.36 respectively.

The coefficients for the 2004-12 sub-sample are all smaller than those for the 2000-08 sub-sample, although the statistical significance is virtually unchanged. This can be explained by the declining annual real revenue growth that occurred over the 2000-12 seasons. Revenues grew by an annual average of 7.3% in 2000-08, but fell to 5.6% in 2004-12.

The winning percentage function (2) was also estimated using fixed effects and weighted least squares. The model was estimated separately for the NL and AL owing to the use of the designated hitter in the AL. Team hitting statistics are somewhat higher and pitching statistics are somewhat lower for the AL relative to the NL where pitchers are required to hit. The results for each league are given in Table 3.

The degree of fit was quite high for both leagues and the F statistic for each regression suggests that the model specification is appropriate.[8] All of the coefficients carried the expected signs and statistical significance, with the exception of the strikeout-walk ratio for the NL. The marginal effects can be found dividing each coefficient by 4 since the linear marginal effect is given by $\beta_i wp(1 - wp)$ and $\overline{wp}$ = 0.5 over the entire sample. Since we focused on the performance of hitters, the *OPS* variable is of key interest. A 100 point increase in team OPS (considerable given that the sample standard deviation for team OPS was just 0.393) is predicted to increase the team winning percentage by (3.149/4)*0.1 = 0.0787 for the NL and (3.459/4)*0.1 = 0.0865 for AL.[9] As expected, pitching was a larger contributor to winning in the NL based on its larger t-ratio for *ERA*, while hitting is a bigger contributor in the AL based on its larger t-ratio for *OPS*.

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[8] This measures the degree of fit for the non-linear dependent variable, but not for the predicted winning percentages themselves.

[9] The team OPS was divided by 1,000 in the regression model to make it comparable with the team winning percentage.

3. CALCULATING NET MRP AND THE PUZZLE IT POSES FOR MULTIYEAR CONTRACTS

Each free agent player's gross MRP was calculated using (3) for the first four seasons or less of their new contract. For multi-year contracts, the estimate gross MRP in seasons 2, 3 and were discounted using a discount rate of 5%, then an average MRP was computed in order to make a comparison with the player's annual salary.

Scully (1974) and others obtained a net MRP estimate by subtracting an estimate of payments to other factors of production and player training and development costs. These should only be costs that vary with the team stock of talent and should not include fixed costs. Many of the costs that MLB teams face are fixed costs, such as stadium financing and maintenance costs, promotional costs, transportation costs and equipment costs. Scully (1974) included many costs that appear to be fixed costs and these figures were subsequently adjusted for inflation and used by Macdonald and Reynolds (1994). Zimbalist (1992) simply assumed that the appropriate costs are 10% of the estimated gross MRP.

Ideally calculating net MRP from gross MRP is accomplished by recognizing that $W_S = MRP/(1 + \varepsilon_S^{-1})$ in a monopsony market for talent, where the supply elasticity of talent is ε_S. Rockerbie and Easton (2019) used a model of a profit-maximizing team owner that chooses a team budget and estimated a long-run talent supply elasticity between 2 and 3 using a sample period of 25 years, suggesting that the salary depression effect of a league monopsony is almost non-existent. Of course, the time horizon the team owner faces in this paper is a single off-season, so the talent supply elasticity will be much smaller and the ability of free agent players to capture a portion of their surplus through bargaining is greater. The 10% approximation used by Zimbalist (1992) implies a talent supply elasticity equal to 9, a value we feel is too elastic. We computed each free agent player's net average MRP using a value of 2, which we then used to compare with the actual average annual salary over the contract.

Our estimates of net MRP are calculated by inserting the estimated coefficients into (3) and using the fitted team winning percentages and fitted revenues for the subsequent seasons of the free-agent player's new contract. A net MRP was estimated for every free-agent hitter over the 2000-2012 MLB seasons.[10]

Table 4 presents what we call the "exploitation rate" defined below, and the MLB average salary for all players for each season in the sample.

$$exploitation\ rate = \frac{\sum_{i=1}^{n}(MRP_i - salary_i)}{\sum_{i=1}^{n} salary_i} \tag{4}$$

A negative exploitation rate indicates an overpayment of salary relative to net MRP and a positive value indicates an underpayment. This calculation suggests that free-agents who are paid above the major league average salary are overpaid in each year of the sample. Owners tend to earn a surplus for players paid below the major league average (again confounding Mr. Veeck).

We then compared the exploitation rates for single-year versus multi-year contracts in Table 5. The results are striking. For every season in our sample, excepting the 2011 season, players on single-year contracts are paid a salary below their estimated MRP, while players on multi-year contracts are paid a salary above their estimated MRP for every season. A small number of free agents were excluded from the calculations in Table 5 due to the anomalous nature of their one-year contracts.[11] These are listed in the notes to Table 5. Each note also includes the value of the exploitation rate if the player was included in the calculation. The result for players with multi-year contracts runs contrary to the monopsony model of the talent market and agrees with the results found in Krautmann and Solow (2018) for MLB. In the next section, we develop a simple model of real options to explain this result.

4. CONTRACT OPTIONS FOR BUYERS AND SELLERS OF TALENT

[10] These estimates can be provided in a spreadsheet file upon request.

[11] These players capture enormous amounts of surplus and are good examples of the "superstar" effect developed by Rosen (1981).

Consider a risk averse team owner who is considering signing a free agent to a 2-year contract.[12] Two years keeps the option problem as simple as possible. Assume the risk-free rate of interest is 5%. The owner considers the risk-free rate of interest as the rate of return on an alternative market investment instead of investing in player talent. The player's financial performance for the owner is modelled as only two possible states at the end of each season. In the good state, the player's MRP is $5 million. In the bad state, the MRP is only $1 million. Each state has a probability of 0.5 of occurring. (This is simple to change.) The 2-year performance is shown below in Figure 1.

What salary will a risk averse owner offer? The salary in year 1 and year 2 is denoted S_1 and S_2 respectively. The owner will compute the present value of the future MRP's to determine the total value of player j's contract, $E(MRP_j)$. The player's output is uncertain, hence the owner will not use the risk-free[13] interest rate, r_f, as a discount rate. Instead the owner will implicitly calculate a risk spread to add to the risk-free rate. In the stock market literature, the value of the Beta coefficient is used for this calculation. The Beta (β) is the measure of the stock's variability in return relative to the market average return (r_m). If $\beta > 1$, the stock, is riskier than the market average. Formally, $\beta_j = COV(r_j, r_m)/VAR(r_j)$. If the current market price of a share, its expected return each period, β_j, and the risk-free rate are known, it is simple to back out the discount rate adjusted for risk from (5) below.

$$PV = \frac{E(MRP_j)}{1+r_f+(r_m-r_f)\beta_j} \qquad (5)$$

For the owner the present value, *PV*, is just equal to the player's discounted salary. The rate of return r_m can be thought of as the average rate of return for all players in the league, calculated as the surplus to the

[12] We assume a single team owner although that is often not the case in professional sports leagues. Nevertheless, most leagues require that a single owner be identified if there is a group of owners.
[13] Or more precisely, a rate of return that is uncorrelated with the baseball player market, and when there is risk-free borrowing and lending, is equal to the risk-free rate. If there is no risk-free rate, then the relationship of beta to the return on the market remains intact although the portfolio cannot be shown to be efficient (Fama and French, 1994).

owners as a percentage of the salary. We will assume for this exercise that the risk-adjusted rate of return is 10% based on (5) and the player's Beta coefficient.[14]

In this way, the owner sets a team budget based on the perceived risk-free rate of return and the risk-adjusted rate of return for players. The owner's problem is how much to invest in the team. The expected return to the owner's portfolio is $E(R_t) = \alpha R_f + (1-\alpha)R_{pt}$ where $R_{pt}$the return from the players on the team is and α is the share of his portfolio allocated to the risk free asset. The separation theorem suggests that any investor (owner), regardless of utility function, will invest the same shares of his or her portfolio in the capital market and the player market when facing the same relative rates of return. In contrast, the manager's problem is how much to invest into the contract, in which the options are other players since the team must have a roster to compete in the league. Choosing a team budget, instead of choosing a stock of player talent, has received recent support in the sports economics literature (Rockerbie and Easton, 2019, Madden, 2011, Szymanski, 2004).

Calculating the present value of the player's expected MRP described in Figure 1 is straightforward. The condition below will hold when the present value of known payments to the player, salary S_i, is equal to the (appropriately) discounted expected value of the player's risky MRP.

$$\frac{S_1}{1+0.05} + \frac{S_2}{(1+0.05)^2} = \frac{0.5(\$5\ m)+0.5(\$1\ m)}{1+0.1} + \frac{0.5(\$5\ m)+0.5(\$1\ m)}{(1+0.1)^2} \tag{6}$$

We can safely assume $S_1 = S_2 = S$ in a player contract, (and we assume no performance incentives) so

$$S = \$3\ m\left(\frac{\frac{1}{1+0.1}+\frac{1}{(1+0.1)^2}}{\frac{1}{1+0.05}+\frac{1}{(1+0.05)^2}}\right) = \$3\ m\ (0.9334) = \$2.8\ m \tag{7}$$

[14] We imagine a world in which players are like highly variable individual stocks. The risk-adjusted rate might differ from 5% in that case and β_{ij} would differ as well if the portfolio is for all players rather than the capital market. The beta coefficient for the entire league of players (the "market risk") is equal to one. If we had the MRP for each player and their salary, we could calculate the market risk and then the beta for each "stock" player and the consequent "portfolio" contribution of a team.

Because he is risk averse, the team owner offers less than \$3 million per year, offering \$3 million only if he were risk-neutral. The dashed line in Figure 1 falls at \$2.8 million per season.

4.1 The player's European put option

Suppose the player is considering signing this 2-year deal or signing a 1-year deal with the same owner to maintain a flexible position. Perhaps in one year's time, the player could sign with a large market team that will pay a higher salary even if the marginal physical product of the player is unchanged. What is the value to the player of this flexibility? This is the value of the purchase of a European put option for the player that permits him to opt out of the 2-year deal at the end of one season. Of course, the team owner also has an option to sign the player to a one-year deal to avoid the uncertainty of the second year and maintain a flexible position - a valuable put option. That exercise is considered in the next section.

To proceed, we need to specify who the possible suitors will be at the end of the first year of the contract. For simplicity, we assume there are only two suitors. There is a probability of 0.5 that a large market team could be interested in signing the player to a two-year deal and pay \$10 million for his MRP in the good state, and just \$2 million for his MRP in the bad state. Both states are higher than the team the player will leave after one year. There is also a probability of 0.5 that a small market team could be the only team interested in signing the player. It's MRP is just \$4 million in the good state and \$0.75 million in the bad state. Both states are lower in MRP than those for the (original) team the player would leave. We can compute the salary each of the two new risk-averse owners would offer by computing the present value of the player's MRP for each. For the large market team, this is

$$S = \$6\ m\left(\frac{\frac{1}{1+0.1}+\frac{1}{(1+0.1)^2}}{\frac{1}{1+0.05}+\frac{1}{(1+0.05)^2}}\right) = \$6m\ (0.9334) = \$5.8\ m \tag{8}$$

For the small market team, the annual salary offer is

$$S = \$\,2.375m\left(\frac{\frac{1}{1+0.1}+\frac{1}{(1+0.1)^2}}{\frac{1}{1+0.05}+\frac{1}{(1+0.05)^2}}\right) = \$2.375m\ (0.9334) = \$2.22\ m \qquad (9)$$

The player has already received his $2.8 million salary from his original team for the first year of his 2-year contract. He faces the decision whether to leave.[15] He will only exercise his option if he can sign with the large market team. The return from the option is $5.8 million - $2.8 million = $3 million in the second year. If only the small market team is interested, he does not exercise the option and it has zero value. The expected value of the option is then 0.5($3 m) + 0.5(0) = $1.5 million. However, he faces this decision at the start of his current 2-year contract. This suggests there may be an expansion of options for each kind and duration of contracts. Already it is becoming more common in professional sports leagues in North America that some contracts include one or more option years at the end of the contract that the player or owner can exercise if they choose. This is one way to recover the value of the option without explicitly including its value in the player's salary in the initial contract (with obvious tax advantages.)

We can compute the present value to the player of the put option value. This is done using the discount rate adjusted for risk since the player does not know his productivity.[16]. Thus the present value to the player is $1.5 million/1.1 = $1.364 million. Possibly the player may choose to demand this option value be included in his salary offer to agree to give up his flexibility and sign a 2-year contract. If so, the total value of the contract is $2.8 m + $2.8 m + $1.364 m = $6.964 million or $3.482 million per year, greater than the average expected MRP.

4.2.1 **Adding an extra year**

[15] Players are only forward-looking to their next contract in our model. That is, they do not consider the put option to leave the new team they sign with at the end of year one at any point in their new two-year contract.

[16] We are assuming he does not manipulate his productivity. Rather it is a random outcome of a process with at least two moments.

It is not hard to show that adding extra years to a player contract may add little in option value to the annual salary the player negotiates. This is a consequence of the increased uncertainty of the player's performance and the uncertainty of the available opportunities from other suitors in future years. Figure 2 provides a lattice for the three-year contract decision for the player. For simplicity, the player's expected MRP is not expected to change, hence the annual salary will be $2.74 million, less than the $2.8 million in the two-year contract due to discounting.[17] In the first year of the contract, the player will receive the present value of the expected annual MRP. The lattice branches at the end of the first year into a good or a bad state. In the good state, the player accepts the same contract offered by the large market team as before with a present value and annual salary of $5.8 million. In the bad state, only the small market team makes an offer with a present value and annual salary of $2.2 million that the player rejects (the option to leave has no value). The price of the put option to leave the current team is the same as before at $1.364 million.

Failing to exercise the option moves the player to the end of the second year of the three-year contract. If the same opportunity set is available -- as at the end of the first year of the contract, the put option to leave will have no value. The player faces an expected salary offer from the large market team (0.5*0.5*5.2 million) that is lower in expected value than the certain amount of $2.74 million in the three-year contract. The player will not exercise the option at the end of the second year, with the only possibility of leaving being at the end of the first year.

The previous example suggests that the largest put option value for the player is in moving from a one-year to a two-year contract. However, adding a third year can add a positive option value to the annual salary if the player's opportunities improve dramatically at the end of the second year. This could be the case of a younger player whose career is on the upswing. Suppose at the end of two years, a large market team is available whose expected annual MRP from the player is $10 million. Discounting this

[17] This can be calculated as $S = \$3\ m \left(\frac{\frac{1}{1+0.1} + \frac{1}{(1+0.1)^2} + \frac{1}{(1+0.1)^3}}{\frac{1}{1+0.05} + \frac{1}{(1+0.05)^2} + \frac{1}{(1+0.05)^3}} \right) = \$3\ m\ (0.931) = \$2.74\ m.$

back two years to the start of the initial three-year contract gives an expected annual salary of $9.33 million from this offer. Also assume that a small market team is also available whose offers an annual salary of $6 million based on its discounted expected annual MRP of the player. Discounting this by two years gives an expected salary of $5.6 million. The price of the put option is (0.5)(0.5)(9.33 – 2.74) + (0.5)(0.5)(5.6 – 2.74) = $2.36 million.[18] The total value of the put options over the lifetime of the contract are $1.364 m + $2.36 m = $3.724 million. Divided over three seasons, the annual salary is $3.98 million if the player can capture all of the put option value. The value of the flexibility the owner recoups to the player is then just over 31% of the total contract value.

Several factors could increase the value of the player's put option and increase his salary above his average expected MRP.

1. The probability of a large market team being available at the end of the first year of the contract increases.
2. The expected MRP of the player for the large market team increases due to an increase in market size (big media contract).
3. The physical productivity of the player increases at the end of the first year of the contract, and the large market team is available. This could be the case for a younger player who is still on the upside of his career.
4. The length of the contract increases from two years to 3 or more years. This would add more complexity to the lattice and give the player more flexible options that are valuable. These "compound options" are options on options.
5. The variance of the player's MRP decreases relative to the average across all players. This would be reflected in a decrease in the player's Beta coefficient.

[18] Since we have already discounted the expected salaries in the good and bad states at the end of year two, there is no need to discount the option value as we did in the previous example of a two-year contract.

6. A decrease in risk-free interest rates.

4.2 The owner's European put option

The team owner faces the same two-year horizon as the player in Figure 1. He or she faces the decision whether to sign the player to a two-year guaranteed contract or a one-year contract that provides flexibility. Unlike the player, the team owner receives no gain if the player bolts to a large market team at the end of the first year – although he does have the opportunity to sign a new player. Hence Figure 1 contains all of the information relevant to the contract decision. The decision to sign the player to a one-year deal can be modelled as equivalent to exercise a European put option on the player's two-year contract at the end of the first year.[19] If this put option has value, we can assume the owner will deduct its purchase price from the player's two-year total compensation as payment by the player to compensate the owner for giving up this flexibility. This could push the player's contracted salary below his MRP, ignoring the value, if any, of the player's put option.

The two-year contract annual salary will still be the \$2.8 million computed in (3). We assume that the owner wishes to avoid any losses over the life of the contract, that is, where the total discounted expected MRP is less than the total two-year compensation.[20] This can occur only in the lowest branch of the lattice in Figure 1. The owner is committed to the first year of the contract regardless, so the discounted expected MRP is also the value of the put option.

$$(0.5)(0.5)\left(\frac{\$1m-\$2.8m}{1.1^2}\right) = -\$0.372m \tag{10}$$

[19] Although the player has a valuable put option to leave the team to sign with a more lucrative team, we assume that the team owner does not face the decision of releasing the player at the end of one season and signing a more valuable player (in terms of expected MRP). This keeps the exposition simple although it would be an interesting strategy game for team owners to anticipate the future availability of valuable players.

[20] This would be consistent with the assumption that the team owner is an expected profit maximizer. In the upper branch of Figure 1, the owner earns a windfall profit, however the owner experiences an unexpected loss in the lower branch. In the two middle branches, the owner just pays the player his expected MRP over the life of the contract.

The present value of the total compensation to the player under a two-year contract is \$2.8m + \$2.8m - \$0.372m = \$5.228m or \$2.614m per year. The player pays for the certainty of a two-year contract by accepting a salary offer less than his expected MRP, but not by much since the team owner incurs the really bad state in only one out of four possible states.[21] This gives the owner's put option a low value.

Extending the contract to a three-year term can increase the value of the owner's put option significantly and, subsequently, lower the salary offer the owner is willing to make. This is because the put option value is zero in good states where the player's actual MRP is greater than the expected MRP, and thus the player's salary. A greater number of really bad states can result in which the put option has value to the owner. Figure 3 demonstrates the lattice for the three-year player contract on the part of the team owner. The end of any branch that occurs at or above the annual salary has no put option value since the player is generating a MRP above or just equal to the expected MRP. In those cases, the owner is earning a windfall profit or just maximizing expected profit.

The bold branches in Figure 3 isolate the paths to the really bad states. The put option value in the bottom branch is $[(0.5)(0.5)(0.5)(\$5 \text{ m} - \$2.74 \text{ m}) + (0.5)(0.5)(0.5)(\$1 \text{ m} - \$2.74 \text{ m})] /1.1^2 = \$0.11$ million. The middle branch falls below the annual salary in the really bad state only. However, this state can be arrived at in two different paths over three seasons. The value of the put option is $2(0.5)(0.5)(0.5)(\$1 \text{ m} - \$2.74 \text{ m})/1.1^2 = -\$0.36$ million. Add to this the value of the put option already calculated after the end of the first year of the contract (-\$0.372 m), and the total value of the put option over the three-contract is \$0.842 million or \$0.28 million per season. If the owner can capture the total amount of the put option from the player, the negotiated annual salary will be \$2.46 million, only 10.2% less than the expected MRP.

The value of the put options will increase if the player's performance is expected to fall over the lifetime of the three-year contract. Suppose that the player's MRP falls to \$4 million in the good state in

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[21] We define states in which the discounted expected MRP is less than the player compensation over the lifetime of the contract as a "really bad state" for lack of some technical term like "superbad".

year 2 of the contract and $3 million in year 3. The discounted expected MRP, divided by three years, is just the salary offer, equal to $2.29 million.

Several factors could increase the value of the owner's put option and reduce the player's salary below his average expected MRP.

1. The physical productivity of the player is expected to decrease at the end of the first year of the contract. This could be the case for an older player who is in the downside of his career.
2. The length of the contract increases from two years to 3 or more years. This would add more complexity to the lattice and increase the number of really bad states for the owner.
3. A decrease in risk-free interest rates.
4. An increase in the variance of the player's MRP relative to the league average, increasing the player's Beta coefficient.

5. CONCLUSION

Our study utilized a number of useful innovations to estimate MRP's for MLB free agents. First, only free-agent players were considered since players in the middle of long-term contracts may not be expected to provide a net MRP equal to their salary that was negotiated several seasons ago. This suggestion was first made by Krautmann (1999) and we employed it here. Second, our club revenue data is the most up to date we could find and includes all revenue sources, whereas Scully (1974, 1989) and Zimbalist (1992) estimate revenue from gate attendance and average ticket price. The importance of using all revenue sources can be noted in our results for the 2001 season when television revenues increased substantially. Third, our regression equation to predict winning percentage used a logistic function instead of the linear probability function, making the estimated marginal effect of OPS dependent upon the overall performance of the club. Finally, we estimated the net surplus (positive or negative) for every free-agent player over a much longer sample period than the one or two-season samples of previous studies.

Two robust results emerged from our empirical results. Free agents that are paid a salary below the MLB average tend to be underpaid, while those paid a salary above the MLB average tend to be overpaid. In addition, free agents on single-year contracts tend to be underpaid, while those on multi-year contracts tend to be overpaid. These results are not consistent with the standard monopsony talent market assumption, unless one resorts to arguing that the talent market is segmented.

We develop a simple model of real options to demonstrate how a player can be overpaid or underpaid depending upon the length of the contract, the available opportunities for the player to move during the contract period and the player's expected performance. Free agents who are early in their careers and whose MRP is expected to increase may be able to capture the value of put options to leave in their negotiated salaries. Older free agents whose MRP is expected to decline will not have put options with any value. For these players, team owners give up valuable put options when signing them to multi-year contracts and will try to capture these values in the form of lower salaries. We believe that a real options approach to player contracting is an important addition to the market-based approaches relied upon in the past.

APPENDIX A

Data sources

R = MLB club revenue from all sources	Taken from http://www.rodneyfort.com which is data compiled from Forbes magazine and Financial World magazine.
P = Average ticket price	Taken from http://www.rodneyfort.com which is data compiled from Team Marketing Report.
WP = Club winning percentage	Taken from Sports Reference, LLC http://www.sports-reference.com
Y = Metropolitan area income per capita	Local metropolitan area personal income and population taken from Bureau of Economic Analysis, Regional Accounts, http://www.bea.gov/regional/reis/
U = State-wide unemployment rate	Taken from Bureau of Labor Statistics, http://www.bls.gov/schedule/archives/metro_nr.htm
CPI = State-wide consumer price index (2000 = 100)	
NEWSTA = dummy variable = 1 for a new stadium	Determined from http://www.ballparks.com/
SA = Team slugging average (total bases / at bats)	Taken from Sports Reference, LLC http://www.sports-reference.com
K/BB = team strikeout to walk ratio	Taken from Sports Reference, LLC http://www.sports-reference.com
CONT = a dummy variable =1 if a club finished the season within five games of the wild-card winner in each league.	Determined from Sports Reference, LLC http://www.sports-reference.com
OUT = a dummy variable = 1 if a club finished the season within twenty or more games behind the wild-card winner in each league.	Determined from Sports Reference, LLC http://www.sports-reference.com
TV1, TV2, TV3 = 1 for the seasons covered by a new national television contract (2001, 2007 and 2012 respectively)	

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Table 1
MLB free agents by position, 2000-12 seasons.

Season	Catcher	1B	2B	3B	SS	OF	Total
2000	8	3	6	3	5	9	34
2001	7	5	4	5	4	13	38
2002	6	5	5	4	5	21	46
2003	7	7	6	5	3	14	42
2004	12	9	9	8	7	32	77
2005	11	7	6	5	9	19	57
2006	8	9	7	5	6	16	51
2007	9	9	14	10	3	25	70
2008	7	3	4	5	3	14	36
2009	7	8	5	4	7	17	48
2010	12	11	8	7	7	19	64
2011	15	8	4	6	6	19	58
2012	9	9	9	3	7	20	57
Total	118	93	87	70	72	238	678

Table 2
Estimates of team revenue function in (1)

	2000-2012	2000-2008	2004-2012
Constant	13.755	13.136	15.727
	(16.51)*	(12.53)*	(30.01)*
WP	0.523	0.565	0.256
	(6.82)*	(7.21)*	(6.01)*
Y	0.873	1.023	0.493
	(3.79)*	(3.46)*	(3.73)*
U	0.252	0.348	0.267
	(0.61)	(0.25)	(1.05)
P	0.457	0.476	0.368
	(14.75)*	(16.59)*	(10.47)*
NEWSTAD	-0.009	0.037	-0.025
	(0.65)	(1.29)	(2.24)*
TV1	0.147	0.137	
	(6.89)*	(4.64)*	
TV2	0.292	0.277	0.101
	(11.74)*	(7.75)*	(4.76)*
TV3	0.364		0.175
	(17.44)*		(9.02)*
Adjusted R^2	0.923	0.922	0.946
F	125.88*	88.46*	130.29*
N	364	252	252

Note: t-statistics appear in parantheses. * denotes statistical significance at 95% confidence.

Table 3
Estimates of logistic winning percentage function in (2)

Coefficient	National League	American League
CONSTANT	-1.520	-1.850
	(4.78)*	(6.19)*
OPS	3.161	3.459
	(6.65)*	(7.40)*
K/BB	0.041	0.073
	(1.58)	(1.96)**
ERA	-0.226	-0.202
	(6.57)*	(5.64)*
CONT	0.172	0.147
	(6.20)*	(6.39)*
OUT	-0.175	-0.180
	(4.26)*	(6.58)*
Adjusted R^2	0.870	0.903
F	69.26*	92.78*
N	195	169

Note: t-statistics appear in parantheses. * denotes statistical significance at 95% confidence. ** denotes statistical significance at 90% confidence.

Table 4
Exploitation rates for MLB free-agents vs. salary

		Exploitation Rate		
Season	MLB average salary	Free agents above average salary	Free agents below average salary	All free agents
2012	$3,440,000	-0.455	0.164	-0.316
2011	$3,305,393	-0.431	-0.147	-0.366
2010	$3,297,828	-0.182	0.450	-0.002
2009	$3,240,206	-0.239	0.439	-0.060
2008	$3,154,845	-0.400	0.137	-0.309
2007	$2,820,000	-0.326	0.509	-0.182
2006	$2,699,292	-0.242	0.799	0.007
2005	$2,632,655	-0.194	0.929	0.088
2004	$2,486,609	-0.200	1.153	0.199
2003	$2,555,416	-0.367	1.057	0.024
2002	$2,340,920	-0.309	0.609	0.057
2001	$2,138,896	-0.444	0.403	-0.289
2000	$1,895,630	-0.116	0.989	0.174

Source: Average salary taken from https://www.cbssports.com/mlb/salaries/avgsalaries. Extracted on June 12, 2018.

Table 5
Exploitation rates for MLB free-agents vs. contract length

	Exploitation Rate	
Season	Free agents with multi-year contracts	Free agents with one-year contracts
2012	-0.429	-0.017[a]
2011	-0.392	-0.317
2010	-0.016	0.039
2009	-0.114	0.157[b]
2008	-0.321	-0.016[c]
2007	-0.308	0.049[d]
2006	-0.291	0.422
2005	-0.159	0.417
2004	-0.203	0.691
2003	-0.248	0.503[e]
2002	-0.246	0.522[f]
2001	-0.503	0.006[g]
2000	-0.043	0.415

[a] Excludes Jose Reyes, Miami Marlins, $17.7 million (-0.112).
[b] Excludes Manny Ramirez, Los Angeles Dodgers, $22.5 million (-0.011).
[c] Excludes Andruw Jones, Los Angeles Dodgers, $18.1 million (-0.289).
[d] Excludes Barry Bonds, San Francisco Giants, $15.8 million (-0.023).
[e] Excludes Ivan Rodriguez, Florida Marlins, $10 million (0.269).
[f] Excludes Juan Gonzalez, Texas Rangers, $11 million (0.234).
[g] Excludes Juan Gonzalez, Cleveland Indians, $10 million (-0.064).

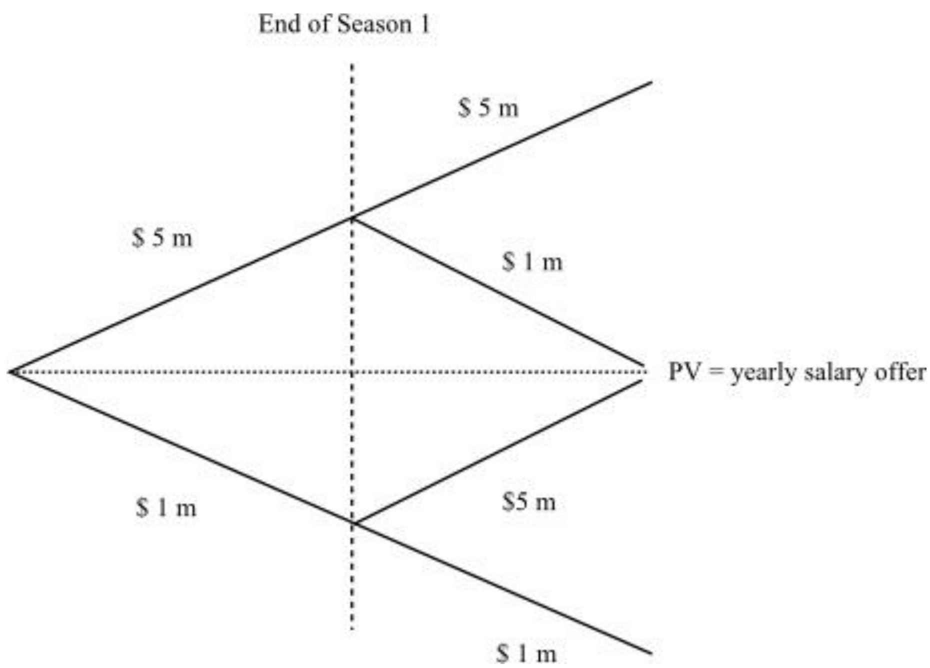

Figure 1. The Two-Year Time Horizon

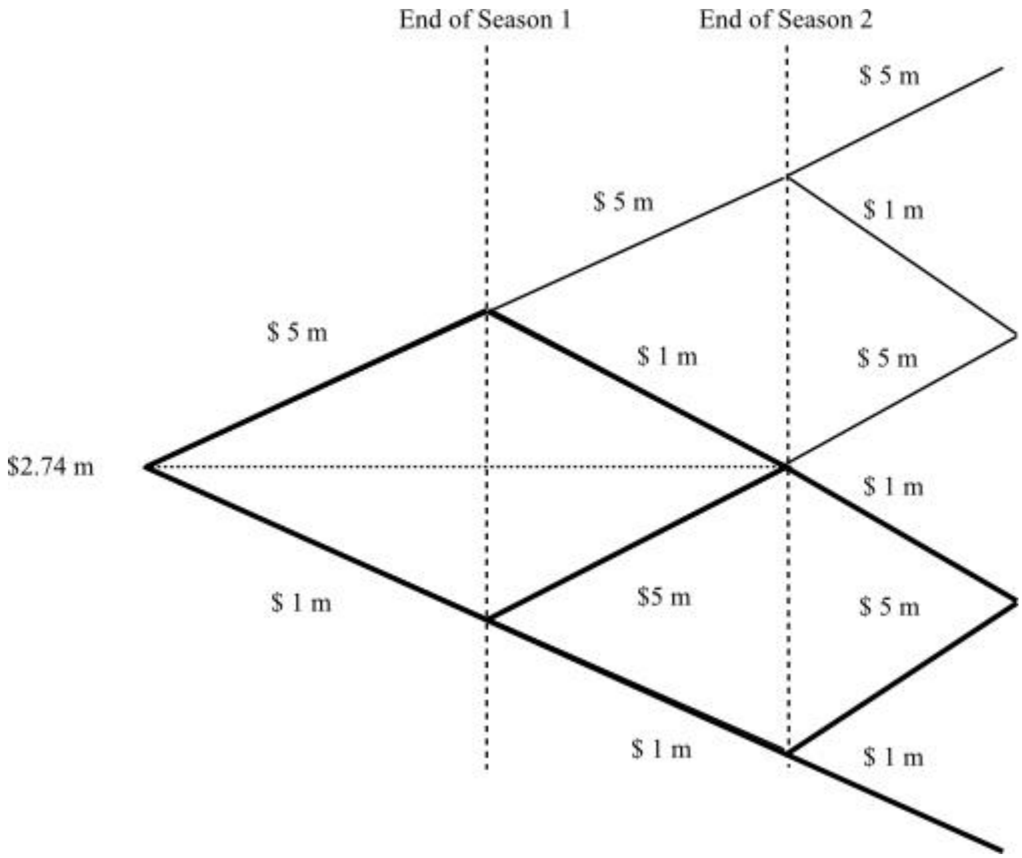

Figure 3. The Three-Year Time Horizon for the Team Owner

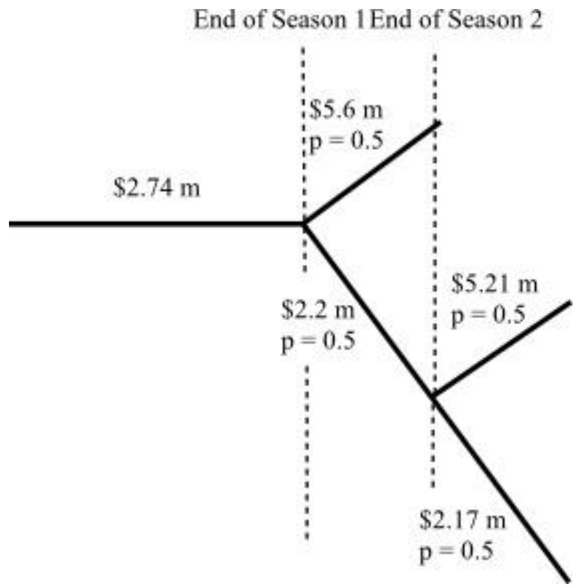

Figure 2. The Three-Year Time Horizon for the Player