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Wage Dispersion and Individual Performance: MLB Pitchers

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ABSTRACT

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Major League Baseball is one of the most valuable sports leagues valued at $10 billion US dollars. While over 40% of payroll is allocated to pitchers, the wage disparity between starting pitchers alone is $7 million US dollars. The disparity between the max starting pitchers and the minimum relief pitchers is $20.5 million US dollars. Previous studies find that there is much evidence to support that as wage dispersion among a team increases, the overall team performance is negatively affected. In addition, there are some studies which find no correlation, or positive correlation between salary inequality and efficiency. Jewell and Molina (2004) find that salary inequality does not appear to be correlated with efficiency in the MLB.

This paper analyzes how wage dispersion and salary inequality affect individual performance among pitchers in Major League Baseball (MLB). To answer this question, we examine the relationship between wage dispersion and individual performance of the rostered pitcher on all 30 MLB teams across 10 seasons using seasonal statistics which include team and player specific metrics. The economic goals of the study is to further the research surrounding two competing salary theories: tournament theory and cohesion theory. The results of this study show that with larger wage dispersions or pay inequality across teams and the pitching specific positional payroll, there is statistically significant negative impact on individual performance.

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Introduction

Professional sports is a subject that is explored in many fields of studies, from the physiological aspect in biology, to the mental aspect in psychology, and the management and financial aspects in economics. Sports franchises are some of the most successful businesses with the top franchises being valued at millions of dollars. The most valuable sports league is the National Football League (NFL), at $13 billion US dollars, with Major League Baseball (MLB) coming close behind at $10 billion US dollars (Randjelovic, 2020). The MLB as a whole is a well operated organization; it is home to 30 teams across 2 leagues generating a total revenue of 9.56 billion US dollars through the 2021 season, and dishing out an average of 132 billion US dollars total payroll across the league in the 2021 season (Gough, 2022; Spotrac, 2021).

In 2016, MLB teams allocated 42.8% of their payroll to pitchers on average with 27.4% going towards starting pitchers and 15.4% going towards relievers and other pitchers (Ross, 2016). Pitching is a vital role in the sport of baseball as a pitcher is the only player on the entire field who touches the ball on every single play, and is able to set the tone for the game. For this reason, pitchers are known for receiving blockbuster deals just as the trade deadlines approach, or during the off season when it is a race to acquire

The disparity among pitchers is large. The disparity between starting pitchers alone is $7 million US dollars (Gaines, 2015). The disparity between the max starting pitchers (the biggest stars) and the minimum relief pitchers (the least known players) is even more drastic at $20.5 million US dollars (Gaines, 2015).

Sports franchises themselves are labor markets where workers should be paid their marginal productivity according to economic theory. Efficiency wage theory states

that skilled workers should be paid enough that they are incentivized to work and not quit. In the context of the MLB, efficiency wage would require the players to be paid a high-enough salary amongst the team payroll to avoid optioning for trade or free agency, as well as be incentivized to continue playing for this specific team.

In previous literature exploring the relative salary of professional athletes, multiple studies find evidence to support the implication of efficiency wage theory that higher relative wages equate to higher player performance (Debrock, Hendricks, and Koenker, 2004; Katayama and Hudan, 2009; Di Domizio, Pellegrini, and Caruso, 2022). However, it is important to examine economic tournament theory and cohesion theory as relates to salary dispersion. Economic tournament theory is centered around the idea that higher wages serve to increase incentives for low level workers (Ekinci, Kauhanen, and Waldman, 2019). The focus in the tournament theory is to work hard for wages, ideally boosting productivity among workers, creating an incentive to work hard and achieve more. Therefore, the higher the wage disparity, the greater the productivity as there is a greater incentive to work hard for a better wage. On the opposing side, the economic cohesion theory is centered around the idea that there is higher productivity among workers in a labor market when the wages are relatively similar. This emphasizes the idea that spreading the wealth creates a better functioning labor market. Empirically, many studies have found that wage dispersion is negatively related to team performance, suggesting that the greater the wage disparity among teams are, the worse the on-field performance (Depken and Lureman, 2018; Mondello and Maxcy, 2009).

This leads to an interesting and not well researched question – to what extent does salary dispersion/wage inequality within Major League Baseball influence an MLB

pitcher's individual performance? This relates directly to the tournament theory versus the cohesion theory hypothesis – does higher wage disparity (supporting the tournament theory) or lower wage disparity (supporting the cohesion theory) produce better individual performance? Investigating how these two theories differ in hindering or helping individual performance could provide further insight and guidance to other labor markets on how to structure pay rolls and salary structures. Focusing on the impact of payroll dispersion on pitcher performance is also particularly useful for pitchers in contract negotiations.

The results of this study suggest that the cohesion theory is a better fit when looking at salary structures and player performance. There is evidence to show that an increase in wage dispersion significantly negatively affects performance. As the wage dispersion increases across the team, multiple individual performance metrics decline showing negative performance.

The next section reviews previous literature related to wage dispersion as well as relative wages on individual performance and team performance and discusses previous literature on salary determination. Section 3 presents the empirical specification and data used in the analysis. Section 4 presents the results of the analysis and discusses the findings while section 5 concludes.

Literature Review

This chapter provides an overview of the existing literature related to wage disparity in the field of sports economics and its effect on performance. It discusses the effect of wage disparity in professional sports on both team levels of performance, as well as factors that could affect independent performance.

A. Salary Determination

It is important to acknowledge and briefly review literature on salary determination, as this research question discusses salary as a determinant of performance, whereas many studies view player performance as a determinant of salary. It is hard to specifically measure an individual player's statistics in baseball, as it is ultimately a team effort that contributes to each measure of ability. There is a consensus that player performance and salary are related; however, there is a disagreement regarding how performance can be measured and how accurately these measurements reflect the individual performance of that player (Scully, 1974). Scully (1974) determines that there are four main statistical categories that determine a player's performance: hitting or pitching performance, weight of the player's contribution to team performance, the number of years spent in the majors, and the greater bargaining power of the superstar players. When specifically looking at the best way to measure pitching performance, Sully (1974) also addresses the issue that it is difficult to determine the best overall determination of MLB pitcher performance as most traditional measurements are not pitcher specific, but rather team efforts. Scully (1974) defines the best way to measure a pitcher's performance as a determinant of salary, is by looking at the pitchers lifetime

strikeout-to-walk ratio, followed by a pitcher's lifetime average percentage of innings pitched.

Berri, Leeds, and von Allmen (2015) explore performance as a determinant of salary. They find that players' popularity, particularly with fans, enhances players' bargaining power giving them greater power. As a large percentage of revenue from major league sports teams in North America are a result of broadcasting rights, the players' compensations are not based on the current performance of any of the plates but rather expected contributions or bargaining model in which negotiations are present (Berri, Leeds, and von Allmen, 2015). The findings show that while player performance increases a player's bargaining power through popularity among fans, there is a relatively small impact on performance directly on salary (Berri, Leeds, and von Allmen, 2015).

In salary determination it is difficult to allot the valuation of players to their performance. Bradbury (2007) addresses a similar issue as Scully (1974); specifically, regarding MLB pitchers, there is evidence that suggests pitchers are paid according to their individual contributions that are equal to the skill sets of which pitchers possess. Bradbury (2007) explains that it is difficult to value an individual pitcher's contributions as many aspects of the pitcher's statistics, such as runs allowed, is a jointly produced defense with their fielders. For a pitcher's value, it is difficult to directly relate it to one metric of success as the factors that are important for imputing pitcher's statistics are conflicting with the overall team production (Bradbury, 2007).

B. Team Performance

Company and business owners have all at some point in time considered the question of the efficiency wage theory, a theory in economics that examines how higher

wages can lead to increased labor productivity due to higher levels of motivation among workers with higher margins of pay. This stands true to professional sports teams, which at the base of their operations is simply a mega-million-dollar company that functions to provide for fans throughout the world. Across the world of sports, this question of relative wage and wage dispersion on team performance remains prevalent as teams look to exhaust all opportunities to produce a winning team. There are relatively consistent results in exploring the relationship between performance and relative wages opposed to wage dispersion.

In exploring relative wages, many studies find that the higher the relative wages, the better the performance among teams (Debrock, Hendricks, and Koenker, 2004; Katayama and Hudan, 2009; Di Domizio, Pellegrini, and Caruso, 2022). Debrock, Hendricks, and Koenker (2004) specifically examine the impact of salary distribution on firm-level outcomes in Major League Baseball, testing the theories of efficiency, wages, and fairness. After controlling for worker characteristics, Debrock, Hendricks, and Koenker (2004) concluded that high-wage strategies are associated with better win-loss team performance. Paying players higher wages and signing larger player contracts, results in a better team performance in the duration of the season, leading to a better overall team seasonal record (Debrock, Hendricks, and Koenker, 2004). In the National Basketball Association (NBA), Katayama and Hudan (2009) had similar results to Debrock, Hendricks, and Koenker (2004) where if the average salary among active players is high, the team is more likely to win. Additionally, in professional soccer, Di Domizio, Pellegrini, and Caruso (2022) find that there is a statistically significant positive association between relative wages and the overall team performance.

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Previous studies also find that there is much evidence to support that as wage dispersion among a team increases, the overall team performance is negatively affected (Depken, 1999; Depken II and Lureman, 2018; Mondello and Maxcy, 2009; Tao, Chuang, and Lin, 2016; Coates, Frick, Jewell, 2016). So, although a higher wage results in better overall team performance, higher wage dispersion within a team tends to be associated lower overall team performance (Tao, Chuang, and Lin 2016; Depken II and Lureman 2018; Katayama and Hudan 2009; Debrock, Hendricks, and Koenker 2004; Mondello and Maxcy 2009). In looking specifically at Major League Baseball, Tao, Chuang, and Lin (2016) find that greater wage disparity among the team is negatively related to team performance, showing that when salary dispersion increases among MLB teams there is a negative impact on that team win-loss record.

These conclusions can be found across most professional sports leagues. In the National Hockey League, Depken II and Lureman (2018) find that increased salary disparity on NHL teams reduces overall team performance, specifically the defensive performance in terms of goals allowed. Cyrenne (2017) finds similar results that specifically in the NHL, teams with higher relative payrolls and lower salary inequality have higher winning percentages. In the National Football League (NFL), Mondello and Maxcy (2009) similarly find that salary dispersion significantly negatively affects on-field team performance. In professional soccer, Bucciol, Foss, and Piovesan (2014) find results that high pay dispersion has a detrimental impact on team performance.

Although there are many studies to support the negative effects of wage disparity on player and team performance, there are some studies which find no correlation, or positive correlation between salary inequality and efficiency. In the MLB, Jewell and

Molina (2004) find that salary inequality does not appear to be correlated with efficiency. Contrastingly, Franck and Nüesch (2010) find empirical evidence that team performance is strongest with either very high or very low wage inequality.

C. Individual Performance

While the previous papers focus on the effect of wages or wage dispersion on team performance, the impact on individual performance has also been considered. Some studies that originally examined the effect of wage dispersion on team performance additionally find evidence of worsened individual performance. Bucciol, Foss, and Piovesan (2014) find results that high pay dispersion has a detrimental impact on team performance, however when further looking into these results it is found that the worsened team performance is due to decreased individual performance as opposed to a reduction of team cooperation and cohesiveness. Bloom (1999) finds similar results when looking at pay dispersion on individuals and organizations as a collective whole. Bloom (1999) finds that a more compressed pay dispersion is positively related to individual performance.

Previous studies have looked at many factors that affect individual performance of athletes. Koop (2001) views baseball players as economic firms and examines the output of these hypothetical firms in terms of offensive production of individual players. The study only relates to performance indicators of those who had 200+ at bats in a season, and the performance indicators are as such: singles, doubles and triples, homeruns, and walks (Koop, 2001). Although Koop (2001) compares players among the league to see the compatibility of such players, seeing how the individual player performance is examined is vital to understand how player performance can be empirically modeled.

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Albert (2008) also examines the individual player performance of hitters in the major leagues, although instead of comparing players to one another, this study aims to explore the streaky hitting patterns of baseball players during the 2005 season. This study looks at individual hitting statistics such as length of success and failure streaks in areas such as outs, hits, and runs (Albert, 2008). An important issue that Albert (2008) encountered is the issue of accounting for player ability and number of opportunities. This is something that will also be considered in our research question, as our dependent variable of individual pitcher performance will have a similar range of players ability and games played throughout the season.

Most closely related to the research question proposed, Torgler and Schmidt (2007) examine whether salary structures in professional soccer and player performance, measured in goals and assists, are correlated. Their approach looks at the impact of relative income level, in relation to other team-mates, on player performance. In using a unique data set covering 8 seasons and the disparity between 1311 players with an average of 2.5 seasons played, Torgler and Schmidt (2007) look at the performance of player *i* at time *t* measured in goals and assists. To determine relative salary, Torgler and Schmidt (2007) measure the difference between teammate's average salaries and the player's individual salary. The findings of this study for these specifications of looking at performance variables such as goals and assists and wage dispersion shows that salary has a statistically significant impact on individual performance, where a larger difference in wage leads to lower performance (Torgler and Schmidt, 2007).

Simmons (2011) additionally analyzes the specific relationship between pay disparity and individual player performance within the National Basketball Association

(NBA). In using data covering 20 seasons, Simmons (2011) compiles the metric PROD that encapsulates the following player variables: three-point field goal made, two-point field goal made, free throw made, missed field goal, missed free throw, offensive rebounds, defensive rebounds, turnovers, steals, opponents free throws made, blocked shot, and assists. The PROD metric is then adjusted to allow for variations in playing time to give the dependent variable for player performance as defined as ADJP48 (Simmons, 2011). Simmons (2011) tests this against variables that represent pay inequality, as well as inequality of player performance for if a player is on a team with players they perceive to be better, they will accept the pay inequality. The findings suggest that a justified inequality appears to have a positive impact on player performance in the NBA (Simmons, 2011).

This paper aims to tie these two areas of research together. While there is plenty of outstanding research regarding relative salary's contribution to individual performance and research surrounding wage dispersion on team wide performance, there is very little that investigates the relationship between relative wages, wage dispersion and individual performance. This will contribute to that gap between these two largely researched areas and aim to provide further information regarding salary structure and optimizing performance.

Methodology and Data

This chapter provides an overview of the methodology and data that will be used to look at the effect that salary dispersion/wage inequality has on individual performance among MLB pitchers.

A. Conceptual Model

Efficiency wage theory is one lens which can be used to examine salary structures in the MLB. These theories state that wages are endogenous to a firm's optimizing behavior, as well as a determinant of labor productivity (Riveros, Bouton, 1993). Riveros and Bouton (1993) review the questions raised via efficiency wage theories regarding the effectiveness of expenditure-reducing and expenditure-switching policies. In looking specifically among the MLB players, efficiency wage would require the players to be paid a high-enough salary amongst the team payroll to avoid optioning for trade or free agency, as well as be incentivized to continue playing for this specific team.

In looking at wage disparity, there are two competing theories: the tournament theory and the cohesion theory. As discussed earlier in the paper, the tournament theory relies on the idea that wage disparity has a positive effect on performance as the gap in wages should encourage lower paid players and/or employees to work harder to achieve the salary of the higher waged players. The cohesion theory on the other hand stands with the assumption that wage disparity will create tension between players and/employees, therefore making the performance overall worse as opposed to equal wages driving everybody cohesively in the right direction.

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Although in theory the tournament theory should work, as seen in the literature review, the findings of studies typically find a negative correlation between wage disparity and performance both individually and team wise. This motivates the question of whether these results remain consistent when looking at the wage disparity among individual pitcher performance in the MLB.

B. Data

This study uses time series from the 2012 to 2022 regular seasons from MLB statistics to investigate the effect of wage dispersion on individual performance. MLB's organizational website holds statistical archives dating back to the 1876 seasons, and holds standard performance on every player as well as expanded statistics and Statcast data. This study looks at the standard performance metrics. The stats are recorded live during the games, and detailed records have been kept dating back to the earliest seasons. This study uses time series data from Spotrac for individual salaries and team payrolls. Spotrac provides team and individual payroll information across all professional sports leagues across multiple years.

The dataset consists of MLB pitchers from the 2012 to 2022 regular seasons[1]. MLB pitchers rostered on the 30 MLB teams across the two major leagues, provides us with a pool of 3,316 pitchers data. To ensure that the sample contains only true rostered pitchers with the correct qualifications, only pitchers who have pitched a minimum of 50 innings in a season are included. This number of innings is large enough to weed out position players who have had an opportunity to pitch in low stakes games, as well as is

[1] Postseason play is not accounted for, as not all teams are involved. It would in turn inflate individual pitcher statistics.

small enough to allow us to include relief pitchers who log significantly less innings a season than the starting rotations. The dataset also only includes pitchers that have a minimum of 3 years' experience at the Major League level to limit the number of rookies and allowing time in the player's career for contract negotiations to better correlate to the on-field production levels during the current season.

Table 1 illustrates the summary of the data of most importance. With the average age being 27.9258, it shows that there is a good variety of rookies and veteran pitchers in the sample. The mean for the wage index is 0.0281, whereas the mean for the wage index across pitchers is 1.2390. With the average wage index variable being lower when looking at the wage index across the entire team, it appears as though there is more dispersion when including the salaries across the entire team as opposed to looking at the salaries of solely the pitchers.

The standard deviation for the individual performance metrics varies slightly. For the WHIP and BB/9, there is a low standard deviation, but for K/BB it is 1.4257 and for SO/9 the standard deviation is 2.0804. The K/BB and SO/9 variables have more variation across the pitchers than that of the BB/9 and WHIP. The roster has a relatively high standard deviation of 4.8628 indicating high levels of variation. The standard deviation for the wage index is relatively low at 0.0301, as is that of the percentage of payroll which is 0.0370. The lower the standard deviation, the less variation. The standard deviation for the wage index pitchers is rather high at 13.5801, meaning that there is quite a rather large amount of variation in this variable.

Additionally the maximum values for the SO/9 and K/BB are both relatively high, showing that some pitchers have greater strengths in strikeouts than others. Surprisingly,

the maximum value of BB/9 is 8.2800 which seems to be a relatively low value for a maximum. The differences between the minimum roster size of 25 and the maximum roster size of 51 is rather surprising, indicating a 26 person gap between the smaller teams and the bigger teams in the markets. The wage index pitcher also has a rather large maximum value of 633.6072, whereas the wage index for the team's max value is only 0.2879 and the percentage of payroll's max value is only 0.3637. This may be because some pitchers hold a large amount of the pitching payroll due to the large superstar salary.

Table 1. Summary Statistics

VARIABLES	M	SD	*Min*	*Max*
Dependent Variables				
WHIP	1.2687	0.1990	0.5500	2.0500
KBB	3.0715	1.4257	0.7900	17.3300
BB9	3.0369	0.9953	0.4200	8.2800
SO9	8.3672	2.0804	1.9100	17.6700
Independent Variables				
Wage Index	0.0281	0.0301	0	0.2879
Wage Index Pitcher	1.2390	13.5801	0.0016	622.6072
Percentage of Payroll	0.2691	0.0370	0.0002	0.3637
Team Level Characteristics				
Roster	34.9683	4.8628	25	51
Win Percentage	0.4974	0.0778	0.2900	0.7200
Individual Characteristics				
Age	27.9258	3.7613	19	49
Age Squared	793.9940	220.9958	361	2401

C. Empirical Specification

To test the effect of salary dispersion on individual performance, pitcher's individual performance will be measured by the pitcher's strikeout to walk ratio (K/BB), strike out rate per nine innings (SO/9), walk rate per nine innings (BB/9), and the ratio of walks plus hits per inning pitched (WHIP). These metrics will best be used to evaluate the individual pitcher's performance. As mentioned in the previous literature, it is difficult to accurately isolate a pitcher's performance as once the ball is in play it becomes a collective defense and pitcher attempt. Walks and strikeouts are the closest metrics to variables specifically isolated to pitchers. Team variables also related to pitching that will be considered in looking at pitcher performance would be a pitcher's win-loss record. The wins and losses of a pitcher is not isolated solely to individual performance, but rather reflects the performance of both the pitcher and the overall team's outing.

The following regression equation is used to structure the empirical model:

$$Y_{ijt} = \alpha + \lambda W_{jt} + X\beta_{1it} + X\beta_{2jt} + \delta_j + \theta_t + \varepsilon$$

In this equation, Y_{ijt} is the performance of the individual player (i) on team (j) in year (t). The individual performance variables include K/BB, SO/9, BB/9, and Whip. Wage inequality is identified as W_{jt}. The wages inequality variables considered are the percentage of payroll which accounts for the relative wages of a player, the dispersion of wages across the entire team, and dispersion of wages across the pitching positional payroll for the team. Both wage dispersion variables are calculated using the wage index variable described below. $X\beta_{1it}$ is a vector of individual player characteristics such as age and age squared and $X\beta_{2jt}$ is a vector of team characteristics such as roster and win

percentage. In using this equation, the effect of wage dispersions and other characteristics on the individual performance of MLB pitchers for a current season can be examined.

To test the effect of wage dispersion on the performance metrics, wage dispersion is calculated using the Herfindahl method as used by Aghion et al (2015) to calculate the dispersion of tax holidays. The Herfindahl method in Aghion et al (2015) helps eliminate issues of potential endogeneity of a typical wage dispersion variable by calculating an index for dispersion with a method of leaving one out in both the numerator and the denominator. This is calculated as follows:

$$\text{Wage Index}_{ijt} = \sum_{h \in j, h \notin i} \left(\frac{Player\ Salary_{it}}{Total\ (Pitcher)\ Salary_{jt}} \right)^2$$

The wage index is equal to the sum of the player i's salary divided by the total team salary excluding that of player i's salary squared. The higher the number, the more concentrated the wages are whereas the lower this number is the more dispersion there is among the salaries. Total salaries for teams include a vast amount of players including those who are in the minor leagues, inactive players whether for injury or suspension, and players that were traded throughout the season. To account for players that contributed to the team performance for much of the duration of the seasons, the total salary component is limited to active players only. In additional specifications, the wage dispersion variable is lagged to represent the wage dispersion from the previous year, and this will be tested against the player performance from the current year. Table 2 reports the definition of the variables.

Table 2. Definition and Measurement of Variables

Variables	Definition
Dependent Variables	
WHIP	Ratio of walks plus hits per inning pitched
K/BB	Ratio of the number of strikeouts to the number of walks for a season
BB/9	Walk rate per nine innings
SO/9	Strikeout rate per nine innings
Independent Variables	
Wage Index	Summation of player i's salary divided by the total team salary excluding player I squared.
Wage Index Pitcher	Summation of player i's salary divided by the total salary for only the pitchers on the team excluding player I squared
Percentage of Payroll	The percentage of player I's salary is of the team's total overall payroll
Team Level Characteristics	
Roster	Total number of players active on the team
Win Percentage	Ratio of games won divided by the total games played throughout the season
Individual Characteristics	
AGE	Player' ages
AGE SQ	Squared value of players' ages

Results

Table 3-6 presents the regression results for the different performance metrics. When looking at the percentage of payroll the player's salary contains at the effect on individual performance, there are consistent statistically significant results. Percentage of payroll represents the relative wages of the player. Across all four dependent variables, the estimation results show a statistically significant impact on the individual performance metric, in all cases appearing to better the performance of the player. For WHIP and BB/9, the more percentage of payroll the player has, the lower these metrics are indicating a better performance. With SO/9 and K/BB, the greater the percentage of payroll the player has, the greater these metrics signaling an increase in performance.

When we use the wage index variable which captures the effect of wage dispersion, we see an opposite effect in most of the variables. When looking at WHIP, presented in column 1 of Table 3, if the percentage of payroll increases by one percent, the WHIP will decrease by 0.3037 units, but when looking at the wage index variable, presented in column 2 of Table 3, if the wage index, or the wage dispersion among the entire team, increases by one percent, WHIP increases by 0.0912. Similarly, when looking at the wage index pitchers, presented in column 3 of Table 3, if the wage dispersion among the pitching staff increases by one percent, WHIP increases by 0.0001. A similar result can be seen when looking at the results for SO/9 in Table 6. There is an opposite effect on performance when looking at percentage of payroll versus the wage indexes, however these numbers do not show statistical significance. Although the values for WHIP and SO/9 are not statistically significant, there is statistical significance in K/BB and BB/9.

Table 3. Estimation Results (Dependent Variable: WHIP)

VARIABLES	(1) WHIP	(2) WHIP	(3) WHIP
Percent of Payroll	-0.3037***		
	(0.1081)		
Wage Index		0.0912	
		(0.1231)	
Pitchers-specific Wage Index			0.0001
			(0.0002)
Age	-0.0127	-0.0183*	-0.0188*
	(0.0100)	(0.0098)	(0.0098)
Age Squared	0.0002	0.0003*	0.0003*
	(0.0002)	(0.0002)	(0.0002)
Roster Size	-0.0014	-0.0014	-0.0014
	(0.0015)	(0.0015)	(0.0015)
Team Win Percent	-0.7871***	-0.7943***	-0.7912***
	(0.0485)	(0.0486)	(0.0487)
Starting Pitcher = 1	0.0444***	0.0381***	0.0377***
	(0.0071)	(0.0067)	(0.0067)
Constant	1.9122***	1.9986***	2.0136***
	(0.1611)	(0.1582)	(0.1578)
Team Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
Observations	3,166	3,166	3,158
R-squared	0.176	0.174	0.173

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4. Estimation Results (Dependent Variable: K/BB)

VARIABLES	(1) K/BB	(2) K/BB	(3) K/BB
Percent of Payroll	4.9785***		
	(0.7843)		
Wage Index		-1.0807	
		(0.8970)	
Pitchers-specific Wage Index			-0.0046**
			(0.0018)
Age	0.0159	0.0158	0.0165
	(0.0110)	(0.0111)	(0.0111)
Age Squared	3.1700***	3.2808***	3.2380***
	(0.3518)	(0.3540)	(0.3545)
Roster Size	0.0159	0.0158	0.0165
	(0.0110)	(0.0111)	(0.0111)
Team Win Percent	3.1700***	3.2808***	3.2380***
	(0.3518)	(0.3540)	(0.3545)
Starting Pitcher = 1	-0.1369***	-0.0310	-0.0276
	(0.0517)	(0.0492)	(0.0490)
Constant	-0.2732	-1.7412	-1.8226
	(1.1684)	(1.1534)	(1.1492)
Year Fixed Effect	Y	Y	Y
Team Fixed Effect	Y	Y	Y
Observations	3,166	3,166	3,158
R-squared	0.123	0.112	0.113

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

When looking at K/BB in Table 4, there again appears the statistical significance between percentage of payroll and performance. In column 1 of Table 4, when the player's percentage of the team's payroll increases by one percent their K/BB increases by 4.9785. Similarly, to the results of the other performance measures, there is an opposite effect of the wage indexes. In Table 4 column 2, if dispersion across the entire

team increases by one percent, the individual pitchers K/BB ratio decreases by 1.0807. For the wage index pitchers, if the dispersion across the entire pitching staff increases by one percent, the individual pitchers K/BB ratio decreases by 0.0046. The wage index pitcher shows a statistical significance that as the wage dispersion increases throughout the pitching staff, the K/BB ratio of a pitcher decreases which signifies a decrease in performance.

Table 5: Estimation Results (Dependent Variable: BB/9)

	(1)	(2)	(3)
VARIABLES	BB/9	BB/9	BB/9
Percent of Payroll	-1.3754**		
	(0.5557)		
Wage Index		1.1990*	
		(0.6319)	
Pitchers-specific Wage Index			0.0031**
			(0.0013)
Age	-0.0430	-0.0656	-0.0680
	(0.0513)	(0.0503)	(0.0504)
Age Squared	0.0003	0.0006	0.0006
	(0.0009)	(0.0009)	(0.0009)
Roster Size	-0.0012	-0.0012	-0.0016
	(0.0078)	(0.0078)	(0.0078)
Team Win Percent	-1.4420***	-1.4874***	-1.4548***
	(0.2493)	(0.2494)	(0.2499)
Starting Pitcher = 1	-0.3406***	-0.3665***	-0.3705***
	(0.0367)	(0.0346)	(0.0346)
Constant	4.9580***	5.2502***	5.3795***
	(0.8279)	(0.8125)	(0.8102)
Year Fixed Effect	Y	Y	Y
Team Fixed Effect	Y	Y	Y
Observations	3,166	3,166	3,158
R-squared	0.123	0.123	0.123

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

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In Table 5 column 1, there is the same statistical significance seen between percentage of payroll and performance where when the percentage of payroll the individual holds increases by one percent, BB/9 decreases by 1.3754 walks per nine innings. Similarly, to all the other results, there appears to be an opposite effect for the two wage indexes. For the wage index, when the wage dispersion among the entire team increases by one percent in table 5 column 2, the individual pitcher increases their number of walks per nine innings by 1.1990. In table 5 column 3, when the wage dispersion among the pitching staff increases by one percent, the individual pitchers' walks per nine innings increases by 0.0031. Both wage indexes for the BB/9 metric show a statistical significance that as wage dispersion increases, individual player performance decreases.

In looking at these results, we see that relative wages are always statistically significant when looking at their effect on individual performance. The percentage of payroll is statistically significant across all individual performance metrics, and shows a positive impact on player performance. As the percentage of payroll the player's salary held increased, the individual player performance was positively impacted. The wage dispersion is also found to be statistically significant, but found an opposite effect than that of the percentage of payroll. As the wage dispersion increased or the more pay inequality on the team, the individual player's performance was negatively impacted.

It is also important to note that the results for percentage of payroll may have been produced by reverse causality. Individuals who do perform better receive a higher percentage of the payroll, which would always yield statistically significant results which we see above. With the wage indexes, all endogenous variables were removed,

eliminating the notion of reverse causality, showing statistical significance that an increase in wage dispersion can decrease individual player performance.

Table 6: Estimation results (Dependent Variable: SO/9)

VARIABLES	(1) SO/9	(2) SO/9	(3) SO/9
Percent of Payroll	6.8686***		
	(1.1124)		
Wage Index		0.9200	
		(1.2720)	
Pitchers-specific Wage Index			-0.0030
			(0.0026)
Age	0.0444	0.1804*	0.1735*
	(0.1028)	(0.1012)	(0.1014)
Age Squared	-0.0022	-0.0040**	-0.0039**
	(0.0017)	(0.0017)	(0.0017)
Roster Size	0.0316**	0.0314**	0.0319**
	(0.0156)	(0.0157)	(0.0157)
Team Win Percent	4.9444***	5.0575***	5.0509***
	(0.4990)	(0.5020)	(0.5031)
Starting Pitcher = 1	-1.1105***	-0.9554***	-0.9594***
	(0.0734)	(0.0697)	(0.0696)
Constant	4.7246***	2.3957	2.5604
	(1.6572)	(1.6355)	(1.6310)
Team Fixed Effects	Y	Y	Y
Year Fixed Effects	Y	Y	Y
Observations	3,166	3,166	3,158
R-squared	0.210	0.201	0.200

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The results fall in line with the results from previous literature that finds that as wage dispersion among a team increase, the overall team performance decreases

(Depken, 1999; Depken II and Lureman, 2018; Mondello and Maxcy, 2009; Tao, Chuang, and Lin, 2016; Coates, Frick, Jewell, 2016). The results of this study could possibly present a reason as to why the overall team performance decreases. If an increase in wage dispersion of each team and each position, in this case the pitchers, led to a decrease in performance then the team would in turn suffer, negatively impacting the overall team's performance.

This is partially seen in Depken II and Luremen (2018) and their study about increased salary disparity on NHL teams. The results from Depken II and Luremen find that in addition to overall team performance decreases because of increased dispersion across the team, there is a specific decline in defensive performance in terms of the team's goals allowed. This would follow if one major part of the team, in this study the pitchers, were to falter because of an increase in wage dispersion then it would lead to an overall decrease in team performance as a result.

These results could be useful when examining salary structure across professional sports leagues, and eventually could be explored at a firm level across many other labor markets. If an increase in wage dispersion is causing a decrease in individual performance, organizations should look to minimize the wage dispersion. To stay in line with the efficiency wage theory and create competitive wage opportunities so players do not opt for trade agreements or free agencies, perhaps further investigation could be investigated for more performance-based bonuses. The league currently has an incentive clause in place, allowing players to earn additional money by achieving performance driven benchmarks (*Incentive clause: Glossary*). However, this clause is mostly used to

entice position players to remain healthy throughout the duration of the season with the most common incentive being plate appearances (*Incentive clause: Glossary*). If the league could potentially restructure the salaries to all be relatively similar, dispersing the wages among the rostered team and redetermining incentive clauses to add bonuses to those players who do excel, there may be an increase in individual player performance.

Possible limitations of the analysis could be that the wages were contemporaneously measured. One could argue that it is the wage dispersion of relative wages from the previous year that indicates a player's performance due to contract negotiations and payouts. Limiting the sample to players who played in the same year two seasons in the row also proved to be a limitation. Multiple players get traded halfway through the year, only spend a single season with one team, injuries causing players to miss a season, or some players hop back and forth between the same team but in non-consecutive years, making it difficult to limit the sample to players who have multiple seasons with the same team. This is something that could possibly be investigated further, however gathering a large enough sample size may cause additional limitations. Supplemental regressions along these lines reduced the sample size substantially and did not yield significant results.

The result of the study additionally leaves room for further investigation. This study limits the pool to just one position across one professional sports league which may limit the results. Further studies could look at how other specific positions individual performance may be affected by wage dispersion and see if there is a discrepancy between all positions and pitchers' performance, or if it all produces a similar result of a

decrease in performance as wage dispersion increases. Additionally, perhaps some positions may have differing results completely dependent on one's specific position meaning that short stops may see similar results to the pitchers, but designated pitchers may see an opposing result. Looking at each position individually may provide interesting results.

Conclusion

Major League Baseball is one of the most well-known professional sports leagues in the nation, having been founded in 1876. Due to its long history and its publicization of salary information, the MLB's profound salary figures are some of the most commonly discussed numbers among multiple generations of people. From the disapproval of high salary figures of players who are underperforming, to the admiration of some of the multi-million dollar deals, professional baseball contracts and how they are structured is something many adoring baseball fans think they know best.

This research aimed to investigate the effect of wage dispersion and relative wages on individual performance among pitchers in Major League Baseball. Based on the quantitative analysis done, it can be concluded that relative wages have a positive effect on individual player performance whereas increases in wage dispersion have a negative effect on individual player performance among MLB pitchers. The results seen from this study trend closely to the results seen in other studies looking at wage dispersion on performance both at a team and firm level. There are some statistical significance relationships that support the claim that greater wage dispersion results in declined individual performance. This could potentially impact negotiations of salaries from an MLB club perspective to optimize player performance.

Further research is needed to see how relative salaries and wage dispersion affect other positions within the sport. Opening this study up further to all the positions could help possibly make salary structures a positional thing. Limiting wage dispersion and upping relative wages may be optimal to getting the best performance out of pitchers, but

seeing how other positions are affected by the wage inequality and relative wages may provide different suggestions towards salary and contract negotiations.

These results can be taken from the sports industry and be applied across labor markets. The greater the wage dispersion across a firm, the less performance output the firm will see across workers. This supports the cohesion theory that the more condense and similar wages are, creating a level playing field among laborers, whether in a firm or a field setting, you will see a better individual level performance.

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