



NBA ENDGAME: DO SALARIES MATTER?

Frank TENKORANG*, Bree L. DORITY**, Eddery LAM***

Abstract: *This paper estimates the association between salary dispersion and the probability that an NBA team leading two minutes before the end of a playoff game won the game. Economic theory indicates the a priori relationship is ambiguous and the existing empirical literature finds mixed results as to the direction of the relationship. We use game-level data from the 2012 and 2013 NBA playoffs and allow the association to be nonlinear. Overall, our results indicate there may be U-shaped relationship between salary dispersion and win probabilities; however, the point estimates individually and jointly are not statistically significant. Thus, we conclude there is no evidence in our sample that salary dispersion and NBA win probabilities are related.*

Keywords: *Salary dispersion; labor economics; National Basketball Association*

JEL Classification: *J3, D2*

1 INTRODUCTION

In 1995, a National Basketball Association (NBA) collective bargaining agreement (CBA) resulted in a change in the distribution of wages in the NBA. From the pre-1995 CBA to post-1995 CBA time period, mean NBA salaries grew 78.5% whereas median salaries only rose by 31.3% (Hill and Groothuis 2001), the average coefficient of variation of NBA salaries increased 17.2% (Berri and Jewell 2004), and the average Gini coefficient for all NBA teams increased from

*Frank TENKORANG, Department of Economics, University of Nebraska-Kearney, Kearney, NE 68849, USA, tenkorangf1@unk.edu

**Bree L. DORITY, Department of Economics, University of Nebraska-Kearney, Kearney, NE 68849, USA, dORITYbl@unk.edu

***Eddery LAM, Department of Economics, Rochester Institute of Technology, Rochester, NY 14623, USA, eddery@rit.edu

0.336 to 0.411 (Simmon and Berri 2011). Economic theory indicates an ambiguous effect of wage dispersion on team performance. According to the theory of tournaments (Lazear and Rosen 1981), greater salary inequality creates competition among workers resulting in more worker effort and increased productivity. Alternatively, cohesion theory (Levine 1991) suggests that equalizing salaries increases productivity as cohesiveness among workers is enhanced. Katayama and Nuch (2011) argue the latter may better explain behavior in the NBA as cooperation among players is necessary for passing, defense, and ultimately final game outcomes.

Previous empirical studies examining salary dispersion and team performance in the NBA find mixed results. Using season-level data from six seasons after the 1995 CBA and game-level data from the 2002 to 2006 regular seasons, Berri and Jewell (2004) and Katayama and Nuch (2011), respectively, find no evidence that salary dispersion and NBA team performance are related. Conversely, Simmons and Berri (2011) use data from the 1990 to 2008 seasons and find that both team and player performances are positively related to salary dispersion which supports tournament theory. In this study, we use game-level data during the 2012 and 2013 playoffs to examine the relationship between wage dispersion and team performance.

During the 2012 and 2013 seasons, the NBA salary cap was \$58.044 million; however, NBA franchises could choose how pay is structured among players. For example, in 2013, the Los Angeles Lakers concentrated its pay among its top four paid athletes (77%) whereas the Sacramento Kings distributed its pay more equally among its athletes (44% went to the top four paid athletes). This article contributes to the existing body of NBA literature on this topic in three ways. First, it uses recent game-level data during the playoffs rather than the regular season. Second, our measure of team performance is “late game winner” or the team leading *two minutes* before the end of a playoff game wins the game. The playoffs in general and the final two minutes of a game in particular are crucial in terms of team performance. Indeed, the NBA requires a public address operator to announce that the game is in the two-minute part (NBA, 2013). Thus, we are interested in how salary dispersion is related to team performance in terms of win probabilities. Third, we allow for the relationship between salary dispersion and team performance to be non-linear. Examining the German soccer league, Franck and

Nuesch (2011) find a U-shaped relationship between salary inequality and team success which supports both tournament and cohesion theories. That is, team performance is strongest when there is very low wage inequality (cohesion) or very high inequality (tournament) (Franck and Nuesch 2011). In the following section, we discuss the empirical literature relevant to this study.

2 RELATED LITERATURE

NBA playoff games are very competitive. Teams face elimination possibility and play each other several times; thus, becoming accustomed to each other's style of play. Because such competitive games generate a lot of interest and discussion among fans and sports presenters, there are two bodies of literature that are relevant for this study. First, a number of sports prediction studies have been conducted that use regular season team performance measures to forecast the outcome of professional sports game. Second, a growing number of studies have examined salary dispersion on team success. Building on both of these bodies of work, the current study estimates the impact of salary dispersion on the win probability of an NBA team leading *two minutes* before the end of a playoff game.

2.1 Sports Prediction Models

In 2012, 13% of the global gambling market was generated by sports betting, and in 2013, the online gaming market had a volume of \$37.6 billion (Statista 2014). Because of large potential financial gains, there are a vast number of studies that use a variety of methods to forecast professional sports game (see Gandar, et al. 2001). Clarke (1993) used an exponential smoothing technique to predict the outcome of Australian Rules football matches. He correctly predicted 70.3 percent of the games for the 1991 season. Using Bayes methodologies based on batting records early in the season, Brown (2008) predicted batting-average performance of baseball players in the 2005 season. His methods outperformed the naïve predictor which relied solely on the current average to predict. Dyte and Clarke (2000) used a Poisson regression to predict the number of goals scored by a team (country) during the 1998 FIFA World Cup tournament. The prediction was based on a subjectively modified FIFA ranking of teams to account for weaker teams from non-traditional soccer federations. Their prediction of 168.2 goals accurately estimated the actual 170 goals scored.

With regard to the NBA, Hu and Zidek (2004) used weighted likelihood to predict the winner of the 1997 NBA playoff finals between the Chicago Bulls and Utah Jazz. They used information from each team's home and away game performance in the regular season to predict the probability of the number of games it would take a team to win a playoff series. They compared the results of their *relevant* weighted likelihood model with that of a logistic model and found that the latter was superior to their model; however, the logistic method was less desirable for forecasting because it required a large number of parameters.

Many studies have found that a home-field advantage is significant in predicting a game's outcome (Clark 1993, Dyte and Clarke 2000, Gill 2000, Hu and Zidek 2004, Rue and Salvesen 2000). For instance in the NBA, home teams are estimated to come back and win 33.3 percent of the time while visiting teams do so only 10.5 percent of the time (Copper et al. 1992). Harville and Smith (2003) estimated the size of home-field advantage over a neutral field to be about four points in college basketball during the 1991-92 seasons. These findings highlight the importance of fans attendance of home games, which is popularly referred to as the Sixth Man. On the other hand, it also shows that a point difference of greater than four could nullify home-field advantage.

2.2 Salary Dispersion & Team Performance

Empirical studies examining the relationship between salary dispersion and team performance have been conducted using NBA, Major League Baseball (MLB), National Hockey League (NHL), National Football League (NFL), Major League Soccer (MLS), and professional German soccer data. Katayama and Nuch (2011) summarize U.S. professional sports team studies that were conducted as of 2006. Across studies, the standard performance measure used was season winning percentage and the primary measure of salary dispersion was the Gini coefficient or the Herfindahl index. Overall, for MLB, studies find a negative relationship between salary dispersion and team winning percentage; however, for NBA and NHL, studies find mixed results (Katayama and Nuch 2011).

More recently, for NBA, studies continue to find mixed results. Simmons and Berri (2011) use data from the 1990 to 2008 seasons and expected pay dispersion as their measure of salary dispersion. In support of tournament theory (Lazear and Rosen 1981), they find that both team and player performances are

positively related to salary dispersion. Katayama and Nuch (2011) use game-level data from the 2002 to 2006 regular seasons and find no evidence that salary dispersion and NBA team performance are related.

Franck and Nuesch (2011) suggest that the mixed results of the previous empirical studies may be due to the examination of linear rather nonlinear effects of wage dispersion on team or firm performance. Using German soccer league data from 1995-96 to 2006-07 and two measures of dispersion (the Gini coefficient and the coefficient of variation), they allow for nonlinear effects in estimation. Overall, they find a U-shaped relationship between salary dispersion and team success which indicates that soccer teams in their sample appear to perform better when pay is structured at the extremes: steeply hierarchical or in an egalitarian manner. Coates et al. (2014) similarly allow for nonlinear effects of salary dispersion when examining MLS team performance during the 2005-2013 seasons. Salary dispersion is measured using the Gini coefficient and the coefficient of variation; however, the authors find a negative relationship between these measures and points per game which supports cohesion theory (Levine 1991).

Finally, Breunig et al. (2014) develop a model to examine the probability that an away MLB team wins the game. Using game-level data from 1985 to 2010 and probit estimation, they find a significant negative effect of own-team wage dispersion on the probability of winning games.

3 METHODS & DATA

- **Model**

Building on the work of Hu and Zidek (2004), Franck and Nuesch (2011), and others, we construct an empirical model that relates salary dispersion to win probabilities in NBA playoff games. The estimation controls for both *before-game factors* (e.g., regular season winning percentage) and *in-game factors* (e.g., point differences) (Hu and Zidek 2004). Using probit and logit, we estimate equations of the following form:

$$P(Y_i = 1) = f(\text{Salary}_i, \text{PCT}_i, \text{In-game}_i)$$

where Y equals 1 if the NBA team leading *two minutes* before the end of a playoff game wins the game. For ease of discussion, we denote this outcome as the “late game leader wins the game.” Salary is a vector of variables that include the coefficient of variation of the late game leader’s top 10 players’ salaries, this

variable squared, and the average of the late game leader's top 10 players' salaries. The variable PCT is the late game leader's win percentage during the regular season, and in-game is a vector of variables that includes the difference in points two minutes before the end of the game and a binary variable that equals 1 if the late game leader is the home team.

Unlike linear probability models, the probit and logit specifications impose 0–1 limits on the probabilities and allow the marginal effects to vary over the range of the explanatory variables. The probit model is a cumulative distribution function (CDF) of the standard normal distribution and the logit model is the CDF of logistic distribution. Because of the difference in their functional forms, the estimated coefficients are not comparable; however, the two models tend to have similar estimated marginal effects.

Our primary variable of interest is salary dispersion. If the estimated coefficients on the linear and squared terms are negative (positive), our results would suggest cohesion theory (tournament theory) more appropriately explains the relationship between NBA salary dispersion and win probabilities. Alternatively, if the relationship is U-shaped and consistent with Franck and Nuesch (2011), then the estimated coefficients on the linear and squared terms will be negative and positive, respectively.

In terms of our control variables, given a higher salary is commensurate with higher player quality, we expect that teams with higher average salaries will more likely be late game leaders that win games. Second, the late game leader's win percentage during the regular season captures a *before-game factor*. Teams are ranked and paired in the playoffs based on their win percentages. Thus, the win percentage measures the team's strength and position in standings, and we expect the estimated coefficient on this variable to be positive. Finally, both *in-game factors* are expected to positively influence win probabilities. That is, in terms of point differences, the larger is the point difference two minutes before the end of the game, the higher is the chance of the late game leader winning. If there is a tie on the two-minute countdown mark, then the difference is calculated after one team has taken the lead, and this team subsequently becomes the late game leader. In cases of overtime, the late game leader is still determined at two minutes before the end of regulation time. Playing at home is perceived to be an advantage; thus, we expect the sign on this variable to be positive. However, in NBA playoff series,

teams play the same opponent consecutively for at least four games. This together with elimination possibility provides incentives to game plan their opponents which could dampen home-field advantage. Table 1 provides a summary of the variables in our model.

- **Data**

The National Basketball Association (NBA) league is made up of 30 teams divided equally into two conferences, East and West. Each conference has three divisions, and each team plays 82 games with all other teams in both conferences. However, the number of games between any two teams depends on whether they are in the same division and/or conference. The teams are ranked by winning percentage. At the end of the regular season, the first eight teams in each conference qualify to play in the playoff season. The first round of the playoff games starts with the 1st team paired with the 8th team; 2nd with 7th, and so on. The winner of the best of seven games advances to the next round of the competition. The two conference champions play each other in the playoff finals for the national championship.

The data necessary to estimate the model was obtained from several sources including the ESPN 2012 and 2013 NBA Playoffs Play-by-Play and Team-by-Team Comparison, as well as, the NBA Player Salaries and Regular Seasons' Standing websites. NBA Playoffs Play-by-Play shows the score as well as major activities on the field in the course of the game. This was the source for the variables late game leader wins and difference in points two minutes before the end of the game. Most NBA games are characterized by several lead changes before the end of the game; therefore, the probability of winning would likely differ at various stages of the game. For example, if the leader at the beginning of the last quarter (e.g., last 12 minutes) is different from the leader at the beginning of the last two minutes, then the predictors' values would be those of the last quarter leader instead of the last two minutes leader. Hence, a different win probability would be expected. The variable win percentages is the number of games won in the preceding regular season with respect to total games played in the regular season and is not updated with playoff games. Teams are ranked by win percentages, and the higher ranked team plays four of the 7-game playoff series at home, if necessary. Although there are separate rankings for the east and west

conferences, the total games used in win percentages include those played against teams in both conferences.

Eighty-four and 85 games were played in the 2012 and 2013 playoff seasons, respectively, for a total of 169 observations. Means and standard deviations for all variables that are included in the regressions appear in Table 1. Out of the 169 games played in the two seasons, late-game leaders won 87.6% of them and played 65.1% of them at home. Moreover, on average, the late game leaders' win percentage during the regular season is 0.665, point difference two minutes before the end of the game is nearly 11 points, and average team salary is \$6.96 million. The coefficient of variation is calculated by dividing the standard deviation by the mean. The average coefficient of variation in our sample is 75.8%.

Table 1 Descriptive Statistics

Variable	Description	MEAN	ST. DEV
<i>Outcome:</i>			
Y	Late game leader wins game (0-1)	0.8757	0.331
<i>Predictor:</i>			
CV	Coefficient of variation of late game leader's top 10 players' salaries	0.758	0.135
CVSQ	CV squared	0.593	0.016
S	Avg. salary of late game leader's top 10 players' salaries (US\$ mil)	6.96	0.104
PCT	Late game leader's win percentage during the regular season	0.665	0.080
D	Difference in points two minutes before the end of the game	10.562	8.199
H	Late game leader is the home team (0-1)	0.651	0.478

Late game leader is defined as the team that is ahead two minutes before the end of the game.

n = 169.

4 RESULTS

4.1 Estimation Results

Table 2 presents the probit and logit results. Overall, the results are similar for the two specifications; however, the marginal effects of the logit specification are slightly smaller in magnitude compared to the marginal effects of the probit specification. The McFadden R-squared is 0.25 for both specifications.

The signs on the estimated coefficients of the control variables are as expected. That is, a higher average team salary, a higher win percentage, a larger

difference in points two minutes before the end of the game, and playing at home all increase the likelihood that the late game leader wins the game. The estimated coefficients on win percentages and difference in points are statistically significant whereas those on average team salary and playing at home are not. The marginal effect of the difference in points for the logit specification indicates that given the mean values for the other variables, a one point additional lead increases the probability that the late game leader wins by 0.395.

The estimated coefficients on the coefficient of variation variables indicate a U-shaped relationship between salary dispersion and win probabilities; however, the results individually and jointly are not statistically significant. Thus, consistent with Berri and Jewell (2004) and Katayama and Nuch (2011), we conclude there is no evidence that salary dispersion and NBA win probabilities are related.

Table 2 Probit and Logit Estimation Results

Variable	Probit		Logit	
	Est. Coef.	Marginal Effect	Est. Coef.	Marginal Effect
CV	-16.057 (10.946)	-1.478	-29.843 (20.937)	-1.288
CVSQ	9.425 (7.004)	0.867	17.448 (13.32)	0.753
S	0.136 (0.116)	0.013	0.246 (0.204)	0.011
PCT	0.111** (0.037)	0.010	0.199** (0.068)	0.009
D	4.836** (2.043)	0.445	9.160** (3.765)	0.395
H	0.124 (0.297)	0.011	0.288 (0.532)	0.012
Intercept	2.884 (4.115)		5.247 (7.981)	

Standard errors are in parentheses.

**denotes statistically significant at the 5% level

4.2 Predicted Probabilities

Using the estimated coefficients from the probit and logit specifications in Table 2, the probability of the late game leader winning the game can be computed. Table 3 shows six estimated probabilities for three scenarios two minutes before the end of the game. In all the scenarios, it is assumed the late game leader is the home team. In scenario 1, the coefficient of variation, winning percentage, and average salary are kept constant at 0.90, 0.8, and US\$7 million, respectively. The predicted probabilities indicate that an increase in the point difference from 5 to 15

increases winning probability from 0.83 to 0.94. In scenario 2, holding all other factors constant, a 0.60 regular season winning percentage results in a winning probability of 0.56 whereas a 0.80 win percentage results in a 0.77 probability. The last scenario shows an increase in salary dispersion reduces winning probability. An increase of 0.3 in the coefficient of variation, *ceteris paribus*, yields a nine percentage points decrease in winning percentage. Finally, a comparison between “a” (scenario 1) and “f” (scenario 3) shows winning probability increases with salary.

Table 3 Probabilities of Late-Game Leader winning the game

	Salaries Coef. of Variation	Salary (US\$ mil)	Point Difference (D)	Win Percentage	Probability
Scenario 1					
a	0.90	7.0	5	0.8	0.83
b	0.90	7.0	15	0.8	0.94
Scenario 2					
c	0.85	7.0	2	0.6	0.56
d	0.85	7.0	2	0.8	0.77
Scenario 3					
e	0.60	4.0	5	0.8	0.85
f	0.90	4.0	5	0.8	0.76

5 CONCLUSION

In this paper, we explored the relationship between wage dispersion and NBA win probabilities. Economic theory indicates the *a priori* relationship is ambiguous (Lazear and Rosen 1981, Levine 1991) and the existing empirical literature finds mixed results as to the direction of the relationship (Berri and Jewell 2004, Katayama and Nuch 2011, Simmon and Berri 2011). In our estimation, we allow for the relationship between wage dispersion and team performance to be nonlinear. Overall, our results indicate there may be U-shaped relationship between salary dispersion and win probabilities; however, the point estimates individually and jointly are not statistically significant. Thus, we conclude there is no evidence in our sample that salary dispersion and NBA win probabilities are related. These results are consistent with Berri and Jewell (2004) and Katayama and Nuch (2011).

It should be noted that an underlying assumption of this research is that salary structure is chosen to maximize game performance; however, given our results, it may be the case that salary structure is chosen instead to maximize NBA

franchise value. Currently, the New York Knicks ($CV=0.99$) are valued at \$1.4 billion whereas the Milwaukee Bucks ($CV=0.49$) are valued at \$405 million. Endorsements by professional athletes are a type of brand strategy (see Erdogan 1999, Ding et al. 2008), and although they are costly, can generate considerable value to the endorsing firm (Mathur et al. 1997, Farrell et al. 2000, Samitasa and Kenourgiosb 2008). To increase team revenues via attendance and team merchandise, franchise owners may hire a small number of superstars although it would create salary dispersion among the players.

REFERENCES

1. Berri, D.J., Jewell, R.T. (2004), "Wage inequality and firm performance: professional basketball's natural experiment," *Atlantic Economic Journal* Vol. 32, pp. 130-139.
2. Breunig, R., Garrett-Rumba, B., Jardin, M., Rocaboy, Y. (2014), "Wage dispersion and team performance: a theoretical model and evidence from baseball," *Applied Economics* Vol. 46, No. 3, pp. 271-281.
3. Brown, L.D. (2008), "In-season prediction of batting averages: a field test of empirical bayes and bayes methodologies," *The Annals of Applied Statistics* 2008, Vol. 2, No. 1, pp.113-152.
4. Clarke, S.R. (1993), "Computer Forecasting of Australian Rules Football for a Daily Newspaper," *Journal of the Operational Research Society*, Vol. 44, No. 8, pp. 753-759.
5. Coates, D., Frick, B., Jewell, T. (2014), "Superstar Salaries and Soccer Success: The Impact of Designated Players in Major League Soccer," *Journal of Sports Economics*, first published on August 21, 2014 doi: 10.1177/1527002514547297.
6. Cooper, H., DeNeve, K. and Mosteller, F. (1992), "Predicting professional sports game outcomes from intermediate game scores." *Chance*, Vol. 5, No. 3-4, pp. 18-22.
7. Ding H., Molchanov A., Stork, P. (2008), "The value of celebrity endorsements: A stock market perspective," *Marketing Letters*, Vol. 22, No. 2, pp. 1-17.
8. Dyte, D. and Clarke S. R. (2000), "A Ratings Based Poisson Model for World Cup Soccer Simulation." *The Journal of the Operational Research Society*, Vol. 51, No. 8, pp. 993-998.
9. Erdogan, Z. (1999), "Celebrity endorsement: A literature review," *Journal of Marketing Management*, Vo. 15, No. 4, pp.291-314.
10. ESPN.GO.com. "NBA Scores", available at http://espn.go.com/nba/bracket/_/year/2013 (accessed 12 December, 2015).
11. ESPN.GO.com. "NBA Regular Season Standings", available at <http://espn.go.com/nba/standings> (accessed 19 January, 2014).
12. ESPN.GO.com. "NBA Player Salaries: 2011-12 and 2013-13", available at <http://espn.go.com/nba/salaries> (accessed 19 January, 2014).
13. Farrell, K., Karels, G., Montfort, K. (2000), "Celebrity performance and endorsement value: The case of Tiger Woods," *Managerial Finance*, Vol. 26, No. 7, pp. 1-15.
14. Franck, E., Nuesch, S. (2011), "The effect of wage dispersion on team outcome and the way the outcome is produced," *Applied Economics* Vol. 43, pp. 3037-3049.

15. Gandar, J., Lamb, R. and Zuber, R. (2001), "The home field advantage revisited: a search for the
16. bias in other sports betting markets", *Journal of Economics and Business*, Vol. 53, pp. 439-453.
17. Gill, P. (2000), "Late-game reversals in professional basketball, football, and hockey", *The American Statistician*, Vol. 54, No. 2, pp. 94-99.
18. Harville, D., and Smith, M. (2003), "The Home-Court Advantage: How Large Is It, and Does It Vary From Team to Team?", *The American Statistician*, Vol. 48, pp. 22-28.
19. Hill, J.R., Groothuis, P.A. (2001), "The new NBA collective bargaining agreement, the median voter model and a Robin Hood redistribution," *Journal of Sports Economics* Vol. 2, pp. 131-144.
20. Hu, F. and Zidek, J. V. (2004), "Forecasting NBA Basketball Playoff Outcomes Using the Weighted Likelihood", *A Festschrift for Herman Rubin Institute of Mathematical Statistics Lecture Notes-Monograph Series*, Vol. 45, pp.385-395.
21. Katayama, H., Nuch, H. (2011), "A game-level analysis of salary dispersion and team performance in the National Basketball Association," *Applied Economics* Vol. 43, pp. 1193-1207.
22. Lazear, E.P. and Rosen, S. (1981), "Rank-order tournaments as optimum labor contracts," *Journal of Political Economy* Vol. 89 No. 5, pp. 841-864.
23. Levine, D.I. (1991), "Cohesiveness, productivity, and wage dispersion," *Journal of Economic Behavior and Organization* Vol. 15, pp. 237-255.
24. Mathur, L., Mathur, I., Rangan, N. (1997), "The wealth effects associated with a celebrity endorser: The Michael Jordan phenomenon," *Journal of Advertising Research*, Vol. 37, No. 3, pp. 67-73.
25. NBA (2013), "Official Rules of the National Basketball Association 2013-2014", available at <http://mediacentral.nba.com/media/mediacentral/Official-NBA-Rule-Book.pdf> (accessed 11 February, 2014).
26. Rue, H. and Salvesen, Ø. (2000), "Prediction and Retrospective Analysis of Soccer Matches in a League", *Journal of the Royal Statistical Society, Series D (The Statistician)*, Vol. 49, No. 3, pp. 399-418.
27. Samitasa, A., Kenourgios, D. (2008), "Athens' Olympic games 2004 impact on sponsors' stock returns," *Applied Financial Economics*, Vol. 18, No. 19, pp. 1569-1580.
28. Simmons, R., Berri, D.J. (2011), "Mixing the princes and the paupers: Pay and performance in the National Basketball Association," *Labour Economics* Vol. 18, pp. 381-388.
29. Statista (2014), "Size of the online gaming market" and "Global gambling market breakdown in 2012, by product category," Available at <http://www.statista.com/topics/1740/sports-betting/> (access December 9, 2014).