Exploring inter-league parity in North America: the NBA anomaly

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Abstract

The relative standard deviation (RSD) measure of league parity is persistently higher for the National Basketball Association (NBA) than the other three major sports leagues in North America. This anomaly spans the last three decades and is not explained by differences in league distributions of revenue, payroll or local market characteristics, placing the standard model of the professional sports league in question. The argument that a short supply of tall players is one possible explanation, but we offer a more attractive explanation. With a much greater number of scoring attempts in each game, basketball reduces the influence of random outcomes in the number of points scored per game and also season winning percentage. Our simulations demonstrate that lesser parity in the NBA is inherent in the rules of the game so that inter-league comparisons must be interpreted carefully.

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1. INTRODUCTION

The most common statistical measure of league parity is the relative standard deviation (RSD) that is the ratio of the standard deviation of winning percentages to the idealized standard deviation (ISD).[1] Some scholars have questioned the accuracy of the RSD, however it is the most common statistic and is simple to compute, so we use it here. The RSD's for the last three decades for the four professional leagues in North America are given in Table 1.[2]

Baseball's American League (AL) has experienced a movement away from parity in the last decade while the National League (NL) has not. The National Hockey League (NHL) moved towards parity consistently over the last three decades while the National Football League (NFL) has maintained the lowest RSD over the same three decades with little change. Baseball and the NFL use very similar revenue sharing systems and the NFL uses a hard salary cap. The NHL adopted a hard salary cap in its 2005 collective bargaining agreement to further improve parity. The most striking result from Table 1 is the lack of parity in the National Basketball Association (NBA) that has remained consistent over the last three decades. Despite modest efforts by the NBA to improve parity with its soft salary cap system adopted in 1984, the league still remains head and shoulders above the other three leagues in terms of RSD. We refer to this lack of parity as the NBA anomaly but we are not the first in the literature to note it.

Table 2 presents the proportion of winning percentages for two decades that fall within and

[1] Cain and Haddock (2006) question the use of the RSD when ties are possible while Fort (2007) dismisses the issue. Trandel and Maxcy (2011) formulate an adjusted RSD that takes into account home advantage that is novel but difficult to compute. Humphreys (2002) provides a review of earlier work.

[2] Calculated as $\sqrt{0.5(1-0.5)/N}$ where N is the number of regular season games each club plays.

outside a parity range. The parity range is calculated by computing the average winning percentage for each decade for each league, then using the average to calculate the idealized standard deviation rather than w = 0.5. The parity range is defined to be plus or minus one ISD from the average winning percentage. The NBA stands out as a league with the haves and have-not teams with far less clubs falling within the parity range than the other four leagues.

Berri et al (2005) explain the NBA anomaly by referring to an human evolution argument that successful teams in the NBA rely on more tall players than unsuccessful teams. The shortage of supply of very tall players (say greater than or equal to seven feet tall) generates a competitive imbalance that can only be improved by finding more scarce tall players. There is no doubt that very tall players are in short supply but the authors do not formally connect this empirical fact with the RSD for the NBA. Certainly the other three professional leagues face scarcities as well in the supply of certain types of players. In hockey and football, players who possess a combination of size, weight and speed are scarce (Alex Ovechkin in the NHL and Calvin Johnson in the NFL for instance) and the teams that have them tend to be winners. As there is little physical contact, baseball relies more on a combination of strength, coordination and speed to define very talented players, of which there are not many.

In this paper, we offer an alternative explanation for the difference in the parity ratios in Table 1 and the NBA anomaly. Like Berri et al (2005), our explanation does not rely on any business practices that are used to redistribute revenues among clubs or affect individual salaries and team payrolls, rather it is something that is inherent in the game of basketball: the high number of scoring attempts relative to the other three sports. Other explanations should be dispelled with first however. The standard two-team league model known so well in the sports economics literature predicts that difference in market sizes are a contributing factor to winning percentages and league parity. These could lead to differences in payrolls and revenues that drive the NBA anomaly result. Greater variability in the distributions of these factors could be important factors. Dobson and Goddard (2004) found that an increasing variance in the distribution of club revenues coincided with declining parity in the English Football Association over the period 1926-99. If the distributions of market sizes are fairly similar across the four leagues, some other force must be at work to generate the differences in parity we observe in Table 1, particularly for the NBA.

II. REVENUES

The revenues that drive the two-team league model that result in winning percentages that differ from parity are local revenues, mostly gate revenue, but also suite revenue, concessions, parking and local media. National revenues tend to be shared equally among all the clubs within a league and thus should not affect parity within the league. These types of revenues include national media, apparel, merchandising, logos, etc. All of these revenues are shared equally in MLB, NFL, NBA and NHL. Differences in local revenues can be significant within a league. Table 2 computes the average revenue and standard deviation of revenue for each of the four North American leagues based on estimates of club revenues obtained from various issues of Forbes magazine. These estimates include local revenues that are redistributed under the revenue sharing agreements for MLB and the NFL.

Revenue sharing will reduce the differences in net local revenues as they are designed to do so. If club owners are forward looking, they will anticipate their net revenue after revenue sharing and base their economic decisions on that net revenue, not revenue before sharing. Economic theory suggests that revenue sharing will not affect parity under fairly general conditions (Fort and Quirk (1995), Vrooman (2009)), but there is disagreement in the literature. Kesenne (2000) finds that revenue sharing will improve league parity whether the club owner is a profit-maximizer or a win-maximizer while Szymanski and Kesenne (2004) find that increased gate revenue sharing worsens parity. The same author in Kesenne (2005) finds that revenue sharing worsens parity for profit-maximizers and improves parity for win- maximizers. Feess and Stahler (2009) find that revenue sharing improves parity if only absolute talent determines club revenue, but worsens parity if relative talent determines club revenue. Dietl and Lang (2008) find that revenue sharing worsens league parity. If clubs face differing marginal costs of talent that are increasing in talent, Cavagnac (2009) finds that revenue sharing improves league parity. Finally, Grossman, Dietl and Trinker (2008) find that revenue sharing reduces league parity but the effect is reduced the greater the elasticity of talent supply. Hamlin (2007) points out that suite and premium seating revenue is not shared in the NFL and that this could lead towards a substitution towards installing more premium seating and lessen parity. This is certainly testable, however it does not change the fact that the NFL has more parity than any of the other three professional leagues in North America by a wide margin.

Whether and how revenue sharing affects league parity has not been settled in the theoretical literature. The choice of the contest success function and the assumptions of talent supply determine the result, so general results do not seem to exist. Few empirical studies exist on the effects of revenue sharing on league parity. Solow and Krautmann (2007) consider the changes to revenue sharing system in MLB over the 1998-2002 period and find that more extensive revenue sharing did not significantly affect league parity. Maxcy (2009) finds that more extensive revenue sharing adopted in 1997 in MLB worsened parity due to the effectively higher marginal tax rate paid by smaller market clubs, while Rockerbie (2012) considers the 2007 change in revenue sharing in MLB and finds no significant effect on league parity.

Although this paper does not offer any theoretical or empirical insights into the revenue sharing debate, it is important to consider whether the revenues reported in Table 2 should be adjusted to give pre-revenue sharing figures or not in order to make comparisons with the RSD for each league reported in Table 1. Revenue sharing in the NFL and MLB will reduce their standard deviations of revenue relative to the NBA and NHL that do not use revenue sharing extensively.[3] Even though the empirical evidence suggests that revenue sharing does not affect parity, it will distort the revenue figures for comparisons across the four leagues. However trying to obtain local revenues before revenue sharing is difficult for enough years to make the comparison useful. Pre-revenue sharing figures can be estimated by "backing out" the revenue sharing formula each league uses - not too difficult for the NFL and MLB, but extremely difficult for the NHL.[4]

In the final analysis, there is no doubt that revenue sharing will reduce the variance of the league distribution of revenues, however a number of papers in the theoretical literature

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[3] The NBA and NHL share national revenues, like their NFL and MLB counterparts. The payroll tax system used in the NBA redistributes salary cap overages to clubs whose payroll falls under the soft salary cap if the total league payroll exceeds an allowable percentage of league revenues, but this is not tied to local revenue. The NHL uses a similar cap redistribution system.

[4] The NHL adopted revenue sharing in the 2005 CBA. A club qualifies for receiving a full revenue subsidy (about $10 million) if it falls in the lower half of the league revenue distribution, operates in a market of less than 2.5 million TV households and averages at least 14,000 tickets per regular season game. Falling short of some of these requirements means a lower subsidy. All six Canadian clubs are exempt from receiving payments regardless of whether they qualify. Clubs classified as "northern U.S. clubs" are also exempt. The amount of monies actually transferred is not publicized, but it is not thought to be large. The NBA adopted a revenue sharing plan in its 2012 CBA but that will not affect the sample period used in this paper.

suggest that this will not affect the variance of the league distribution of winning percentages with some caveats. The empirical literature seems to confirm this result, although more extensive work is needed. Hence we use estimates of total revenues in the rest of the paper as these are easily available and have been shown to have an acceptable degree of accuracy (Rockerbie (2012)). Forward-looking club owners will form an expectation of revenues from all sources after the various revenue sharing plans have had their redistributive effects, hence it is these revenues that will drive their business operations. Krautmann (2009) uses the same reasoning to justify utilizing total revenue in the revenue function rather than just local revenue and we do the same here.

The mean revenue, standard deviation of revenue and coefficient of variation (CV) is calculated in Table 3 for each league[5] for the two decades where revenue estimates exist. These were computed for each season and then averaged over each decade. Due to the effect of the New York Yankees high revenue, the AL numbers are presented with and without the Yankees in the sample. The NBA has the highest CV, followed by the NHL, MLB and the NFL. The NFL has the rather novel feature that it had the highest average net revenue of the four leagues and the lowest CV. The NFL relies greatly on national revenues that are split evenly among all of the clubs - more so than the other three leagues. National revenues can serve to reduce the volatility of net revenues when they are a large share of total revenue. The NFL and MLB also use revenue sharing for local revenues that are largely composed of gate revenue.

Table 1 suggests that parity has improved for the professional sports leagues in North America since the 1990-99 decade, with the exception of the AL in baseball (unless the Yankees are

[5] The 2004-05 NHL season was not played due to a labour dispute.

excluded). This is broadly matched by a reduction in the variance of total revenue for the leagues evidenced in Table 3. This seems to fit well with the prediction of the standard two-team league model that less variability in revenue (marginal revenue in particular) should be accompanied by less variability in winning percentages and hence a movement towards parity in each league. However the interleague comparisons do not show any clear association between revenue variability and parity. A ranking of the CV's would have the NFL with the lowest revenue variability over the last two decades, followed by baseball's NL and AL (excluding the Yankees), the NBA and lastly the NHL. However the CV's for the 2000-09 decade do not differ by much between leagues making any ranking less informative. The NL and AL have CV's that are significantly greater than the NFL at 95% confidence while the CV for the NFL is significantly below the CV's for the NHL, NBA and MLB at 95% confidence.[6]

III. PAYROLLS

The NFL has been using a hard salary cap system since 1992 while the NBA introduced a soft salary cap system in 1984. The NFL adopted a hard salary cap system in 2005. MLB has yet to adopt a salary cap system, rather it uses a competitive balance tax that is fairly ineffective at influencing club payrolls. The standard competitive league model predicts that a hard salary cap system will move the league towards parity as clubs are forced to maintain similar payrolls. This should reduce the RSD for leagues that maintain salary caps relative to those that do not despite unexpected shocks to club revenues. Table 1 suggests mixed results based on casual observation. The NFL salary cap had little if any effect on its RSD over the last two decades, while the soft cap system adopted by the NBA had no effect on its RSD over the last

[6] Reh and Scheffler (1996) provide a table of critical values for the test.

three decades. The NHL did experience a reduction in its RSD in the last decade, although attributing it to the salary cap completely is speculative. Both the NL and AL have CV's that are significantly greater than the NBA, NHL and NFL at 95% confidence while the CV for the NFL is significantly below the CV's for the NHL, NBA and MLB at 95% confidence.

Looking at the inter-league comparisons, the NFL and NHL with their hard salary caps have achieved much greater parity than MLB and the NBA, although the NFL already had much greater parity before the introduction of its hard cap in 1992. The outlier again is the NBA - its lack of parity in winning percentage compared to the other three leagues is at odds with its soft salary cap system. Considering differences in the distributions of league payrolls makes the results even more puzzling. Descriptive statistics are provided in Table 3. Over the last decade, the NFL, NBA and NHL have achieved very similar CV's and much lower than MLB. The NHL is particularly striking given that its CV for the 2000- 2001 to 2003-2004 seasons before the strike season of 2004-05 is 0.332 and drops to a very low 0.148 after the strike season when the new hard salary cap system was adopted.

Based on the relative variability of payrolls, MLB should have the least parity in winning percentage, followed together by the NBA and NHL with the NFL having the most parity. Yet the NBA dominates the other leagues in RSD with MLB falling a distant second and the NHL and NFL bringing up the rear (most parity).

IV. MARKET FACTORS

Local market characteristics also determine the MRP schedule for each club in a league by influencing the demand for tickets and other club products. Differences in the distribution of market sizes across leagues could explain the behavior of the RSDs. To investigate, we collected data for real income and population of the local metropolitan area and computed the coefficient of variation for each league for the last decade. These are reported in Tables 4 and 5. Metropolitan area population and income were taken from the Bureau of Economic Analysis regional accounts (http://www.bea.gov/regional/reis/) and cover the largest economic area for each city. Metropolitan area population and income figures for Canadian cities were taken and interpolated[7] from Statistics Canada (http://www.citypopulation.de/Canada- MetroEst.html and http://www12.statcan.gc.ca/censusrecensement/2006/ respectively).

Income and population are strongly associated measures of market size so the numbers in Tables 5 and 6 tell the same story. There is nothing unusual about the distribution of city populations and incomes in the NBA compared to the other leagues - nothing significant enough to suggest that the NBA should have lower parity than the other leagues, despite a significant number of new expansion clubs and relocations.

V. INTRINSIC DIFFERENCES

Basketball is played differently in many ways from hockey, baseball and football, but perhaps the most striking difference is the number of scoring opportunities. Without a goalkeeper to stop shots from scoring points (as in the NHL), successful shot attempts are as frequent as a 24 second shot clock will allow in the NBA. Scoring attempts are harder to define in MLB and the NFL but

[7] Canadian population and total income estimates were only available from census data for the years 2002 and 2007. Estimates of the full 2000-2009 sample were obtained by assuming the same growth rates between the years 2002 and 2007.

the lack of scoring compared to the NBA suggests that legitimate scoring attempts are far fewer. The comparison is the easiest for the NBA and NHL as scoring attempts are defined similarly as field goals and shots on goal respectively. In both cases, defending players attempt to prevent scoring opportunities without committing fouls or penalties. In the NBA, points can be scored by sinking a field goal, free-throw or three-point shot, whilst only point can be scored in any shot in the NHL.

In what follows, we will show that the NBA parity anomaly could be the result of the large number of scoring attempts giving rise to a limit theorem effect. More scoring attempts will tend to reduce the variance of points scored around a mean value that is determined by the quality of the players on each of the competing clubs. This will result in each club moving towards its "true" winning percentage with much less random variation (upsets). For given initial distributions of winning percentages, the NBA distribution will display a smaller standard deviation than the NHL's due to a larger number of scoring attempts in each game. The average number of shots in the NBA for the 2010-11 season is as follows: 2 point field goals = 80, 3 point field goals = 18, free throws = 24. The average number of shots per game in the NHL for the 2010-11 season is only 30 for each club.

A scoring attempt in the NBA or NHL possesses an expected number of points based on the number of points if the shot is successful and the probability of success, estimated by a scoring percentage. If we consider a two-point field goal in the NBA, the actual number of points scored in a scoring attempt by team j is the expected value plus a random error term that we assume is normally distributed with a known variance.

$$S = E(P_j) + e_i = 2p_j + e_j \quad (1)$$

$$e_j \sim N(0, \sigma_j^2) \quad (2)$$

The actual number of points scored for each scoring opportunity in the NHL is defined the same as (1) with the exception that the expected number of points is just p_j. The greater the number of shots, the more the random errors will tend to cancel each other out and the total number of points scored in a game will approach the number of shots multiplied by the team scoring percentage (calculated over an entire season). Fewer upsets will be observed – the winning team will tend to be the one with the higher scoring percentage.

We performed a Monte Carlo simulation to estimate the winning percentage distributions for the NBA and the NHL over many hypothetical seasons. Scoring percentages for each type of shot were obtained for each club in both leagues for the 2010-11 season while we used the average number of shots across all teams in each league. We also calculated the standard deviation of each scoring percentage from game to game for each type of shot to calibrate the random shocks. The simulation required each team to play a balanced schedule (each team plays each other team the same number of times) that is not representative of the NBA or the NHL but much easier to implement. Each team in the simulation plays each other team three times for an 87 game schedule with 30 teams, close to the 82 game schedules of the NBA and NHL. The winner of each contest is the one with the higher point total at the end of the game where a random shock is generated for each team. The total number of wins for a season then determines the winning percentage.

We performed simulations over 50 hypothetical seasons with the results displayed in histogram form in Figures 1 and 2.[8] The results clearly demonstrate that the NBA has less parity than the NHL ($s_{NBA} = 0.11179, s_{NHL} = 0.05722$), however this is not conclusive evidence as this merely approximates the levels of parity between the two leagues for the 2010-11 seasons. As a further test, the number of scoring opportunities for the NBA was reduced in half for all types of shots (40 field goals, 9 three point shots and 12 free throws) while leaving all other parameters unchanged and the simulation was re-run for another 50 seasons. The resulting value of $s_{NBA} = 0.08902$ indicates that parity improved for the hypothetical NBA league with fewer scoring opportunities. This result was consistent in repeated simulations. As a further check, the number of shot attempts in an NHL game was increased from 30 to 60 shots for each team and the simulation was re-run over 50 seasons. The simulation generated $s_{NHL} = 0.09453$ with a similar result over repeated simulations. Parity in the hypothetical NHL worsened with more scoring attempts.

VI. CONCLUSIONS

The short supply of tall people is certainly a feature of the NBA but it is not clear that it is the only explanation for the NBA anomaly. The standard two-team competitive equilibrium model of a professional sports league predicts that market factors play a large role in determining season outcomes and league parity. Our analysis of market factors for the four professional sports leagues in North America suggests little evidence for this as an explanation of the NBA anomaly.

[8] The simulation program is available upon request to the author.

This paper has shown that a sort of limit theorem result could be a better explanation. The greater number of scoring attempts in basketball mitigates the uncertainty in the total number of baskets scored to a much greater extent than goals in hockey, runs in baseball or touchdowns in football. Fewer upsets will be observed in basketball as random chance plays a much lesser role in the outcome of each contest. Teams will come much closer to their "true" winning percentages based on their own stocks of talent even if we impose that the prior distribution of true winning percentages is the same in each of the four leagues. The distribution of winning percentages for the NBA will then display a higher RSD than the other three professional leagues.

We demonstrate this argument using simulations for the NBA and NHL using data from their 2010-11 seasons to calibrate the model. The simulations generated an RSD for the NBA nearly twice the value for the NHL. Decreasing the number of scoring attempts by half reduced the RSD for the NBA markedly, while doubling the number of scoring attempts in the NHL increased its RSD significantly.

If the NBA seriously wishes to improve parity (it is not clear that greater parity is a league objective), we offer an alternative method to revenue sharing and salary caps: reduce the number of scoring opportunities. Prior to the 1954-55 NBA season, the league had no 24-second clock so that scoring attempts were less frequent.[9] The lowest recorded score in NBA history occurred in 1950 when the Fort Wayne Pistons defeated the Minneapolis Lakers by the score of 19 – 18. We don't recommend a return to boring basketball, however an increase in the shot clock from 24 to perhaps 40 seconds could reduce the number of scoring opportunities and increase the influence

[9] A good review of the history of the shot clock in the NBA can be found at http://www.nba.com/analysis/00422949.html

of random outcomes. Parity would be improved at little cost with the exception of fans screaming for more entertaining basketball and the potential for lost revenues. In the end, maybe this is not such a good idea.

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Table 1. Relative standard deviations

	ISD	1980-89	1990-99	2000-09
National League (NL)	0.039824	1.753	1.739	2.026
American League (AL)	0.039824	1.687	1.757	1.683
National Basketball Association (NBA)	0.05522	2.766	2.909	2.726
National Hockey League (NHL)	0.05522	2.040	1.829	1.606
National Football League (NFL)	0.125	1.506	1.502	1.581

Data sources are listed in an appendix.

Table 2. Frequency of winning percentages (%)

	1990-99			2000-09		
	w < 0.5-*ISD*	0.5 ±*ISD*	*w* > 0.5+*ISD*	*w* < 0.5-*ISD*	0.5 ±*ISD*	*w* > 0.5+*ISD*
NL	30.8	40.4	28.8	31.3	38.1	30.6
AL	26.9	44.6	28.5	32.3	33.1	34.6
NBA	38.7	21.3	40.0	35.4	28.0	36.6
NHL	27.6	41.2	31.2	30.3	41.5	28.2
NFL	28.8	47.3	23.9	30.0	45.5	24.5

Table 3. Statistics for total revenue ($ millions)

		1990-99	2000-09
AL	Mean revenue	65.0	156.6
	Standard deviation	23.4	57.7
	CV	0.352	0.368
AL (Yankees excluded)	Mean revenue	62.1	145.9
	Standard deviation	20.3	40.5
	CV	0.315	0.278
NL	Mean revenue	60.3	152.3
	Standard deviation	17.4	41.3
	CV	0.283	0.271
NBA	Mean revenue	50.0	106.9
	Standard deviation	14.8	26.3
	CV	0.297	0.246
NHL	Mean revenue	36.7	79.7
	Standard deviation	11.3	20.4
	CV	0.313	0.255
NFL	Mean revenue	73.0	188.0
	Standard deviation	9.8	26.2
	CV	0.128	0.140

Table 4. Statistics for total payroll ($ millions)

		1990-99	2000-09
AL	Mean payroll	34.5	78.2
	Standard deviation	11.5	37.6
	CV	0.322	0.481
AL (Yankees excluded)	Mean payroll	33.2	70.8
	Standard deviation	10.8	26.8
	CV	0.316	0.384
NL	Mean payroll	32.1	72.6
	Standard deviation	10.5	24.2
	CV	0.312	0.334
NBA	Mean payroll	26.4	62.7
	Standard deviation	6.0	12.5
	CV	0.220	0.200
NHL	Mean payroll	17.3	45.2
	Standard deviation	4.7	9.2
	CV	0.261	0.207
NFL	Mean payroll	39.9	102.4
	Standard deviation	5.2	10.6
	CV	0.135	0.106

Table 5. Statistics for total metropolitan area population

		1990-99	2000-09
AL	Mean population Standard deviation CV	8080938 5733641 0.710	8326536 5870017 0.705
NL	Mean population Standard deviation CV	6740198 6006156 0.891	719888 5914975 0.822
NBA	Mean population Standard deviation CV	6772059 5727114 0.846	7391602 6129035 0.829
NHL	Mean population Standard deviation CV	7038367 7030098 0.999	7435963 6835450 0.919
NFL	Mean population Standard deviation CV	5520457 4864747 0.881	6082885 5174622 0.851

Table 6. Statistics for total metropolitan area income ($ billions)

		1990-99	2000-09
AL	Mean income Standard deviation CV	20.9 16.4 0.788	34.3 26.9 0.764
NL	Mean income Standard deviation CV	17.9 17.1 0.952	28.4 26.7 0.941
NBA	Mean income Standard deviation CV	17.6 16.8 0.955	30.7 27.9 0.909
NHL	Mean income Standard deviation CV	18.7 20.3 1.083	30.3 32.6 1.076
NFL	Mean income Standard deviation CV	14.7 15.2 1.032	24.2 24.9 1.029

Figure 1. Winning percentage distribution for NBA for 50 seasons

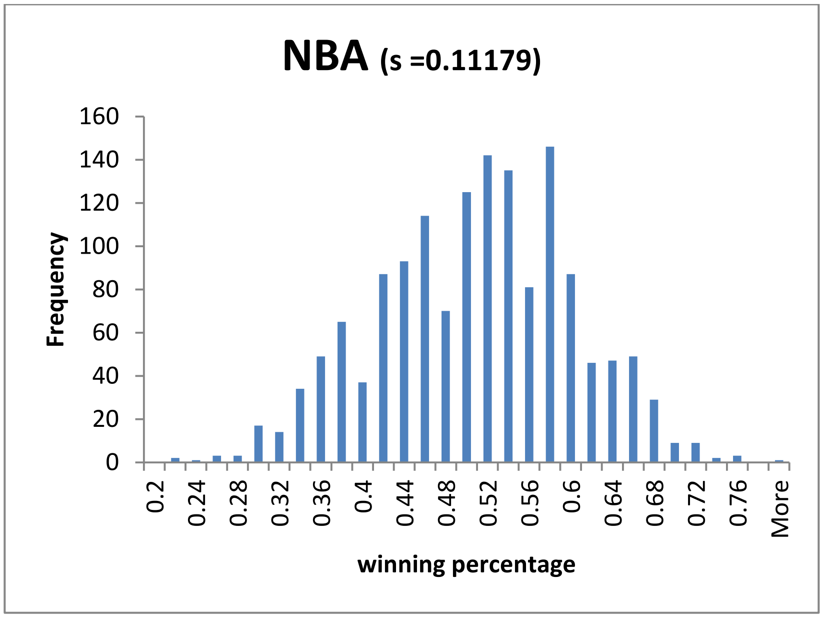

Figure 2. Winning percentage distribution for NHL for 50 seasons