The Impact of Travel on Team Performance in the NBA in the 2014-15 and 2018-19 Seasons

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Abstract

Does travel affect how an NBA team plays? In the summer of 2017, the league changed its schedule to reduce frequent travel and give players more time to recover between games. This paper looks into flight distance, rest, and time-zone movement and their impact on team performance, using cleaned team-game data and one regression specification (applied to both seasons) that controls for home court, opponent schedule burden, fixed effects, and season timing. Point differential and shot selection did not show an association with flight distance, however, physical movement (distance traveled on the court) did. An additional 1,000 flight miles corresponded to 0.450 less team miles traveled on the court in the 2014-15 season. No difference was measured in team miles traveled in 2018-19. That gap between seasons was statistically significant. While back-to-back games decreased player movement in 2014-15, that effect remained the same across the two seasons. In 2017, the league office overhauled the schedule, reducing back-to-back games and eliminating four-games-in-five-nights. These changes could explain the weaker relationship between flight distance and distance traveled by players in the 2018-19, but it also must be noted that more data across seasons would be needed to determine whether schedule reform, team investment, or something else entirely drove the difference.

Introduction

Professional athletes are required to travel constantly across the country, exposing them to travel-induced stressors. Players and coaches have often anecdotally attributed these stressors to a decrease in team performance. Multiple regression analysis can help empirically examine the relationship between travel and team performance. Travel can be calculated by measuring the distance a team flies from its previous game, the number of calendar days between games, and the direction and magnitude of any time-zone change. Measurements of team performance vary by sport; however, point differential is a standard statistic that indicates whether a team won and by how much. While point differential indicates the outcome of a game, shot-selection rates measure how teams attempt to score, and player-tracking statistics measure the aggregate distance players cover on the court.

Athletes in the major American leagues rack up tens of thousands of miles over a single regular season. Of the major leagues, the NBA asks the most of its players. Teams play 82 games in about five and a half months. NFL players travel just as widely but play only 16 regular-season games in about 17 weeks, with a bye week given to each team. NBA teams simply travel more than their NFL counterparts as a result.[1] Baseball players play far more games than basketball players, but they often play two to four consecutive games in the same city, which limits the number of separate trips. Given this, NBA teams travel more than their baseball counterparts too.[2] Given the unique combination of heavy travel and a condensed schedule, the NBA is the ideal league to examine and ask whether schedule burden actually shows up in performance.

Not only can you identify the effect of schedule on league performance in the aggregate, you should also evaluate whether the schedule yields an even playing field. If travel is associated with performance, coastal teams may face a greater burden than inland and

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[1] Beth Hammon, "Which Sports Teams in North America Travel Farthest?" July 2, 2019, https://www.icelandair.com/en-ie/blog/which-sports-teams-in-north-america-travel-farthest/.
[2] Hammon, "Which Sports Teams in North America Travel Farthest?" 2019.

centrally located teams. The Portland Trail Blazers have often flown more than 50,000 miles over a regular season, while the Cleveland Cavaliers have flown fewer than 40,000 miles.[3] Geographic differences have even greater effects on time-zone movement. Western Conference teams are spread across three time zones, while most Eastern Conference teams are located in the Eastern time zone.

In the years leading to the NBA schedule overhaul, NBA coaches spoke publicly about travel and recovery. San Antonio coach Gregg Popovich was one of the first to warn about grueling travel schedules and their effects on player sleep, health, and performance.[4] While it had been common practice to reduce the minutes of aging stars or rest players after playoff position had been secured, Popovich also rested healthy players during difficult portions of the travel schedule and sometimes left them at home. Other teams increasingly followed this approach.

The strategy gained attention as marquee players who rested while healthy accumulated deep playoff runs. Fans, who often paid hundreds of dollars to attend games, became understandably outraged when they missed opportunities to watch star players despite no reported injuries. The strategy also drew substantial media attention in the years prior to the schedule overhaul. In 2017, NBA commissioner Adam Silver described the resting of star players as an “extremely significant issue for [the] league.”[5]

The NBA convened with its owner’s association and the players’ union to make significant changes to the schedule: the 2017-18 season began one week earlier, four-games-in-five-nights stretches were eliminated, and back-to-backs were reduced. By 2018-19, teams averaged 13.3 back-to-backs, down 31% from 19.3 in 2014-15. Moreover, no team was

[3] Daren Willman, "Interactive Team Schedule Map," NBA Savant, August 11, 2016, https://nbasavant.com/apps/map.php?team_id=1610612754&season=2015.

[4] Sam Borden, "Basketball Players' Night Off Makes a Stand for Sitting Out," The New York Times, December 1, 2012, https://www.nytimes.com/2012/12/01/sports/basketball/david-stern-fines-spurs-for-day-off-raising-question-for-all-bosses.html.

[5] Ramona Shelburne, "Adam Silver: Resting Star Players a Significant Issue for the League," ESPN, March 21, 2017, https://www.espn.com/nba/story/_/id/18962901/resting-star-players-significant-issue-league.

scheduled for four games in five nights.[6] Adam Silver instituted these changes to reduce schedule compression and provide more recovery time. Given changes to the schedule in the summer of 2017, the 2014-15 and 2018-19 seasons offer a useful before-and-after comparison of travel and performance. This statistical analysis across two seasons cannot be conflated with results from a controlled experiment, given playing style, recovery practices, rosters, and measurement systems all changed too.

Research Questions

Over the course of four years, the NBA made substantial changes to their schedule to diminish the burden of travel on their players. Does travel, however, truly impact team performance in a statistically significant way? Assuming that travel is measured by three categories: 1. distance traveled by team (mi), 2. rest between games (days), and 3. change in time zone, do these categories equally affect (if at all) team performance? If not, which categories affect team performance the most and which are negligible? Team performance is broken into three categories: 1. basic statistics (team point differential), 2. shooting statistics (shot distribution), and 3. Player-tracking statistics (team on-court distance). Does travel significantly impact any of these team performance categories? Lastly, due to changes in travel schedules, two seasons—the 2014-15 season and the 2018-19 season—have significantly different travel burdens on their players. When analyzing team performance statistics on the aforementioned seasons, is there a noticeable difference in the burden of travel? In this analysis the data are observational, so I read the results as conditional associations, not as causal effects of travel or schedule reform.

[6] NBA, "NBA Unveils 2018-19 Game and Broadcast Schedules," official release, August 10, 2018, https://pr.nba.com/2018-19-nba-schedule/.

Literature review

While there is a myriad of medical research investigating the biological consequences of travel, far less has been done on how travel affects team performance in athletic settings. Travel—measured by the distance teams travel, rest between games, and time-zone changes—is rarely studied comprehensively. Instead, there are several studies that investigate the impact of one of travel's categories on winning outcomes. While these studies are based on data from other sports, their findings can help us better understand the impacts of travel.

Studies that isolate the effects of long-haul travel are scarce; however, results from a study of skeleton athletes suggests that the athletes who underwent extensive travel—greater than 2,000 miles per flight—saw drops in maximal sprinting ability.[7] Due to air travel, athletes experience extended exposure to mild hypoxia (lack of enough oxygen in the tissues to sustain bodily functions), diminished air quality in the cabin (drier air and low hyperbaric pressure), sleep disturbance from exposure to loud stimuli, disruption of routines, and lack of mobility due to limited space in the cabin.[8] Analysis of the saliva of the skeleton athletes showed that there was a significant drop in salivary cortisol concentrations.[9] This biological marker is an indication of an athlete's ability to readjust their circadian rhythms. Changes in an individual's circadian rhythms have been shown to impact their energy levels, concentration, and physical performance.[10] While this study indicates that NBA athletes would similarly experience drops in speed after long-haul travel, the same effects may not hold. For one, the skeleton athletes in the study were not given any resources to combat the effects of travel. On the other hand, some NBA organizations have team doctors and nutritionists that aid athletes in adjusting their

[7] N. Bullock et al., "Effect of Long-Haul Travel on Maximal Sprint Performance and Diurnal Variations in Elite Skeleton Athletes," British Journal of Sports Medicine 41, no. 9 (2007): 569-73, https://doi.org/10.1136/bjsm.2006.033233.

[8] Olivier Coste, Pascal Van Beers, and Yvan Touitou, "Hypoxia-Induced Changes in Recovery Sleep, Core Body Temperature, Urinary 6-Sulphatoxymelatonin and Free Cortisol after a Simulated Long-Duration Flight," Journal of Sleep Research 18, no. 4 (2009): 454-65, https://doi.org/10.1111/j.1365-2869.2009.00744.x.

[9] Bullock et al., "Effect of Long-Haul Travel," 2007.

[10] Thomas Reilly, Greg Atkinson, and Jim Waterhouse, "Exercise, Circadian Rhythms, and Hormones," in Sports Endocrinology (2000), 391-420, https://doi.org/10.1007/978-1-59259-016-2_22.

circadian rhythms. While the specifics of recovery practices are unknown, their effects are likely substantial enough to suggest that the findings may not hold for NBA athletes.

While travelling long distances may induce fatigue, lack of rest is certainly tied to weaker recovery. Frequent air travel (multiple flights within five days) has been shown to negatively affect an athlete's sleep quality and quantity, hydration, and nutritional practices.[11] A 2002 study of soccer athletes demonstrated that players who had played more than one match a week during the last ten weeks of the regular season were more likely to experience worsened recovery. Moreover, roughly two thirds of those athletes either incurred injuries or "underperformed in the World Cup."[12] While data from training sessions was not considered, a significant difference was noted between athletes who had crammed schedules and those who had played less than seven games over the course of ten weeks. Certain limitations of the study, including a subjective measurement of player performance, make it difficult to translate the findings onto NBA athletes. Biological markers taken from team doctors do suggest, however, that there is a relationship between lack of rest and a player's recovery. Moreover, the study suggests that athletes who participated in a condensed schedule were twice as likely to incur an injury than players who had more than a week's rest between games.[13] While I am not looking to analyze the relationship between rest and injury, as there are methodological difficulties in proving such a causation, this study of soccer players asserts conclusive findings that player recovery is significantly hindered by lack of rest. Lastly, the study suggests that less than 3-4 days of rest between games will significantly hinder an athlete's performance and recovery.[14] Because most games in the NBA schedule are played with less than 3-4 days of rest (over 98%), the study's findings would indicate that NBA athletes are in a perpetual state

[11] Whitney E. Leatherwood and Jason L. Dragoo, "Effect of Airline Travel on Performance: A Review of the Literature," British Journal of Sports Medicine 47, no. 9 (2012): 561-67, https://doi.org/10.1136/bjsports-2012-091449.
[12] J. Ekstrand, "A Congested Football Calendar and the Wellbeing of Players: Correlation between Match Exposure of European Footballers before the World Cup 2002 and Their Injuries and Performances during That World Cup," British Journal of Sports Medicine 38, no. 4 (2004): 493-97, https://doi.org/10.1136/bjsm.2003.009134.
[13] Ekstrand, "A Congested Football Calendar and the Wellbeing of Players," 2004.
[14] Ekstrand, "A Congested Football Calendar and the Wellbeing of Players," 2004.

without proper rest, thus decreasing their ability to recover properly and increasing their risk of injury. It is important to note, however, that findings of soccer athletes cannot be directly translated to basketball athletes. Differences in game duration, distance covered over the course of a game, aerobic exertion, et cetera, indicate that a soccer match is more aerobically taxing for non-goalkeepers than a basketball game is to their players. For this reason, an analysis of the impact of days rest on basketball players is necessary given their specific circumstances.

Much like the effects of long-haul travel, changes in time zones significantly disrupt an athlete's circadian rhythms. While there are several studies that examine the impact of time zone change on team performance across different sports, their findings are contradictory. A study was conducted on the effects of time zone changes on team winning percentages in the NFL which showed that Western time zone teams (home or away) had significant winning advantages over Central and Eastern time zone teams.[15] The significant changes in winning percentages imply that not only do Eastern teams experience a performance decline when travelling westward, but also that Western teams experience a performance enhancement when travelling eastward. Their study claims that teams travelling westward experience disruption in their circadian rhythms, causing decreases in energy, concentration, and physical performance.[16] Moreover, when Eastern teams fly westward for night games, the results are most pronounced. In this case, players are performing from 8-11 p.m. locally, however, their circadian clocks are three hours ahead. As a result, the Eastern team players are performing at a time in which their bodies would be accustomed to sleeping. This dramatic disruption of a player's circadian rhythms is reported to cause a 7.1% drop in winning percentage.[17] A similar analysis of Western teams flying eastward indicates that they experience a 3.5% increase in

[15] Richard Jehue, David Street, and Robert Huizenga, "Effect of Time Zone and Game Time Changes on Team Performance: National Football League," Medicine & Science in Sports & Exercise 25, no. 1 (1993): 127-31, https://doi.org/10.1249/00005768-199301000-00017.
[16] Jehue, Street, and Huizenga, "Effect of Time Zone and Game Time Changes," 1993.
[17] Jehue, Street, and Huizenga, "Effect of Time Zone and Game Time Changes," 1993.

winning percentage as a result of time zone changes.[18] In this case, the circadian clock of players from Western teams are three hours ahead, meaning that they are playing earlier than home games. While the findings of the study are statistically significant, the authors indicate that the results may be caused by the difference in quality between Western and Eastern teams. Over the period studied, Western teams were proportionally more likely to make the playoffs than their Eastern counterparts.[19]

Another study that investigated the effects of time zone changes on MLB team performance suggests that baseball teams experienced insignificant effects of westward travel for both night and day games.[20] Certain assumptions were made when recording the effects of jet lag that may impact the results of their study. For one, the authors assumed that as soon as the game before the trip was over, the team traveled to adapt to a new time zone. Also, they assumed that one day of rest would correspond with a 1-hr time zone recovery. These assumptions are made to simplify the analysis of the data, however, do not consider how athletes adjust differently to time zone changes. The differing results of studies in the NFL and the MLB regarding the effects of time zone changes on team performance indicate that this relationship is worthy of further investigation.

After analyzing the relevant literature of the effects of travel on team performance, it is clear that the subject matter is ripe for investigation. Because it is difficult to translate the results of any of these studies onto the NBA, given the drastic differences in play styles and travel schedules, a comprehensive analysis of the effects of travel on team performance in the NBA would provide new insight. Moreover, while the aforementioned studies examine the effects of travel on winning percentages or subjective player performance ratings, they often ignore the means by which teams score and their speed over the course of a game. By incorporating

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[18] Jehue, Street, and Huizenga, "Effect of Time Zone and Game Time Changes," 1993.
[19] Jehue, Street, and Huizenga, "Effect of Time Zone and Game Time Changes," 1993.
[20] Andrew W. Nutting and Joseph Price, "Time Zones, Game Start Times, and Team Performance," Journal of Sports Economics 18, no. 5 (2017): 471-78, https://doi.org/10.1177/1527002515588136.

advanced shooting and player-tracking statistics into my analysis, I will investigate the effects of travel on previously unexplored team performance variables.

Methodology

To examine the relationship between travel and NBA team performance, I estimated multiple linear regressions for the 2014-15 and 2018-19 regular seasons separately. As discussed in the introduction, the NBA drastically changed team travel schedules from the summer of 2015 to 2018. These changes decreased travel of over 15,000 miles by 20%, eliminated all four games in five nights, and reduced back-to-back games by 29%. Thus, regression analyses of both seasons are also used to see if the impact of travel differed after the NBA's schedule changes. As previously stated, a cross-season difference is not proof that schedule reform caused it.

The dependent variables fall into three categories: 1. basic team statistics, including team point differential; 2. advanced shooting statistics, including 3PA share (three-point shot attempts divided by total field-goal attempts) and FT rate (free-throw attempts divided by total field-goal attempts); and 3. player-tracking statistics, including total team on-court distance normalized to 48 minutes.

Travel variables with the greatest impact are miles traveled by the team between games, rest days between games, and time-zone change. The distance coefficient shows the association with an additional 1,000 miles. Rest considers eastward and westward time-zone movement separately (given circadian adjustment may not run the same way in both directions).

Data Collection and Adjustments

I collected game, box-score, and player-tracking data from the 2014-15 and 2018-19 NBA regular seasons using records available through NBA.com. The unit of observation is a team-game. Each game contributes 2 records (1 per team), resulting in twice the number of team-game observations than there are games. The 2014-15 season considers cleaned point-differential and shot-selection data from 2,270 team-games (1,135 games played). The 2018-19 season considers 2,282 team-games (1,141 games played). There are fewer team-distance samples (2,270 and 2,276 team-games), due to the exclusion of three 2018-19 games with incomplete aggregate player minutes.

Games in which either team was playing its season opener were dropped, given there was no comparable prior game to measure travel burden against. Overtime games were excluded from the underlying data.

The source rest variable counts calendar days between games, not full days of rest. A value of one is a back-to-back: zero full rest days. Time-zone changes were checked directionally and split into eastward and westward movement. For every team-game the opponent's distance (as the crow flies), rest category, and directional time-zone burden were calculated.

Model Creation and Determining Unique Predictor Variables

I estimated regression models using one common specification in both seasons. I chose predictor variables for their role as potential confounders, not through trial and error aimed at maximizing R-squared. Every model contains the team's distance, rest, and directional time-zone variables, the opponent's matching schedule variables, and an indicator for whether the team was at home. Home-court status is meaningful because teams that travel farther are disproportionately likely to be the ones playing away.

The models include fixed effects from team-season, opponent-season, and calendar week-by-season. Team fixed effects include each team's persistent quality and style; opponent fixed effects do the same for their opponents. Week fixed effects consider league-wide changes over the course of the season (largely decreased pace in the final third of the season). Standard errors were clustered by both team and game given that each team appears repeatedly and the two team records from a single game are not independent of each other.

I pooled the data and interact each travel variable with an indicator for the 2018-19 season, which tests directly whether a coefficient changed, to compare seasons. Given multiple travel coefficients are tested, Holm-adjusted p-values are used for secondary hypotheses. Robustness checks were conducted for thoroughness in the analysis, zero-distance observations were excluded, long-distance tails were trimmed, and home and away subsamples were estimated separately; I also allowed nonlinear distance relationships, added pregame performance controls, and compared the two teams within the same game.

Data and Results

Table 1: Descriptive Statistics for the Cleaned Team-Game Samples

Measure	2014-15	2018-19	Change
Mean flight distance per team-game	558 miles	553 miles	-0.9%
Back-to-back share	23.5%	16.7%	-29.0% relative
One full day off	57.4%	61.3%	+3.9% points
Two full days off	13.7%	18.1%	+4.4% points
Three-plus full days off	5.4%	3.9%	-1.5% points
Mean team on-court distance	17.204 miles	18.077 miles	+0.873 miles
Mean three-point-attempt share	26.8%	35.9%	+9.1% points
Mean free-throw rate	27.6%	26.1%	-1.5% points
Primary team-game sample	2,270	2,282	4,552 pooled

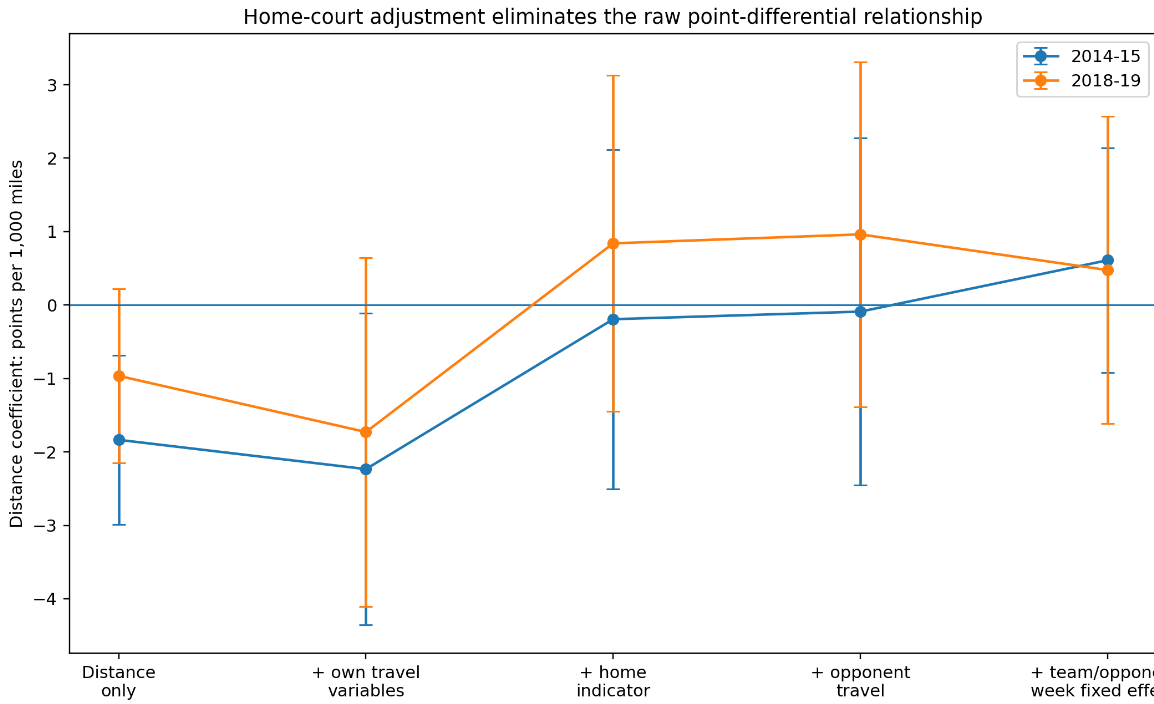
Notes: The team-distance outcome has 2,276 observations in 2018-19 because three games with incomplete tracking minutes are excluded. Mean point differential is zero by construction in a paired team-game sample. Percent changes may not equal displayed values because of rounding.

Source: NBA.com, author calculations

Scheduling difference between the two seasons was concentrated in game spacing, not average flight length, as seen in Table 1. Mean flight distance per team-game barely moved, from 558 to 553 miles (less than a 1% change) while the share of back-to-backs fell from 23.5% to 16.7%. This is a roughly 29% decline that coincides with the league cutting back-to-backs. From the 2014-15 season to the 2018-19 season, league-wide playing style shifted (three-point-attempt share rose 9pp), indicating the need for season-specific controls.

In 2014-15, the unadjusted relationship between flight distance and point differential looks negative, however, travel distance is closely tied to whether a team is playing at home or away (home teams often travel less than away teams).

Figure 1: Flight Distance and Point Differential Across Regression Specifications



Source: NBA.com, author calculations

Table 2: Travel Variables and Team Point Differential

Travel variable	2014-15	2018-19	2018 minus 2014	p
Distance: +1,000 miles	0.610 [-0.918, 2.139]	0.477 [-1.614, 2.567]	-0.134 [-2.873, 2.606]	0.921
Back-to-back	-1.288 [-2.842, 0.266]	-2.144 [-4.156, -0.132]	-0.856 [-3.498, 1.786]	0.513
Two full days off	0.900 [-1.288, 3.088]	0.105 [-1.624, 1.833]	-0.795 [-3.539, 1.948]	0.558
Three-plus full days off	1.807 [-0.253, 3.866]	0.718 [-2.964, 4.400]	-1.089 [-5.424, 3.246]	0.611
Eastward: +1 hour	-0.887 [-2.433, 0.659]	-0.337 [-2.137, 1.463]	0.550 [-2.191, 3.291]	0.685
Westward: +1 hour	-1.031 [-2.289, 0.227]	0.538 [-1.409, 2.484]	1.569 [-0.685, 3.823]	0.165

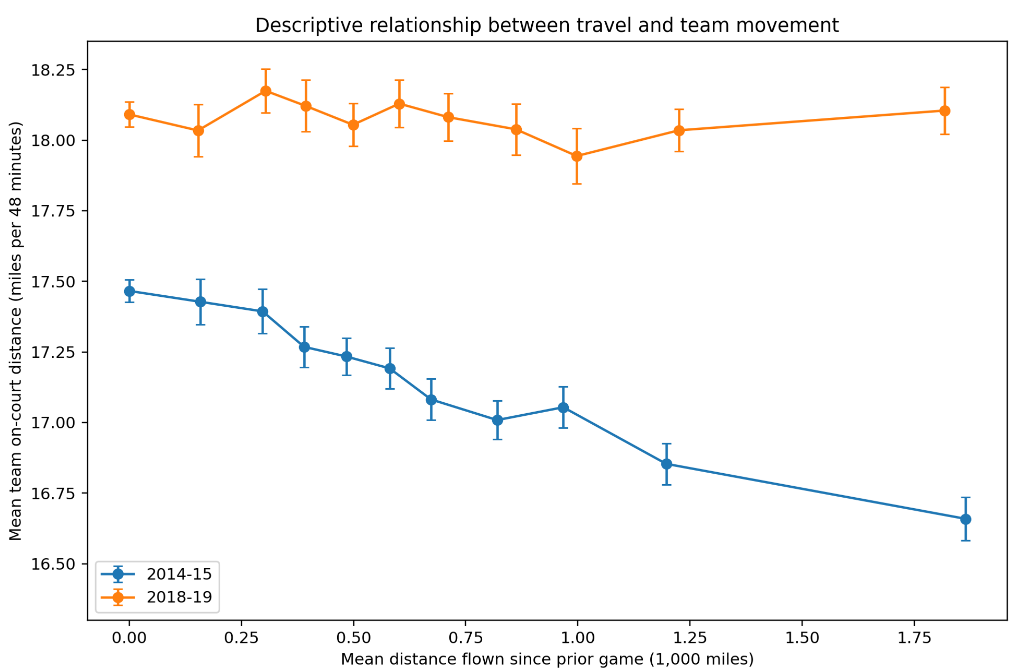
Notes: Cells report coefficients with 95% confidence intervals. Point-differential estimates are measured in points; the distance coefficient is per 1,000 miles. One full day off is the omitted rest category. All models control for home court, opponent schedule burden, team, opponent, and week fixed effects. Standard errors are clustered by team and game. The final column tests the cross-season difference.

Source: NBA.com, author calculations

In the preferred model, an additional 1,000 miles was associated with 0.610 points of point differential in 2014-15 (95% confidence interval: -0.918 to 2.139; p = 0.421) and 0.477 points in 2018-19 (95% confidence interval: -1.614 to 2.567; p = 0.644). The cross-season difference was -0.134 points (95% confidence interval: -2.873 to 2.606; p = 0.921)—essentially nothing. Flight distance, on its own, is not associated with winning margin. Teams that travel farther are simply more likely to be away from home (which drives much of the initial negative relationship).

Player-tracking outcomes in Figure 2 groups observations by flight distance (minimum distance between two cities' major airports) and plots mean team on-court distance with confidence intervals. The 2014-15 series shows a steady decline as flight distance rises, while 2018-19 stays more or less flat. Given changes in playing style and tracking measurements, the elevated 2018-19 level isn't a causal season effect. Therefore, the comparison that should be considered is the slope within each season.

Figure 2: Descriptive Relationship Between Flight Distance and Team On-Court Distance



Source: NBA.com, author calculations

Table 3: Travel Variables and Team On-Court Distance per 48 Minutes

Travel variable	2014-15	2018-19	2018 minus 2014	p
Distance: +1,000 miles	**-0.450 [-0.509, -0.392]**	**0.003 [-0.068, 0.075]**	**0.454 [0.363, 0.545]**	**<0.001**
Back-to-back	-0.080 [-0.115, -0.046]	-0.029 [-0.080, 0.023]	0.052 [-0.015, 0.119]	0.124
Two full days off	0.010 [-0.037, 0.057]	0.036 [-0.006, 0.079]	0.026 [-0.037, 0.089]	0.399
Three-plus full days off	0.004 [-0.071, 0.079]	0.027 [-0.059, 0.114]	0.024 [-0.102, 0.149]	0.703
Eastward: +1 hour	-0.044 [-0.088, -0.000]	-0.042 [-0.091, 0.008]	0.002 [-0.057, 0.061]	0.945
Westward: +1 hour	-0.013 [-0.059, 0.033]	0.009 [-0.049, 0.068]	0.022 [-0.052, 0.097]	0.546

Notes: Cells report coefficients with 95% confidence intervals in team miles per 48 minutes. The distance coefficient is per 1,000 flight miles. One full day off is the omitted rest category. Models and inference are otherwise identical to Table 2. Secondary p-values are evaluated with Holm adjustments in the text.

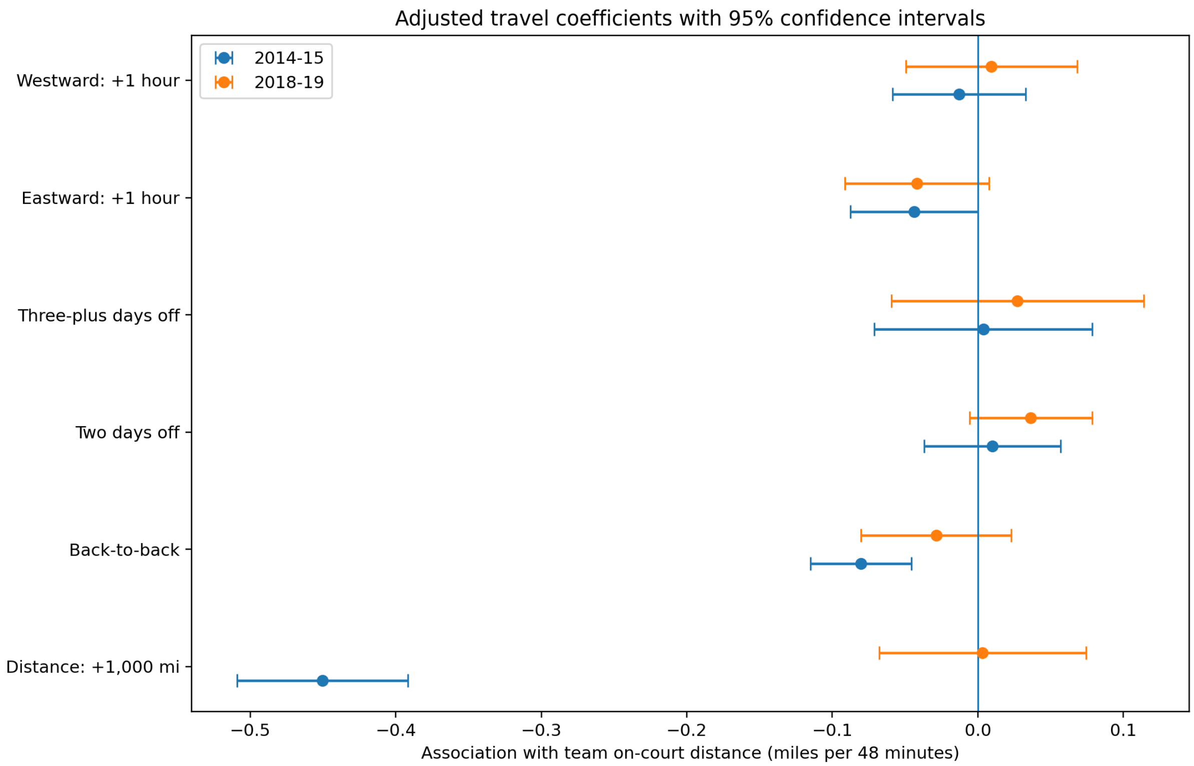
Source: NBA.com, author calculations

Flight distance was strongly associated with lower team on-court distance in 2014-15. Conditional on the other schedule variables, home-court status, opponent schedule burden, and fixed effects, an additional 1,000 flight miles corresponded to 0.450 fewer team miles traveled on court (95% confidence interval: 0.392 to 0.509 fewer; $p < 0.001$)—about 2.62% of the 2014-15 mean. In 2018-19, that same estimate was just 0.003 additional team miles (95% confidence interval: -0.068 to 0.075; $p = 0.925$), essentially nothing. And the gap between the two is real: the pooled interaction estimate puts the increase in the distance coefficient at 0.454 team miles between seasons (95% confidence interval: 0.363 to 0.545; $p < 0.001$), meaning the negative 2014-15 association simply was not there in 2018-19.

This finding is still present even after: 1. not considering zero-distance observations, 2. trimming the top 1% of distances, 3. removing trips above 2,000 miles, 4. estimating home and away games separately, and 5. comparing the two teams within the same game. A categorical specification shows the same pattern holds in 2014-15: relative to zero travel, the estimated reductions run 0.123 miles for trips up to 500 miles, 0.308 miles for 500-1,000 miles, 0.512 miles for 1,000-1,500 miles, and 0.715 miles for >1,500 miles (a clean upward step-like increase). The 2018-19 estimates, on the other hand, are near-zero across the board.

Rest does not seem to contribute as significantly to player performance as team distance traveled does. Relative to one full day off, a back-to-back cost teams 0.080 fewer team miles in 2014-15 (95% confidence interval: 0.046 to 0.115 fewer). This holds even with a Holm adjustment. In 2018-19 that estimate fell to 0.029 fewer miles and lost significance, though the cross-season difference in the back-to-back coefficient was not itself statistically significant (p = 0.124). It cannot be determined that the rest relationship changed due to schedule changes. No eastward or westward time-zone coefficient survived the multiple-testing adjustment. Figure 3 demonstrates the team-distance coefficients and their confidence intervals.

Figure 3: Adjusted Travel Coefficients for Team On-Court Distance



Source: NBA.com, author calculations

Table 4: Flight Distance and Shot-Selection Rates

Outcome	2014-15	2018-19	2018 minus 2014	p
Three-point-attempt share	0.127 [-0.777, 1.032]	-0.274 [-1.122, 0.575]	-0.401 [-1.725, 0.922]	0.540
Free-throw rate	-0.198 [-1.700, 1.305]	0.767 [-0.690, 2.224]	0.965 [-0.850, 2.779]	0.286

Notes: Cells report percentage-point changes per 1,000 additional flight miles with 95% confidence intervals. Three-point-attempt share equals 3PA/FGA; free-throw rate equals FTA/FGA. Models include the full control set used in Tables 2 and 3. No secondary travel coefficient for these outcomes survives Holm adjustment.

Source: NBA.com, author calculations

Table 4 turns up no robust evidence that flight distance changed the shot-distribution measures I looked at. An additional 1,000 miles corresponded to a 0.127pp change in three-point-attempt share in 2014-15 and a -0.274pp change in 2018-19; both confidence intervals include zero. Free-throw rate is also imprecise, and there is no rest or directional time-zone coefficient that survives multiple-testing correction for either shot-selection outcome. The evidence indicates that travel distance had effects on physical movement in 2014-15. These effects diminished in 2018-19 after the NBA implemented schedule changes.

Explanations and Future Research

The results from the data are not entirely surprising, but they certainly raise many questions. For one, how can travel cut into team movement without leaving any visible mark on point differential? Well, to state the obvious, basketball is not swimming or track; running faster doesn't necessarily result in more games won. Coaches can implement playbooks that alter spacing, substitutions, and shot selection without changing their scoring margin at all. Research and analysis on NBA pace supports this conclusion.[21] Team on-court distance, in other words, measures how much teams move, not how well they play.

What explains the difference between the 2014-15 and 2018-19 distance coefficients? It's likely the NBA's schedule changes. Between these seasons the league stretched the season out, cut back-to-backs by about a third, and got rid of four-games-in-five-nights stretches. The back-to-back share dropped from 23.5% to 16.7% even though average flight distance per team-game barely budged. With more time to recover the physical burden of any given flight eases. The reforms targeted the problem, and the 2018-19 distance coefficient vanished.

Despite rigorous modeling efforts, the models do not necessarily identify the schedule changes as the sole cause of the coefficient difference. Another explanation is that teams

[21] Grant Hughes, "Does Pace Matter in the NBA?" Bleacher Report, October 2, 2017, https://bleacherreport.com/articles/2209761-does-pace-matter-in-the-nba.

became increasingly aware of the impacts of travel on player sleep and recovery. As mentioned in the introduction, coach Popovich spurred the conversation and popularized the practice of resting star players. Moreover, teams considerably increased investments in state-of-the-art practice facilities, medical staffs, and nutritionists over the same span.[22] With improved medical treatment and nutrition, players are more able to adjust their circadian rhythms and mitigate the impact of travel.

The NBA, the players' union, and coaching staffs should look at multiple seasons before and after the schedule reforms, not just the two compared here. With proprietary data they could conduct an event-study or difference-in-differences design that could test whether teams with less back-to-backs also saw larger performance changes. Teams have far more available data on their players and can use it to optimize recovery programs and provide actionable recommendations to the league.

This paper shows that flight distance decreased team on-court distance in 2014-15, but not in 2018-19; while other factors should be considered (including team investment, playing-style change, or simple measurement differences), the analysis suggests that the NBA's 2017 schedule reform likely contributed to the decreased effect of flight distance on team on-court distance.

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[22] Jeff Zillgitt, "NBA Teams Investing Millions in New State-of-the-Art Practice Facilities," USA Today, January 26, 2016, https://www.usatoday.com/story/sports/nba/2016/01/26/nba-multi-million-practice-facilities-76ers/79124364/.

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