Does momentum affect an NBA team's subsequent game result?

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Abstract

In this report, we attempt to answer the question of whether or not the momentum an NBA team experiences, affects their next games result in a significant way. We, therefore, perform different chi-squared independence tests. The required match data is obtained in form of a dataset containing basketball results from the last 16 seasons.

1 Introduction

This report deals with the highly debated and deep-rooted term of *momentum*, interpreted as a psychological state of teams in the context of sports [6]. This definition is based on the assumption, that the confidence of a team affects the ability of good performance in the future.
Although there are many factors influencing whether or not a team experiences momentum, this report attempts to answer the question by using a specified set of recent, binary results (win or loss), that allows an analysis of match-to-match momentum caused by success in previous matches.
This approach can not be applied to all kinds of sports, as other league systems also involve draws as a match result. That is why this report focuses on basketball games. Due to availability, credibility and reputation, we chose a dataset containing games from the National Basketball Association *NBA*.

2 Data Collection

The source for the required match dataset is the basketball analytics website *basketball-reference* which supplies a wide range of statistical data in basketball [1]. Although the website normally requires a fee for accessing the data, it also allows to scrape the data for private use. Based on this fact, we built a web scraper that is implemented in python.
The scraper downloads a seasons' html document that contains separate links to season and year specific game data. Therefore we scrape the seasons html and using BeautifulSoup, obtain all links to the regarding months.
In a months html are tables that contain all basic information on games being played that month 1.
To prevent the crawler from terminating and loosing the scraped data, we implemented a cache function that saves the already downloaded html documents, so that there is no need to download them multiple times.
To improve the execution speed of the script, all the tasks are parallelized over each core of the cpu using *asyncio*. For the same reason, we use *ProcessPoolExecuter* to further improve the eficiency of the crawler.
As output the crawler supplies the dataset in form of a csv file, that contains the entire data set.

3 Definitions

As already pointed out, we interpret momentum as a psychological factor for a team's winning probability after experiencing a successful period of game results. To gain insights on if it has an

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Date	Start (ET)	Visitor/Neutral	PTS	Home/Neutral	PTS			Attend.	Arena
Tue, Oct 22, 2019	8:00p	New Orleans Pelicans	122	Toronto Raptors	130	Box Score	OT	20,787	Scotiabank Arena
Tue, Oct 22, 2019	10:30p	Los Angeles Lakers	102	Los Angeles Clippers	112	Box Score		19,068	STAPLES Center
Wed, Oct 23, 2019	7:00p	Chicago Bulls	125	Charlotte Hornets	126	Box Score		15,424	Spectrum Center
Wed, Oct 23, 2019	7:00p	Detroit Pistons	119	Indiana Pacers	110	Box Score		17,923	Bankers Life Fieldhouse
Wed, Oct 23, 2019	7:00p	Cleveland Cavaliers	85	Orlando Magic	94	Box Score		18,846	Amway Center
Wed, Oct 23, 2019	7:30p	Minnesota Timberwolves	127	Brooklyn Nets	126	Box Score	OT	17,732	Barclays Center
Wed, Oct 23, 2019	7:30p	Memphis Grizzlies	101	Miami Heat	120	Box Score		19,600	AmericanAirlines Arena

Figure 1: Sample schedule from basketball-refernce.com for October 2019.

impact, it is necessary to define a measure for momentum. In this report, we want to compare two different approaches.

Strict momentum On the one hand, we want to define momentum as a pure winning streak of n games. Setting n to three would therefore imply, that a team is experiencing momentum if and only if it won the last 3 games. We define this measure as *strict momentum*.

Soft momentum On the other hand, it also seems reasonable to weaken this measure. That is why the second approach is based on the moving average of a team's winning probability - calculated for the previous n games. This will most probably lead to an increased number of on-momentum games within a season and is defined as *soft momentum*.

As we also try to get an understanding of how long a potential momentum effect lasts, we are additionally differentiating between a window size of three and five. To take into account a team's home-court advantage, a differentiation between home, away and all-season games are made [4].

4 Model

We extract the initial information from the dataset in form of a season and team wise list of wins and losses. This format is provided for home and away games as well as the entire season, covering the period from 2004 to 2020. Furthermore, it is to mention that momentum can not be tracked across seasons, due to not neglectable changes regarding team structure and quality from season to season.

Test model For the given sets of games, we differentiate between being off or on streak and if a team won the following game or not. These features can be expressed in $2x2$ contingency tables for all sets. For that reason, hypothesis tests that yield a statistical statement on the independence of both features need to be constructed. Each test involves the entire set of games, that applies to the respective test model.
With data of 19 to 38 games per season and team available (depending on home-away differentiation), the underlying $2x2$ contingency table does empirically not always provide a large sample size. The reason for that is teams, who are not experiencing momentum often and therefore mostly contribute off-streak results.

Table 1: Arbitrary sample contingency table for an NBA team's home season stats with respect to strict momentum

	Momentum	
	Yes	No
Win	6	1
Loss	6	6

To face this issue, we consider two alternative models. The first approach is to perform multiple Fisher exact tests for individual teams and seasons. This approach requires a heavy reduction of the significance level to counteract alpha error accumulation. With at least 19 tests per season, this results, no matter which correction is chosen (e.g. Bonferroni, Holm-Bonferroni), in a very conservative test model and can potentially lead to a high number of false negative tests [5]. In addition, the required assumption of independent tests is not met, because in accumulating team-wise tests, each game is

involved in two tests per definition.
The second approach is to still generate individual contingency tables for each season and team separately but only perform one large hypothesis test. This can be accomplished by adding up all the generated contingency tables. As the sample size would be increased, a chi-squared independence test can be chosen. Again, this involves the consolidation of partially dependent data.
Comparing both alternatives, we see that both approaches fail to assure fully independent tests respective data. We choose the second option, as it seems to promise a less conservative test result, which we think is more attractive for this report. Nevertheless, we are aware of the not met requirements and their potential influence on the expressiveness of the tests.

Further assumptions Given the previously explained definitions and test models, it is important to point out neglected features that may also influence and manipulate a team's winning probability by affecting the quality and morale of the team. Table 2 provides a representative list of these features.

Table 2: neglected influences on a teams match-to-match momentum in NBA

Feature	Example	Potential effect
injury	player is injured	loss of quality
squad rotation	reduction of risk of injury of key players	loss of quality
trades	during the season player is traded to different club	loss of quality
days of rest	opponents had more recovery time after last game	loss of relative quality
change of coach	coach gets sacked due to bad performance	increase of morale
in-game momentum	luck or strong temporary performance	increase of morale

Summary We will perform 12 chi-squared independence tests using all the crawled data by adding up the generated team and season specific contingency tables, differentiating between home, away and all games concerning the measures for *soft momentum* and *strict momentum* and streak lengths of three and five. With these test models, we will test under the null hypothesis H_0. The two features win/loss and on/off streak are independent and thereby try to investigate if there is an effect of momentum in the NBA.

5 Results

Table 3: p-values for the chi-squared independence tests performed on all seasons from 2004 to 2020

	streak length	home games	away games	all games
Soft momentum	3	$1.2 \cdot 10^{-39}$	$8.5 \cdot 10^{-14}$	$2.2 \cdot 10^{-18}$
	5	$4.0 \cdot 10^{-76}$	$6.33 \cdot 10^{-39}$	$4.7 \cdot 10^{-49}$
Strict momentum	3	$1.2 \cdot 10^{-127}$	$2.2 \cdot 10^{-47}$	$4 \cdot 10^{-91}$
	5	$2.6 \cdot 10^{-98}$	$8.9 \cdot 10^{-30}$	$8.0 \cdot 10^{-77}$

Every p-value of the performed chi-squared independence tests (table 3) is significantly smaller than the chosen significance level of 5%. Therefore every null hypothesis can be rejected, which implies, that for the given dataset it is very unlikely that there is no impact of momentum, no matter where a game takes place or which definition and streak length is applied.
Each test is based on contingency tables containing about 18000 (home/away) to 36000 games. We can also observe, that all home games' p-values are orders of magnitude smaller than away games' p-values. The same applies to strict momentum compared to soft momentum. For H_0, this implies that the observed data is more unlikely for home games. This proposes the conclusion, that a potential effect of momentum in the NBA applies most to home games.

In figure 2 we can see that on streak events, the relative gap between wins and losses is positive, while we can see more losses than wins for off streak events.
Differenciating between home, away and all games, it is also visible that the discrepancy for on-streak events is largest for home games and lowest for away games. At the same time, we can observe a tendency that off streak events' wins account for the largest relative share considering home games.

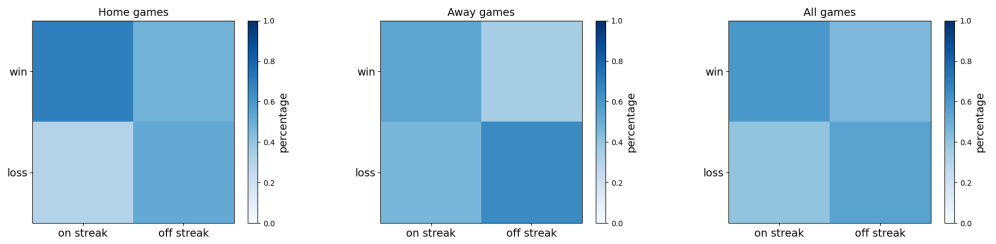

Figure 2: Percentages of the games won or lost depending on if NBA teams are on or off streak with strict momentum and a streak length of three.

Both observed properties seem to be expectable considering the existence of momentum and home-field advantage. Across all games, both effects tend to be moderated.

6 Discussion

Given the results we obtained, the question on momentum seems to be answered very clearly. Nevertheless, it is necessary to discuss three further limitations of our applied test model.

Sample size As described earlier, the p-values of each test are extremely small. The underlying reason for that is the extremely large dataset size of 16 years. While a large dataset provides a lot of statistical power, there also may be a large sample size problem leading to artificially small p-values [3]. As the defined objective of our report aims on discussing the impact of momentum in the entire NBA, we are not able to avoid this circumstance without risking a too conservative approach with many false negatives (Fisher exact test). Though, it is necessary to investigate if the observed results are also given for a smaller set of season data.

Team selection A further limitation may lie in the goal to assess momentum for all teams within the league. In fact, some less successful teams almost never experience momentum as defined in this report. This leads to a large contribution to off-streak wins and losses. As these teams predominantly contribute losses, their contribution to the overall contingency table is not balanced which can manipulate the test result. That is why we suggest to, analogous to the season data, only assessing a set of "top teams", as they are the only members that can experience momentum as defined by us. This phenomenon specifically applies to the definition of strict momentum.

Test model Lastly, as already pointed out before, different test models should be applied. Besides a model addressing alpha error accumulation, a different option is to incorporate additional features (e.g. injuries). Both concepts have already been applied by Arkes in 2011, which lead to a similar outcome to this report [2].

References

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