UNC CHARLOTTE ECONOMICS WORKING PAPER SERIES

EXPLOITING THE "WIN BUT DOES NOT COVER" PHENOMENON IN COLLEGE BASKETBALL

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Working Paper No. 2016-007

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August 2016

ABSTRACT

Wolfers (2006) was the first to document that heavy favorites in college basketball win but fail to cover the pre-game point spread at a statistically higher rate than expected. We generate a strategy to exploit this “win but does not cover” (WDNC) phenomenon using two wagers: bet the underdog (favorite) on the sides-line (money-line). Both bets win if the favorite WDNC the spread and one bet wins otherwise. The minimum-variance portfolio best exploits this anomaly, yielding an average return of 0.34% per game with a positive return in five of the seven seasons of college basketball analyzed.

Exploiting the "Win but Does Not Cover" Phenomenon in College Basketball

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Abstract

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JEL Classifications: Z22, L83,

Keywords: portfolio theory, inefficiency, betting markets

I. Introduction

Wolfers (2006) shows that heavy favorites in National Collegiate Athletic Association (NCAA) basketball, defined as teams favored to win by twelve or more points, tend to win their games but fail to cover the spread more frequently than expected.[1] While Wolfers (2006) attributes this finding to point shaving, other researchers have questioned this conclusion (see, for example, Barnhardt and Heston, 2010, and Borghesi, 2008). However, there has been no evidence disputing the finding that heavy favorites win but do not cover more frequently than expected. In this paper we create a profitable betting strategy that exploits the "win but does not cover" (WDNC) phenomenon.

Betting markets have been shown to have similar characteristics as traditional financial markets such as buyers and sellers, uncertainty and expected returns, initial offerings, and the ability to diversify across various assets. Furthermore, betting markets have characteristics beyond those of traditional financial markets in that they yield terminal values which allow researchers to compare the true price of an asset to the market or trading price (see Levitt (2004) and Avery and Chevalier (1999)).

In this paper we investigate three possible strategies to exploit the WDNC phenomenon in the context of a portfolio of bets on various college basketball games. Our approach is similar to diversification in other areas of finance: it consists of betting on the underdog against the spread, e.g. sides line, and on the favorite on the money line for NCAA Division I basketball games with a heavy favorite. This strategy utilizes a hedge to reduce the investor's exposure. We design three portfolios to exploit the WDNC phenomenon, minimum-variance portfolio, naïve strategy, where

[1] Wolfers (2006, p. 280) notes that strong favorites are those anticipated to win by more than twelve points, but his analysis shows that such strong favorites win the game but do not cover the spread more frequently than expected.

we put half of our money in both securities, and an optimal portfolio, as defined by modern portfolio theory. We show that the minimum-variance portfolio exploits this anomaly better than both the naïve strategy and an optimal portfolio.

While the optimal portfolio does well, it struggles in years when one strategy has a negative historical return. In such years, the optimal portfolio calls for investing in only the wager with the positive return which, in turn, dramatically lowers expected returns and increases the portfolio's risk exposure. The minimum-variance portfolio has many characteristics that appeal to its application in betting markets, specifically its lack of reliance on historical returns and its ability to exploit risk-based pricing anomalies, as documented by Scherer (2011), The minimum-variance portfolio yields an average return of 0.34% per game over a horizon of seven seasons, while yielding a profit in five of the seven seasons analyzed. The naïve strategy yielded an average return of 0.02% per game over the seven seasons while the optimal portfolio had an average return of -0.41% per game over the seven seasons.

II. Overview on Betting Markets

Our analysis utilizes both the sides line and the money line. On either line one can bet on the favorite or the underdog.[2] The sides line reflects the anticipated point differential at the end of the game. A bet on the underdog (favorite) wins as long as the point differential is less (greater) than the sides line, otherwise the bet loses; if the game ends with a point differential that is the same as the line, commonly referred to as a push, there are no winners or losers and all bets are returned. The sides line is commonly set so that the expected value of betting on either side of the line is approximately equal. A fair bet of $100 would win $100 plus the initial bet; however, the

[2] It is also possible to look at both bets from the home team-away team prospective.

bookmaker charges a vigorish, similar to a transaction fee in traditional financial markets, which results in a bettor typically having to bet $105 to win a $100.[3]

A bet on the money line is a bet on either the favorite or the underdog winning regardless of the score differential. In the absence of transaction costs imposed by the bookmaker, money lines should reflect the fair probability of each team winning. However, because the bookmaker charges a vigorish, an adjustment to the actual money line is needed to calculate the fair odds (see Sauer, 2005). The money line for the underdog (favorite) is posted as a positive (negative) wager. The positive money line for the underdog indicates how much will be won on a $100 wager on the underdog if the underdog were to win as well (in addition to the original wager). The negative money line for the favorite indicates the amount of money that must be wagered to win $100 if the favorite were to win. [4] Due to the vigorish charged by the bookmaker, it is always the case that the amount one bets on the favorite in order to win a $100 is greater than the amount one wins on a $100 bet on the underdog. Since both the sides line and money line already include the vigorish, when returns or profits are discussed in this paper they already incorporate the transaction cost charged by the bookmaker. Hence, the returns in this paper already represent net profits/losses to the bettor (investor).

In addition to the various types of betting lines available, there is a distinction between “opening lines” and “closing lines.” The timing of these lines is somewhat arbitrary, but an "opening line" is the line, i.e., the price, that the bookmaker offers when first accepting bets on a

[3] In most of our games the vigorish is set at $5, however there are several games where the vigorish is $6 or $10.

[4] If the favorite wins, the initial wager is also returned. Bettors can wager more or less than the $100 and receive a proportional payoff, for example a $50 wager payoff is half the quoted line.

particular game. A "closing line" is the final betting line offered before the game starts, i.e., the last price at which bets are accepted.

An important element of the analysis here is that in betting markets it is not possible to wager a large sum, such as $1,000,000 or more, on a single bet without the bookmaker adjusting the line (the betting markets are not “deep”). Much like the case where an individual might “move the market” in a traditional financial setting, an individual who bets a sufficiently large amount will force a bookmaker who wishes to keep its books relatively balanced to move the line to the disadvantage of the large bettor. In most gambling markets bookmakers accept bets of $10,000 or less without adjusting the line, while anything larger might be accepted only after an adjustment to the line or might even be turned away.[5] As a result, our proposed strategy is not of interest to institutional investors as the strategy is restricted to small amounts of money. However, previous studies by Barber et al. (2009) and Lee and Radhakrishna (2000) use trades of $5,000 or less as a proxy for trades by individual investors. As $5,000 can easily be bet on a given game without impacting the offered lines, the strategy discussed here would be of interest to individual investors/bettors.

III. Data

The data employed in this study were provided by SportsInsight and contain betting-market information and actual scores for 26,751 NCAA Division I men’s basketball games from the 2005-06 through the 2012-13 seasons. The data are missing betting lines for games played between

[5] Professional bettors do wager more than $10,000, by utilizing runners to place bets at multiple books simultaneously so that bookmakers do not move the line on them. It would be possible to bet a large amount of money this way but for brevity we look at the strategy of only making a bet at one book. In addition, it may be the case that some bookmakers may accept wagers of more than $10,000 on certain bets.

November 5, 2007 and January 25, 2008, which explains the limited number of games for the 2007-08 season. These missing games should not affect the results; as the results are similar to those obtained when the 2007-08 season is removed.

Of the 26,751 games in the sample 21,884 games have both an opening sides line and an opening money line, while 26,526 have both a closing sides line and a closing money line. Since the proposed strategy focuses on heavy favorites, games with a sides line less than twelve are dropped from the sample leaving 3,680 games with both opening lines and 5,404 games with both closing lines. Table 1 provides summary statistics of the opening and closing sides lines on heavy favorites and the payoffs for winning unit ($1) bets on both sides-line underdogs and money-line favorites. The maximum opening and closing sides lines in the sample is 33; some games with greater sides lines had to be dropped from the sample because money lines were not offered for these games.

<Insert Table 1 here>

In games with heavy favorites, a sides-line unit bet on (either proposition) typically pays a little over $0.95, depending on the bookmaker's vigorish.[6] Money lines for heavy sides-line favorites reflect the very high probability that the favorite will win the game outright so that payoffs for a winning money line unit bet on these heavy favorites was typically below $0.10. As a result, as reported in Table 1, a winning payoff averaged just below $0.08 for opening money lines and just below $0.07 for closing lines. However, our sample also contains some outliers. For

[6] Odds (in the form of a money line) have been added by the bookmaker to most sides lines as the lines are not always identical, implying that both outcomes are not equally likely. Even when the outcomes are equally likely SportsInsight offers different money lines such as (-105, -105) or (-106,-106). As a result, we calculate the actual payoff and return on each wager based on the money line offered.

example, the maximum winning payoff for an opening money line unit bet on a heavy favorite is $0.83 and there are 13 instances where these payoffs were above $0.20. It also appears that a market correction occurred for all these cases as the maximum winning payoff for a closing money line was just over $0.14. In addition, there was one game where the winning payoff on the closing sides-line unit bet was a surprising $7.89. For this particular game the closing sides line was 14.5 but the money line odds attached to this game were (789, -1073)[7] which creates the unusually high payoff to an underdog bet. However, it should be noted that the sides-line bet on this underdog lost so that this unique payoff had no impact on our results. All other underdog sides-line unit bets had a winning payoff of no more than $1.30 and no actual winning bet had a payoff higher than $1.15.

Table 2 shows the average returns to betting on the underdog sides-line bet and the favorite money-line bet. Panel A provides statistics on the opening lines and Panel B does the same on the closing lines.

<Insert Table 2 here>

Looking at opening line performance, neither individual wager generates a positive return in our sample. However, both have substantially smaller actual losses than their expected losses. The underdog sides-line bet yields an average return of -0.15% per game across all games in our sample. What is more surprising is the favorite money-line bet offers an average return of -0.17% per game even though the favorite wins 92.7% of the sample games. Looking at the average returns on betting at the closing lines, both bets offer a positive return for the whole sample with the underdog sides-line bet yielding a positive return in four of the eight seasons of the sample and the favorite money-line bet yielding a positive return in five out of the eight seasons of the sample. An underdog sides-line bet yields an average return of 0.29% while a favorite money-line bet yields

[7] This money line implies a $100 bet on the underdog wins $789 while a favorite bet of $1,073 wins $100.

an average return of 0.34%. The finding of positive returns in the closing lines and negative returns in the opening lines is surprising as previous studies have shown that closing lines are better forecasts of game outcomes (see Gandar et al., 1998 and 2000). Since the closing line wagers perform better, we utilize closing line wagers to construct our portfolios and generate our returns.

IV. The Win but Does Not Cover Phenomenon and Betting Strategies

There are only two possible outcomes in a basketball game, the underdog wins or the favorite wins. However, a wager in the sides line hinges on whether the favorite is able to cover the spread. Thus there are four possible game outcomes from the betting market prospective:

1) The underdog wins;
2) The favorite wins by less than the spread (WDNC);
3) The favorite wins by more than the spread;
4) The favorite wins by the same amount of points as the spread.[8]

If one were to bet on the sides line and the money line simultaneously it is possible to take advantage of the various outcomes enumerated above. Table 3 shows which bets win under the four outcomes.

<Insert Table 3 here>

Wolfers (2006) finds the WDNC (outcome 2) phenomenon occurs more often than it should under the assumption that the distribution of game outcomes around point spreads is symmetric. Using the symmetry argument, Wolfers argues that the favorite should WDNC as often as it wins and covers the sides line by no more than the sides line:

[8] This last case can only happen when the sides line is a whole number. If the sides line includes half a point, e.g., 14.5, then there are only three possible outcomes as outcome four cannot occur.

$$p(0 < Winning\ Margin < Sides\ Line) = p(Sides\ Line < Winning\ Margin < 2 \times Sides\ Line) \quad (1)$$

where p(·) indicates the objective probability of such an event occurring. Figure 3 of Wolfers (2006) shows a graphical plot of these calculations by point spread deciles. For the upper two deciles, (games in which favorites are favored by twelve or more points), this figure shows that the WDNC outcome occurs with a statistically greater probability than the equivalent, higher interval alternative. We replicate this figure with our sample of eight seasons of NCAA basketball games and find quantitatively similar results; see Figure 1.

<Insert Figure 1 here>

Since the WDNC phenomenon persists in our sample, we develop a strategy that exploits this occurrence. An underdog sides-line bet and a favorite money-line bet both win when the favorite WDNC. While it seems intuitive to bet the underdog on the sides line to exploit the WDNC phenomenon, doing this alone exposes the bettor to the downside of the favorite winning and covering the spread. Conversely, only betting the favorite in the money line leaves the bettor with a relatively small return and exposed to the unlikely but possible outcome of the underdog winning outright. By making an underdog sides-line wager and a favorite money-line wager a bettor is assured that at least one wager always wins and both wagers win if the favorite WDNC.

While betting the underdog in the sides line and the favorite in the money line does not yield a perfect hedge, it minimizes the bettor's exposure while exploiting the WDNC phenomenon. The question that remains is what percentage of the portfolio should be bet on the underdog sides-line bet and the favorite money-line bet. We test three strategies: (1) naïve approach, (2) minimum-variance, and (3) optimal portfolio in calculating portfolio weights. The naïve approach just puts half the money in both securities. The minimum-variance approach determines the percentage bet on each wager by finding the portfolio with the lowest variance; this strategy lies at the left-most point on the efficient frontier. Lastly, we determine the optimal portfolio as the portfolio that falls on the efficient frontier and maximizes the Sharpe ratio.

The minimum-variance portfolio has some characteristics that make it best suited to exploit the WDNC phenomenon in the betting market. First, it offers the portfolio with the lowest possible variance with our securities, which is beneficial because the betting market is highly volatile as there are only two possible outcomes - the bet either wins or loses.[9] Secondly, as Clarke, de Silva, and Thorley (2006) note, "the minimum-variance portfolio at the left-most point of the mean-variance efficient frontier has the unique property that security weights are independent of the forecasted or expected returns on the individual securities." In other words, the minimum-variance portfolio does not use a measure of return to calculate the portfolio weights. Not using returns is well suited for betting markets as historical returns in betting markets are often negative which leads to an optimal portfolio where all funds are "invested" in just one security, thus removing the benefit of diversification. In addition, because of the bookmaker's vigorish expected returns are negative. Third, while previous literature finds a minimum-variance portfolio outperforms a capitalization-weighted benchmark in financial markets, Scherer (2011) points out a large amount of the minimum-variance portfolio's success is the result of it leveraging known risk-based pricing anomalies. As a result, we believe that the minimum-variance portfolio should also successfully exploit the WDNC anomaly. It is because of these attributes that we expect the mean-variance portfolio will best exploit the WDNC phenomenon.

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[9] As noted above, a push is possible when the sides line is a whole number. In the case of a push, all wagers are returned. However, pushes are rare, occurring about two percent of the time in our sample.

Since Justin Wolfers first presented his research on the WDNC phenomenon at the American Economic Association Annual Meeting in January 2006 with a May 2006 publication in the *Papers and Proceedings* edition of the *American Economic Review*, the combined betting strategy we test was not publicly known prior to at least the middle of the 2005-06 college basketball season. As a result, we take the conservative approach of testing returns from our three portfolios starting with the 2006-07 season, only using 2005-06 data to calculate the proportion of the portfolio bet on each wager for the minimum-variance portfolio and the optimal portfolio. As each season passes we recalculate the weights in each security for these two portfolios, incorporating the previous year's data into calculating the weights. As a robustness test we consistently use two years of rolling data, implying the robustness check starts with the 2007-08 season.

Given that the three betting strategies have only two securities, the portfolio return and its standard deviation are calculated as:

$$Portfolio\ Return = \omega_{USL} \times R_{USL} + \omega_{FML} \times R_{FML} \quad (2)$$

$$Portfolio\ Std.Dev. = \sqrt{\omega_{USL}^2 \times \sigma_{USL}^2 + \omega_{FML}^2 \times \sigma_{FML}^2 + 2 \times \omega_{USL} \times \omega_{FML} \times COV(USL, FML)} \quad (3)$$

,

where ω_i represents the percentage of the portfolio invested in security *i*, R_i represents the average return of security *i*, σ_i represents the standard deviation of the average return of security *i*, and *COV(USL, FML)* is the covariance between the two wagers.

Table 4 Panel A provides a summary of these statistics. As seen in Table 2, the underdog sides-line wager has more risk and offers a lower return than the favorite money-line wager. This goes against conventional financial theory that suggests a security with greater risk should yield a compensating higher return. However, this unusual finding is at least partially the result of the favorite money-line bet benefiting from the so-called favorite-longshot bias, similar to that documented in Berkowitz et al. (2015).

<Insert Table 4 here>

Using the equations for portfolio return and standard deviation the opportunity set of investing in these two securities is calculated each year. Figure 2 provides a plot of the opportunity set for the 2007-08 season.[10] The naïve approach does not involve any calculations to find weights as by definition it has 50% of the portfolio bet on the underdog sides-line bet and the favorite money-line bet. This portfolio is denoted in Figure 2 with a diamond and is always in the suboptimal portion of the efficient frontier. The minimum-variance portfolio is defined by finding the portfolio weights that minimize the standard deviation of the portfolio, defined in equation 3 and is denoted in the figures by a square. This portfolio and all points that lie above it make up the efficient frontier, which is designated as a solid line in the figures. Figure 3 provides a plot of only the efficient frontier. After finding the efficient frontier the optimal portfolio is calculated by finding the capital allocation line (CAL) with the greatest slope that is tangent to the efficient frontier. The CAL crosses through the risk-free rate and a risky portfolio and therefore has a slope of:

$$S_i = \frac{R_i - R_f}{\sigma_i}. \quad (4)$$

[10] Each year's opportunity set looks similar in nature but varies as the historical returns, standard deviation, and correlation between the securities adjust as different data are utilized to calculate these variables. Whether using the cumulative data or the rolling two-year data the 2007-08 season is the only season that uses the same data in both approaches.

The optimal portfolio is noted by a triangle in the figures. Since bets in our strategy are only invested for the length of a college basketball game, which typically spans two and a half hours, we make the assumption that the risk-free rate (R_f) is zero, especially in light of the low interest rates that existed during our sample period. The optimal portfolio is the point on the efficient frontier tangential to the CAL. Figure 4 provides a plot of the efficient frontier with the optimal portfolio noted with a triangle and the CAL is plotted with a dotted line.

<Insert Figure 2, Figure 3, and Figure 4 here>

The portfolio weights calculated for the minimum-variance portfolio and the optimal portfolio are provided in Panel B of Table 4. It is important to note that in both calculations of the optimal portfolio that if the average historical return for one wager is negative all funds are allocated to the other security. Using cumulative data this only occurs in the first season, 2006-07, when the favorite money-line historic return is negative, resulting in no portion of the portfolio being allocated to the favorite money-line bet. Using the two-year rolling data, this occurs two times, once when the favorite money-line historical return is negative, in 2012-13, and once when the underdog sides-line historical return is negative, in 2008-09. It is these occurrences that leave the optimal portfolio exposed due to its lack of diversification.

V. Strategy Performance

Table 5 provides the performance of all three portfolios on a yearly basis as well as their cumulative performances under both approaches to calculate the portfolio weights. Panel A provides the results with cumulative data and Panel B provides the results with the two-year rolling data. To examine the performance of our portfolio, we report the return per game and the dollar performance of investing \$5,000 on each game. While it can be argued that one can invest \$10,000 on each game without affecting the betting line, we use \$5,000, following Barber et al. (2009) and

Lee and Radhakrishna (2000), to proxy for individual investor trades, i.e. small trades. The results from all strategies are provided in Table 5.

The minimum-variance portfolio has the best average game return with a 0.34% average game return using the cumulative data and a 0.24% average game return using rolling data. This strategy leads to a profit of $81,623.06 on a $5,000 wager on each game using the cumulative data and a profit of $50,031.78 using the two-year rolling data. The naïve portfolio offers positive returns of 0.02% and 0.20% using the cumulative and rolling data, respectively; the difference between the two returns is that the 2006-07 year is not included in the two-year rolling data. The optimal portfolio yields an average return per game of -0.41% with cumulative data and -0.73% with the two-year rolling data. However, as mentioned above, the optimal portfolio directs all of money placed on one bet in three of the thirteen annual calculations. It is in two of these three years, 2006-07 in the cumulative data and 2012-13 in the two-year rolling data, that the portfolio takes a loss exceeding $100,000 and has an average daily game loss exceeding 3.6%.

As expected, the optimal portfolio's lack of diversification in some years leaves the investor highly exposed to massive losses, highlighting the importance of diversification through our strategy of investing in both the underdog in the sides-line and the favorite in the money-line. This leads to an important question: does the minimum-variance portfolio actually have the lowest amount of variation in its returns? It is clear from the per-game standard deviation reported in Table 5 that the minimum-variance portfolio lives up to its name and yields a smaller measure of volatility than the other portfolios. The standard deviation in the minimum-variance portfolio is less than half that of the other strategies regardless of which approach is utilized. This reduction in the portfolio's risk adds to the appeal of utilizing the minimum-variance portfolio to exploit the WDNC phenomenon.

In our strategy at least one of the bets wins and both wagers win when the favorite WDNC. Therefore, the distribution of the returns for the three portfolios are plotted in Figure 5(a), Figure 5(b) and Figure 5(c). As can be seen, the returns to these strategies are not Normal nor are they easily classified using any standard distribution. As a result, traditional tests of statistical significance, such as t-tests or z-tests, are not appropriate. To examine significance we bootstrap the average return for each portfolio using 5,000 iterations with replacement and create 95% confidence intervals centered on the median of the 5,000 bootstrap samples using the 2.5th percentile and 97.5th percentile to define the upper and lower bounds of the bootstrapped 95% confidence interval.[11]

The optimal portfolio is the only strategy that significantly outperforms the expected return at the five-percent level over the entire sample and a year by year examination as well. In other words, it is the only strategy for which the average expected return falls to the left of the lower bound of the bootstrap 95% confidence interval, both for the entire sample period and for each individual year. However, only in the 2009-10 season is the minimum-variance and the optimal portfolio return statistically greater than zero at the ten percent level. In other words, for these two portfolios and for these two years the value zero falls to the left of the bootstrap 90% confidence interval.[12] The naïve returns are never significantly different from zero at conventional levels.

We do not annualize our returns as the college basketball season spans from November to April and there is not always a game with a heavy favorite every day during the season. For example, in our sample we never observe a heavy favorite in a game played in April. Hence, we report average returns on a per-game basis.

[11] We do not present the bootstrap results for brevity. However, the results are available from the authors upon request.
[12] We calculate the bootstrap 90% confidence level as being centered on the median of the 5,000 bootstrap average actual returns with the upper and lower bound defined by the 95th and 5th percentile of the 5,000 bootstrap average actual returns. These results are also available from the authors upon request.

VI. Conclusion

We develop a betting strategy that exploits the "win but does not cover" phenomenon first documented by Wolfers (2006). Our strategy of betting on the underdog in the sides line and the favorite in the money line provides a partial natural hedge, where both bets win when the favorite "wins but does not cover" and at least one of the bets wins in any other outcome. The strategy of using a minimum-variance portfolio exploits the WDNC phenomenon while offering a smaller amount of risk in the portfolio than the naïve portfolio or the optimal portfolio. The minimum-variance portfolio outperforms the naïve portfolio and the optimal portfolio offering a 0.34% average game return with the cumulative returns approach which generates $81,623.06 of profit from betting $5,000 per game over the seven year horizon of 2006-07 through 2012-13. This strategy also offers a profit in five of the seven seasons. While the return is not significantly different from zero it is significantly different from the expected loss, due to the bookmakers' vigorish. As expected, the minimum-variance portfolio also has the lowest volatility in its returns compared to the other strategies, adding to its appeal in exploiting the WDNC phenomenon.

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TABLE 1. Summary Statistics

Table 1 offers summary statistics on the sides line (SL) and the expected payoff on a unit bet on the sides-line underdog bet and the money-line (ML) favorite bet. Panel A provides the opening line summary statistics while Panel B provides the closing line summary statistics.

	Favorite Sides Line	Winning Payoff on a $1 Bet on the Underdog SL	Winning Payoff on a $1 Bet on the Favorite ML
Panel A: Opening Lines (3,680 Games)			
Mean	15.1891	$0.9508	$0.0777
Std. Dev.	2.9316	$0.0088	$0.0465
Minimum	12.0000	$0.8621	$0.0020
Maximum	33.0000	$1.1100	$0.8333
Panel B: Closing Lines (5,404 Games)			
	Favorite Sides Line	Winning Payoff on a $1 Bet on the Underdog SL	Winning Payoff on a $1 Bet on the Favorite ML
Mean	16.0168	$0.9540	$0.0670
Std. Dev.	3.6322	$0.1032	$0.0337
Minimum	12.0000	$0.7519	$0.0020
Maximum	33.0000	$7.8900	$0.1429

TABLE 2. Returns on Bets

Table 2 offers the performance of the underdog sides-line bet and the favorite money-line bet on heavy favorites over the entire data as well as on a yearly basis. Panel A provides the performance of the opening lines while Panel B provides the performance of the closing lines.

PANEL A: Opening Lines

		Sides Line				Money Line		
	Observations	Actual Return on Underdog	Expected Return on Underdog	# of Games Underdog Wins	# of Games That End in a Push	Actual Return on Favorite	Expected Return on Favorite	# of Games Favorite Wins
ALL	3680	-0.1535%	-2.4703%	1886	81	-0.1669%	-2.4298%	3413
2012-13	719	-1.7647%	-2.8314%	364	13	-0.2495%	-2.8182%	668
2011-12	586	1.3117%	-2.3975%	304	10	-0.4470%	-2.5041%	537
2010-11	485	3.8929%	-2.3794%	259	13	-1.3112%	-2.4991%	440
2009-10	686	-1.0953%	-2.3800%	348	24	0.4944%	-2.5342%	642
2008-09	701	-0.4173%	-2.3766%	358	12	0.1236%	-1.9921%	658
2007-08	6	-34.9206%	-2.3810%	2	0	1.3846%	-2.6639%	5
2006-07	497	-1.4071%	-2.3806%	251	9	0.0586%	-2.1830%	463
2005-06		N/A	N/A			N/A	N/A	

PANEL B: Closing Lines

		Sides Line				Money Line		
	Observations	Actual Return on Underdog	Expected Return on Underdog	# of Games Underdog Wins	# of Games That End in a Push	Actual Return on Favorite	Expected Return on Favorite	# of Games Favorite Wins
ALL	5404	0.2865%	-2.4227%	2714	121	0.3378%	-2.3233%	5088
2012-13	809	-4.0166%	-2.8121%	393	13	0.5989%	-2.6697%	763
2011-12	751	-2.9337%	-2.3984%	366	14	0.3155%	-2.3392%	705
2010-11	746	3.2825%	-2.3646%	385	18	-1.0863%	-2.3066%	693
2009-10	834	3.8590%	-2.3634%	430	25	0.9611%	-2.4046%	791
2008-09	723	0.8241%	-2.3470%	365	15	-0.0946%	-1.9757%	680
2007-08	264	-1.0742%	-2.3540%	130	8	1.9333%	-2.4061%	252
2006-07	677	-3.6895%	-2.3254%	326	15	1.4894%	-2.1315%	645
2005-06	600	5.8656%	-2.3139%	319	13	-0.5628%	-2.3425%	559

TABLE 3. Betting Lines that Win by Possible Game Outcomes

Table 3 indicates which wager on the sides line and money line wins in the four possible outcomes of a basketball game in a betting market.

	Underdog Wins	Favorite Wins		
	Underdog Wins	Favorite Wins But Does Not Cover	Favorite Wins By Amount Equal to Spread (i.e. Push)	Favorite Wins And Covers
Sides Line	Underdog	Underdog	No Winner	Favorite
Money Line	Underdog	Favorite	Favorite	Favorite

TABLE 4. Portfolio Statistics

Panel A provides historical average returns per game for the cumulative data and the two-year rolling data. Panel B provides the calcualted security weights for both the minimum-variance portfolio and the optimal portfolio on a seasonal basis using the cumulative and rolling weights.

PANEL A: Line Performance

	Money Line				Sides Line				
	Cumulative Data		Rolling Data		Cumulative Data		Rolling Data		
	Average Return per Game	Std. Dev. of Average Return	Average Return per Game	Std. Dev. of Average Return	Average Return per Game	Std. Dev. of Average Return	Average Return per Game	Std. Dev. of Average Return	Covariance Between Bets
ALL	0.338%	0.2522			0.287%	0.9653			-0.0602
2012-13	0.292%	0.2527	-0.383%	0.2671	1.044%	0.9654	0.164%	0.9669	-0.0602
2011-12	0.287%	0.2516	-0.006%	0.2564	1.821%	0.9647	3.587%	0.9632	-0.0601
2010-11	0.618%	0.2454	0.471%	0.2451	1.469%	0.9648	2.450%	0.9650	-0.0593
2009-10	0.491%	0.2483	0.448%	0.2462	0.589%	0.9658	0.316%	0.9659	-0.0567
2008-09	0.766%	0.2458	1.614%	0.2277	0.479%	0.9649	-2.956%	0.9652	-0.0587
2007-08	0.525%	0.2499	0.525%	0.2499	0.800%	0.9661	0.800%	0.9661	-0.0575
2006-07	-0.563%	0.2714	-0.563%	0.2714	5.866%	0.9628	5.866%	0.9628	-0.0599

PANEL B: Weights for Portfolios

	Cumulative Weights				Rolling Weights			
	Money Line Minimum-Variance	Sides Line Minimum-Variance	Money Line Optimal Portfolio	Sides Line Optimal Portfolio	Money Line Minimum-Variance	Sides Line Minimum-Variance	Money Line Optimal Portfolio	Sides Line Optimal Portfolio
2012-13	88.894%	11.106%	79.897%	20.103%	87.852%	12.148%	0.000%	100.000%
2011-12	88.980%	11.020%	73.931%	26.069%	88.700%	11.300%	47.201%	52.799%
2010-11	89.413%	10.587%	84.203%	15.797%	89.482%	10.518%	76.835%	23.165%
2009-10	89.176%	10.824%	88.325%	11.675%	89.360%	10.640%	90.675%	9.325%
2008-09	89.343%	10.657%	91.033%	8.967%	90.597%	9.403%	100.000%	0.000%
2007-08	89.035%	10.965%	86.859%	13.141%	89.035%	10.965%	86.859%	13.141%
2006-07	87.528%	12.472%	0.000%	100.000%				

TABLE 5. Performance of Three Portfolio Strategies

Table 5 provides the average net return for each strategy on a per game basis over each season and the entire dataset. It also offes the net profit for betting $5,000 per game and per game standard deviation using each strategy. Panel A reports each strategy's performance using the cumulative approach while Panel B offers each strategy's performance using eh two-year rolling approach to calcualte historical returns.

PANEL A: Cumulative Data

	Naïve Portfolio		Minimum-Variance Portfolio		Optimal Portfolio	
Year	Avg Return	$5,000/Game Performance	Avg Return	$5,000/Game Performance	Avg Return	$5,000/Game Performance
ALL	0.020%	$ 4,799.13	0.340%	$ 81,623.06	-0.412%	$ (98,884.31)
2012-13	-1.709%	$ (69,123.61)	0.086%	$ 3,489.74	-0.329%	$ (13,307.03)
2011-12	-1.309%	$ (49,155.85)	-0.043%	$ (1,597.45)	-0.532%	$ (19,958.57)
2010-11	1.098%	$ 40,959.24	-0.624%	$ (23,265.12)	-0.396%	$ (14,775.57)
2009-10	2.410%	$ 100,499.16	1.275%	$ 53,156.29	1.299%	$ 54,184.38
2008-09	0.365%	$ 13,186.82	0.003%	$ 120.58	-0.012%	$ (440.65)
2007-08	0.430%	$ 5,669.73	1.603%	$ 21,166.13	1.538%	$ 20,302.32
2006-07	-1.100%	$ (37,236.36)	0.844%	$ 28,552.90	-3.689%	$ (124,889.18)
Standard Deviation		$ 2,340.37		$ 1,109.19		$ 2,124.69

PANEL B: Rolling Data

	Naïve Portfolio		Minimum-Variance Portfolio		Optimal Portfolio	
Year	Avg Return	$5,000/Game Performance	Avg Return	$5,000/Game Performance	Avg Return	$5,000/Game Performance
ALL	0.204%	$ 42,035.48	0.242%	$ 50,031.78	-0.725%	$ (149,582.41)
2012-13	-1.709%	$ (69,123.61)	0.038%	$ 1,543.97	-4.017%	$ (162,471.71)
2011-12	-1.309%	$ (49,155.85)	-0.052%	$ (1,938.23)	-1.400%	$ (52,570.68)
2010-11	1.098%	$ 40,959.24	-0.627%	$ (23,378.35)	-0.074%	$ (2,768.68)
2009-10	2.410%	$ 100,499.16	1.269%	$ 52,933.93	1.231%	$ 51,344.92
2008-09	0.365%	$ 13,186.82	-0.008%	$ (295.66)	-0.095%	$ (3,418.58)
2007-08	0.430%	$ 5,669.73	1.603%	$ 21,166.13	1.538%	$ 20,302.32
Standard Deviation		$ 2,338.63		$ 1,120.79		$ 2,563.14

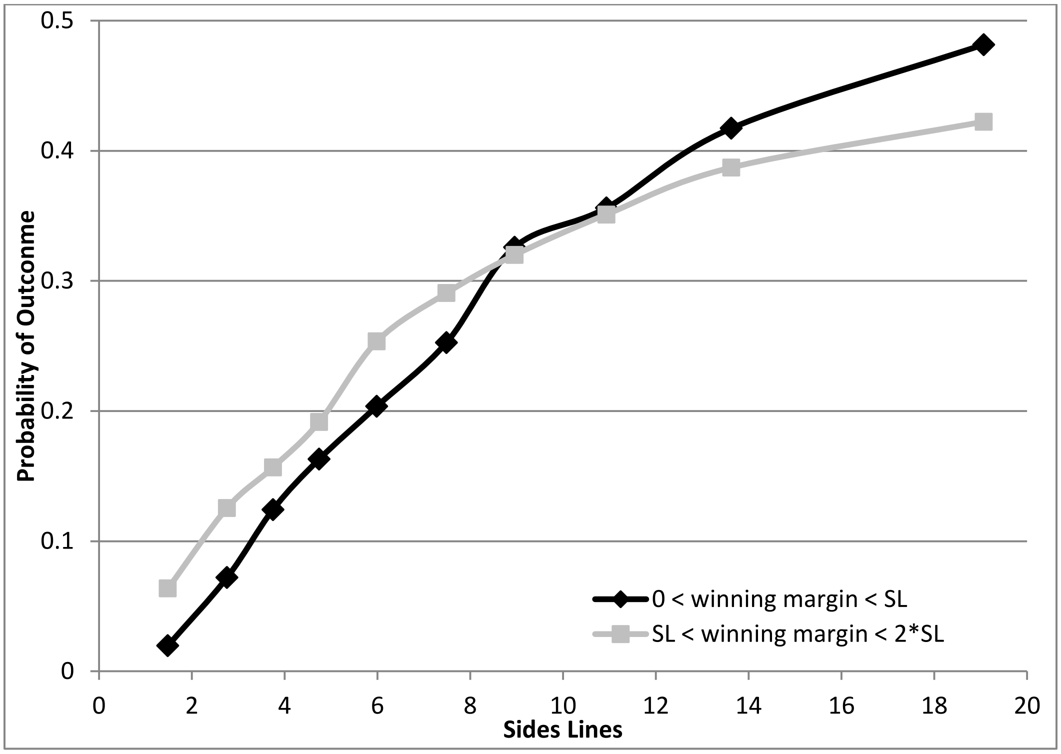


Figure 1: NCAA Betting Lines and Game Outcomes. The figure displays the frequency of the favorite winning but not covering and the favorite winning and covering by no more than the sides line in our sample of 5,404 NCAA men's basketball games.

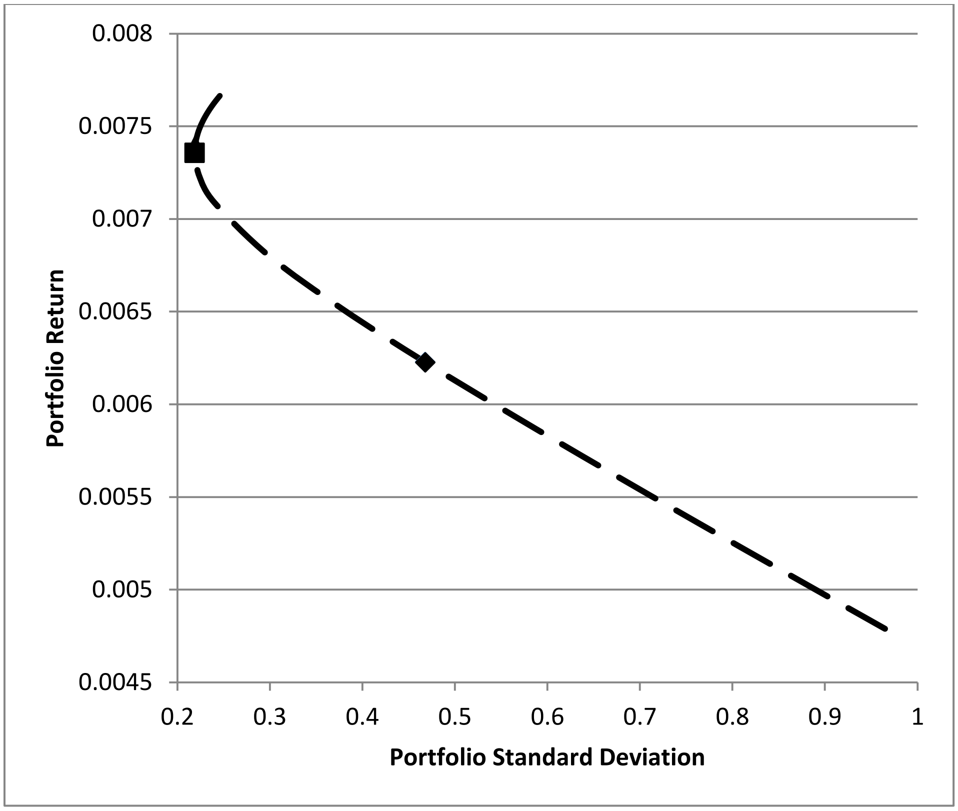


Figure 2: Opportunity Set to Exploit the WDNC Phenomenon. The figure displays the opportunity set available from betting on both the underdog in the sides-line market and the favorite in the money-line market for the 2007-08 season. The dotted line shows the opportunity set that is below the minimum variance portfolio, noted by a black square, while the solid line provides the efficient frontier that includes the minimum-variance portfolio and all points with a return above the minimum variance portfolio's return. The naïve portfolio is also represented by a black diamond and lies in the suboptimal portion of the efficient frontier.

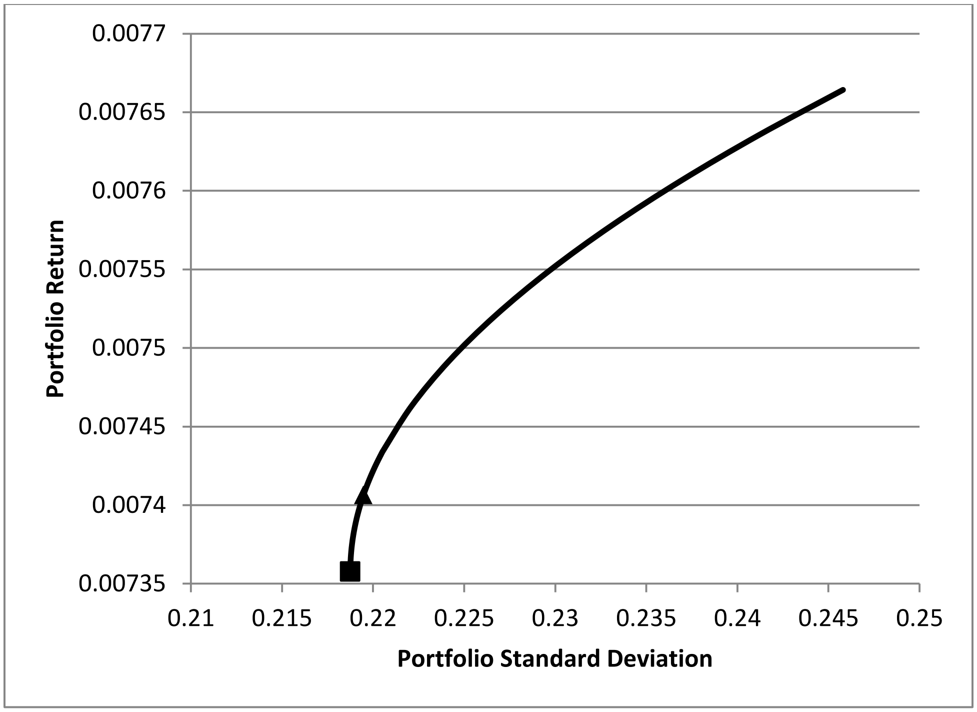


Figure 3: Efficient Frontier to Exploit the WDNC Phenomenon. The figure shows the efficient frontier for exploiting the WDNC phenomenon by betting on the underdog in the sides line and the favorite in the money line. The optimal portfolio is indicated by a black triangle while the minimum-variance portfolio is indicated by a black triangle.

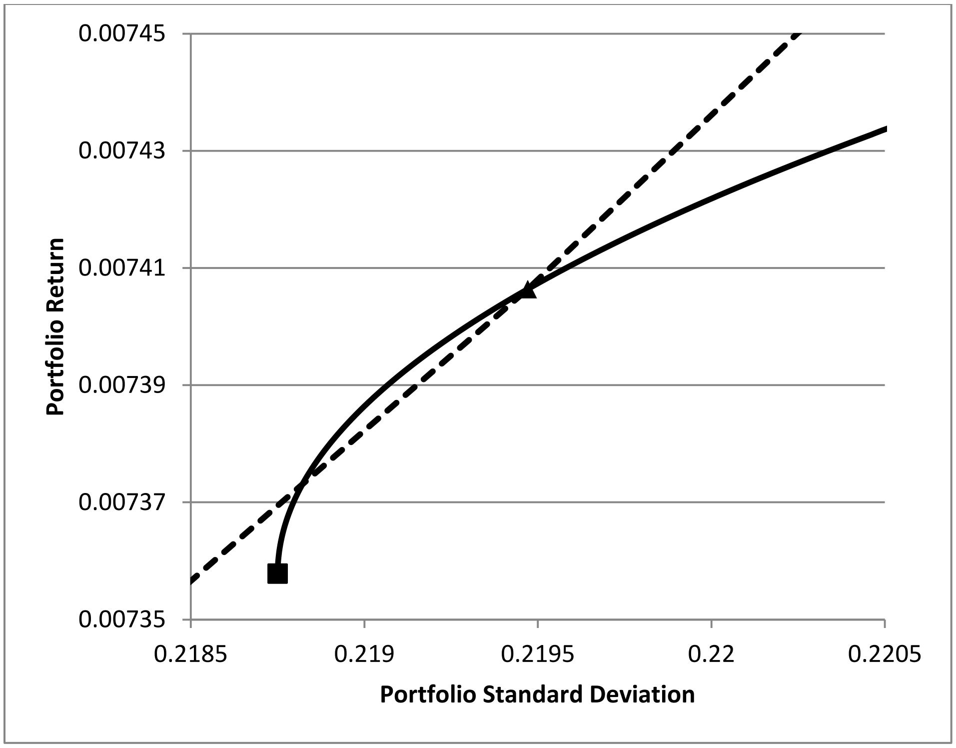
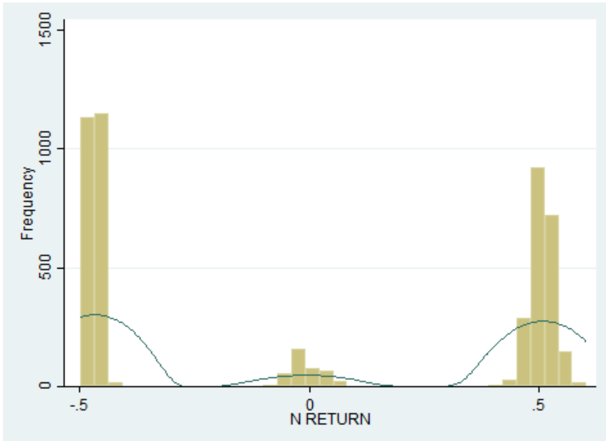
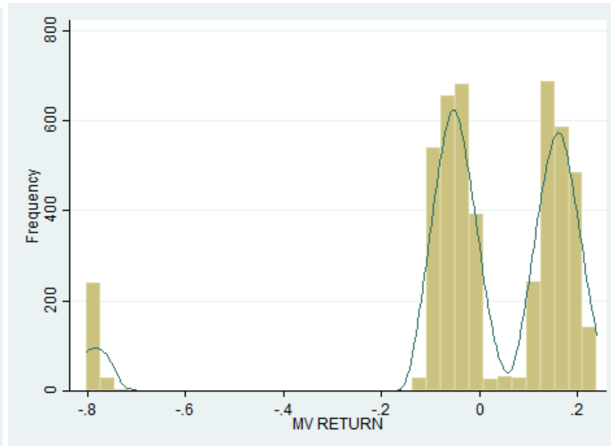


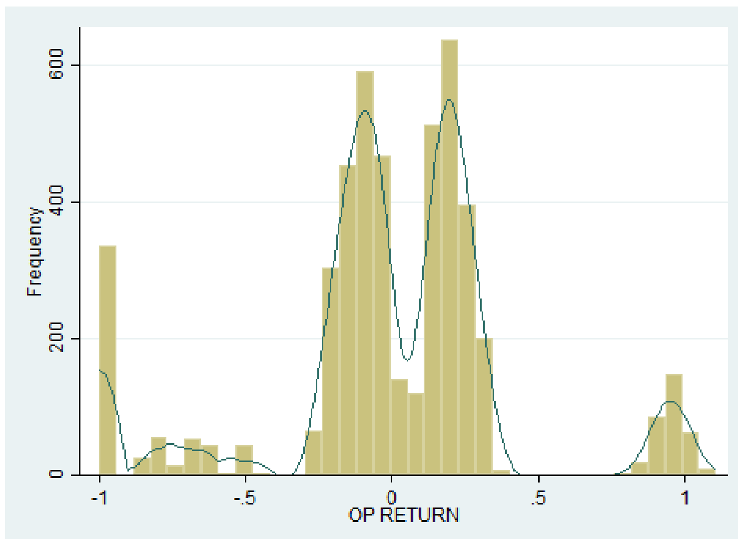
Figure 4: Optimal Portfolio to Exploit the WDNC Phenomenon. The figure shows the efficient frontier, indicated by a solid black line, and the Capital Allocation Line, indicated by a dotted black line, as well as the tangent point between these two lines, known as the optimal portfolio, indicated by a triangle. The minimum-variance portfolio is also noted by a black square.





(a)

(b)



(c)

Figure 5: Distributions of Portfolio Returns: The figures show the histogram of returns for each portfolio with (a) the naïve portfolio, (b) the minimum-variance portfolio, and (c) the optimal portfolio. In each graph the solid line is a kernel density approximation of the return distribution.