Does the Basketball Market Believe in the 'Hot Hand,'?

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Most people who watch basketball believe in the "hot hand": Players who make a shot are more likely to hit the next shot than players who miss a shot (i.e., shots are positively autocorrelated rather than independent). Almost everyone in the sample studied by Thomas Gilovich, Robert Vallone, and Amos Tversky (1985), including several successful professionals, believed in the hot hand.

There is no hot hand in basketball shooting. Gilovich et al. found that the outcomes of consecutive shots are approximately independent. (In fact, outcomes are slightly *negatively* autocorrelated). They rejected many explanations of their surprising finding. For instance, the hot hand might be masked because players defend more aggressively after a player has made a shot. But shots are also independent during free-throw shooting and in experiments with college players in which there is no defensive pressure. (Their paper contains several other clever demonstrations; the still-skeptical reader should consult it).

Belief in the hot hand is a mistake generated by persistent misunderstanding of randomness. People usually expect more alternations and fewer long streaks than actually occur in a random series (Willem Wagenaar, 1972). They expect properties of large samples, like convergence of the relative frequency of heads to the population parameter 0.5, to hold in small samples too (see Tversky and Daniel Kahneman, 1971). While watching a random process, it is therefore easy to believe that the expected alternations do not occur because observations are actually positively autocorrelated.[1]

Does Belief in the Hot Hand Matter for Economics? The important question for economics is whether mistaken beliefs like the hot hand fallacy make allocations of resources suboptimal. Every basketball game provides casual evidence that belief in the hot hand affects coaches' choices of which players should shoot or leave the game, but it is difficult to tell whether these decisions are important mistakes without an experimental comparison of coaching techniques (which no team owner would allow!)

While a study of coaching decisions is virtually impossible, a resource-allocation question that can be answered is whether belief in the hot hand affects betting. It does. Gilovich et al. had college players take shots while the players (and other observers) bet small or large amounts on the outcome.[2] Both players and observers made larger bets after players had just made shots, as the hot hand theory prescribes, but bet size and actual performance were uncorrelated.

If people believe that players have hot hands within a game, and belief in the hot hand stems from misunderstanding of random sequences in general, then bettors should also believe teams have hot and cold streaks across games. (For instance, suppose bettors expect that teams with losing streaks are due for wins. When they lose more often than expected, bettors will come to believe in cold and hot hands). This conjecture can be tested by examining point spreads and actual results.

The point spread is the number of points the favored team is expected to win by. If Philadelphia is favored by 6 over Boston, a

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[1]That is, if one creates a "random" series which actually has negative autocorrelation—too few long runs—then a truly random series with zero autocorrelation will seem to have positive autocorrelation and too many long runs.

[2]All the bets paid a positive amount if the shot was made and a negative amount if the shot was missed, so the shooter had no incentive to miss deliberately.

bet on Philadelphia wins only if they win the game by 7 points or more. (A win by 6 points is a tie, neither a win nor a loss).

If bettors overestimate the magnitude of the hot hand, teams with winning (losing) streaks will have point spreads which are *too high* (*low*) compared to actual results.

Point spreads are set by bookmakers to balance the dollar amount bet on each team, thus minimizing their risk and guaranteeing revenue. (Their revenue comes from charging a percentage of losing bets). While point spreads are offered by bookmakers, they are an expression of the dollar-weighted average opinion of the public. If most fans believe in the hot hand but a few high rollers do not, then point spreads might reflect no hot hand fallacy even if most people believe in it. This test thus makes a small contribution to the empirical and theoretical debate about whether judgment errors by individuals matter for economics (for example, Robin Hogarth and Melvin Reder, 1987; my 1987 paper and my 1989 paper with George Loewenstein and Martin Weber).

The Data. The data are actual results and published betting odds on professional basketball games between 1983–86.[3] (Betting on such games is illegal in the United States, except in Nevada and Atlantic City, but is common anyway). Playoff games were excluded because data were more difficult to find and systematic elimination of teams meant that most streaks were short.

In each game both teams have a previous winning or losing streak of some length. We take the game as data for the team with the longest streak.[4] Point spreads are forecasts, so the difference between the point spread and the actual outcome is a forecast error. We take the performance of the team with the longest streak against the point spread (the forecast error) and put it in a sample with forecast errors in games played by teams with streaks of identical length. Thus, one sample consists of the forecast errors of games played by teams with 1-game winning streaks, another sample consists of errors from games with 2-game streak teams, etc.

Subsamples of games in which teams with winning streaks played teams with losing streaks were created. These subsamples are useful because the hot hand effect might be strongest when a team with a winning streak plays a team with a losing streak (instead of playing a team with a shorter winning streak). In each sample, the mean forecast error and the fraction of positive forecast errors (excluding ties, which were rare) were calculated.

The Results. Statistics for games involving winning streaks are shown in Table 1. Superscripts a, b, and c denote statistical significance (by t-tests for means and binomial tests for fractions) at the 0.10, 0.05, and 0.01 levels.

Consider the 1983–84 season (left columns). There were 59 times when teams with 1-game winning streaks played teams with streaks that were shorter or equal in length. The teams with 1-game streaks beat the spread 59 percent of the time, by an average of 1.44 points.

If point spreads reflect mistaken belief in the hot hand, teams with winning streaks should do *worse* than expected; forecast errors should be negative. They *are* mostly negative—teams with winning streaks are thought to have hotter hands than they actu-

[3] The source was the NBA Pointspread Handbook sold by Tony Salinas' High Roller Inc., Las Vegas. Two seasons of data were checked against point spreads published in the *Philadelphia Inquirer*; no discrepancies of more than a point were found. Salinas's data are "closing lines," reflecting bookmakers' adjustment of the initial "opening line" for imbalances in betting.

[4] For instance, if Philadelphia has a winning streak of 6 games and plays Boston, which has a losing streak of 3 games, the outcome is only used as evidence of how teams with 6-game winning streaks perform. To use the same observation as evidence for streaks of $+6$ *and* -3 would cause statistical dependence across streak categories. This procedure also shifts observations from short streaks to long streaks, which improves overall statistical power because short streaks are common and long streaks are rare. (Indeed, basketball is useful to study because it contains more long streaks than most other sports, and point spreads are used rather than odds). When two teams had equal-length streaks of opposite sign, the observation was randomly assigned to streaks of one of the two signs.

TABLE 1—MARKET FORECAST ERRORS (OUTCOMES MINUS POINT SPREADS) FOR TEAMS WITH WINNING STREAKS

Streak Length	1983–84 Mean Error	1983–84 Fraction Positive	1983–84 n	1984–85 Mean Error	1984–85 Fraction Positive	1984–85 n	1985–86 Mean Error	1985–86 Fraction Positive	1985–86 n	All Years Mean Error	All Years Fraction Positive	All Years n
Against All Teams												
+1	1.44	0.59	59	1.07	0.49	61	−1.30	0.47	53	0.47	0.52	173
+2	1.47	0.55	113	1.25	0.50	106	0.84	0.47	118	1.18[b]	0.51	337
+3	−2.33[a]	0.49	103	−1.51	0.40[a]	81	1.36	0.53	83	−0.93	0.47	267
+4	0.28	0.51	51	−0.55	0.48	58	−2.02	0.38[a]	50	−0.75	0.46	159
+5	−2.54	0.40	35	−2.47	0.47	32	−0.31	0.51	35	−1.75	0.46	102
+6	−3.21	0.26[a]	19	1.38	0.54	24	0.44	0.44	18	−0.33	0.43	61
+7	−0.81	0.54	13	2.31	0.63	16	−2.92	0.23	13	−0.27	0.48	42
+8	−4.86	0.14	7	2.67	0.50	12	−2.10	0.30	10	−0.79	0.34[a]	29
≥ 9	−9.50	0.00	3	−2.10	0.41	17	−3.11	0.50	18	−3.16[b]	0.42	38
Total	−0.49	0.50	403	0.08	0.48	407	−0.19	0.46	398	−0.20	0.479	1208
Against Teams with Losing Streaks												
+1	1.44	0.59	59	1.07	0.49	61	−1.30	0.47	53	0.47	0.52	173
+2	4.26[c]	0.64[b]	56	0.66	0.49	61	−0.27	0.44	62	1.46[a]	0.52	179
+3	−2.75	0.49	53	−1.74	0.38[a]	50	0.51	0.49	43	−1.44	0.45	146
+4	1.43	0.59	29	0.47	0.52	31	−1.52	0.48	25	0.21	0.53	85
+5	−3.44	0.39	18	−2.5	0.47	17	1.13	0.60	15	−1.78	0.48	50
+6	−3.36	0.29	7	3.16	0.63	16	1.42	0.50	12	1.26	0.51	35
+7	2.31	0.75	8	−6.17	0.33	6	−1.25	0.50	4	−1.31	0.56	18
+8	−7.00	0.33	3	−0.50	0.33	3	2.00	0.50	4	−1.45	0.40	10
≥ 9	−18.50	0.00	1	−4.83	0.44	9	−5.75	0.50	8	−6.00[c]	0.44	18
Total	0.48	0.56[a]	234	−0.17	0.47	254	−0.49	0.48	226	−0.06	0.501	714

[a] $p < 0.10$.
[b] $p < 0.05$.
[c] $p < 0.01$.

ally do—when data from all three seasons are pooled. However, the effects are very small, they do not increase much with streak length (except for the striking results for streaks of 9 wins or more), and the effects are not stronger when teams with winning streaks played teams with losing streaks.

Data from teams with losing streaks, shown in Table 2, also provide some evidence of hot hand fallacy. The forecast errors are mostly positive—losing-streak teams do better than expected—and pooled means are often statistically significant. But the effects are still small in magnitude.

The asymmetry in results between winning and losing streaks is curious. It is reminiscent of Werner De Bondt and Richard Thaler's (1985) finding that stocks of firms which have lost market value ("losers") rebound in price more than stocks of winner firms drop. People seem to believe there is more permanence to losing than to winning, and they overestimate this permanence.

Bookmakers profit by charging a percentage of losing bets (usually 10 percent). Bettors must therefore win 52.4 percent of their bets to break even.[5] Table 2 shows that across the three seasons, bets on teams with losing streaks would *exactly* break even. Bets against teams with winning streaks (see Table 1) win 52.1 percent of the time, almost breaking even.

Discussion. The answer to my title question is Yes, but the market's error is too small to be profitably exploited. The data

[5]The break-even winning probability p is determined by $p+(1-p)(-1.1)=0$, which implies $p=1.1/2.1=0.524$.

TABLE 2—MARKET FORECAST ERRORS (OUTCOMES MINUS POINT SPREADS) FOR TEAMS WITH LOSING STREAKS

Streak Length	1983–84 Mean Error	1983–84 Fraction Positive	1983–84 n	1984–85 Mean Error	1984–85 Fraction Positive	1984–85 n	1985–86 Mean Error	1985–86 Fraction Positive	1985–86 n	All Years Mean Error	All Years Fraction Positive	All Years n
Against All Teams												
−1	1.89	0.39[a]	59	1.76	0.57	56	1.53	0.62[a]	58	1.73[b]	0.53	173
−2	0.39	0.53	111	1.22	0.55	95	−0.42	0.48	118	0.34	0.52	324
−3	1.08	0.51	89	2.16[a]	0.55	83	1.12	0.49	76	1.45[a]	0.52	248
−4	0.19	0.53	59	−0.76	0.55	51	1.88	0.54	48	0.40	0.54	158
−5	−0.61	0.39	36	−0.64	0.45	29	1.36	0.52	33	0.04	0.45	98
−6	6.30[b]	0.65	20	0.33	0.60	20	0.06	0.53	17	2.34[a]	0.60	57
−7	0.44	0.44	9	−2.23	0.55	11	−1.00	0.38	16	−1.02	0.44	36
−8	1.92	0.67	6	−4.00	0.40	5	11.11[c]	1.00	9	4.58[a]	0.75[b]	20
≤ −9	11.00	1.00	2	1.21	0.58	19	0.80	0.60	5	1.88	0.62	26
Total	1.03	0.50	391	0.87	0.55[b]	369	0.92	0.53	380	0.94	0.524[a]	1140
Against Teams with Winning Streaks												
−1	1.89	0.39	59	1.76	0.57	56	1.53	0.62[a]	58	1.73[a]	0.53	173
−2	0.14	0.55	60	2.15	0.57	54	−0.98	0.46	59	0.39	0.53	173
−3	0.31	0.51	51	0.70	0.58	40	2.74	0.47	38	1.15	0.52	129
−4	−1.38	0.44	32	0.17	0.56	27	3.68	0.64	25	0.62	0.54	84
−5	−5.13[a]	0.25	12	1.78	0.58	19	2.13	0.60	15	0.09	0.50	46
−6	6.83	0.78	9	1.44	0.56	9	−0.44	0.56	9	2.61	0.65	26
−7	−1.13	0.50	4	−6.80	0.40	5	−3.17	0.33	6	−3.84	0.40	15
−8	−6.25	0.50	2	−4.17	0.33	3	11.50[c]	1.00	6	4.00	0.73	11
≤ −9	–	–	0	1.25	0.60	10	3.33	0.67	3	1.73	0.62	13
Total	0.33	0.48	229	1.17	0.57[b]	223	1.44	0.55	219	0.97	0.531[a]	670

[a] $p < 0.10$.
[b] $p < 0.05$.
[c] $p < 0.01$.

suggest psychological and economic explanations of betting behavior are both useful. Psychological prediction of hot hand fallacy suggests the *direction* of the systematic forecast error correctly. However, the economic thesis that errors should be too small for traders to profit predicts the *size* of the forecast errors (placing an upper bound on their frequency).

The novelty in this test is that psychological evidence suggested where to find a bias, and found one. There are many other studies of betting; some conclude that simple betting strategies which exploit judgment error are profitable. A profitable rule for football betting, related to the hot hand fallacy, is to bet against favorites who beat the spread by a wide margin in the previous week (John Gandar et al., 1988, rule 7). Richard Thaler and William Ziemba (1988) reviewed many studies of betting in parimutuel markets. Betting on heavy favorites in horse races can be profitable, either because people overestimate the chance of high-odds long shots winning or because they prefer the positive skewness of long-shot bets. Betting in purely random lotteries can be profitable too because people overbet certain numbers.

In basketball betting, the hot hand fallacy exists but it is slight, perhaps because traders can study past data and exploit such errors easily. In other economic settings, rational traders cannot discipline less rational traders so easily—in labor markets, markets for housing, and illiquid assets, or in infrequent decisions about relationships, for instance. In such situations, biases like these might be especially important for economics.

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