Applied Economics, 2008, **40**, 75–87

Routledge
Taylor & Francis Group

Do horses like vodka and sponging? – On market manipulation and the favourite-longshot bias

Stefan Winter[a,*] and Martin Kukuk[b]

[a]*Chair of Human Resource Management, University of Bochum, Universitätsstraße 150D-44780 Bochum, Germany*
[b]*Chair of Econometrics, University of Wuerzburg, Sanderring 2D-97070 Wurzburg, Germany*

One of the most striking empirical patterns of horse race betting markets is the favourite-longshot bias: Bets on favourites have dramatically higher expected returns than bets on longshots. The literature offers a couple of different, though not mutually exclusive, explanations based on risk preferences and probability perceptions. This article adds a new possible explanation: The favourite-longshot bias may be the rational answer of an honest audience to a simple, but highly lucrative cheating opportunity of insiders. We provide anecdotal evidence that the type of cheating we model here really takes place. What is more, by employing a large scale German data set we are able to demonstrate that the pattern of the favourite-longshot bias changes as the opportunity of cheating vanishes. The changes we observe are in accord with the cheating model we suggest.

I. Introduction

One of the main findings of empirical racetrack research is the favourite-longshot bias (FLB). Empirically it is found that bets on longshots on average lose much more money than bets on favourites (e.g. Griffith, 1949; Weitzman, 1965; Ali, 1977; Williams and Paton, 1997; Jullien and Salanié, 2000). While the probability that the longshot will win is well below that of the favourite its payoff is of course higher. But as it turns out, it is not high enough to fully compensate for the lower probability of winning. Empirical studies have shown that the FLB exists in North America (e.g. Snyder, 1978), the UK (e.g. Bruce and Johnson, 2000), Australia (e.g. Tuckwell, 1983) and Germany (Winter and Kukuk, 2006). The FLB seems to be a stable phenomenon over time. The empirical literature documents no relevant timing effect, since the FLB has been found as early as 1949 by Griffith (1949) as well as late as 2006 by Winter and Kukuk (2006).

While earlier studies dealt mainly with pari-mutuel markets, the FLB has later also been found with respect to bookmaker odds as well (Dowie, 1976; Tuckwell, 1983; Henery, 1985; Williams and Paton, 1997; Jullien and Salanié, 2000; Bruce and Johnson, 2000, Law and Peel, 2002). All studies mentioned above concentrate only on win bets.

The literature has offered a variety of explanations of the FLB. These range from risk-loving betting strategies of rational, purely financially motivated gamblers at the one extreme to betting as a pure consumption activity with a higher consumption value of betting on longshots. A more recent approach is to explain the FLB by information deficiencies.

*Corresponding author. E-mail: stefan.winter@rub.de

Applied Economics ISSN 0003–6846 print/ISSN 1466–4283 online © 2008 Taylor & Francis
http://www.tandf.co.uk/journals
DOI: 10.1080/00036840701731538

If for example there are noise traders backing horses evenly, while informed traders back only the good horses, then the longshots will be backed by too much money given their true chances of winning and the favourites are underbet. Especially the risk-love and the misperception models have triggered much empirical work. Recent evidence is more in favour of the misperception explanation.

However, neither analytical nor any empirical work seems to be available on the likely effects of cheating by manipulation of a race's outcome. This article is a first effort in this direction. The main finding is that the FLB may be a rational response of uninformed outsiders to a very simple but eventually highly lucrative cheating opportunity of insiders. We provide anecdotal evidence that the modus operandi of cheating we model below really is put to use at times. We then present evidence that the pattern of the FLB changes significantly when the opportunity of cheating is absent.

The article is organized as follows. In Section II the main explanations for the FLB offered in the literature so far are reviewed. Section III outlines the simple model of cheating and derives the empirically testable hypotheses. Section IV reviews some anecdotal evidence on race manipulation in general and some examples for the cheating technique we discuss here. We then show that the pattern of the FLB in a large-scale German data set depends on the existence vs. nonexistence of cheating opportunities. Some caveats of our theoretical as well as empirical results are discussed in Section V. Section VI concludes.

II. Explanations of the FLB

The literature offers a variety of explanations for the FLB. One of the most prominent explanations of the FLB suggested in the theoretical literature is the assumption of homogenous bettors with a preference for risk. Bettors can then be represented by Mr Avmart, the average man at the race track (Weitzman, 1965) and the market outcome can be derived from this man's equilibrium behaviour. In a mean-variance framework of expected utility the FLB has even been shown to be the equilibrium market outcome (Quandt, 1986). Market data has then been employed to estimate the utility function of a representative bettor. Of course, when the FLB was present in the data, the representative bettor showed a preference for risk indeed (see e.g. Ali, 1977; Jullien and Salanié, 2000).

While, Quandt (1986) focuses on a mean-variance framework, others have argued that bettors may have a positive preference for skewness (see e.g. Bird *et al.*, 1987; Golec and Tamarkin, 1998; Cain *et al.*, 2002). Since returns on longshots are most highly skewed, longshots would be backed disproportionately, again resulting in the FLB.

Another idea to explain the FLB is to assume that bettors do not mainly follow financial goals. Here, gambling boils down to a consumption activity like spending money on an opera ticket. If this would be true, then it would be futile to discuss risk preferences in this context. In this line of argument it has been suggested that bettors may primarily play for fun and that it is more fun to bet on longshots (Thaler and Ziemba, 1988). The authors suggest that 'bragging rights' can only be earned by picking a longshot correctly.

On the supply side of the bookmaker market, it has been argued that bookmakers face the strongest price competition for bets on favourites but are less constrained for longshots. They are therefore able to shorten longshots' odds disproportionately, resulting in the FLB (Henery, 1985). Bookmakers in contrast to organizers of pari-mutuel markets are financially endangered by inside traders. They are extremely vulnerable by positive inside information on longshots. They therefore shorten longhots' odds even more (Shin, 1991, 1992, 1993). The incidence of insider activity is well documented in bookmaker markets (e.g. Crafts, 1985; Cain *et al.*, 2001). The strategic pricing decision of bookmakers is only a partial explanation of the FLB, though, since the bias is present in pari-mutuel markets as well.

Another explanation is that bettors simply overestimate the probability of winning for longshots (Thaler and Ziemba, 1988). This could be considered a Kahneman-Tversky (1979) type of (erroneous?) probability weighting (Hurley and McDonough, 1995). This explanation has been criticized on the grounds that races are frequent and data availability is good, offering a sound opportunity to update beliefs and arrive at correct estimates (Sauer, 1998). Still, Jullien and Salanié (2000) found a Kahneman-Tversky type of utility concept to fit their data better than rank-dependent utility or expected utility models. This latter result is corroborated by Snowberg and Wolfers (2006).

Another type of explanation of the FLB assumes that there are at least two different types of bettors. For example, Sobel and Raines (2003) use pari-mutuel data from UK greyhound races. Their prior is that the better informed bettors gamble more regularly, bet more on exotic bets and their average bet is higher as compared to more casual bettors.

Casual bettors are expected to gamble especially at weekends, while the serious bettors gamble more evenly over the week. Sobel and Raines (2003, p. 375, Table 1) show that attendance is indeed much higher at weekend races, that at weekends more of the total betting volume is bet on simple bets and that the average bet is lower. What is more, they find that the percentage of money wagered on the favourites is lower at weekends, suggesting that the casual gamblers spend too much money on longshots. This composition effect even leads to a reversal of the FLB at weekday races. It is found that the longshots perform much better than the favourites and that the extreme longshots even provide for a positive average return (Sobel and Raines, 2003, p. 379, Table 3). Since this market outcome is presumably driven by informed bettors, they exhibit risk averting behaviour. Almost no bias is found at weekends. When it comes to combined bets, the subjective calculation of wining probabilities becomes quite complex. When confronted with the combined bets, even informed bettors may not be able to do these calculations correctly. Indeed, it is found that for combined bets the usual FLB occurs. Sobel and Raines (2003, p. 382) conclude that the cause of the FLB is rather due to a lack of understanding than to a preference for risk. So the FLB is expected to occur whenever the audience is dominated by casual gamblers or when bets become too complicated. Coleman (2004) suggests that there may not only be better informed bettors but rather risk averse insiders with even positive expected returns from gambling. These insiders are confronted with a larger group of risk loving gamblers who back longshots and have negative expected returns. Both papers, Sobel and Raines (2003) as well as Coleman (2004) suggest that the FLB may vanish or be even reversed as the

Table 1. Probabilities and returns for win and show bets (taken from Kukuk and Winter, 2006)

Odds	Average			Probability of winning		Return (%)
Category i[a]	Odds[b]	# Races[c]	# Winners[d]	Empirical[e]	Implied[f]	Win bet[g]
1	0.99	0 (35608)	16231	0.456[h]	[i] 0.409[h]	−16.56[h]
2	2.85	0 (35608)	7828	0.220[h]	[j] 0.215[h]	−23.98[h]
3	5.29	1 (35608)	4574	0.128[h]	[i] 0.135[h]	−29.23[h]
4	8.86	34 (35607)	2789	0.078[h]	[i] 0.090[h]	−36.46[k]
5	14.34	328 (35573)	1826	0.051[h]	[i] 0.060[h]	−39.10[k]
6	23.56	2019 (35245)	1156	0.033[h]	[i] 0.041[h]	−43.07[k]
7	39.01	5998 (33226)	704	0.021[h]	[i] 0.028[h]	−47.37
8	61.43	10012 (27228)	349	0.013[h]	[i] 0.019[h]	−50.41
9	87.58	8882 (17216)	146	0.008	[i] 0.015[h]	−53.54
10	123.92	7210 (8334)	67	0.008	[i] 0.011[h]	−42.56
11	146.88	627 (1124)	7	0.006	[j] 0.011[k]	−34.56
12	126.29	252 (497)	4	0.008	0.010[h]	13.74
13	151.92	55 (245)	1	0.004	0.009[h]	−72.45
14	194.55	32 (190)	2	0.011[k]	0.007[h]	−36.11[k]
15	218.16	23 (158)	0	0.000	0.006[h]	−100.00
16	880.92	26 (135)	0	0.000	0.002[k]	−100.00
17	926.46	42 (109)	0	0.000	0.001	−100.00
18	922.30	65 (67)	0	0.000	0.001	−100.00
19	169.05	2 (2)	0	0.000	0.005	−100.00

Notes: [a]Odds rank; favourites ranked lowest. We break ties in the odds by order of appearance in data set. Alternative random selection does not change results.
[b]Average odds of all horses in category i. The average odds of category 19 are lower than those in category 18. This result is not an error. In the 65 races with exactly 18 horses, most of the horses ranked 18th had extremely high odds.
[c]Number of races with exactly i horses. Numbers in parentheses indicate the number of races with atleast i horses.
[d]Number of winners in odds rank i. The sum of the numbers of all winners exceeds the number of races due to 76 races with deadheads (ties).
[e]Actual winning probability of horses of odds rank i. [h]([k]) indicates that the difference in winning probabilities between category i and $i+1$ is significant at the 1% (10%) level. (one sided two-sample t-test, unequal variances).
[f]Average winning probability implied by the odds for horses of odds rank i. [h]([k]) defined as in column 5. [i]([j]) indicates that the difference between implied and empirical winning probabilities within category i is significant at the 1% (10%) level. (two sided two-sample t-test, unequal variances).
[g]Average return of win bets on all horses in category i. The positive return in category 12 is due to a single outlier that paid 433.4 to 1. [h] ([k]) indicates that the return difference between category i and $i+1$ is significant at the 1% (10%) level. (one sided two-sample t-test, unequal variances).

composition of the betting population changes from more to less outsiders or uninformed bettors.

Information problems are also at the heart of a transaction costs argument (Hurley and McDonough, 1995). They suggest that as transaction cost like the track take and costs of acquiring information on horses' capabilities increase, betting will become less informed. This results in underbet favourites and overbet longshots, i.e. the FLB. The information costs argument is empirically supported by Williams and Paton (1997). The information costs as well as the transaction costs arguments are backed by Smith *et al.* (2006).

In a sense, the cheating explanation offered below is in the tradition of the misperceptions and information problems explanations. The difference it that those models just assume that there are given informational problems while the cheating model assumes that the informational problems are intentionally 'produced' by a cheater. The advantage of the latter approach is that the conditions under which cheating and therefore informational problems may occur can be identified quite easily.

III. The Simple Model of Cheating

Assume that there are n horses in a race with given, objective probabilities of winning, denoted by $p_i, i = 1, \ldots, n$. Probabilities are common knowledge and fully reflect the horses' true capabilities. However, these probabilities may be subject to manipulation by an insider like a jockey or a trainer. In what follows, it is assumed that collusion of insiders is not feasible, so that each insider is restricted to manipulate only her own horse and eventually bet accordingly. What is more, it is assumed that there will be only one cheat per race at most so that cheaters can ignore the behaviour of other potential cheaters. The model is further restricted to analyse only cheats that make horses slower. This is not to say that there are no manipulations of horses intended to make them faster. But making them slower is likely to be performed easier and harder to detect. Slowing a horse down may therefore be an extremely comfortable way of earning money without raising to much concern. However, even if the cheater would be able to guarantee that her horse, say horse j, will not win, there are no 'not-win' bets available at the tracks or at the bookmakers. Direct exploitation of reduced winning probabilities such is impossible. But eventually there are now win bets on other horses which have positive expected returns. We will derive sufficient conditions under which profitable betting opportunities occur.

We start by introducing the notation. Let b_i be the amount of money wagered on horse i by outsiders. Normalize betting volume so that $\sum_{i=1}^{n} b_i = 1$. Thus, b_i is the percentage of the betting pool wagered on horse i. The pay out q to the winning bets is the total pool of wagers minus the track take, i.e. $q = (1-t)\sum_{i=1}^{n} b_i$. Since $\sum_{i=1}^{n} b_i = 1$ by definition q just becomes $q = (1-t)$. Since the pay out must be shared proportionally by those who bet on the winning horse, the pay out ratio, i.e. the amount of money paid back for each unit wagered on the winning horse is given by the gross odds O, which for horse k are simply calculated as

$$O_k = \left[\frac{(1-t)\sum_{i=1}^{n} b_i}{b_k}\right] = \frac{1-t}{b_k} \tag{1}$$

The total profit of the bets on the winning horse is given by $r_k = b_k O_k - b_k = q - b_k$. The expected profit R_i of the bets on horse i is thus $p_i q - b_i = p_i(1-t) - b_i$ before manipulation. Let P_i be the winning probability of horse i after the chances of horse j eventually have been manipulated. The expected profit R_i then becomes $R_i = P_i(1-t) - b_i$. Even after manipulation the sum of all expected profits must be minus one times the track take, i.e. $\sum_{i=1}^{n} R_i = \sum_{i=1}^{n} [P_i(1-t) - b_i] = -t$

Proposition 1: *If $b_j > t$ and $P_j = 0$ there exists an i, $i = 1, \ldots, n$; $i \neq j$, so that $R_i > 0$.*

Proof: Assume $b_j > t$ and $P_j = 0$. Since $-t = \sum_{i=1}^{n} [P_i(1-t) - b_i] = P_j(1-t) - b_j + \sum_{i=1, i\neq j}^{n} [P_i(1-t) - b_i]$ and $P_j = 0$ one obtains:

$$\sum\nolimits_{i=1, i\neq j}^{n} [P_i(1-t) - b_i] = b_j - t > 0 \tag{2}$$

However, if it is now assumed that $R_i \leq 0$ for all i, $i = 1, \ldots, n$; $i \neq j$, then $\sum_{i=1, i\neq j}^{n} [R_i] = \sum_{i=1, i\neq j}^{n} [P_i(1-t) - b_i] \leq 0$, contradicting (2). This proves that at least one of the $R_i's$ must be strictly positive.

Now, let a win bet on horse k have positive expected returns, i.e. $R_k = P_k(1-t) - b_k > 0$. Outsiders have already wagered the finite amount b_k on horse k. An additional, infinitely small bet on horse i will have no effects on the odds so that the additional bet also has positive expected returns. This proves that the downward cheat $P_j = 0$ offers profit opportunities for the cheater. The profit opportunities for the cheater improve as the betting volume increases. This is because higher betting volume diminishes the effects of additional bets on the odds. At high volume, the cheater could also bet

high stakes without reducing the expected returns of her bets by lowering the odds.

Proposition 1 just proves that there will be a betting opportunity with positive expected returns. It does not guarantee that the cheater will be able to make a profit irrespective of the race's outcome. If the cheater is highly risk averse, profits in a given race can not be guaranteed, and cheating opportunities are rare, she may still refrain from cheating. However, it turns out that when the conditions of Proposition 1 hold, i.e. $b_j > t$ and $P_j = 0$, the cheater can construct a portfolio of bets with a positive profit guarantee.

Proposition 2: If $b_j > t$ and $P_j = 0$ *there exists a portfolio of bets that guarantees a positive profit.*

Proof: Assume a bettor wants to bet an amount of money on horse i so that if i wins she will get one unit of money in return. The amount bet on horse i thus can be interpreted as the price for playing a binomial bet that pays 1 if the horse wins and 0 otherwise. Given the money wagered by the outsiders, the price π_i of such a bet on horse i is simply:

$$\pi_i = \frac{b_i}{1-t} \tag{3}$$

If the bettor buys these binomial bets on all horses except j, then she has to pay the sum of all prices, i.e. $\Pi = \sum_{i=1,\, i\neq j}^{n} \pi_i = \sum_{i=1}^{n} \pi_i - \pi_j$. Feeding in (3) yields:

$$\Pi = \sum\nolimits_{i=1,\, i\neq j}^{n} \pi_i = \frac{\sum_{i=1}^{n} b_i}{1-t} - \frac{b_j}{1-t} \tag{4}$$

Since by definition $\sum_{i=1}^{n} b_i = 1$ one obtains

$$\Pi = \frac{1-b_j}{1-t} \tag{5}$$

It follows $\Pi < 1$ since $b_j = t$ by assumption. What is more, $P_j = 0$ and thus one of the horses covered by the portfolio Π must win. The portfolio's payoff will be 1 irrespective of which horse wins and the price of the portfolio is less than one. If only marginal amounts of money are additionally invested in this portfolio, the prices of the binomial bets will not change and therefore the additional portfolio will be profitable. This completes the proof.

While proposition 2 proves that a profitable marginal portfolio exists, it leaves open to question what a guarantee portfolio would yield in absolute figures, given that the cheater maximizes her minimum guaranteed profit.

Proposition 3: *Maximization of the guaranteed profit d yields a profit of at least $d = (b_j - t)^2$.*

Proof of Proposition 3: Let B_i be the amount of money wagered on horse i by the cheater. Betting on all horses except j, her profit if k wins will be:

$$r_k = B_k \frac{(1-t)(1+\sum_{i=1,\, i\neq j}^{n} B_i)}{b_k + B_k} - \sum\nolimits_{i=1,\, i\neq j}^{n} B_i \tag{6}$$

Since the profit shall be guaranteed, it must be independent of k, i.e. $r_i = c > 0$ for all $i = 1, \ldots, n;\ i \neq j$, where c is some constant. Since $r_k = r_l = c$ for all $k, l \neq j$ it follows:

$$\begin{aligned} r_k &= B_k \frac{(1-t)(1+\sum_{i=1,\, i\neq j}^{n} B_i)}{b_k + B_k} - \sum\nolimits_{i=1,\, i\neq j}^{n} B_i \\ &= B_l \frac{(1-t)(1+\sum_{i=1,\, i\neq j}^{n} B_i)}{b_l + B_l} - \sum\nolimits_{i=1,\, i\neq j}^{n} B_i = r_l \end{aligned} \tag{7}$$

Simplifying yields:

$$\frac{B_k}{b_k + B_k} = \frac{B_l}{b_l + B_l} \tag{8}$$

This system of equations for all $k, l \neq j$ can only hold if the cheater's bets B_i equal the outsiders' bets b_i multiplied by a positive constant v, i.e. $B_i = vb_i$ for all $i \neq j$. In that case (6) can be rewritten to

$$\begin{aligned} r_k &= B_k \frac{(1-t)(1+\sum_{i=1,\, i\neq j}^{n} B_i)}{b_k + B_k} - \sum\nolimits_{i=1,\, i\neq j}^{n} B_i \\ &= vb_k \frac{(1-t)(1+v\sum_{i=1,\, i\neq j}^{n} b_i)}{b_k + vb_k} - v\sum\nolimits_{i=1,\, i\neq j}^{n} b_i \end{aligned} \tag{9}$$

Substitution of $\sum_{i=1,\, i\neq j}^{n} b_i = 1 - b_j$, simplifying, and dropping subscript k gives:

$$r = \frac{(1-t)(v + v^2(1-b_j))}{1+v} - v(1-b_j) \tag{10}$$

The function $r = r(v)$ is continuous since v is positive and it is differentiable to any degree. The f.o.c. for an optimized multiplier v is:

$$\begin{aligned} \frac{\mathrm{d}r}{\mathrm{d}v} &= \frac{(b_j - t - 2tv + 2b_j tv)}{1+v} \\ &\quad + \frac{(tv - b_j v + tv^2 - b_j tv^2)}{(1+v)^2} = 0 \end{aligned} \tag{11}$$

The solutions of Equation 11 are $v_1 = \left[\sqrt{b_j(1-t)}\right]\left[\sqrt{t(1-b_j)}\right]^{-1} - 1$ and $v_2 = -\left[\sqrt{b_j(1-t)}\right]\left[\sqrt{t(1-b_j)}\right]^{-1} - 1$. Because $b_j > t$ by assumption, simple algebra shows that v_1 is positive while v_2 is obviously negative. Since v must be positive, only v_1 is a feasible solution. Indeed, $r(v_1)$ must be a maximum. This follows from the observation that $\mathrm{d}r/\mathrm{d}v = b_j - t > 0$ at $v = 0$. Thus r is increasing as one moves from $v = 0$ to v_1. It can not be decreasing

in between since r is continuous and has no other positive extremum but v_1. Therefore v_1 characterizes a maximum.

Lemma 1:

$$r(v) \geq 0 \quad \text{for} \quad 0 \leq v \leq (b_j - t)/(t - tb_j)$$

Proof of Lemma 1: $r(v) = 0$ has one obvious solution at $v = 0$. Simple algebra shows that $v = (b_j - t)/(t - tb_j)$ is the only other solution. Since $\mathrm{d}r/\mathrm{d}v = b_j - t > 0$ at $v = 0$ and $r(v)$ is continuous it immediately follows that $r(v) \geq 0$ for $0 \leq v \leq (b_j - t)/(t - tb_j)$. Q.e.d.

Let $r(y) = d$ for some y satisfying $0 < y < (b_j - t)/(t - tb_j)$. So d is positive and is a lower bound for the profit the cheater would be able to obtain. Let $y = b_j/t - 1$. Again, simple algebra shows that $0 < y < (b_j - t)/(t - tb_j)$. Feeding in $v = y$ in Equation 10 and simplifying yields:

$$r(y) = (b_j - t)^2 \tag{12}$$

Since $r(y)$ is a lower bound for the cheater's guaranteed profit, the proof is completed.

Next, we introduce a simple stylized version of the favourite-longshot bias. We start by observing that if $p_i = b_i$ for all i and if there is no cheating, then betting would be totally unbiased and all bets would have the same expected returns. Ignoring exact patters the FLB just means that $p_i > b_i$ for the favourites and $p_j < b_j$ for the longshots. Now assume that the outsiders' betting strategy is given by $b_i = p_i + z(p_i - 1/n)$ for all i. The parameter z is a bias measure where $z < 0$ produces a favourite-longshot bias, $z = 0$ represents unbiased betting, and $z > 0$ implies a reversed favourite-longshot bias. In order to guarantee nonnegative bets and bets of 1 at most, z must satisfy $z \in [\underline{p}/(\underline{p} - 1/n); (1 - \overline{p})/(\overline{p} - 1/n)]$, where $\underline{p}$ is defined as the minimum of all $p_i's$, while $\overline{p}$ is the respective maximum and it is assumed that not all probabilities are equal.

By Proposition 3 we have the cheater's minimum profit being $d = (b_j - t)^2$. It follows $dd/db_j = 2b_j - 2t$. This derivative is strictly positive since by assumption $b_j > t$. The more money wagered on horse j, the more profitable it becomes to cheat. Now assume that the objective winning probability of the cheater's horse j also satisfies $p_j > 1/n$, i.e. the horse has a higher than average winning probability. This assumption is not hard to justify since only in races with a very small number of runners could a horse attract a percentage of total betting volume in excess of the percentage of the track take and at the same time have a probability of winning that is below average. Given the outsiders' betting strategy and holding the objective winning probabilities constant, the betting volume on horse j is $b_j = p_j + z(p_j - 1/n)$. Therefore $\mathrm{d}b_j/\mathrm{d}z = p_j - 1/n$. The derivative is strictly positive by assumption. If the betting volume on horse j increases in z and the cheater's profits increase in the betting volume, the cheater's profits also increase in z. So if one moves from the favourite-longshot bias via unbiased betting to a reversed longshot bias, the profit opportunity of the cheater increases. Since all profits of the cheater stem from the outsiders' bets, outsiders as a group lose less money when a favourite-longshot bias is present and lose more if it isn't. They lose most if there is a reversed favourite-longshot bias. The implication is that the FLB may be an equilibrium response of outsiders to the possibility of being taken for a ride on the back of the cheater's horse.

However, even if this explanation is valid, then there may still be other forces at work in favour of the FLB. This has to be taken into account when proposing empirical tests of the cheating model. Still, appropriate controls may be available. The profitability of cheating hinges on the assumption that the percentage of money wagered on horse j exceeds the track take. If there is a race with no horse meeting this condition, outsiders must not be concerned with cheating. Therefore, in races with all horses having odds of $O_i \geq (1 - t)/t$, there will be no such cheating. If the possibility of cheating is perceived as being important, the FLB should be weaker in such races as compared to the other races. To check this conjecture is the main goal of our empirical section below. However, there will likely be a strong negative correlation between the percentage of money wagered on the single horses and the number of horses in a race. So while there is less cheating in bigger races, it may at the same time become more difficult for bettors to estimate winning probabilities correctly. The one effect may therefore offset the other when it comes to the FLB. It would thus be appropriate to control for the number of runners in the field.

The cheating model has not explicitly taken into account techniques of detecting and punishing cheaters. It is highly likely that cheating is easier when other good horses are around. Suppose an extreme scenario with all horses but that of the potential cheater having only three legs. Outsider betting on her horse will be heavy but cheating by not winning will be definitely detected. On the other hand, if there are other horses around also attracting heavy betting, not winning will hardly be considered a cheat. Therefore, cheating will be less likely with highly different odds, and will be more likely with at least one horse being in the odds range of the

potential cheater. Since odds are known, this conclusion can also be tested.

The cheating story also suggests some patterns of organizational responses to the threat of cheating. Organizers of pari-mutuel betting markets have at least three techniques to deter cheating. The first is to invest in detection technology. The second is to improve the composition of races so that all horses in a race attract nontrivial fractions of the total pool, thereby reducing the probability of single horses attracting more than the take. The third is to increase the number of runners per race. Since cheating is most profitable at high betting volume, one would expect a positive correlation between the total betting volume and the number of runners. If the composition technique is used one would observe a negative correlation of betting volume and variance of betting fractions across horses. Investments in detection technology on the other hand should be expected only at tracks that regularly attract high betting volume. One therefore would expect cross track investments in detection technology to be positively correlated with cross track betting volume.

IV. Empirical Evidence

Before we present our own evidence based on betting market data we briefly review some direct anecdotal evidence on cheating. For reasons of better readability we document the sources we used in the appendix. Manipulation of races does not seem to be a contemporary invention. As Higgins (2006) notes, one ancient writer reported that manipulation of a chariot horse could be punished by crucifixion in Rome.

Overall, the anecdotal evidence on race manipulation is dominated by reports on doping intended to make horses run faster. Besides some drugs only known to specialist, there were cases of horses given cocaine, morphine, strychnine, or nowadays even Viagra. The use of so called 'speedballs' and heroin was quite common in the US after the 1933 legalization of pari-mutuel betting. It was estimated that about 50% of all horses had a stimulant or anesthetic administered before the races at that time (Higgins, 2006). Anabolic steroids were also used but only some time ago since they are easy to detect nowadays. Ethorphine, also known as 'elephant juice', is a tranquilizer that if applied correctly is very stimulating and has produced some scandals especially in the 1980s. Since some horses seem to be quite nervous before races, they are eventually treated with tranquilizers or they are even given vodka to calm them down. Then there is caffeine, EPO, ACE and Beta Blockers. 'Blue Magic' (propantheline bromide) helps to relax muscles and increase the blood flow and is suspected to have been used mainly in harness horse racing. Butazolidin and other pain killers like snake-venom make injured horses perform better.

When it comes to slow horses down, there is much less material available. Higgins (2006) relates the story of a stable lad having been hanged on Newmarket Heath in 1812 for poisoning a horse with arsenic. One more recent technique is that of 'sponging': sponges are put in the horse's nostrils to make breathing harder. Without getting enough air, horses will of course slow down. What is more, sponges can not be detected by doping tests based on the horse's saliva, urine or blood. Slowing down horses by application of forbidden substances also seems to have taken place. Another technique of cheating is to exchange horses. Though we were able to identify only one case, there may have been other undetected cases of exchanged horses. By exchanging one horse for another, the audience may think to bet on a favourite while the horse actually running is a look-alike longshot. A funny technique, since one obviously can not ask a horse its name. From an ethical point of view exchanging horses may be considered the least problematic of all cheating techniques since at least no harm is done to the horses.

Though we restrict our analysis to a static one time cheat it may be noted that slowing a horse down could offer a further dynamic advantage to the cheater: The audience starts to perceive the horse of being of inferior quality and stops to bet on it. By abandoning the negative doping or other slowing down techniques the horse suddenly becomes fast again, offering new profitable betting opportunities to the cheater.

While the anecdotal evidence on pure slowing down cases is rather scarce, the scarceness can have two different explanations. One is that this type of cheating just does not happen very often. The other explanation would be that if clever administered it is almost impossible to detect. For example, a horse may not receive a proper amount of training or it is just not fed enough before a race. No doping test will ever detect such techniques.

Last but not least, there seem to have been some successful attempts of race fixing. To fix a race means to fully determine the outcome of a race. Fixing thus is only possible by collusive behaviour of all participants. Race fixing proves most profitable if the favourites are made to lose and the longshots are made to win. So race fixing is just a collusive

combination of slowing some horses down and speeding others up. Given its collusive character, it is not surprising that a lot of fixing cases became known. They seem to be quite common all over the world.

To summarize, anecdotal evidence on simply slowing horses down is rather scarce. That scarceness may be due to the fact that slowing down is a rare event. It may also be due to the fact that slowing down can be easily administered, is hard to detect, and does not require collusive efforts. In the latter case, i.e. if slowing down is done more often, an informationally efficient betting market could eventually provide some better clues than a search for anecdotal evidence. So betting market data is what we check next.

We employ a large-scale data set of betting data on some 300 000 horses running in 35 608 races run at 13 different German tracks between January 2000 and March 2004. Data were provided by TROT-ONLINE, an Internet-based information broker for German pari-mutuel harness horse races. For a more detailed description of the data set see Kukuk and Winter (2006).

The take at German tracks is between 20 and 30%, depending on the track and the type of bet offered. It is higher than in most other countries, where the take is typically less than 20%. This difference is due in part to the high German federal tax on horse bets, which alone is already 16.67%. Straight win bets typically trigger the lowest take, while the take for combined bets is typically highest. We have no specific information on the take for the individual races.

We classify horses with respect to their favourite or longshot statuses according to the odds prevailing in the betting market. We thus simply define the favourite as the horse with the lowest odds. In that case, any horse that is ranked first in the odds is the favourite by definition, and no two horses in a race can be in the same category. One can break eventual ties in the odds by randomly assigning the respective ranks to the horses. We can then calculate the average odds across races for each rank and then can use these rankings to calculate the winning probabilities implied by the odds, which we can compare to the average empirical winning probability of that specific rank. Table 1 presents the results for the win bets.

As can be inferred from the return column in Table 1, the FLB is strongly present in German harness horse racing.

We now divide the data into two subsets. Subset 1 is the set of races in which slowing down the favourite and betting on all other horses according to the betting strategy described in propositions 2 and 3 of Section III would have been profitable. Subset 2 is the set of races in which slowing down the favourite would not have been profitable. Since we have no information on the actual track takes, we employ the midrange of the 20 to 30% interval of actual takes. This corresponds to a cut point of 3.0 for the odds. Therefore, all races that include at least one horse with odds of 3.0 or lower define subset 1 and all races that have all horses with odds of more than 3.0 define subset 2.

In Fig. 1 the average return of the first ten favourite categories are plotted against the log of the corresponding average odds. For subset 1 a clear FLB is obtained whereas the 2321 races in subset 2 (for categories 6 to 10 we have 2318, 2296, 2157, 1673 and 975 races, respectively) at least the first seven categories show only a slightly negative slope. Testing for equal returns of two subsequent categories (see note 7 of Table 1) in subset 1 highly significant differences result for the first four favourite categories and moderate significance for the following four categories. In subset 2 only the peak of category 3 is significant.

Since it is more likely to observe all odds being larger than three in races with more horses in a next step we consider only races with a given number of horses and divide them into the two subsets as above. The resulting average returns of the different favourite categories are illustrated in Fig. 2 for races with exactly 10 horses. Again we observe a FLB for subset 1 comprehending 6256 races with significantly falling average returns in the first four categories. For subset 2 it even looks like a reversed FLB in the first six categories where again only the difference in returns of categories 2 and 3 is significant. Categories 7 to 10 exhibit falling returns. Analysing races with 7, 8 or 9 horses, respectively, the results also show a FLB for subset 1 and no clear FLB but a more erratic behaviour due to lower number of races in the

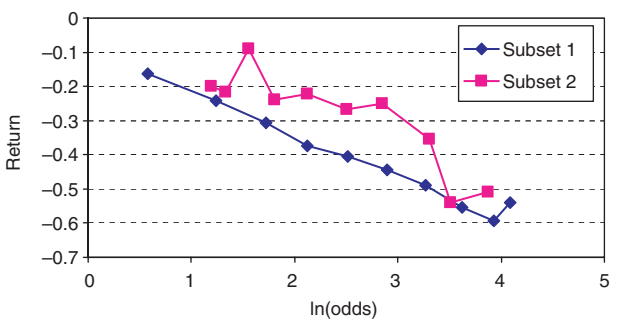

Fig 1. Log-odds/return profiles for races with at least one odd less than 3 (subset 1) and races with all odds greater than or equal to 3 (subset 2)

respective subsets 2. Using other cutting point odds for separating the two subsets we get similar results which for some values are less pronounced. This may reflect the fact that the track take differs among different German tracks.

The results on an aggregate level show that the favourite horses are underbet if at least the lowest odd is below three resulting in a FLB as suggested by our theoretical analysis of Section III. However, these aggregate results could be driven by some sort of selection process. We therefore consider the favourite with the lowest odd in each race and analyse her winning probability as a function of the share of the betting pool being wagered on the favourite (b_1), the difference to the share of the second favourite ($b_1 - b_2$), the number of horses in the race, and two dummy indicators for b_1 being greater than a given threshold and the difference ($b_1 - b_2$) being greater than 2, respectively. We run a binary probit regression and allow for nonlinearities in betting share and also for the difference in betting shares. The estimation results are recorded in Table 2. Note that the marginal effects and not the parameter estimates are reported.

As expected the favourite's share of the betting pool is positively linked to the likelihood of winning. The relationship is first concave up to the inflection point at $b_1 = 0.52$ and then convex. The influence of the difference is estimated to be nonmonotonic. It is falling up to about $(b_1 - b_2) = 0.1$ and then increasing until 0.59. Thus, for about one third of the sample having differences below 0.1 a small increase in this variable (implying an increase in the odds of the second favourite) the chances of winning decrease. Additional to this effect we find that if the odds between the first and the second favourite differ by more than 2 the favourite's probability of winning the race is significantly smaller by about 2.5 percentage points. If the lowest odd in the race is 2.6 or more the winning probability increases by 3 percentage points. According to Section III this estimated odds threshold translates into a track take of 27.8% which corresponds to the finding of Winter and Kukuk (2006, Tables 6a, 6b). In other specifications using a dummy indicator for odds greater than 2.5 and 2.8, respectively, we find similar but slightly less significant results whereas for 2.7 and 2.9, respectively, the parameter estimate is only significant at a significance level of 15%. Other specifications including weekday dummies, dummies for the number of horses in the race, the size of the betting pool, and the prize money as explanatory variables did not obtain significant parameter estimates. For the latter two variables this finding might be due to the fact that we do not observe those variables for all races.

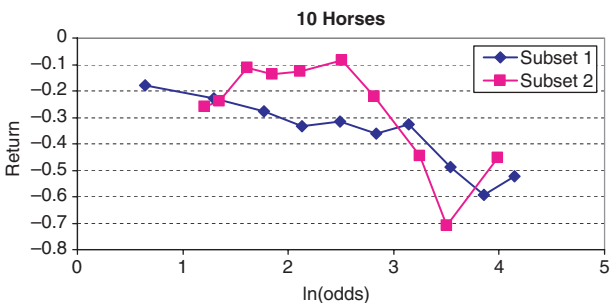

Fig. 2. Log-odds/return profiles for races with exactly 10 horses

V. Some Caveats

One obvious caveat of our analysis is that we employ only a partial model. We have therefore not provided a complete proof that the FLB is an

Table 2. Binary probit estimates for dependent variable winning of first favourite

	Marginal eff.dF/dx	SE.	z	P > |z|	x-bar
I[$(b_1 - b_2) > 2$]*	−0.0248461	0.0108869	−2.28	0.023	0.38166
I[$b_1 > 2.5$]*	0.030491	0.0132367	2.31	0.021	0.161269
b_1	4.453453	1.297419	3.43	0.001	0.408812
b_1^2	−6.676461	3.107343	−2.15	0.032	0.179334
b_1^3	4.270006	2.412985	1.77	0.077	0.084027
$(b_1 - b_2)$	−0.4264324	0.167398	−2.55	0.011	0.19501
$(b_1 - b_2)^2$	2.404268	0.8477782	2.84	0.005	0.05887
$(b_1 - b_2)^3$	−2.307615	1.135549	−2.03	0.042	0.022083
# of horses	−0.002376	0.0021222	−1.12	0.263	8.44578
Log lik.	−23054.104				
Pseudo R^2	0.0606				

Note: (*) dF/dx is for discrete change of dummy variable from 0 to 1 z and $P > |z|$ are the test of the underlying coefficient being 0.

equilibrium response of outsiders. Rather, we have only identified some arguments in favour of the FLB being an equilibrium response. For example, our discussion leaves open why then outsiders should at all bet fractions on single horses in excess of the track take when this betting behaviour triggers cheating. The answer may be that by not doing so, betting on favourites could become a positive expected return activity. Insiders thus could profit by just backing their favourite horses and cease cheating. But then outsiders as a group could lose even more as compared to the cheating situation. So while we have not yet developed a complete equilibrium model of cheating, we feel that the technique of cheating we discuss here could be an equilibrium activity of insiders and that a more pronounced FLB could be an equilibrium response of outsiders.

The next problem worth mentioning is that we introduced an artificial, linearized version of the FLB. This approach simplified the description of the bias by making it depend on just one parameter z. This in turn enabled us to demonstrate the profit opportunity of the cheater to increase in z, implying that the existence of the FLB tends to protect the outsiders. But what we found empirically was not that the FLB unequivocally diminishes but rather that its pattern changes. It changes to a diminished bias across the favourite categories but becomes steeper as one approaches the longshots. This in turn implies that our stylized description of the FLB may not have been appropriate in the first place. Still, the difference in the patterns of the FLB we found across subsamples 1 and 2 are striking. This change of patterns suggests that the cheating model has its merits but that other factors like biased probability estimates especially for longshots also may play a role.

Still another problem lies in the lack of control for other cheating incentives. For example, Fernie and Metcalf (1999) suggested that a jockey believed to have underperformed may loose future employment opportunities. However, jockeys approaching their retirements may not be concerned with their labor market reputation any more and could therefore feel stronger inclinations to cheat. So a control for future employment opportunities would be appropriate. What is more, we have not even controls for the incentive contracts of the jockeys covered by our data. A jockey that receives a high fraction of the prize money may be less inclined to slow his horse down than a jockey getting rather flat pay. On the other hand, a jockey's incentive for not winning should depend on the combination of compensation for winning and profit opportunities in the betting market. While we have data on the total betting volume at the tracks under observation, there are additional betting opportunities offered by bookmakers for which we have no information. This implies that we can not properly estimate the profit opportunities offered by cheating combined with betting simultaneously around the world.

VI. Conclusion

The model presented in this article suggests that the FLB may be a rational response of uninformed outsiders to simple cheating opportunities by insiders. While the FLB may be induced by other forces as well, the FLB should be expected to be more pronounced in races offering a cheating opportunity as opposed to other races.

We found anecdotal evidence of market manipulation taking place all over the world. Horse doping, 'sponging', and race fixing seem to be quite common techniques of manipulation and the evidence suggests that some of these activities are unequivocally due to profit opportunities in the betting markets. While we found little direct anecdotal evidence of horses made to run slower, our betting market analysis showed a different picture. We found the pattern of the FLB to change significantly as the opportunity of cheating is removed. Our finding suggests that slowing horses down is a realistic option for insiders and that outsiders act accordingly.

On the other hand it should be remembered that the model presented above is only a first effort to understand the possible effects of cheating. It is only one technique of cheating that has been analysed while there may be a whole array of other cheating opportunities. The anecdotal evidence provided here indeed suggests that more theoretical work on cheating techniques should be worthwhile. Especially models of horse doping to make them faster and models of race fixing should be interesting.

There are also interesting empirical questions that remain unanswered. For example, we were not able to control for additional incentives to cheat nor were we able to control for countervailing incentives not to. Last but not least we think that it should be worthwhile to have a closer look at the dynamics of cheating. As suggested above, making a good horse slower in one race improves its win bet profitability in the next. It should therefore be interesting to watch out for conspicuous patterns of a given horse's performances over time. However,

this approach would require individual identification of horses, jockeys and maybe trainers. And it would require data sets that are much larger than ours to have enough individuals that can be followed over time. Maybe the data set used by Snowberg and Wolfers (2006) would meet these criteria.

References

Ali, M. M. (1977) Probability and utility estimates for racetrack bettors, *Journal of Political Economy*, **85**, 803–15.

Asch, P., Malkiel, B. G. and Quandt, R. E. (1982) Racetrack betting and informed behaviour, *Journal of Financial Economics*, **10**, 187–94.

Bird, R., McCrae, M. and Beggs, J. (1987) Are gamblers really risk takers?, *Australian Economic Papers*, **49**, 237–53.

Bruce, A. C. and Johnson, J. E.V. (2000) Investigating the roots of the favorite-longshot bias: an analysis of decision-making by supply- and demand-side agents in parallel betting markets, *Journal of Behavioral Decision Making*, **13**, 413–30.

Busche, K. and Hall, C. D. (1988) An exception to the risk preference anomaly, *Journal of Business*, **61**, 337–46.

Cain, M., Peel, D. and Law, D. (2002) Skewness as an explanation of gambling by locally risk averse agents, *Applied Economics Letters*, **9**, 1025–28.

Coleman, L. (2004) New light on the longshot bias, *Applied Economics*, **36**, 315–26.

Dowie, J. A. (1976) On the Efficiency and Equity of Betting Markets, *Economica*, **43**, 139–50.

Friedman, M. and Savage, L. (1948) The utility analysis of choices involving risk, *Journal of Political Economy*, **56**, 279–304.

Fernie, S. and Metcalf, D. (2001) It's not what you pay it's the way that you pay it and that's what gets results: Jockeys' pay and performance, *Labour*, **13**, 385–411.

Gandar, J. M., Zuber, R. A. and Johnson, R. S. (2001) Searching for the favourite-longshot bias down under: an examination of the New Zealand pari-mutuel betting market, *Applied Economics*, **98**, 1621–29.

Golec, J. and Tamarkin, M. (1998) Bettors love skewness, not risk, at the horse track, *Journal of Political Economy*, **106**, 205–25.

Gramm, M. (2005) Betting market efficiency at premiere racetracks, *Southwestern Economic Review*, **32**, 85–92.

Griffith, R. M. (1949) Odds adjustments by American horse race bettors, *American Journal of Psychology*, **62**, 290–4.

Hausch, D. B. and Ziemba, W. T. (1990) Arbitrage strategies for cross-track betting on major horse races, *Journal of Business*, **63**, 61–78.

Hausch, D. B. and Ziemba, W. T. (1995) Efficiency in sports and lottery markets, , in *Finance - Handbooks in Operations Research and Management Science*, Vol. 9 (Eds) R. A. Jarrow, V. Maksimovic, and W. T. Ziemba, Elsevier, North Holland, pp. 545–80.

Henery, R. J. (1985) On the average probability of losing bets on horses with given starting price odds, *Journal of the Royal Statistical Society*, **148**, 342–9.

Higgins, A. J. (2006) : From ancient Greece to modern Athens: 3000 years of doping in competition horses, *Journal of Veterinary Pharmacology and Therapeutics*, **29**, 4–8.

Johnson, J. E. and Bruce, A. C. (1993) Gluck's Second Law: An empirical investigation of horserace betting in early and late races, *Psychological Reports*, **72**, 1251–8.

Jullien, B. and Salanié, B. (2000) Estimating preferences under risk: the case of racetrack bettors, *Journal of Political Economy*, **108**, 503–30.

Kahneman, D. and Tversky, A. (1979) Prospect theory: an analysis of decision under risk, *Econometrica*, **47**, 263–92.

Kopelman, R. E. and Minkin, B. L. (1991) Toward a psychology of parimutuel behavior: test of Gluck's Law's, *Psychological Reports*, **68**, 701–2.

Law, D. and Peel, D. A. (2002) Insider trading, herding behaviour and market plungers in the British horse-race betting market, *Economica*, **69**, 327–38.

Markowitz, H. (1952) The Utility of Wealth, *Journal of Political Economy*, **56**, 151–8.

McGlothlin, W. H. (1956) Stability of choices among uncertain alternatives, *American Journal of Psychology*, **69**, 604–16.

Quandt, R. E. (1986) Betting and equilibrium,:, *Quarterly Journal of Economics*, **101**, 201–7.

Sauer, R. D. (1998) The economics of wagering markets, *Journal of Economic Literature*, **36**, 2021–64.

Schnytzer, A. and Shilony, Y (1995) Inside information in a betting market, *Economic Journal*, **105**, 963–71.

Shin, H. S. (1991) Optimal betting odds against insider traders, *Economic Journal*, **101**, 1179–85.

Shin, H. S. (1992) Prices of state contingent claims with insider traders, and the favourite-longshot bias, *Economic Journal*, **102**, 426–35.

Shin, H. S. (1993) Measuring the incidence of insider trading in a market for state-contingent claims, *Economic Journal*, **103**, 1141–53.

Smith, M. A., Paton, D. and Williams, L. V. (2006) Market efficiency in Person-to-Person betting, *Economica*, **73**, 673–89.

Snyder, W. W. (1978) Horse racing: testing the efficient markets model, *Journal of Finance*, **33**, 1109–18.

Snowberg, E. and Wolfers, J. (2006) Explaining the Favorite-Longshot Bias: Is it Risk-Love, or Misperceptions? In: Working Paper, available at http://cbdr.cmu.edu/seminar/Wolfers.pdf, download. 13 February 2007.

Sobel, R. S. and Raines, T. (2003) An examination of the empirical derivatives of the favourite-longshot bias in racetrack betting, *Applied Economics*, **35**, 371–85.

Swidler, S. and Shaw, R. (1995) Racetrack wagering and the "uninformed" bettor: a study of market efficiency, *Quarterly Review of Economics and Finance*, **35**, 305–14.

Thaler, R. H. (1985) Mental accounting and consumer choice, *Marketing Science*, **4**, 199–214.

Thaler, R. H. and Johnson, E. J. (1990) : Gambling with the house money and trying to break even: the effects of prior outcomes on risky choice, *Management Science*, **36**, 643–60.

Thaler, R. H. and Ziemba, W. T. (1988) Parimutuel betting markets: racetracks and lotteries, *Journal of Economic Perspectives*, **2**, 161–74.

Tuckwell, R. H. (1983) The thoroughbred gambling market: efficiency, equity and related issues, *Australian Economic Papers*, **22**, 106–18.

Tversky, A. and Kahneman, D. (1992) Advances in prospect theory: cumulative representation of uncertainty, *Journal of Risk and Uncertainty*, **5**, 297–324.

Williams, L. V. and Paton, D. (1997) Why is there a favourite-longshot bias in British racetrack betting markets?, *Economic Journal*, **107**, 150–8.

Walls, W. D. and Busche, K. (2003) Breakage, turnover and betting market efficiency: new evidence from Japanese horse tracks, in *The Economics of Gambling* (Ed.) L. V. Williams, Routledge, London, pp. 43–66.

Weitzman, M. (1965) Utility analysis and group behavior: an empirical study, *Journal of Political Economy*, **73**, 18–26.

Winter, S. and Kukuk, M. (2006) Risk love and the favorite-longshot bias: evidence from German harness horse racing, *Schmalenbachs Business Review*, **58**, 349–64.

Appendix

A) Sources of information on drugs used in horse doping

http://www.theage.com.au/news/Horse-Racing/The-drugs-challenge/2004/12/27/1103996492071.html

http://www.horsesport.org/mcp/PDFS/Prohibitedsubstances.pdf

http://www.horsesport.org/mcp/PDFS/EADMCR-2006.pdf

http://www.berlinonline.de/berliner-zeitung/archiv/.bin/dump.fcgi/1999/0504/sport/0040/index.html

B) Sources of information on unusual drugs like vodka, Viagra and baking powder

http://www.research.uky.edu/odyssey/spring98/sponging.html

http://grg51.typepad.com/steroid_nation/2007/01/advances_in_hor.html

http://www.nypost.com/seven/02052007/news/columnists/race_fix_scandal_columnists_murray_weiss.htm

http://www.castelligasse.at/Politik/Doping/doping.htm

C) Sources of information on horses manipulated to run faster

C1: Horses having manipulated with ACP in Plumpton, England, 2001 and 2002

http://news.bbc.co.uk/sport2/hi/other_sports/horse_racing/1959450.stm#

http://www.findarticles.com/p/articles/mi_qn4158/is_20010202/ai_n14364521

http://www.findarticles.com/p/articles/mi_qn4158/is_20010202/ai_n14364521

C2: Former jockey and trainer was claimed to have doped 23 horses in 1990; 10-year disqualification

http://news.bbc.co.uk/sport2/hi/other_sports/horse_racing/2491017.stm

C3: One of Australia's most respected trainers being investigated for the alleged use of illegal anabolic steroids in 45 cases, 1999.

http://www.abc.net.au/am/stories/s37898.htm

C4: A horse owned by gentleman jockey George Herbert Bostwick was found to have been stimulated for a race and won it, USA 1933.

http://www.time.com/time/magazine/article/0,9171,753989,00.html

C5: Horse was manipulated with a bicarb stomach drench, England, 2004

http://www.theage.com.au/news/Horse-Racing/The-drugs-challenge/2004/12/27/1103996492071.html

D) Sources of information on horses manipulated to run slower

D1: Favourite horse delivered unexpected poor racing result. As a consequence a doping control for negative doping was administered with no result till now, Germany, 2006

http://www.abendblatt.de/daten/2006/09/05/606907.html

D2: Sponges found in the nostrils of different horses; USA, 1997.

http://www.lasvegassun.com/sunbin/stories/sun/1997/jun/16/506000899.html?sponge

D3: The vetenary found a sponge in the nostril of a horse which finished 3rd, USA, 1933.
http://www.time.com/time/magazine/article/0,9171,753989,00.html

D4: Officials failed to catch the person who placed sponges in the nasal passages of eight horses, USA, 1999.
http://www.research.uky.edu/odyssey/spring98/sponging.html

D4: Jockey was blackmailed to hold his horse back and finished fourth. Germany, 1999.
http://www.berlinonline.de/berliner-zeitung/archiv/.bin/dump.fcgi/1999/0504/sport/0040/index.html

E) Sources of information on race fixing schemes

E1: Jockeys suspended and fined for race fixing. USA, 2006.
http://www.usatoday.com/sports/horses/2006-04-03-meadowlands-arrests_x.htm
http://www.boston.com/sports/other_sports/horse_racing/articles/2006/04/03/police_suspect_race_fixing_at_meadowlands/
http://www.boston.com/sports/other_sports/horse_racing/articles/2006/04/12/five_suspended_in_race_fixing_case/

E2: Bookmaker was informed by jockeys that their horses would not win. England, 2006.
http://www.allhorseracing.com/thoroughbred-horseracing-news.php?id=1111
http://www.thehra.org/doc.php?id=41656

E2: Bookmaker was informed by jockeys that their horses would not win. England, 2006.
http://www.allhorseracing.com/thoroughbred-horseracing-news.php?id=1111
http://www.thehra.org/doc.php?id=41656

E3: Group of jockeys sentenced for race fixing over a couple of years, USA, 2001.
http://www.thoroughbredtimes.com/national-news/2001/May/01/Jockeys-sentenced-in-Penn-National-scandal.aspx
http://espn.go.com/horse/news/2000/1215/952050.html

E4: One horse was exchanged for another. England, 1974.
http://news.bbc.co.uk/sport2/hi/other_sports/horse_racing/2295403.stm
http://archives.tcm.ie/irishexaminer/2004/09/02/story269069470.asp

E5: The Mafia fixed races for many years by positive and negative doping and collaborating with jockeys. Italy, 1990s.
http://www.berlinonline.de/berliner-zeitung/archiv/.bin/dump.fcgi/2001/0921/vermischtes/0067/index.html

E6: Other sources of information on race fixing activities
http://sport.guardian.co.uk/horseracing/comment/0,,2016749,00.html
http://www.thehra.org/doc.php?id=44468
http://www.usatoday.com/sports/horses/2006-12-20-tampa-bay-downs_x.htm
http://www.sptimes.com/2006/12/20/Sports/Seven_jockeys_are_ban.shtml
http://query.nytimes.com/gst/fullpage.html?res=940CE3D8123BF934A25751C0A964948260&n=Top%2fReference%2fTimes%20Topics%2fSubjects%2fH%2fHorse%20Racing
http://www.allhorseracing.com/thoroughbred-horseracing-news.php?id=699
http://query.nytimes.com/gst/fullpage.html?res=940CE3D8123BF934A25751C0A964948260&n=Top%2fReference%2fTimes%20Topics%2fSubjects%2fH%2fHorse%20Racing
http://www.allhorseracing.com/thoroughbred-horseracing-news.php?id=699

Copyright of Applied Economics is the property of Routledge and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.