To What Extent do Investors in a Financial Market Anchor Their Judgments? Evidence from the Hong Kong Horserace Betting Market

by

Johnnie E.V. Johnson[*]

Shuang Liu[*]

and

Adi Schnytzer[†]

Abstract

This paper explores the use of the anchoring and adjustment heuristic by decision makers in a financial market; in particular, the degree to which horserace bettors anchor their probability judgments on the advantage afforded by a horse's barrier-position. The results suggest that under certain conditions bettors anchor on barrier-position information revealed at previous race meetings, but not on the most recent race outcomes. In fact, bettors appear to use the most recent race outcomes appropriately when forming probability estimates; but only when the results are in line with their mental model of barrier-position advantage. Bettors with varying levels of expertise are shown to be subject to anchoring, although greater expertise is generally associated with less anchoring. The paper concludes that the manner and degree of anchoring in real world environments is complex.

Introduction

It has been demonstrated in numerous studies that individuals use simple rules of thumb or heuristics to make decisions within their limited knowledge and computational capacities. However, these heuristics can result in systematic biases (e.g., Cohen, 1993; Kahneman, Slovic, & Tversky, 1982; Kahneman & Tversky, 1972; Tversky & Kahneman, 1974). Individuals who use one of the most common heuristics (*anchoring and adjustment*) to make estimates, start from an initial value (the anchor) and adjust this upwards or downwards to account for the information they have available. Previous research suggests that these adjustments are often crude and inadequate (Tversky & Kahneman, 1974). However, most studies have been undertaken in laboratories. The purpose of this empirical enquiry is to

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[*] School of Management, University of Southampton

[†] Dept. of Economics, Bar Ilan University

contribute to the understanding of these anchoring effects in naturalistic environments. In particular, to what extent these effects are a feature of decisions made in financial markets; specifically, the horserace betting market. Consequently, this study provides a rare analysis of anchoring effects in a naturalistic environment. Previous real world studies of anchoring effects often analyze the decisions of individuals made under artificial conditions, where they are aware that they are being monitored (which may result in modified behavior). On the contrary, this study explores anchoring where individuals make decisions in their own domain when they *do not* know that they are being investigated.

Betting markets aggregate individual decisions, and will, to some extent, reflect the biases displayed by individual bettors. However, Wallsten *et al.,* (1997) note that markets also involve interactions between different participants in an environment which offers incentives for individuals to effectively use information (Waller *et al*., 1999). As a result, one might expect less pronounced anchoring effects in markets.

The paper is organized as follows: A brief review of the anchoring effect literature is provided in section II. In section III, relevant features of the horserace betting market are described; in particular, those which make it an ideal real world environment to explore anchoring effects. In addition, the hypotheses to be tested are outlined. The data and the models which are employed to examine the extent to which bettors anchor their judgments are described in section IV. The results are presented and discussed in section V and some conclusions are drawn in section VI.

Anchoring Effects

It has been found that, faced with uncertainty, individuals tend to use external suggestions or self-generated values (e.g., Cervone & Peake, 1986; Chapman & Johnson, 1994) as anchors. Adjustments are then made from the anchor value to the target value, but these adjustments are often insufficient (e.g., Quattrone *et al*., 1984; Tversky & Kahneman, 1974).

Two forms of anchoring have been investigated in previous studies: 'traditional' and 'basic' anchoring. Traditional anchoring effects appear when a two stage process is involved: subjects are asked to compare an anchor value (perhaps a randomly drawn number) with the value to be estimated (e.g. the length of the river Nile). Subsequently, subjects are asked to give their own estimates of this value (Tversky and Kahneman, 1974). Basic anchoring occurs when subjects anchor on some piece of information, even when they are not asked to compare this information with the value to be estimated (e.g. Mussweiler and Englich, 2005). It has

been shown that basic anchoring effects occur unintentionally and unconsciously when sufficient attention is paid to the anchor value, even if the anchor is completely irrelevant to the value to be estimated (e.g. Wilson et al., 1996).

Most previous studies have focussed on traditional anchoring, and these, in general, have found that anchoring is a widespread phenomenon affecting a broad range of judgments (e.g., Cervone & Peake, 1986; Chapman & Johnson, 2002; Epley & Gilovich, 2001; Hinsz *et al*., 1997; Joyce & Biddle, 1981; Northcraft & Neale, 1987; Wright & Anderson, 1989). In addition, a number of factors, such as, anchors from different sources (self-generated or externally provided) (e.g., Davies, 1997), the degree of relevance of the anchors to the targets (e.g., Chapman & Johnson, 2002; Ritov, 1996; Shelton, 1999), the representation of anchors (e.g., Mussweiler & Englich, 2005; Mussweiler & Strack, 2001; Wong & Kwong, 2000), positive affect (e.g., Estrada et al., 1997), the absolute value of anchors and the level of knowledge and experience of decision makers (e.g., Caverni & Pris, 1990; Joyce & Biddle, 1981; Northcraft & Neale, 1987) have been shown to lead to different anchoring effects. The durability of anchoring effects has been shown to be greater with self-generated (c.f. externally provided) anchors and to increase with the frequency with which relevant information is involved. In fact, under certain conditions some individuals' judgments have been shown to be influenced by anchors one week after they first became aware of them (Mussweiler, 2001).

The majority of the anchoring effect literature has arisen from studies conducted under controlled experimental conditions. Laboratory settings offer a number of advantages over field-based environments, including their ability to investigate the effect of discrete factors under a set of manufactured conditions using controlled groups of participants. However, "such controlled settings, whilst allowing unequivocal identification of relationships between variables, often omit vital elements which are present in real-world decision environments" (Bruce & Johnson, 1997, p.287). The complex, dynamic, and high-stakes settings experienced by decision-makers in real world contexts are often difficult to replicate in the laboratory (Yates, 1992). As a result, different decision-making behaviors have been observed in experimental and naturalistic studies (Anderson & Brown, 1984). In order to understand a phenomenon, it is important to examine results from both laboratory and field settings. Consequently, the current study investigates to what extent anchoring effects, often observed in laboratory settings, are a feature of a real world setting, the horserace betting market.

Horserace Betting Markets

Horserace betting markets are valuable settings for developing insights regarding anchoring effects because they (i) incorporate the characteristics of many dynamic and naturalistic decision-making environments, where the use of information is a key ingredient to success; and (ii) involve a number of features which enable anchoring to be explored more easily than in other real world decision-making settings. These issues are now discussed.

Horserace betting markets as dynamic naturalistic decision settings

Horserace betting markets, like many other real world settings, are dynamic environments in which participants make probability estimates and risky choices in the face of an evolving information set. In common with wider financial markets, they involve a large number of participants, and a variety of information is available to inform choices, including considerable advice from professionals. Outcomes of bettors' decisions matter to them and the risks and pressures inherent in these markets are not easy to replicate in laboratory experiments (Orasanu & Connolly, 1993). In addition, betting markets contain action-feedback loops and decisions are made in a limited time period; bettors being able to assimilate information concerning race outcomes into their decision models in order to improve subsequent decision accuracy (Goodman, 1998; Johnson & Bruce, 2001). Moreover, the procedure for selecting the horse on which to wager varies for different individuals. These are very similar to the conditions faced in many other real world environments (Orasanu & Connolly, 1993).

As a result of the factors discussed above, it is argued that betting markets can shed light on behaviors in other real world contexts. More specifically, data from betting markets has been extensively employed to shed light on investors' behavior (e.g., Asch & Quandt, 1987; Dowie, 1976; Johnson, et al., 2006; Hausch & Ziemba, 1985; Levitt, 2004; Schnytzer & Shilony, 1995; Sung & Johnson, 2007) and Law and Peel (2002) argue that betting markets offer a valuable arena in which to explore the manner in which information is used by investors in wider financial markets. One of the key reasons for this is that horserace betting markets share a number of fundamental characteristics with wider financial markets, including, extensive market knowledge, ease of entry, large numbers of participants (who can be classified as noise traders and informed traders) and the factors which influence a horse's prospects (an asset's value) are complex and interdependent (Snyder, 1978). Horserace betting markets are in fact directly equivalent to options and futures markets since each "*n*-horse race corresponds to a market for contingent claims with n states in which the ith state corresponds to the

outcome in which the *i*th horse wins the race" (Shin, 1993, p.1142). In state contingent claims terms, the purchase price of a claim on horse *i* in race *j* which pays \$1 if horse *i* wins and nothing if it loses, is given by $1/(1+O_{ij})$, where O_{ij} represents horse *i*'s quoted market odds. The purchase prices of claims are clearly associated with the subjective probability judgments of the betting public, since these judgments lead to betting decisions which directly influence the odds. In the same way, investors' expectations concerning an asset's future value will affect their investment decisions, which in turn will affect the price of the option/future etc.

Investment in any financial asset involves transactions costs, and, at least in the short run, offers a negative expected return. This is particularly the case in state contingent claims markets and it is not uncommon for those who write about these markets to refer to investments as 'bets'. For example, Saber (1999, p.30) devotes a section of his book on financial markets to "valuing an option as a 'bet' ". There is, therefore, no reason to believe that bettors at the racetrack should behave differently to investors in such markets.

The Hong Kong horserace betting market, which provides the data for this study, is strictly organized and regulated, with enforcement to prevent illegal activity, including insider trading. These are similar to the conditions under which most financial markets operate and this lends weight to the view that behavior in these markets may offer an insight into investors' behavior in other financial markets. However, whilst the Hong Kong market is regulated, there is no monitoring of individuals' bets and the dynamic environment faced by bettors is far removed from the controlled environments experienced in the laboratory.

Anecdotal evidence might suggest that moral hazard is an issue which affects horseracing results (e.g. race fixing by various methods) and therefore may have a bearing on decisions made in these settings. However, the tight regulation of the Hong Kong horserace betting market and the failure of any studies to prove systematic activity of this sort in any horseracing market negate this concern (e.g. Schnytzer & Shilony, 2007). In addition, openness with regard to information concerning previous results is also a feature of the Hong Kong market. Consequently, bettors, like investors in financial markets, are able to access relevant data when making their betting decisions

Advantages of Horserace Betting Markets over other Real World Settings

Horserace betting markets offer a number of advantages over other real world decision settings for exploring anchoring effects: First, a large quantity of relevant decision data is available. For example, there are over 650 races per annum in Hong Kong and decision-relevant and race outcome information is accessible. Second, horserace betting markets are

relatively simple financial markets, providing a clear view of pricing issues (odds and their movements) which are complicated in other markets (Sauer, 1998), and this is clearly demonstrated in Bruce and Johnson (2005). Third, unlike some naturalistic settings, each betting decision is made under similar conditions, and the result of the combined decisions of participants is recorded, in the form of market odds.

A few studies have explored anchoring effects in real world decision environments, such as, auditing, real estate, and negotiation (e.g., Ashton & Ashton, 1988; Northcraft & Neale, 1987; Ritov, 1996), but these studies have generally employed questionnaires or specific (artificial) projects. In addition, participants often knew that they were taking part in an experiment and may have modified their reactions. Consequently, there is a need for an exploration of anchoring effects where individuals make decisions in their own domain without knowing that they are being investigated. Betting markets provide such conditions.

Barrier-position as a Potential Anchoring Factor: Hypotheses

In Hong Kong, horses begin their races from "starting stalls". These devices ensure that all horses are released simultaneously. Each horse is randomly allocated a stalls or "barrier-position" (BP) from 1 (the inside rail) up to 14 (the outside rail) and these are announced the day before the race. The BP determines where in relation to the inside of the racetrack the horse starts and where it is often forced, due to the position of other runners, to run much of the race. Due to track configuration (e.g., short oval racetracks with sharp bends) or other racetrack topography (e.g., faster ground on the inside of the track) certain BPs may be advantageous. Most racing publications advocate careful consideration of BP when assessing the chances of each horse. For example, Cotton (1990), advises "…make no mistake (BP) can be the most important component in the outcome of many flat races" (p. 113). Similarly, Beyer (1983, p.42) observes, "while some [post position] biases are due to the idiosyncrasies in the racing surface, many tracks have shapes that influence the results. At tracks less than a mile in circumference, the sharp turns and short straight almost always work to the advantage of the front runner and the horses on the inside." Some influential racing writers devote whole chapters of their books to exploring the impact of post position on results (e.g. Mordin, 1992) and some devote whole books to the subject (e.g. Wheldon et al., 2002)

Both racetracks in Hong Kong, Happy Valley (HV) and Sha Tin (ST), are oval circuits and the track configuration suggests that those horses with BPs on the inside of the track (low BPs) will be favored, since they will be required to run less distance. HV has a circumference of only 1454 meters, whereas the circumference of ST is 1933 meters. The bends at HV are

therefore tighter than those at ST; the tightest bend at HV having a radius of only 91 meters, whereas the equivalent bend at ST has a radius of 158 meters. Consequently, the configuration of both these tracks suggests that horses with a low BP will be favored (more so at HV). In addition, the results of previous races point to the advantage of low BPs; and this attracts media attention. In considering the degree to which bettors may focus on BP, the R^2 of the BP variable in Table 1 (i.e. 0.0145 for HV) should not be considered in isolation. Odds have been shown to be a reasonable guide to horses' chances of success (i.e. odds successfully incorporate information from a variety of sources: e.g. Johnson & Bruce, 2001). Despite this, there are many factors which influence results that odds do not account for. For example, it is clear from the R^2 value in Table 2 that at HV a model which simply incorporates odds and BP, accounts for only 12.61% of the variation in results. However, BP alone accounts for 1.45% of the variation in results at HV (see Table 1). Consequently, at HV, BP alone accounts for 0.0145/0.1261 (11.5%) of the variation in results predicted by odds. This is a significant proportion for one variable and it is likely to figure prominently in a bettors' assessment of a horse's prospects.

It has been shown that that basic anchoring effects occur unintentionally and unconsciously when sufficient attention is paid to the anchor value, even if the anchor is completely irrelevant to the value to be estimated (e.g. Wilson et al., 1996). Consequently, given the strong evidence for anchoring observed in the laboratory, we would expect bettors, who are subject to the media and numerous racing publications advocating the importance of BP and who are faced by the classic low post position favoring configuration of ST and, particularly, HV, to focus on this factor when assessing a horse's chances, to the neglect of other information. We therefore believe that they will be subject to a form of basic anchoring on this factor. This view is encapsulated in the first hypothesis:

(1) Bettors in the Hong Kong horserace betting market anchor their judgments of horses' winning probabilities on low BP advantage.

Race meetings in Hong Kong are generally run twice a week, often alternating between locations; weekends at ST and mid-week (evenings) at HV. Both tracks are within eight miles of each other, and are readily accessible by public transport. Consequently, many bettors attend both meetings. Bettors at the racetrack often have little time between races to fully assimilate the results which occur that given day (races are typically run every 35 minutes) but they will often spend considerable time reviewing the results during the subsequent days. As discussed above, we expect BP to be one of the key factors which bettors consider when assessing a horse's prospects and it is likely, therefore, that they will review the BP advantage

displayed in the results at the previous race meeting. This activity is facilitated by local newspapers and specialist racing publications which print the results of previous race meetings, including the winning BPs. Media comment concerning the BP advantage displayed at the racetracks during certain meetings is also common. Since many bettors will attend both HV and ST in the same week it is likely that the results from the race meeting held earlier that week will be at the forefront of their minds, and this may unduly influence their subjective probability judgments. Consequently, we test a second hypothesis:

(2) Bettors at a given race meeting anchor on the results of the previous race meeting.

Previous research suggests that individuals tend to anchor on information which is the most immediate/vivid. For example, Whyte & Sebenius (1997) demonstrated that negotiators were more likely to anchor on useless/irrelevant information which was encountered immediately prior to making their judgments than on information which was relevant but encountered earlier. They suggested that "the order in which potential anchors are encountered may determine what anchor or anchors are used" while "the relevance to the estimation task to be performed may not be the dominant criterion in anchor selection" (p. 82). At a race meeting the most immediate information concerns the result of the previous race. We therefore test the following hypothesis:

(3) Bettors anchor their probability judgments on the BP of the winning horse in the previous race.

Finally, experimental studies suggest that decision makers with greater expertise are less prone to anchoring effects (e.g., Bonner, 1990; Mussweiler & Strack, 2000; Northcraft & Neale, 1987). To explore whether this phenomenon applies in naturalistic environments we test the following hypothesis:

(4) The probability judgments of bettors with greater expertise are less prone to anchoring associated with BP advantage than the judgments of bettors with less expertise.

Method

Data

The data, drawn from the pari-mutuel horserace betting markets operating at HV and ST racetracks in Hong Kong (where the odds reflect the decisions of bettors), include the win odds, BP, and finishing position for all horses running in races between September, 3, 2000 and October, 18, 2006; 1,428 races in 183 meetings at HV (16,971 horses) and 2,817 races in 295 meetings at ST (37,364 horses). Both these racetracks stage 'flat' horse races (no races over jumps) on both grass and artificial ('dirt') surfaces. The races are a mixture of handicap

(where each horse is allocated a weight to carry based on its ability, in order to try to make the race competitive) and stakes races (where weights are not allocated on the basis of ability) run over distances of between 1000 and 2400 metres, where the mean winning times are 57.58 and 150.57 seconds, respectively. The number of horses in each race at these tracks varies from 7 to 14 with modes of 12 and 14 at HV and ST, respectively. Odds prevailing in the market at three different times were collected: (a) the final odds, observed when the betting market closes as the race starts; (b) the odds 5 minutes before the start of the race ("late odds"); and (c) odds observed at midnight prior to the days' racing ("early odds"), formed as a result of bets placed on the day before the race. Odds at these different times are collected in order to compare the degree of anchoring displayed by bettors with more and less betting expertise; these distinctions are discussed below.

Models and Variables

In a pari-mutuel betting market, the odds on horse i in race j (O_{ij}) are determined by the proportion of money bet on this horse, as follows:

$$O_{ij} = \left(\sum_{i=1}^{n_j} W_{ij} \Big/ W_{ij} \right)(1-d) - 1, \tag{1}$$

where W_{ij} is the amount of money bet on horse i in race j, n_j represents the number of horses in race j and d is the deduction by the pari-mutuel operator from the total money bet made. It is expected that the odds will change as the market develops according to equation (1) until the odds finally reflect the market's best estimate of a horse i's chance of winning race j (Asch *et al.*, 1984; Figlewski, 1979; Johnson & Bruce, 2001). Consequently, bettors' collective judgments concerning the chance that horse i wins race j is given by $p_{ij}^s = W_{ij} \Big/ \sum_{i=1}^{n_j} W_{ij}$, where p_{ij}^s represents bettors' subjective probability judgment of horse i winning race j. Based on the published O_{ij} we are able to estimate the p_{ij}^s using Eq.1, since the deduction d and the rules concerning rounding are known[1].

Conditional logit model.

We employ conditional logit (hereafter CL) models to detect the extent to which bettors' subjective judgments of horse i's chance of winning race j, p_{ij}^s, deviate from horse i's true probability of success. These deviations are used to assess the degree to which bettors anchor their judgments on BP information.

CL models are popular means of exploring the factors which influence horserace results (e.g., Figlewski, 1979; Schnytzer & Shilony, 1995; Johnson & Bruce, 2001). They are used to estimate the chance of horse i winning race j (i.e. its objective winning probability, p_{ij}^o) based on the information available concerning horse i and all other runners in race j. These are models in which the winning probabilities are derived such that the winning probabilities of all horses in a given race sum to one. In a linear regression, for example, there is nothing to guarantee that this would happen and, indeed, it almost never does. Consequently, CL models account for the competitive element of a horserace (see McFadden, 1974).

We estimate two CL models. The first estimates the probability of horse i winning race j based solely on information concerning BP, as follows:

$$p_{ij}^o = \exp(a_1 BP_{ij}) \Big/ \sum_{i=1}^{n_j} \exp(a_1 BP_{ij}) \quad \text{for } i = 1, 2, \ldots n_j, \tag{2}$$

where BP_{ij} is the BP of horse i in race j, n_j is the number of runners in race j and a_1 indicates the contribution which BP makes to the horse's chance of winning race j. The second model estimates the probability of horse i winning race j based on information concerning BP *and* the bettors' subjective probability estimate of horse i winning race j (p_{ij}^s), as follows:

$$p_{ij}^o = \exp(a_2 BP_{ij} + b_1 \ln p_{ij}^s) \Big/ \sum_{i=1}^{n_j} (a_2 BP_{ij} + b_1 \ln p_{ij}^s) \quad \text{for } i = 1, 2, \ldots n_j. \tag{3}$$

The coefficients a_1, a_2 and b_1 are measured by maximizing the joint probability of observing the winners of all the races in the sample. The degree to which BP affects winning probabilities and the extent to which bettors anchor on BP information can be discerned from the significance and signs of these coefficients. In particular, if a_1 is significant this suggests that BP has an impact on a horse's winning probability. If, in addition, a_2 is insignificant this implies that bettors fully account for the impact of BP in their subjective probability judgments. If both a_1 and a_2 have the same sign and are significant this implies that bettors' judgments do not sufficiently account for BP advantage. Equally, if a_2 has the opposite sign to a_1 and both are significant, this suggests that bettors anchor on BP information. If bettors' subjective judgments concerning horses' winning chances are perfect (i.e., $p_{ij}^s = p_{ij}^o$), then a_2 would equal 0 and b_1 would equal one.

Hypothesis Testing

Hypothesis one, that bettors in the HK horserace betting market anchor their judgments of horses' winning probabilities on low BP advantage, is tested by exploring whether horses with low BPs are over-bet in the Hong Kong market as a whole.

In testing hypothesis two, that bettors at a given meeting anchor on the results at the previous meeting, we make use of the fact that HV has tighter bends and a smaller circumference (c.f. ST). Consequently, horses with a low BP at HV are likely to be at a greater advantage; the results detailed below confirm this. Consequently, we might expect bettors, who have recently observed a significant low BP advantage at HV to anchor on this and over-bet horses with a low BP at ST (where the BP advantage is less marked). Similarly, we might expect bettors, who have recently observed only moderate low BP advantage at ST to anchor on this fact, and to under-bet horses with low BP at HV (where low BP offers a significant advantage). Consequently, we test hypothesis two by exploring whether horses with low BPs are under-bet at HV and are over-bet at ST; if this is the case it will suggest that results from the previous meeting may be unduly influencing bettors' subjective probability judgments.

Whilst ST and HV race meetings generally alternate, it is not always the case, and this provides an opportunity to further test hypothesis two. In particular, we explore "different track meetings" separately (i.e. ST preceded by HV, and vice-versa) and "same track meetings" (e.g. ST [HV] preceded by ST [HV]). Hypothesis two would be supported if low BPs are under-bet at HV and are over-bet at ST at different track meetings but they are appropriately bet at same track meetings.

It has been demonstrated that individuals use outcome feedback in a dynamic environment to reduce their decision biases (Johnson *et al*., 2006). Consequently, if anchoring causes bettors at HV to over-rely on the results from ST (held earlier in the week) (and vice-versa), it is likely that this effect will be most pronounced in the first few races of the race meeting. Observation of the outcomes of early races should, via appropriate learning, enable bettors to adjust their probability judgments to more appropriately account for BP advantage in later races. To further test hypothesis two, we explore differences in the degree to which low BP horses are over-bet at HV and ST in the first three and the last three races. Support for hypothesis two would arise if low BP horses were under-bet in the first three races at HV. This is predicted by hypothesis two because a low BP should afford a considerably greater advantage at HV than at the previous ST meeting. In addition, less under-betting on low BP horses should occur in the last three races at HV, as bettors learn from the earlier race outcomes at HV and place less emphasis on the outcomes of races at the previous ST meeting. Similarly, hypothesis two would be supported if there was evidence of less over-betting on low BP horses at ST in the last three races (c.f. the first three).

We also explore the degree to which low BP horses are under/over-bet at ST/HV in the first three and the last three races at (a) same and (b) different track meetings. Hypothesis two would be further supported if there was greater evidence of under/over-betting of low BP horses in the first three races at different track meetings at HV/ST than in same track meetings at HV/ST.

We test hypothesis three, that bettors anchor their probability judgments on the BP of the winning horse in the previous race, by exploring if bettors over-estimate the prospects of horses with a low/high BP immediately following a low/high BP victory. As discussed above, the configurations of both ST and HV suggest that low BP confers an advantage since horses running close to the inside rail travel less distance. However, other factors can affect the BP advantage. In particular, it is possible that the condition of the surface on certain sections of track (perhaps as a result of weather conditions) may lead to certain BPs offering an advantage at a particular time on any given day. The results of previous races run on the same day may, therefore, provide some guidance to the particular BP advantage operating; a low (1-4)/high (>7) BP victory suggesting an enhanced/reduced low BP advantage in the next race. However, since individuals often anchor on the most immediate information, it is possible that bettors place too much emphasis on the most recent race result when forming their subsequent probability judgments. Consequently, we explore whether a low/high BP victory in the previous race leads bettors to over-estimate the probability of horses with a similar BP winning the following race.

We test hypothesis four, that the probability judgments of bettors with greater expertise are less prone to anchoring associated with BP advantage than the judgments of bettors with less expertise, by making use of the fact that a bettor's level of expertise has been shown to be related to the time at which they bet. This enables a distinction to be made between bettors with three levels of expertise: The odds formed by bets placed on the day preceding the race (early odds) are taken to represent the bets of those with the *least expertise*, since these bettors have chosen to bet at a time when significant information concerning a horse's prospects is not available (e.g., the horse's condition as displayed in the parade ring prior to the race, late jockey changes). Those who possess important information concerning horses' winning prospects have an incentive to bet late in pari-mutuel markets since this minimizes the chance of others simply mirroring their bets and reducing the odds on their selected horse(s). Late bettors are confirmed as relatively knowledgeable bettors, who achieve higher returns than other bettors, by a number of studies (e.g., Asch *et al*., 1984; Dowie, 2003; Johnson & Bruce, 1992). The odds observed five minutes before the race starts (late odds) are therefore regarded

as being influenced by individuals with *moderate expertise*. It is well known that professional bettors operate in the Hong Kong market and that they spend considerable resources in analyzing results of previous races in order to make their selections. They tend to bet heavily in the last couple of minutes before the race (Benter, 1994). Since odds in a pari-mutuel market are determined by the relative amount of money bet on each horse (see Eq. 1), it could be argued that the final odds will also be influenced by the bets of those with less expertise who bet early. However, late bettors have the opportunity to bet in a manner to exploit any biases they observe in earlier betting patterns. Consequently, final odds are assumed to be those most influenced by bettors with the *greatest expertise*.

Clearly, the final odds not only incorporate the wagers of those with greatest expertise, but also those with moderate and least expertise. Similarly, the odds five minutes before the race incorporate the wagers of those with moderate expertise and of those with least expertise. The distinctions between the betting of those distinguished by their level of expertise may therefore be masked to some extent by comparing the odds at these different points in time. This problem would be overcome if we could compare early odds with those determined by the amount of money wagered on horses (a) from the commencement of betting on the day of the race up to 5 minutes before the start of the race and (b) from 5 minutes before the race until the race starts. This would enable the marginal odds created by the three groups distinguished by their levels of expertise to be more clearly defined. Unfortunately, this would require knowledge of the amount bet in the market in these different time periods, which we could not obtain. Consequently, in analyzing the results it should be bourn in mind that any distinctions we do observe in the early, late and final odds are likely to under-state the true distinctions between the betting behavior of these those with different levels of expertise.

Each of the models used to test hypotheses 1-3 are developed on the basis of (a) early, (b) late, and (c) final odds and these are used to assess differences in the degree and the nature of anchoring effects between bettors with different (increasing) levels of expertise.

Results and Discussion

Anchoring in the Hong Kong Horserace Betting Market as a Whole

The results of estimating CL models to examine to what extent a horse's BP affects its finishing position are given in Table 1. For the Hong Kong market as a whole, and for both HV and ST, the coefficient of BP is negative and significant at the 1% and 5% levels,

respectively, suggesting that a low BP improves a horse's winning chance and that the effect is greater at HV.

<div align="center">Insert Tables 1 and 2 about here</div>

The results of estimating CL models with the horse's BP and bettors' subjective probability judgments as independent variables are reported in Table 2. We focus, at this stage, on the results associated with the final odds in the market, since these represent the combined probability judgments of all the market participants.

For the Hong Kong market as a whole the coefficient of the natural log of the bettors' subjective probability is significant at the 1% level, suggesting that bettors' judgments are generally in line with horses' actual winning probabilities. In addition, the BP coefficient is not significant at the 5% level, suggesting that the public appropriately account for BP in their subjective probability judgments. Taken alone, these results suggest that Hong Kong bettors do not anchor their judgments on the clear advantage afforded to those horses with low BP; this advantage being easily discerned from the configuration of the racetracks, from previous race results and from media comment. Consequently, one might conclude that anchoring on BP advantage is absent. This finding is clearly at odds with the main conclusions of the anchoring literature (e.g., Thomas & Handley, 2005; Northcraft & Neale, 1987). However, as demonstrated below, this inconsistency arises because the conclusions based on the Hong Kong market as a whole are misleading.

In fact, combining results from the two racetracks leads to model mis-specification since the effect of BP on winning probabilities and the manner in which bettors handle BP information at the two racetracks appears to be different. This is confirmed by comparing the sum of the information contained in the separate CL models for the two racetracks with the information contained in the CL model developed for the Hong Kong market as a whole. This is achieved by conducting a likelihood ratio (LR) test based on the maximum log-likelihood (LL) values for models simply incorporating BP (given by Equation 2), based on (a) HV data (L_{HV}: represents the LL of a BP model simply based on HV data) (b) ST data (L_{ST}: represents the LL of a BP model simply based on HV data) and (c) for the Hong Kong market as a whole (i.e. HV+ST: L_{HK}: represents the LL of a BP model based on HV+ST data). The quantity K= $2(L_{HK} - [L_{HV} + L_{ST}])$ is distributed χ_n^2, where n is the difference between the total number of parameters estimated in the individual racetrack's models and in the combined model. A similar LR test is conducted for models based on HV, ST and HV+ST data incorporating both BP and odds implied probabilities (given by Equation (3)).

The results of the two LR tests for the models incorporating simply (i) BP and (ii) BP and odds implied probabilities (where K takes the values 54.6 ($\chi_1^2[.01] = 6.64$) and 9.2 ($\chi_2^2[.01] = 9.2$), respectively), suggest that significantly more information concerning the effect of BP on winning probabilities and the manner in which bettors incorporate this information in their judgments can be derived from exploring models for the two racetracks separately (than by combining the data for the two tracks).

In fact, the coefficient of BP in the HV CL model incorporating bettors' subjective probabilities is negative and significant at the 10% level, whereas it is positive and significant at the 1% level in the ST model (see Table 2). These results suggest that bettors at HV/ST *under/over* use BP advantage information. It is clear, therefore, that the results for the Hong Kong market as a whole mask the manner in which bettors at the two tracks use information. However, at both tracks the coefficient of the natural log of the odds implied probability is significant at the 1% level, suggesting that bettors' subjective probability judgments are a reasonable guide to a horse's winning chance.

In sum, the evidence presented above appears, in relation to bettors at ST, to support hypothesis one, namely, that bettors anchor their probability judgments on BP advantage, whereas the evidence drawn from HV appears to reject the hypothesis. Consequently, there is no clear evidence that bettors simply anchor on their pre-conceived view of BP advantage discerned from the configuration of the racetrack or from the results of previous races.

Anchoring on the Results of the Previous Race Meeting

The race meetings in Hong Kong often alternate between HV and ST and the results displayed in Table 1 suggest that low BP affords a greater advantage to horses running at HV (c.f. ST). Consequently, the results displayed in Table 2 and discussed above may point to anchoring by bettors on the results from the previous race meeting held at the other venue earlier in the week (in support of hypothesis two). Laboratory experiments have demonstrated that subjects' judgments can be influenced by anchors encountered up to seven days earlier (Mussweiler, 2001). Therefore, it is entirely feasible that bettors' judgments are influenced by anchors formed by race outcomes observed at a race meeting held three or four days earlier.

If bettors at HV/ST anchor their probability judgments on the results of races run earlier in the week at ST/HV, they are likely to under/over-estimate the value of a low BP. The results displayed in Tables 1 and 2 confirm the over- and under-betting of low BP horses in the manner predicted by hypothesis two.

In addition, a comparison of the degree of under/over betting of low BP at HV/ST for same track meetings (i.e. HV/ST meetings following HV/ST meetings) with that for different track meetings (i.e. HV meetings following ST meetings, and vice-versa) also supports hypothesis two (see Table 3). In particular, at both HV and ST, the coefficients of BP in CL models (simply incorporating BP) developed for same track meetings are negative and significant at the 5% and 10% levels, respectively. In equivalent CL models for same track meetings, incorporating bettors' subjective probabilities, the BP coefficient is not significantly different to zero at HV or at ST, suggesting that bettors appropriately account for BP advantage. At different track meetings the coefficient of BP in CL models (simply incorporating BP) is negative and significant at the 1% level at HV, but is not significantly different to zero at ST. In CL models incorporating bettors' subjective probabilities and BP for different track meetings the BP coefficient is negative and significant at the 10% level at HV and is positive and significant at ST. These results imply that bettors over-estimate the advantage of low BP at ST and underestimate it at HV at different track meetings. Consequently, taken together, these results offer strong support for hypothesis two. In particular, there appears to be anchoring on the results from the previous race meeting for the different track meetings; BP being under-bet at HV following a ST meeting and over-bet at ST following a HV meeting. However, in races at HV and ST which follow a previous meeting at the same track, BP is correctly accounted for in bettors' subjective probabilities. It appears that bettors are able to learn to appropriately account for BP at a particular track, provided this learning is not disrupted by an intervening race meeting at the alternative venue, where a different BP bias prevails. In the latter case, bettors appear to anchor on the results from the previous meeting, even when these are not relevant to races at the current track.

Further evidence to test hypothesis two is presented in Tables 4 and 5. The results of estimating CL models (incorporating BP) for the first three and last three races at HV and ST are reported in Table 4. At HV the BP variable has a coefficient which is negative and significant in both sets of races, but the level of significance is greater in the last three races than in the first three races; suggesting that a low BP offers more advantage in the later races. This may arise because the race types and distances of races can vary between early and late races, and these factors may influence BP advantage. In addition, the inside rail is often moved for later races, allowing horses drawn on the inside to run on fresh ground which has not been damaged by previous runners. The precise manner in which these factors combine to influence the effect of BP on race results is not clear, but the key issue in respect of the current research is that at HV the advantage of a low BP increases in later races.

Insert Tables 3, 4 and 5 about here

At ST the coefficient on BP is again negative for both early and late races; significant at the 10 % level in early races but insignificant in later races. This suggests that low BP confers some advantage in the first three races but no advantage in the later races. The differences in levels of significance of the BP variable between the models developed for HV and ST also demonstrate the greater advantage afforded to horses with a low BP at HV.

As indicated above, many factors could contribute to the BP advantage changing between the early and late races (e.g. race types, distance, prize money etc). However, the reasons for this are not the central focus of this enquiry. Rather, we are concerned with the extent to which bettors anchor on BP, whatever level of advantage it confers at different times of the betting day. Consequently, when exploring to what extent BP is accounted for in odds, we do not control for different factors which could cause changes in the BP advantage throughout the betting day.

Table 5 reports the results of estimating CL models incorporating the BP and bettors' subjective probabilities in the first three and the last three races run at both HV and ST. Once again, we first explore the results associated with the odds which represent the combined probability judgments of all the market participants; that is, the final odds. As expected, at both HV and ST the coefficients of the natural log of the bettors' subjective probability are significant at the 1% level, suggesting that the probability judgments of bettors are highly correlated with actual winning probabilities. In the first three races at HV the BP coefficient is negative and significant at the 5% level. This suggests that, as the coefficient in the model incorporating only BP is also negative for the first three races at HV, bettors fail to take full account of the advantage of low BP in the early races. On the other hand, bettors at ST fully incorporate the low BP advantage in their subjective probability estimates in the first three races (the BP coefficient is not significant at the 5% level in the model combining bettors' subjective probability and BP).

A different picture emerges in relation to the last three races at both tracks. At HV, low BP advantage increases substantially in later races, and bettors fully account for this in their probability judgments (the BP coefficient in the model incorporating bettors' probabilities is not significant at the 5 % level). However, at ST, where low BP advantage is significantly lower in the last three races, the BP coefficient (in a CL model incorporating bettors' subjective probabilities) is positive and significant at the 5% level; suggesting that bettors over-estimate low BP advantage when forming their probability judgments.

Taken together, the results relating to the manner in which bettors account for BP advantage in the early and late races offer some support for hypothesis two: In particular, bettors in the first three races at HV significantly under-estimate the low BP advantage when assessing their subjective probabilities; suggesting that they may be anchored on the results of previous races run at ST. However, by the end of the HV race meeting (there are typically ten races at ST and eight at HV) they have fully adjusted their subjective probability estimates to account for the clear advantage enjoyed by horses with low BPs. Similar results are obtained when separating races run at HV immediately following a race meeting at ST. In particular, for the first three races, the BP coefficient in a CL model also incorporating bettors' subjective probabilities is significant at the 5% level (-0.0307, $SE = 0.0143$, $N = 1301$) but is not significantly different to zero in the last three races (-0.0095, $SE = 0.0176$). Consequently, bettors at HV appropriately account for BP in these later races, but they probably do not achieve this by simply relying on information from the first few race results at HV, since the advantage of low BP is much greater in the last three races. It is possible that a combination of re-familiarization with the racetrack configuration (having observed earlier races, the tight angle of the bends may once again influence their decision-making), previous results, and adjustment of their mental model to include consideration of the effect of different race types/distances on the BP advantage, may all play a part in the bettors' learning process. The ability of bettors to develop such sophisticated mental models is confirmed by Ceci and Liker (1986).

The influence of anchoring from the previous race meeting is further confirmed when examining same track meetings at HV separately. In this case BP advantage in the first three races at the meeting is *fully* accounted for in bettors' subjective probability judgments; the BP coefficient in a CL model also incorporating bettors' subjective probabilities not being significantly different to zero (-0.0538, $SE = 0.0461$, $N = 127$). This result is in contrast to that indicated above for races run at HV following a meeting at ST, where low BP advantage was not fully accounted for in bettors' subjective probabilities. These results together provide strong evidence of anchoring on experience from the previous race meeting at ST.

Further support for hypothesis two is provided by an analysis of early and late races at ST. In later races where the actual advantage of a low BP decreases (and becomes insignificant) bettors' judgments over-estimate the advantage of a low BP (see Table 5). It may be that bettors anchor on the results of races run earlier that afternoon at ST. In addition, the lack of low BP advantage displayed in the results of later races at ST may well act as a considerable anchor on the judgments of bettors in the subsequent early races at HV; and the results

reported above support this view. However, the analysis of early races at ST offers a challenge to hypothesis two: in the first three races of a ST meeting, where low BP confers a moderate advantage, bettors fully account for this in their betting decisions. However, because the advantage of a low BP at ST in these early races is considerably lower than that experienced in the last three races at HV, hypothesis two would predict that ST bettors would anchor on the later results at HV and, consequently, would over-estimate the benefit of a low BP at ST. Separating races run at same and different track meetings does not shed additional light on the reasons for bettors at ST correctly accounting for BP advantage in the first three races. No BP advantage is discerned in the first three races at ST in either same or different track meetings; the BP coefficients in CL models simply incorporating BP are not significantly different to zero (same track meetings: -0.0150, SE= 0.0133, N = 1176; different track meetings: -0.0163, SE= 0.0117, N = 1642). Bettors at both same and different track meetings appear to be aware of this lack of BP advantage, since the coefficients of BP in CL models incorporating BP and bettors' subjective probability judgments are not significantly different to zero (same track meetings: 0.0113, SE = 0.0140; different track meetings: 0.0063, SE= 0.0125).

Taken together, the results relating to the manner in which bettors at ST and HV account for BP bias in early and late races offer some support for the view that bettors anchor their probability judgments on race results they encounter at the previous race meeting. However, the simple relationship suggested by hypothesis two is not confirmed. There may, for example, be complicated inter-relationships between the anchoring based on the previous race meeting's results and the impact which racetrack configuration has on bettors' probability judgments: ST has a large circumference with relatively gentle bends and this may cause bettors to considerably reduce their estimates of low BP advantage (formed by anchoring on the outcomes of races at the previous HV meeting). However, the results demonstrate that bettors at HV, when observing the track's tighter bends and smaller circumference, do not sufficiently increase their probability estimates of low BP advantage (formed by anchoring on the outcomes of races at the previous ST meeting)

It may well be that the anchoring effect of previous race outcomes interacts in a complicated manner with anchoring effects caused by racetrack configuration. Whilst this is difficult to confirm, we aim to further our understanding of the extent to which bettors anchor on previous race outcomes by testing hypothesis three, namely, that bettors anchor their probability judgments on the BP of the winning horse in the previous race.

Anchoring on the Outcome of the Previous Race

Due to a variety of factors (e.g., certain weather conditions, watering regimes), the advantage of certain BPs can alter throughout a racing day. One way in which bettors can discern such changes is to observe the result of the preceding race. Table 6 summarizes the BP advantage at both ST and HV in a subsequent race when the previous race was won by a horse with a (a) low BP (1-4) and (b) a high BP (>7). At both racetracks, when the previous race was won by a low BP horse, the BP coefficients in the CL models are negative and significant at the 1% level. In addition, at both racetracks these coefficients are more negative and more significant than those for CL models based on all races at these meetings (see Table 1). Following a winner from a high BP, the coefficient of BP remains negative but is of reduced significance at HV, and at ST it is no longer significant at any conventional level. In this case these coefficients are both less negative and less significant than for those for CL models based on all races at these meetings (see Table 1). Taken together, these results suggest that the chance of a horse with a low BP winning is increased/decreased if the previous race was won by a horse from a low/high BP, although none of the changes in the BP coefficients are significant at the 5% level (i.e. following low BP win: HV, $t=0.37$; ST, $t= 1.69$; following high BP win: HV, $t= 1.14$; ST, $t=1.32$). Our main concern is to examine to what extent bettors base their probability judgments on the BP advantage information contained in the most recent race outcome. Consequently, we estimate separate CL models for HV and ST, incorporating odds probabilities and BP for races where the previous race was won by a horse from (a) low and (b) high BPs. The results are displayed in Table 7, and again we focus on the results associated with the final odds, which represent the combined probability judgments of all the market participants.

When the previous race was won by a horse from a low BP, the BP coefficients are not significant at any conventional level in models developed for ST and HV which incorporate both BP and odds implied probabilities. These results suggest that bettors at both tracks fully account for BP advantage in race following a low BP winner. In addition, when the previous race was won by a horse with a high BP, the BP coefficients are not significant at any conventional level in the model developed for HV which incorporates both BP and odds implied probabilities. However, in equivalent models developed for ST, the BP coefficient is positive and significant at the 5% level. These results imply that bettors at HV fully account for BP advantage in the race following a high BP winner, whereas bettors at ST over-estimate the BP advantage.

Insert Table 6 and 7 about here

Bettors at HV generally *underestimate* the advantage of a low BP (see Table 2). However, following a low-BP winner they fully account for low BP advantage in the next race. This suggests that bettors use previous race outcome information to improve their calibration. The analysis also demonstrates that the low BP advantage at HV is reduced in a race following a high BP winner (see Table 6). There are potentially two reasons for bettors correctly accounting for BP advantage in this subsequent race. It may be that bettors use the previous race outcome information appropriately when forming probability estimates or, given that bettors at HV generally under-estimate the advantage of low BPs, the reduction in the winning chances of a horse from a low BP may be all that is needed to bring bettors' views into line with reality. In other words, the results are also consistent with bettors ignoring the previous race result (when a high BP horse wins) because it does not accord with their mental model of the likely BP advantage. Previous research suggests that individuals discount evidence which runs counter to existing perceptions; the inconsistent evidence may be discounted deliberately to reduce dissonance and effort (Harries *et al*., 2004). Bettors certainly do not appear to unduly anchor on a high BP victory (a low probability event according to their mental model) in the previous race. A somewhat similar effect has been found in a laboratory gambling task (Carlson, 1990).

At ST, the chance of a horse with a low BP winning when the previous race was won from a low BP, significantly increases (the BP coefficient being significant at the 1% level (see Table 6), whereas it is only significant at the 5% level where no information on the previous winner is available (see Table 1). Bettors at ST generally over-estimate the value of a low BP (see Table 2). However, following a winner from a low BP they correctly account for the enhanced low BP advantage in the next race. Whether this arises from appropriate use of information contained in the result of the previous race, or simply because the advantage of a low BP is now more in line with bettors pre-conceived view of this advantage, can not be determined.

At ST, horses with a low BP have an advantage (see Table 1). However, when a horse from a high BP wins a race the low BP advantage in the subsequent race becomes insignificant (see Table 6). Bettors do not appear to fully account for the information contained in a high BP victory, since the results show that they continue to over-estimate the advantage of a low BP in the subsequent race (see Table 7). It is again possible that they discount the high BP winner since it is a low probability event according to their mental model of BP advantage (Carlson, 1990).

Taken together, the results of exploring the degree to which bettors account for changes in the BP advantage which can be discerned from the outcome of the previous race, do not provide support for hypothesis three. When a race result accords with the bettors' mental model of BP advantage (determined, for example, from racetrack configuration) there is evidence that bettors may use this information appropriately (e.g. bettors at HV appear to use a low BP victory to correctly increase their assessment of the chances of a low BP victory in the subsequent race). This result is in accord with the notion of "recency", whereby individual's judgments tend to hinge more on the most recent evidence in a sequence of evolving information (e.g., Ashton & Kennedy, 2002; Krull *et al.*, 1993). However, some of the evidence presented above suggests that bettors may fail to take full account of previous race outcomes which fall outside their mental model of BP advantage; this result is in line with some previous research (e.g. Harries *et al.*, 2004). Consequently, it is suggested that the manner in which bettors use information, and hence their degree of anchoring, may depend upon a complex relationship between the strength of their existing mental model, the degree to which the potential anchor accords with this mental model, and the nature of the anchor information.

Expertise and Anchoring

Finally, we turn to testing hypothesis four, which is based on previous laboratory findings that decision makers with greater expertise are less prone to anchoring effects (e.g., Northcraft & Neale, 1987; Shelton, 1999). In particular, we examine whether the degree of anchoring observed when testing hypotheses one to three, is related to bettors' expertise.

It was suggested above, that the observed under/over-valuation of low BP advantage at HV/ST, could have been caused by bettors anchoring on the results of races run at the other racetrack earlier in the week. These effects are considerably more pronounced when the bets of those considered as having less expertise are examined. For example, the BP coefficients in the CL models incorporating odds and estimated using HV data are considerably more significant for models based on early odds and late odds than in models based on final odds (see Table 2). A similar pattern is observed for the CL models based on ST data (see Table 2). These results are confirmed when races are separated into same and different track meetings. For example, at HV, for different track meetings, the BP coefficient in a CL also incorporating bettors' subjective probabilities, is significant at the 1% level when the model is based on early odds (-0.0362, $SE = 0.0087$, $N = 1301$) but is not significant at the 5% level when based on final odds (-0.0151, $SE = 0.0089$). At same track meetings the difference

between models based on early and final odds is less pronounced (as might be expected, since less bias is introduced by anchoring on an inappropriate BP advantage observed at the alternative venue). However, final odds still appear to correctly account for BP to a greater extent. For example, in CL models incorporating bettors' subjective probabilities and BP, developed for same track meetings at ST, the coefficient on BP is significant at the 10% level when the model is based on early odds but is not significant at any conventional level when the model is based on final odds (early odds: 0.0132, *SE* = 0.0080; final odds: 0.0108, *SE* = 0.0080).

Taken together, these results suggest that those with less expertise are more likely to anchor their judgments on race outcomes from the previous race meeting. In practice this phenomenon is more pronounced than is demonstrated by the results displayed in Table 2. This arises because the odds are determined by the relative amounts of money on each horse (see Eq. 1). Consequently the final odds, which we have associated with those with the greatest expertise, will be determined by the money wagered by these individuals *and* by the earlier bets of those with less expertise.

Examination of the degree to which BP advantage is accounted for in odds in early and late races at HV and ST suggests that those with less expertise are more likely to anchor on the results at the previous race meeting. In particular, it was postulated that bettors at HV, particularly in the first three races, anchor their judgments on the bettors' experience earlier that week at ST (where low BP offers less advantage). It is clear from the results for the first three races at HV, displayed in Table 5, that the BP coefficients, in CL models incorporating BP and bettors' subjective probabilities, are negative for bets at early, late and final odds. These coefficients are increasingly significant for models based on odds formed by bettors with less expertise; suggesting that less experienced bettors under-value the advantage of low BP to a greater extent than those with more expertise. These results are confirmed when specifically exploring different track meetings. For example, in the first three races at HV the BP coefficient is negative and significant at the .01% when the model is based on early odds (-0.0518, *SE* = 0.0141, *N* = 1301), but is only significant at the 5% level when based on late odds (-0.0307, *SE* = 0.0143). Consequently, bettors with less expertise appear more prone to anchor on the results from the race meeting at ST held prior to the HV meeting. For HV races at same track meetings a less pronounced difference is observed between models based on early and late odds (as might be expected, since less bias is introduced by anchoring on an inappropriate BP advantage observed at the previous ST meeting); the BP coefficients for the

first three races are not significant at the 5% level in either case, although the significance of the BP coefficient is greater in the model based on early odds (early odds: -0.0586, *SE* = 0.0461; late odds: -0.0538, *SE* = 0.0461, *N*=127).

None of the coefficients for BP in the CL models estimated on the three sets of odds (final, late and early odds) for the first three races at ST are significant (see Table 5; this result also holds for models based on both same and different track meetings), although they are all positive and the Z value is greatest for the model based on odds formed by bettors with least expertise. These results provide weak evidence in favor of more anchoring on the results from the previous HV meeting by those bettors with less expertise.

In the CL models estimated for the last three races at ST, based on final and late odds (early odds are not included in the comparison since these were formed by individuals without the benefit of observing the earlier races at ST), the BP coefficients are positive and significant (see Table 5). This suggests that, despite the reduced advantage of low BP in these late races, bettors continue to anchor on the results from earlier in the day when low BP had a more distinct advantage. However, the degree of anchoring on earlier results is slightly less pronounced for those bettors with greater expertise. Neither of the coefficients for BP in CL models for the last three races at HV, estimated on the late and final odds, is significant, although their relative size provides some weak evidence that bettors with greater expertise use information from earlier results more appropriately to adjust their probability estimates in later races.

Taken together, the results discussed above suggest that bettors with greater expertise are less prone to anchoring effects. As indicated in section IV, our method for distinguishing the bets of those with different levels of expertise somewhat understates the degree to which they differ. Consequently, our results point strongly to expertise reducing the degree to which anchoring is employed. This finding is this is in line with the results of experimental studies. For example, Shelton (1999) found that more-experienced auditors (audit managers and partners) were less influenced by irrelevant information encountered during audit judgments than auditors with less experience (audit seniors). Similarly, Northcraft and Neale (1987) demonstrated that naive subjects (undergraduate business school students) were more prone to anchor their estimates of a house's value on less relevant information than expert subjects (real estate agents).

The final set of results exploring the relationship between expertise and anchoring do not accord with conclusions reached in previous research: A comparison of CL models based on final and late odds, estimated for races run at HV and ST, reveal no appreciable differences in

the manner which the immediately preceding race outcomes are used by bettors with varying levels of expertise (see Tables 6 and 7). It appears that bettors with varying levels of expertise are able to appropriately employ information contained in the most recent race result. However, as indicated above, those bettors with less expertise are more prone to anchoring on an earlier *series* of race outcomes.

Overall, the results suggest that experts are less prone to anchoring. However, it could be argued that to some extent it is surprising that the experts in the Hong Kong market are subject to any anchoring at all. It has been widely reported (e.g. Benter, 1994) that large betting syndicates, using sophisticated computer models operate in the Hong Kong market. They are attracted to these markets due to the high betting volumes, which provide them with the opportunity to recoup the significant set up and operating costs of such operations. In addition, the strict regulation of these markets by the Hong Kong Jockey Club (which helps to eliminate mal-practice and insider trading, which would be difficult for their models to incorporate) and their openness with regard to information about prior results, provides the ideal conditions for the construction of 'rational' models. These are designed to systematically account for factors likely to influence the probability of a horse winning. The syndicates will then bet on horses where the public's assessments (as evidenced by the market odds close to the start of the race) under-estimate a horse's chance of winning, as predicted by their model. Anecdotal evidence suggests that these syndicates make substantial profits and there is evidence that their betting activities may eliminate some biases which are observed in markets where these syndicates do not operate (e.g. the favorite-longshot bias: Busche & Hall, 1988; Busche, 1994). However, whilst these syndicates may employ computer models and be successful, the models are developed by human beings and there is no evidence that they bet optimally. In fact, whilst their bets do reduce the degree of anchoring displayed in the odds in this market, some anchoring remains, suggesting that even highly sophisticated experts judgments remain subject to the bias caused by this heuristic.

Conclusion

A number of conclusions emerge from the research: First, that caution must be exercised when examining anchoring effects in a real world environment, since mis-specification of the problem can easily occur by combining data inappropriately. In the current study, no anchoring was observed when data for the Hong Kong betting market as a whole was analyzed. However, this false conclusion arose because bettors, when making their probability

judgments, under-valued the advantage of a low BP at one track and over-valued it at another. It is suggested, and demonstrated, that both of these behaviors arise through anchoring and yet their effects were masked when examining the market as a whole.

Second, the paper demonstrates that anchoring in real world environments is a complex phenomenon. Bettors do not, for example, simply anchor on the configuration of a racetrack or on media analysis which suggests that particular BPs will have an advantage. Rather, bettors appear subject to complex anchoring effects. In particular, the research suggests that bettors can anchor on a series of race outcomes from a race meeting held earlier that week. However, this behavior appears to be moderated by other factors, such as the current racetrack configuration and their own mental model of BP advantage. In fact, bettors do not anchor on the result of the most recent race or series of races run on the same day when they are forming probability judgments. On the contrary, they appear to appropriately use this information when forming their probability judgments later that day, particularly, when the previous race outcomes are in line with their mental model of BP advantage. However, there is some evidence that when race outcomes are contrary to their mental model, bettors fail to take full account of the information. For example, following a high BP victory, bettors do not sufficiently adjust their subjective probability estimates of a horse with a low BP winning the next race. In summary, the results suggest that anchoring effects in the horse race betting market are subtle and are influenced by a range of factors, including racetrack configuration and previous race outcomes; these factors appear to interact to produce a complex anchoring phenomenon.

Third, the results suggest that basic anchoring effects in a real world environment can be robust and relatively long lived. This result is in sharp contrast to previous studies conducted in the laboratory, which suggest that because basic anchoring does not involve a direct comparison process between anchors and targets, basic anchoring effects are fragile and can easily disappear (e.g. Brewer and Chapman, 2002). Further work is needed to explore the nature of the factors experienced in a real world environment which appear to increase the impact of basic anchoring effects.

Fourth, the results suggest that, in general, decision makers with greater expertise use information more appropriately and are less prone to anchoring effects. However, whilst this is true for anchoring based on a recent *series* of previous races, either at the current, or at another racetrack, no differences were detected between those with greater and less expertise in terms of the degree to which they anchor on the results of the *last* race encountered. This, to some extent, accords with expectations in betting markets, since expert bettors are widely

regarded as being distinguished from those with less expertise by the considerable resources they spend in overcoming the complexity of analyzing (and developing probability estimates based on) the outcomes of previous *series* of races (Benter, 1994).

In summary, the paper presents evidence of subtle, complex anchoring effects in a real world environment. Most previous anchoring studies have been conducted in the laboratory on individuals. An important feature of the current study is that it examines behavior in a financial market. In many ways one might expect markets to eliminate individual anchoring effects, as some individuals seek to exploit the biases of others. The odds, reflecting the betting behaviors of those subject to the biases and the behaviors of those who seek to capitalize on the biases, should, in theory, be driven to a point where no bias exists. Remarkably, we find that these markets still exhibit the effects of anchoring. Clearly, the anchoring effects we observe are complex and it is possible that the behavior of individuals in a betting market, who are faced by a negative expected return, may be different to that of individuals facing other situations involving risk. In addition, race specific factors (e.g. race distance, race quality etc.) may influence the extent to which bettors anchor their judgments Equally, institutional factors associated with the Hong Kong horserace betting market which are discussed above (e.g. large betting syndicates, openness of information, strict regulation) may have an impact on the degree of anchoring which we detect. Consequently, more research is needed to identify the factors which influence the degree and nature of anchoring in betting markets and in other real world contexts.

Endnotes

1. All odds in HK are rounded to the nearest (lower) 10 cents. Consequently, by knowing this and the level of deductions d, we can use Equation (1) to work back from the final odds to provide an estimate of p_{ij}^s.

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Table 1: Results of Estimating CL Models with the Horse's BP as Independent Variable

	Model[a] based on races run at:		
	HV	ST	HV+ST
BP_{ij} coef. [b]	-.0782**	-.0107*	-.0299**
SE	*.0078*	*.0048*	*.0041*
Z	-10.03	-2.20	-7.27
LL	-3488.90	-7272.80	-10789.00
Model LR (χ_1^2)	102.81**	4.82*	53.00**
Pseudo-R^2	0.0145	0.0003	0.0025
No. of horses	16971	37364	54335
No. of races	1428	2818	4246

[a] Model employed: $p_{ij}^o = \exp(a_1 BP_{ij}) \Big/ \sum_{i=1}^{n_j} \exp(a_1 BP_{ij})$

[b] BP_{ij} : the BP of horse i in race j

HV: Happy Valley racetrack in Hong Kong

ST: Sha Tin racetrack in Hong Kong

HV+ST: Combination of all races run at HV and ST racetracks

** Significant at the 1% level

*   Significant at the 5% level

Table 2: Results of Estimating CL Models with the Horse's BP and Bettors' Subjective Probability Judgments as Independent Variables

	Models[a] based on subjective judgments derived from:								
	Final odds			Odds 5 minutes before race starts			Overnight odds		
	HV	ST	HV+ST	HV	ST	HV+ST	HV	ST	HV+ST
$\ln p_{ij}^{s}$ coef. [b]	.9514**	1.0282**	1.0112**	.9297**	1.0175**	.9983**	.9574**	1.0533**	1.0325**
SE	*.0369*	*.0227*	*.0193*	*.0373*	*.0230*	*.0195*	*0.4000*	*.0242*	*.0207*
Z	25.77	45.27	52.49	24.95	44.32	51.26	23.95	43.47	49.95
BP_{ij} coef. [c]	-.0141[+]	.0136**	.0065	-.0216*	.0133*	.0042	-.0342**	.0153**	.0016
SE	*.0085*	*.0052*	*.0044*	*.0084*	*.0052*	*.0044*	*.0083*	*.0052*	*.0043*
Z	-1.66	2.62	1.47	-2.56	2.58	0.96	-4.14	2.97	0.38
LL	-3093.9	-5983.9	-9082.4	-3126.0	-6065.7	-9198.7	-3177.7	-6204.3	-9395.6
Model LR (χ_2^2)	892.8**	2582.6**	3466.3**	828.7**	2419.0**	3233.5**	725.2**	2141.8**	2839.8**
Pseudo-R^2	0.1261	0.1775	0.1602	0.1170	0.1662	0.1495	0.1024	0.1472	0.1313
No. of horses	16971	37364	54335	16971	37364	54335	16971	37364	54335
No. of races	1428	2818	4246	1428	2818	4246	1428	2818	4246

[a] Model employed: $p_{ij}^{o} = \exp(a_2 BP_{ij} + b_1 \ln p_{ij}^{s}) \big/ \sum_{i=1}^{n_j}(a_2 BP_{ij} + b_1 \ln p_{ij}^{s})$

[b] $\ln p_{ij}^{s}$: natural log of the odds implied probability of horse *i* winning race *j*;

[c] BP_{ij}: the BP of horse *i* in race *j*

HV: Happy Valley racetrack in Hong Kong; ST: Sha Tin racetrack in Hong Kong; HV+ST: Combination of all races run at HV and ST racetracks;

** Significant at the 1% level; * Significant at the 5% level; [+] Significant at the 10% level

Table 3: Results of Estimating CL Models with (a)Horse's BP and (b) Horse's BP and Bettors' Subjective Probability Judgments as Independent Variables for Same and Different Track Meetings

	Same track meetings		Different track meetings	
	HV	ST	HV	ST
BP_{ij} coef. [a]	-.0527*	-.0127[+]	-.0808**	-.0093
SE	.0257	.0075	.0082	.0064
Z	-2.05	-1.68	-9.86	-1.46
LL	-312.9	-3032.3	-3175.5	-4240.3
Model LR (χ_1^2)	4.26*	2.83[+]	99.64**	2.12
Pseudo-R^2	.0068	.0005	.0154	.0003

Model employed: $p_{ij}^o = \exp(a_1 BP_{ij}) \big/ \sum_{i=1}^{n_j} \exp(a_1 BP_{ij})$

	HV	ST	HV	ST
$\ln p_{ij}^s$ coef. [b]	.8105**	1.004**	.9666**	1.0451**
SE	.1158	.0352	.0390	.0297
Z	7.00	28.50	24.81	35.16
BP_{ij} coef.	-.0035	.0108	-.0151[+]	.0156*
SE	.0278	.0080	.0089	.0068
Z	-.13	1.35	-1.70	2.29
LL	-284.5	-2528.5	-2808.4	-3454.9
Model LR (χ_1^2)	61.0**	1010.4*	893.9**	1573.0**
Pseudo-R^2	.0969	.1665	.1293	.1854
No. of horses	1521	15586	15450	21778
No. of races	127	1176	1301	1642

Model employed: $p_{ij}^o = \exp(a_2 BP_{ij} + b_1 \ln p_{ij}^s) \big/ \sum_{i=1}^{n_j} (a_2 BP_{ij} + b_1 \ln p_{ij}^s)$

[a] BP_{ij}: the BP of horse i in race j

[b] $\ln p_{ij}^s$: natural log of the odds implied probability of horse i winning race j

HV: Happy Valley racetrack in Hong Kong; ST: Sha Tin racetrack in Hong Kong

** Significant at the 1% level; * Significant at the 5% level; [+] Significant at the 10% level

Table 4: Results of Estimating CL Models for the First and Last Three Races with the Horse's BP as Independent Variable

| | | Model[a] based on races run at: | |
		HV	ST
First 3 races	BP_{ij} coef. [b]	-.0970**	-.0157[+]
	SE	*.0130*	*.0088*
	Z	-7.51	-1.79
Last 3 races	BP_{ij} coef. [b]	-.6570**	-.0038
	SE	*.1570*	*.0079*
	Z	-4.19	-0.48
Overall model statistics:			
LL		-3502.2	-7273.5
Model LR χ^2_2		76.2**	3.43
Pseudo-R^2		0.0108	0.0002
No. of horses		16971	37364
No. of races		1428	2818

[a] Model employed: $p^o_{ij} = \exp(a_1 BP_{ij}) \Big/ \sum_{i=1}^{n_j} \exp(a_1 BP_{ij})$

[b] BP_{ij}: the BP of horse i in race j

HV: Happy Valley racetrack in Hong Kong

ST: Sha Tin racetrack in Hong Kong

** Significant at the 1 % level

Table 5: Results of Estimating CL Models for the First and Last Three Races with the Horse's BP and Bettors' Subjective Probability Judgments as Independent Variables

		Models[a] based on subjective judgments derived from:					
		Final odds		Odds 5 minutes before race starts		Overnight odds	
		HV	ST	HV	ST	HV	ST
$\ln p_{ij}^{s}$ coef. [b]		.9517**	1.0261**	.9338**	1.0155**	.9674**	1.0502**
SE		*.0363*	*.0227*	*.0367*	*.0229*	*.0396*	*.0242*
Z		26.20	45.28	25.43	44.32	24.44	43.48
First 3 races	BP_{ij} coef. [c]	-.0330*	.0086	-.0421**	.0078	-.0524**	.0096
	SE	*.0137*	*.0094*	*.0137*	*.0093*	*.0135*	*.0093*
	Z	-2.41	0.91	-3.08	0.84	-3.88	1.03
Last 3 races	BP_{ij} coef. [c]	-.0073	.0174*	-.0125	.0178*	.0261	.0197*
	SE	*.0167*	*.0085*	*.0167*	*.0085*	*.0164*	*.0084*
	Z	-0.44	2.05	-0.75	2.10	-1.59	2.35
Overall model statistics:							
LL		-3092.3	-5984.8	-3124.2	-6066.5	-3177.5	-6205.4
Model LR (χ_2^2)		896.1**	2580.8**	832.2**	2417.4**	725.7**	2139.5**
Pseudo-R^2		0.1265	0.1774	0.1175	0.1661	0.1025	0.1470
No. of horses		16971	37364	16971	37364	16971	37364
No. of races		1428	2818	1428	2818	1428	2818

[a] Model employed: $p_{ij}^{o} = \exp(a_2 BP_{ij} + b_1 \ln p_{ij}^{s}) \Big/ \sum_{i=1}^{n_j}(a_2 BP_{ij} + b_1 \ln p_{ij}^{s})$

[b] $\ln p_{ij}^{s}$: natural log of the odds implied probability of horse i winning race j

[c] BP_{ij}: the BP of horse i in race j

HV: Happy Valley racetrack in Hong Kong

ST: Sha Tin racetrack in Hong Kong

** Significant at the 1% level

* Significant at the 5% level

Table 6: Results of Estimating CL Models for Races Where Previous Race won by Horse with Low/High BP, with the Horse's BP as Independent Variable

Previous race won by horse with BP		Model[a] based on races run at:	
		HV	ST
Low (≤ 4)	BP_{ij} coef. [b]	-.0838**	-.0281**
	SE	*.0130*	*.0092*
	Z	-6.44	-3.06
	LL	-1262.7	-2039.5
	Model LR (χ_1^2)	42.48**	9.41**
	Pseudo-R^2	0.0165	0.0023
	No. of horses	6156	10548
	No. of races	520	790
High (> 7)	BP_{ij} coef. [b]	-.0624**	-.0001
	SE	*.0114*	*.0064*
	Z	-5.47	-0.02
	LL	-1612.4	-4156.7
	Model LR (χ_1^2)	30.4**	0.0000
	Pseudo-R^2	0.0093	0.0000
	No. of horses	6575	18601
	No. of races	552	1408

[a] Model employed: $p_{ij}^o = \exp(a_1 BP_{ij}) \Big/ \sum_{i=1}^{n_j} \exp(a_1 BP_{ij})$

[b] BP_{ij}: the BP of horse i in race j

HV: Happy Valley racetrack in Hong Kong

ST: Sha Tin racetrack in Hong Kong

** Significant at the 1% level

Table 7: Results of estimating CL models for races where previous race won by horse with low/high BP, with the BP and bettors' subjective probability judgments as independent variables

Previous race won by horse with BP:		Models[a] based on subjective judgments derived from:			
		Final odds		Late odds	
		HV	ST	HV	ST
Low (≤ 4)	$\ln p_{ij}^{s}$ coef. [b]	1.0012**	.9849**	.9674**	.9724**
	SE	*.0622*	*.0432*	*.0622*	*.0436*
	Z	16.10	22.77	15.55	22.32
	BP_{ij} coef. [c]	-.0123	.0004	-.0200	-.0004
	SE	*.0141*	*.0097*	*.0141*	*.0097*
	Z	-0.87	0.04	-1.42	-0.04
	LL	-1106.4	-1721.0	-1120.6	-1740.8
	Model LR (χ_2^2)	355.1**	646.3**	326.8**	606.9**
	Pseudo-R^2	0.1383	0.1581	0.1272	0.1484
	No. of horses	6156	10548	6156	10548
	No. of races	520	790	520	790
High (> 7)	$\ln p_{ij}^{s}$ coef. [b]	.8969**	1.0418**	.8843**	1.0349**
	SE	*.0538*	*.0299*	*.0548*	*.0303*
	Z	16.68	34.89	16.14	34.15
	BP_{ij} coef. [c]	-.0049	.0242**	-.0117	.0242**
	SE	*.0123*	*.0068*	*.0123*	*.0067*
	Z	-0.39	3.52	-0.96	3.53
	LL	-1449.1	-3381.4	-1461.8	-3430.1
	Model LR (χ_2^2)	357.0**	1550.6**	-331.65**	1453.1**
	Pseudo-R^2	0.1097	0.1865	0.1019	0.1748
	No. of horses	6575	18601	6575	18601
	No. of races	552	1408	552	1408

[a] Model employed: $p_{ij}^{o} = \exp(a_2 BP_{ij} + b_1 \ln p_{ij}^{s}) \Big/ \sum_{i=1}^{n_j} (a_2 BP_{ij} + b_1 \ln p_{ij}^{s})$

[b] $\ln p_{ij}^{s}$: Natural log of the odds implied probability of horse i winning race j; [c] BP_{ij}: BP of horse i in race j

HV: Happy Valley racetrack in Hong Kong; ST: Sha Tin racetrack in Hong Kong

** Significant at the 1% level

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