

Schnytzer, Adi; Luppi, Barbara

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Painful Regret and Elation at the Track

Adi Schnytzer¹
Barbara Luppi²

Abstract

We present an empirical study of loss aversion in the Hong Kong horse betting market. We provide evidence of the presence of loss aversion in a context of complete absence of the favourite-longshot bias. This would suggest that, since loss aversion is a psychological bias, the favourite-longshot bias may not necessarily be caused by psychological issues and may be due, for instance, to informational asymmetry. We investigate different types of bettors and their attitude towards loss aversion. Our data set enables us to distinguish approximately among insiders, unsophisticated outsiders and sophisticated outsiders. The results show clearly that even sophisticated bettors are beset by loss aversion, while even unsophisticated outsiders display no favourite-longshot bias. Thus, our paper provides evidence that loss aversion may be an attitude innate rather than learned, regardless of the level of sophistication in designing economic behaviour or the extent of information asymmetry. Chen et al (2006) show that capuchin monkeys display biases when faced with gambles, including loss aversion, and provide evidence that loss aversion extends beyond humans. The present work supports the idea that loss aversion may be a more universal bias, arising regardless of experience and culture and demonstrates that loss aversion is displayed even by those bettors regarded in the market as “smart money”. Further, we find that more sophisticated and experienced bettors display a higher level of loss aversion. This result is consistent with the findings of Haigh and List (2005), who show that professional traders in financial markets exhibit *more* loss aversion than do students.

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¹ Corresponding Address: Department of Economics, Bar Ilan University, Ramat Gan, Israel 52900. Email: schnyta@mail.biu.ac.il

² Corresponding Address: Department of Economics, University of Modena and Reggio Emilia, Viale Berengario, 22 44110 Modena. Email: barbara.luppi@unimore.it

1. Introduction

Is loss aversion acquired or innate in traders? Are expert traders more or less susceptible to loss aversion than amateurs? Is the favourite-longshot bias a psychological bias or is it, perhaps, a consequence of asymmetric information in the markets in which it is observed? These are among the important questions in contemporary behavioural finance. Our purpose in this paper is to shed some light on these questions by conducting an empirical study of the Hong Kong horse betting market. This market is characterized by very high turnovers and a parimutuel-only betting system. It is thus a market of sufficient size to proxy other types of financial market while, permitting the evaluation of some aspects of these questions via asset prices determined solely by demand³.

Horse betting markets are very good natural experiment candidates to test theories of preferences under risk: they allow for the collection of large datasets, and the average amount of money at stake is significant⁴. Racetrack studies may provide key insights for the analysis of risk-taking behaviour in other financial markets as well as in other contexts where risk is the key issue. Betting markets have the advantage of being short-run, lasting for one period only; this facilitates the calculation of the precise ex-post return on each bet. A win bet may be interpreted as an Arrow security, which provides revenue of $(1+R)$ dollars in the event the horse wins the race and 0 otherwise. R indicates the odds of the horse, defined as the net return contingent upon the backed horse winning the race⁵.

In a parimutuel market, odds are endogenous, determined by the distribution of wagers over the horses: the odds of horse i are the ratio of total money B wagered on the race net of the track revenue (including the take, i.e. the percentage of bets collected by racetrack organizers and the taxes, and the breakage, equal to the return loss due to rounding the return to the nearest monetary unit) and total money B_i wagered on horse i .

We investigate the presence of loss aversion in the context of the Hong Kong horse betting market, for which we first show that there is no favourite-longshot bias. This constitutes one of the points of major interest of the paper since loss aversion – in one guise or another - has been used widely in the literature on betting markets in order to explain the presence of a favourite-longshot bias. This paper provides evidence of the presence of loss aversion in a context of complete absence of the favourite-longshot bias. This would suggest that, since loss aversion is a psychological bias, the favourite-longshot bias may not necessarily be caused by psychological issues and may be due, for instance, to informational asymmetry⁶.

As distinct from Jullien and Salanie (2000), we do not perform a calibration exercise of the utility function type on the data. Rather, we implement a simple direct test for the presence of loss aversion on the betting price, based on the definition of loss aversion. Thus, in the presence of loss aversion, bettors would increase the winning price (reduce the winning odds) of a horse whose performance they expect to improve at its next start, by less that they would reduce its price if they expected a decrease in performance of equal measure. We show that bettors exhibit a degree of loss aversion which is consistent with the empirical findings of Kahneman and Tversky: bettors weigh a loss from 2 up to 3 times an equivalent expected gain.

³ In a parimutuel only market, the supplier (tote) is not an active goal oriented economic agent merely setting a take-out rate which guarantees it a profit. Prices are thus determined exclusively on the demand side.

⁴ This is particularly true in the case of Hong Kong. The annual revenue of the Hong Kong Jockey Club, which controls the betting market, was around \$HK82 billion in 2000, roughly equal to that of the Tel Aviv Stock exchange at the time. Typically, there is over \$US 1 million in the win pool for every race.

⁵ In this paper, we are concerned exclusively with the win betting market.

⁶ See Schnytzer, Shilony and Thorne (2003) for an explanation along these lines.

As shown in Schnytzer and Shilony (1995), bettors with different levels of information have different betting strategies and are able to obtain different profit levels. Traditionally, economic theory has regarded bettors with higher levels of information as more rational. However, less attention has been devoted to investigate how widespread loss aversion, specifically, is. We investigate different types of bettors and their attitude towards loss aversion. In other words, we aim to understand whether bettors who can access different information sets and employ different levels of sophistication in their betting strategies, all display loss aversion and, if so, whether they do so to the same extent. Our data set permits us to distinguish approximately among insiders, unsophisticated outsiders and sophisticated outsiders, at least insofar as the information is imbedded in the odds data at different times during the betting. Our results show clearly that even sophisticated bettors are beset by loss aversion. We thereby provide evidence that loss aversion may be an innate rather than a learned attitude, regardless of the level of sophistication in designing economic behaviour or the extent of information asymmetry. Chen et al (2006) show that capuchin monkeys display biases when faced with gambles, including loss aversion, and provide evidence that loss aversion extends beyond humans. The present work supports the idea that loss aversion may be a more universal bias, arising regardless of experience and culture and demonstrates that loss aversion is displayed even by those bettors regarded in the market as “smart money”.

Indeed, we find that more sophisticated and experienced bettors display a higher level of loss aversion than "amateurs". This result is consistent with the findings of Haigh and List (2005), who show that professional traders in financial markets exhibit *more* loss aversion than do students. This result is particularly interesting in light of the discussion as to whether loss aversion is limited to those agents who are inexperienced with markets. The evidence is not unambiguous on the topic: for example, Camerer et al. (1997) find that loss aversion is limited to less experienced subjects in a field study of New York taxi drivers.

Hong Kong has only two race tracks: Sha Tin and Happy Valley. Since our dataset includes nearly all the win bets at both tracks over a number of seasons, the empirical test on loss aversion is performed on the entire population of horse bettors in Hong Kong.

These tracks are, however, rather different. In particular, Happy Valley is a more difficult track than Sha Tin⁷. Both tracks are oval circuits and the track configuration suggests that those horses with barrier-positions on the inside of the track will be favoured, since, *ceteris paribus*, 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 these tracks suggests that horses with a low barrier-position will be favoured more at HV. This means that when measuring the extent of loss aversion, it is important to control for barrier positions of the horses (as well as, obviously, other control variables such as weight carried and so on). We find that loss aversion is present in different degrees at the two tracks: at Happy Valley - the more difficult track - there is less loss aversion for all kinds of bettors. The evidence indicates that even if loss aversion is innate in human beings, the type of economic context is relevant in determining its overall intensity.

The rest of this paper is organised as follows. In Section 2 we present an overview of the related literature, both in horse betting markets and in the alternative frameworks of standard expected utility. In Section 3 we provide the theoretical analysis underlying our empirical analysis. In section 4 the main empirical results are presented and discussed and Section 5 concludes.

⁷ There is a broad consensus among horse bettors in Hong Kong that Happy Valley is a far more difficult for both horses and bettors than Sha Tin.

2. Related literature

A major literature branch relevant to the present paper examines alternative frameworks to the expected utility model of behaviour under uncertainty. Experimental research into choice under uncertainty has revealed that people behave in ways that systematically violate the set of basic axioms formulated by Von Neumann and Morgenstern (1947) and Savage (1954), upon which the conventional expected utility theory is built. In particular, the empirical evidence presented by Kahneman and Tversky (1979) and others shows a number of patterns of choice that reveal behavioural regularities that systematically contradict the predictions of conventional expected utility theory. Following the discovery of the Allais and Ellsberg paradoxes, many attempts have been made to develop alternative frameworks for the analysis of choice under uncertainty, consistent with the observed behavioural regularities⁸. A subset starts from an attempt at a psychological explanation of Allais Paradox phenomenon. One of the earliest was Prospect Theory (Kahneman and Tversky, 1979), later generalized to cumulative prospect theory (1992). A central feature of Prospect Theory is the incorporation of the idea that people care about changes in financial wealth – i.e. they utilize a reference point when evaluating an uncertain prospect - and they exhibit loss aversion over wealth changes, i.e. the decrease in utility associated with a loss is greater than the increase in utility level associated with a gain of equal size.

Two more intuitive and parsimonious psychologically based theories are regret theory (Sugden and Loomes, 1982, 1987) and disappointment theory (Sugden and Loomes, 1986); both of which incorporate *ex ante* considerations of *ex post* psychological feelings: of regret or rejoicing, in the former and of disappointment or elation, in the latter.

"The fundamental idea behind regret theory is that the psychological experience of "having x" can be influenced by comparison between x and y that one might have had, had one chosen differently. If, for example, I bet on a horse which fails to win, I may experience something more than a reduction in my wealth: I may also experience a painful sense of regret arising out of the comparison between my current state of wealth and the state that I would have enjoyed, had I not bet" (Sugden, 1991).

A number of empirical studies investigate the importance of non-expected utility theory and the role of loss aversion in different economic settings. In racetrack betting, Jullien and Salanié (2000) offer an alternative explanation of the *favourite-longshot bias*⁹ that affects pari-mutuel betting markets. They compare expected utility and prospect theory in pari-mutuel betting on horse races. Using a ten-year sample of flat races run in England, they assume that bettors value bets according to either expected-utility theory, rank-dependent utility theory or cumulative prospect theory and infer the parameters of bettor's utility and probability weighting functions from the marginal bettor who is indifferent among bets on all horses at the odds established when the race is run. Jullien and Salanié show that cumulative prospect theory fits the data better than expected utility theory or rank-dependent theory. Further, they show that the weighting function for losses severely overweighs low probability of loss, while the one for gains is roughly linear. These findings offer a different explanation for the favourite-longshot bias: bettors who like to gamble ($u(x)$ is convex) are heavily afraid of losing in the case of bets on favourites with small loss probability, while this is not the case for longshots with a

⁸ See Camerer (2004) for a detailed review on Prospect Theory and Starmer (2004) for detailed references on Non-Expected Utility Theory.

⁹ The *favourite-longshot bias* identifies the phenomenon according to which bettors tend to over-bet "longshots" (i.e. horses with a relatively small probability of winning) and under-bet favourites. In other words, within the context of a parimutuel betting system, the percentage of money bet on longshots is much higher than the fraction of winning horses within the class formed according to the percentage of money bet on them. See, for example, Thaler and Ziemba (1988) and Hausch and Ziemba (1995) for analyses of this bias.

high probability of loss. Bradley (2002) assumes an agent maximising expected utility with a reference point (the case of no bet) and an asymmetric treatment for gains and losses incorporated under the hypothesis of a different constant relative risk aversion utility function for losses and gains. The author obtains a better fit of the data than Jullien and Salanié, enabling an alternative explanation the favourite-longshot bias.

3. The betting market

We present a concise model of a tote betting market where the bet price is characterised under a non-expected utility framework.

We assume that the agent's preferences are described by the following utility function (Loomes and Sugden, 1986):

$$(1) \quad U(x_{ij}) = x_{ij} + D(x_{ij} - x_i)$$

where x_{ij} denotes the payoff of betting on horse i in race j and x_i denotes the expected payoff of horse i .

According to this utility function, the economic agent receives not only the utility derived directly from the actual consequence of an uncertain prospect, but in addition feels some degree of disappointment or elation. When the agent evaluates a prospect, he forms an a priori expectation about any uncertain prospect and after the uncertainty is resolved, he compares the actual consequence of the prospect with the a priori expectation. If the actual consequence turns out to be worse than the expectation, he feels disappointment. On the other hand, the individual experiences some degree of elation if the actual consequence is better than the *a priori* expectation.

We assume the following functional form for the disappointment-elation component of the utility function, $D(\cdot)$:

$$(2) \quad D(y) = \begin{cases} \beta_g y & \text{if } y \geq 0 \\ \beta_l y & \text{if } y < 0 \end{cases}$$

and

$$(3) \quad \beta_g < \beta_l$$

According to assumption (2), the utility function is defined on deviations from the reference point, i.e. the utility function is kinked at the origin. The parameter β_i , $i = g, l$ captures the intensity of loss (= disappointment) aversion and we require the utility function to be steeper for losses than for gains, as given by assumption (3). This characteristic reflects a salient feature of attitudes to changes in welfare, that is, the disappointment associated with a loss with respect to the expected result appears to be greater than the pleasure associated with an equal-sized gain. This specification of the $D(\cdot)$ function captures the attitude of loss aversion in the spirit of the Kahneman-Tversky descriptive theory of decision-making under uncertainty (Kahneman and Tversky, 1979).

The choice of this utility function allows us to investigate the effect of a psychological attitude such as loss aversion in the betting market. Since we are investigating the betting market, we do not endow the agent with any legacy or other forms of wealth inherited from the past. The reference point is represented by the expected payoff from betting on a specific horse.

We develop a simple and intuitive model to explain the price of a horse in a given race in order to test the presence of loss aversion. Let R_{ij} be the odds of horse i in race j and p_{ij} be the horse's subjective probability of winning of race j . Under the assumption of a linear utility function, the price of a horse i for an expected utility maximizer would be:

$$\text{Price of horse } i \text{ in race } j = p_{ij}R_{ij} - (1 - p_{ij})$$

However, in our case, the price equation must be modified to take into account the anticipation of disappointment or elation. Thus, under assumptions (1) (2) (3) we derive the modified expected utility function as:

$$(4) \quad \text{Price of horse } i \text{ in race } j = p_{ij} [R_{ij} + \beta_g (R_{ij} - R_i)] - (1 - p_{ij}) [1 + \beta_l (1 + R_i)]$$

We derive an appropriate econometric form of equation (4) in the next section.

4. Empirical tests

The data consist of 4258 Hong Kong races in which 54,335 horses took part between the 3rd of September 2000 and the 18th of October 2006. For each horse i in race j , $i=1 \dots N_j$, $j=1 \dots 4258$ ¹⁰, we observe the odds for horse i in race j , which are the (net) return on HK\$1 placed on that horse, if it wins. Further, we observe the final placing of all the horses in each race. We have these data for both tracks in Hong Kong: Happy Valley and Sha Tin.

The data set allows us to observe bet prices at three different time slices: overnight (indicated as _00), 5 minutes before race start (indicated as _05) and at the closure of bets (indicate as _fo). The prices at different time slices capture different types of bettors. Overnight bets are usually placed by people prepared to bet before the day of the race. This suggests that they are outsiders who are not expert, otherwise they would have not bet without knowing in what state the horse appears to be, the conditions of the track and the weather, etc. It cannot be ruled out that some insiders who wish to bet “un-noticed” place bets overnight, but this may be assumed to be a small percentage of the total pool. The bet price registered 5 minutes before race start adds to outsiders the bets placed by insiders, who have private information. Five minutes before the race most of money is in except for very late bettors, whose presence is captured in the closing price: usually they are professionals with very sophisticated analysis of public information and, of course, further bets by insiders and normal outsiders. The three bet prices indicate the role of a different type of bettor: the overnight price indicates non-expert bettors (outsiders) with public information, the price 5 minutes before race start capture the role of insiders with private information along with betting by outsiders, and the closing price adds to the pool the behaviour of insiders who bet late and professional syndicates with sophisticated analysis techniques.

Prior to testing for the presence of loss aversion in the Hong Kong betting market, it must be shown that the three set of prices contain different information and that there is no favourite-longshot bias implied at the three stages of the betting. That there is different information incorporated in the three sets of prices is shown in Table I, where we show the results of running a linear probability model, regressing a dummy which receives 1 for race winners and 0 otherwise, on the overnight odds, *Odds open*, the odds five minutes before the race, *Odds_05* and final odds, *Odds final*, respectively, in the presence of interactions between all the horses and their jockeys in the sample. The regression in Table I shows clearly that the set of information contained by prices at different times during the betting period is different, since each of the implied probabilities is significant at 0,1% or better.

¹⁰ Note that the number of starters in a race runs from 7 through 14, with most races having 12 or 14 starters.

Table I
The role of different information sets

Explanatory Variables	
<i>Odds open</i>	-.0030464*** (.0002629)
<i>Odds_05</i>	.0020522*** (.0003918)
<i>Odds final</i>	-.0047497*** (.0003488)
<i>Observations</i>	54,335
<i>Adjusted R²</i>	3.54

Table I: Dependent variable: Win, a dummy which receives 1 for the winning horse in the race and zero otherwise. In addition to the explanatory variables shown in the table, the regression also contains horse-jockey interactions. Standard errors corrected for heteroskedasticity as required by the linear probability model are reported in parenthesis. *** The coefficient is significant at the 1% level.

The second step is to show that there is no favourite-longshot bias in Hong Kong. This is a key point since loss aversion is used often to explain why the favourite-longshot bias arises. We present results for the aggregate of both tracks, since the results do not differ significantly across tracks¹¹. We divide the data set into 20 groups by each of the three sets of probability equivalents¹² of the overnight odds, *Prob_00*, odds five minutes before the race, *Prob_05* and final odds, *Prob_fo*, respectively, and run weighted least squares regressions of winning frequencies on mean probability equivalents for each of the three sets of odds for each group. The weights are the numbers of horses in each group. The results were as follows:

¹¹ Results by track are available upon request.

¹² Since we do not have data on proportions of the pool bet on individual horses, we calculate probability equivalents as follows: Since the Hong Kong tote rounds all payouts down to the nearest 10 cents, we add 5 cents to all (odds+1), take the reciprocal and normalize the results over all races.

Table II
The presence of Favourite-longshot Bias and different types of bettors

Variables	Overnight bettors	Betting 5 minutes before race start	Betting at the close
<i>Prob_00</i>	1.024971*** (.0187403)		
<i>Prob_05</i>		.9968372*** (.0127564)	
<i>Prob_fo</i>			1.000875*** (.0122404)
<i>Constant</i>	-.0017853 (.0019371)	.0004127 (.0013713)	.0000972 (.0013326)
<i>Observations</i>	20	20	20
<i>Adjusted R²</i>	99.37	99.69	99.72

Table II: Dependent variable: Win, a dummy which receives 1 for the winning horse in the race and zero otherwise. Standard errors corrected for heteroskedasticity as required by the linear probability model are reported in parenthesis.

*** The coefficient is significant at the 0,1% level.

In order to test the presence of favourite-longshot bias, we perform an F- test on the joint hypothesis:

$$\begin{aligned}
 prob_i &= 1 \quad i = 00, 05, fo \\
 Constant &= 0
 \end{aligned}$$

Table III
F-test results for the presence of Favourite -longshot Bias

Variables	Overnight bettors	Betting 5 minutes before race start	Betting at the close
<i>F-test</i>	0.90	0.05	0.02
<i>(Prob>F)</i>	(0.4255)	(0.9550)	0.9817

It is clear from these results that bettors exhibit no favourite-longshot bias. Note that this result holds not only for closing prices, but even for those bettors who bet on the day before the races and five minutes before race start. The finding that prices before the close of betting display no statistically significant favourite-longshot bias is, to the best of our knowledge, entirely new in the literature on the favourite longshot bias.

Since Shin (1991, 1992) a number of papers have shown that insiders and outsiders have different betting strategies, reflecting the role of private information [see among others Schnytzer and Shilony (1995)]. However, none has ever investigated whether different types of agents reflect a different attitude towards risk. Here we investigate the loss aversion attitude for the three types of bettors.

According to the model described in the previous section, we design a simple empirical test, which consists in testing the hypotheses that β_g and β_l are significantly different and that β_g is lower than β_l . However, in equation (4), the deviation, $(R_{ij} - R_i)$, of the odds for horse i in race j from the expected odds is correlated with the price of horse i in race j , since the price of horse i in race j is calculated simply as the inverse of the odds plus one. Accordingly, we need to find an instrumental variable that will allow us to test our hypotheses on β_g and β_l .

We define the normalized finishing position¹³ of horse i in race j NFP_{ij} as:

$$(4) \quad NFP_{ij} = 1 - \frac{\text{Ordinal finishing position}}{\text{Number of runners}}$$

for all horses but the winner and set $NFP_{ij} = 1$ for all winning horses.

¹³ Note that according to the definition used, the variable NFP takes values over the interval [0,1], where the winner gets 1 and the last horse 0. The definition used differs from the one used by Brecher (1980), according to which NFP takes values over the interval [-0.5, 0.5], and the winner gets 0.5 and the last horse -0.5.

We use a functional form of the difference between NFP for horse i in races j and race $j-1$ (described below) as an instrumental variable for $(R_{ij} - R_i)$: it is a measure of whether the bettor's expectations over the winner of the race are satisfied or disappointed, but it is not directly correlated with the price of horse i in race j . In order to perform the empirical test on the presence of loss aversion and test whether bettors react more to losses than gains, we need to distinguish between horses that improve their finishing positions and those that do not, in a sense that is meaningful in terms of win betting. We construct two separate variables, Pla_up_{ij} and Pla_down_{ij} , that provide a quantitative measure of how much a horse i has improved or worsened its finishing position with respect to the expectations. Analytically, we define the variables Pla_up_{ij} and Pla_down_{ij} as follows:

$$\begin{aligned}
pla_{ij} &= NFP_{ij} \quad \text{if } NFP_{ij} < 4 \\
pla_{ij} &= 0 \quad \text{if } NFP_{ij} \geq 4 \\
delpla_{ij} &= pla_{ij} - pla_{ij-1} \\
Pla_up_{ij} &= delpla_{ij} \quad \text{if } pla_{ij} - pla_{ij-1} > 0 \\
Pla_down_{ij} &= delpla_{ij} \quad \text{if } pla_{ij} - pla_{ij-1} < 0
\end{aligned}$$

The main idea behind these indicators is that only “meaningful” changes in expectations will affect betting prices. Thus, according to the definitions of Pla_up_{ij} and Pla_down_{ij} , meaningful changes in performance relate to differences in finishing position in successive starts as between first, second, third and unplaced¹⁴. Therefore, a horse that run 8th in one race and 6th at its next start will register no change, even though it has improved its finishing position, but it will register a change if it finishes anywhere in the first three places. In other words, the shift from finishing in two different position neither of which is at least third is unlikely to impact meaningfully on a win bettor's regret or elation, where these changes were anticipated. On the other hand, a horse expected to win which runs second can be a source of considerable regret! While a horse that was considered only likely to run a place provides both profit and elation if it wins! Note that adaptive expectations are, by definition, implicitly assumed, since bettors compare NFP_{ij} in this race with NFP_{ij-1} in the previous race (in which horse i took part). This assumption can be motivated in light of the typical behaviour of the bettor, who does not look too far into the past. In particular, in Hong Kong there are usually only two race meetings per week during the racing season (typically one for each track), and more importantly, the mean number of days between race starts for the horses in the data set is 36. This allows us to focus exclusively on comparison with a horse's performance at its previous start.

We investigate the presence of an asymmetric impact on prices of a gain or a loss defined with respect to expected win, as measured by a change in horse's final position as between the forthcoming race and the horse's last start as defined above. We use ordinary least squares and control for a number of factors affecting race conditions, such as the barrier (a particularly important variable as between the two tracks, as noted above), distance of the race, turf (or dirt) track surface and the weight carried by the horse. We control for the specific track by inserting a dummy for the track Happy Valley and interacting the dummy with both Pla_up_{ij} and Pla_down_{ij} . We run the regression on each of the three sets of prices available in order to detect the loss aversion attitude of different types of agent. We run the models twice: once without fixed effects and once with interaction dummies between the horses and the jockeys¹⁵.

¹⁴ Or "did not show" in American terminology.

¹⁵ Simple OLS with other fixed effects and interaction models were also run (not reported here) with similar results.

The results are reported in Table IVa for the case without fixed effects and in Table IVb for regressions including a dummy for each separate horse-jockey pair.

Table IVa

Regression results: The presence of Loss Aversion and different types of bettors: simple ordinary least squares

Variables	Overnight bettors	Betting 5 minutes before race start	Betting at the close
<i>Pla_up</i>	.0380452*** (.0014714)	.0441875*** (.0015542)	.0483988*** (.0016183)
<i>Hvpla_up</i>	-.0052159** (.0024947)	-.0042817** (.0026351)	-.0040731 (.0027437)
<i>Pla_down</i>	-.0525902*** (.0014154)	-.0653861*** (.001495)	-.0678672 *** (.0015567)
<i>Hvpla_down</i>	-.0003724 (.0025351)	-.0030016 (.0026778)	-.0020635 (.0027881)
<i>Happy Valley</i>	.0097712*** (.0009851)	.0094857*** (.0010406)	.0096682 *** (.0010835)
<i>Turf</i>	-.0054565*** (.0012417)	-.0058753*** (.0013116)	-.00623*** (.0013656)
<i>Barrier</i>	-.0030746*** (.0000949)	-.003403*** (.0001002)	-.0035826*** (.0001043)
<i>Wt</i>	.0027932*** (.0000612)	.0035549*** (.0000647)	.0032675*** (.0000674)
<i>Constant</i>	-.2308314*** (.0091615)	-.3201571*** (.0096772)	-.2885259 *** (.0100761)
<i>Observations</i>	51,186	51,186	51,186
<i>Adjusted R²</i>	11.46	14.77	13.80

Table IVa: Dependent variable: The relevant prices. Robust standard deviations are reported in parenthesis.

***- The coefficient is significant at the 1% level

Table IVb*Regression results: The presence of Loss Aversion and different types of bettors: the fixed effect case*

Variables	Overnight bettors Horse-jockey interactions	Betting 5 minutes before race start Horse-jockey interactions	Betting at the close Horse-jockey interactions
<i>Pla_up</i>	.0068856*** (.0014973)	.0070963*** (.0015856)	.0098*** (.0016061)
<i>Hvpla_up</i>	.0048379*** (.0023462)	.0083589*** (.0024859)	.0088742 *** (.002596)
<i>Pla_down</i>	-.0266834*** (.0016741)	-.0341977*** (.0017001)	-.035001*** (.0017366)
<i>Hvpla_down</i>	-.0058686*** (.0026555)	-.0088214*** (.0027753)	-.0079*** (.0028241)
<i>Happy Valley</i>	.0132661*** (.0009293)	.0141848*** (.0009629)	.0147886*** (.0010042)
<i>Turf</i>	-.0121525*** (.0011645)	-.0141276*** (.0011957)	-.0147886*** (.0012392)
<i>Barrier</i>	-.0032932*** (.0000991)	-.0036856*** (.0001041)	-.0038916*** (.000109)
<i>Wt</i>	.0016021*** (.0000734)	.0022956*** (.0000776)	.0018781*** (.0000797)
<i>Constant</i>	-.0534271*** (.012239)	-.1422848*** (.0128929)	-.0940949 *** (.0133648)
<i>Observations</i>	51,186	51,186	51,186
<i>Adjusted R²</i>	34.80	41.60	41.57

Table IVb: Dependent variable: The final prices on each run. Robust standard deviations are reported in parenthesis.

*** The coefficient is significant at the 1% level.

Loss Aversion (defined with respect to expectations of winning) appears to be present in bets in *all* set of regressions, at *all* three time slices, and at *both* tracks, Sha Tin and Happy Valley. In Tables IVa and IVb we measure loss aversion in the reaction of outsiders (overnight price), outsiders plus insiders (price 5 minutes before the race) and professional late bettors added to the other bettors (final price).

Consider the presence of loss aversion in the regression on final prices (reported in summary form from Table IVb in the third row of Table V): $\hat{\beta}_l$ ¹⁶ is significantly higher in absolute value than $\hat{\beta}_g$ at both tracks, Happy Valley and Sha Tin: in both sets of regressions a positive “surprise” in a horse’s final position increases the price by a lower amount than the price reduction caused by a same-sized loss measured in terms of worsening final position of the horse with respect to previous race. The set of coefficients $\hat{\beta}_l$ and $\hat{\beta}_g$ is significantly different at both tracks (as can be seen through an F-test on the equivalence restriction $\hat{\beta}_g = -\hat{\beta}_l$). Loss aversion affects final prices at *both* tracks Happy Valley and Sha Tin. Moreover, at Happy Valley – where it is more difficult to predict the winner of the race - bettors show a lower level of loss aversion, since $\hat{\beta}_l$ (=0.0429) is about 2 times the value of $\hat{\beta}_g$ (=0.019), while at Sha Tin, $\hat{\beta}_l$ (=0.035) is about 3.5 times $\hat{\beta}_g$ (=0.0098). Therefore, the intensity of loss aversion is lower at the more difficult track with respect to the (by consensus) “easier” track. This latter result may suggest the role of learning effects on shaping the loss aversion bias: in a more difficult environment – as at Happy Valley - the degree of loss aversion tends to be lower since it is more difficult to learn – because there are fewer possibilities to improve the capacity to forecast the race winner, the bettor cannot be disappointed by her own mistakes. By contrast, at Sha Tin, the presence of a learning effect may increase the intensity of loss aversion, since each bettor can more readily improve his ability to bet on the winning horse. As shown in Table V, bettors at Sha Tin display a higher level of loss aversion than at Happy Valley, confirming the presence of learning effects. Further, these results allow us to focus on the behaviour of “smart money”, represented by insiders (whose major impact is seen in the prices 5 minutes before the race start) and professional bettors (who are known to bet right before the close). The main result is that even insiders and professional bettors, like outsiders who are not trained to bet and have no informational advantage, exhibit loss aversion,. This provides new evidence of the presence of loss aversion in a particular context: supporting the idea that loss aversion is a basic behavioural bias affecting trained and untrained bettors. This result is consistent with the empirical evidence presented in Chen et al (2007) – which shows that loss aversion is present in the trading behaviour of capuchin monkeys as an innate attitude.

However, the intensity of loss aversion is not homogenous across types of bettors: both at Sha Tin and Happy Valley professional traders (with late bets) exhibit a lower level of loss aversion, while in case of insiders we can observe different patterns: at Happy Valley (in absence of a learning effect) trained bettors exhibit a lower level of loss aversion, while insiders at Sha Tin (with its learning effect) display an increased the level of LA, which becomes 4 times the coefficient in the case of gain. Note that since the extent of loss aversion does not fall monotonically between the overnight odds and the final odds, we cannot argue that insiders have less loss aversion than outsiders.

¹⁶ β_l is negative since *pla_down_{ij}* is a dummy variable that takes on the value 1 when a horse worsens its *NFP*. Therefore the effect of a negative surprise in final race placement is to reduce the bet price of the losing horse.

Table V: *Loss Aversion in the three time slices at Sha Tin and Happy Valley.*
Summary of results of Table IV

	SHA TIN			HAPPY VALLEY		
	$\hat{\beta}_l$	$\hat{\beta}_g$	$\frac{\hat{\beta}_l}{\hat{\beta}_g}$	$\hat{\beta}_l$	$\hat{\beta}_g$	$\frac{\hat{\beta}_l}{\hat{\beta}_g}$
OVERNIGHT	.027	.0069	3.9	.033	.012	2.78
MIN BEFORE5	.034	.0071	4.8	.042	.015	2.8
FINAL PRICE	.035	.0098	3.57	.043	.019	2.29

5. Conclusions

In this paper we have presented a simple theoretical model of regret and elation in a betting market. We have shown that our Hong Kong horse betting market data set may be divided into three sets of prices which incorporate significantly different kinds of information. We used this finding to show that neither amateur outsiders, who bet on the day before the race, nor insiders or sophisticated outsiders, bet with a statistically significant favourite-longshot basis. We then used our theoretical model to perform a direct test for the presence of loss aversion in this market and found that, indeed, every type of bettor appeared to be beset by loss aversion. The absence of a favourite-longshot bias not only in final prices, as in the standard literature on the favourite-longshot bias, but also for overnight prices and prices five minutes before the start of the race, in the presence of loss aversion at each stage, suggests that the favourite-longshot bias may not be psychologically based. Moreover, the results provide additional evidence supporting the idea that loss aversion is innate, as in Chen et al. (2006). Finally, we have investigated how widespread loss aversion is across different types of bettors and have shown that more sophisticated and experienced bettors display a higher level of loss aversion than amateurs, as in the Haigh and List (2005) study of professional traders.

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