Late Money and Betting Market Efficiency: Evidence from Australia

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I. Introduction

Timing and information are two important variables affecting participants in a prediction market. In parimutuel betting it is of added importance since prices are determined by the final amount wagered on each betting interest. An informed bettor or insider, defined as an individual whose perceptions of the true probability of an outcome are better than those of the general public as derived from the tote board, has to evaluate *when* is the optimal time to place a bet. As reported by Gramm and McKinney (2009), approximately 40% of all the money wagered in a given race is taken through the betting windows within the final minute in which a gambler can place his bet. Even when the bell rings and the gates open with the horses running down the track, the final odds are not known until all of the betting interests are added up and the size of the betting pool is determined. Thus, the impact of late money is not known until the final update of the tote board which only happens after the race commences. The advent of internet gambling has accentuated this late money betting since internet gambling is tied into the same parimutuel pools that exist at the track where the race is happening live and there are no lines to stand in to be sure a gambler can get his bet down.

Market efficiency requires that market prices are truly reflective of all available relevant information and that excessive returns cannot persist. In the case of horse racing and betting to win, horses are efficiently priced if their odds are reflective of their true underlying probability of victory. For example, ignoring the track takeout (the money the track and the government remove from the pool to pay for expenses, purses and transfers to the state) and breakage (the amount a track and/or state take in rounding off the payouts since a winning ticket of $34.58 would be truncated at $34.50) if a horse that has a true 50% chance of winning a race, for that horse to be efficiently priced, 50% of the win pool should be bet on him and his odds will be at even money or one-to-one. If a horse has a true 25% chance of winning, for that horse to be efficiently priced, 25% of the win pool should be bet on him and his odds will be at three-to-one. The same horse would be inefficiently priced, for example, if his odds on the tote board were six-to-one and not three-to-one so that a winning bet at those odds would over-compensate the gambler for the true risk of the horse. In horse racing such bets are called “overlays” with the obvious implication that an "underlay" means a gambler is not being adequately compensated for the true risk that he is bearing. Underlays are market inefficiencies as well. A horse that is an underlay may very well win. However, betting on underlays leads to the gambler being under-compensated for the true risk that is assumed and repeated betting on underlays will result in certain losses.[1]

There have been studies on the impact of late money on parimutuel betting with the conventional wisdom and evidence indicating that late money improves market efficiency. For example, Asch, Malkiel and Quandt (1982), Crafts (1985) and Gramm and McKinney (2009) provide empirical support for the hypothesis that late money is more informed money and moves a horse's subjective odds closer to their true probability of winning. Gramm and McKinney (2009) show this relation also holds across the place and show pools as well. Ottaviani and Sorensen (2003, 2006) provide a rigorous theoretical explanation of why late money should be of such importance and why a bettor would want to wait until the end to place their bets.

The purpose of this paper is to take one more look at the empirical importance of late money on market efficiency in horse race gambling. We have three reasons in particular that motivate our further inquiry. First, in the scientific method that economics has embraced, hypotheses marshal (or lose) credibility and become more embedded in the state of economic knowledge when they can be confirmed (or rejected) in successive, repeated experiments with independent data sets. Second, this paper uses a data set, compared to existing studies, that increases the sample size by almost an order of scientific magnitude. Thus, the statistical precision with which any empirical relation can be quantified will be far greater as larger sample sizes improve the econometric efficiency of the estimators. Lastly, this paper improves on Gramm and McKinney (2009) not only by having a much larger sample size but also by controlling for interaction terms that were unaccounted for in their earlier work.

[1] We recognize that when considering the takeout, as a general proposition horse race gambling is a negative expected outcome activity.

To anticipate, this paper looks at the effect of late money on parimutuel pools for Australian thoroughbred horse races over the entire 2006 racing season and includes every race at all thoroughbred tracks. This amounts to 14,854 races with an average of 10.37 starters per race. The evidence overwhelmingly supports the hypotheses that late money is smart money and late money improves market efficiency.

The paper proceeds as follows: Section II provides a brief review of the literature and section III presents the methodology and results. Section IV concludes.

II. Literature Review

In a standard regression of net return to a unit win bet on the odds of each horse in a respective race, the coefficient on "odds" should be zero if the subjective odds that the public places on the horses' probability of winning are equal to the true probability of those horses winning. So for example, make a \$2 bet 100 times on a set of even money horses. If their true probability to win is 1-to-1 then the \$200 investment will win 50 times out of 100 and pay back \$200 (50 win bets that pay \$4 each). Alternatively, a set of horses that will win 5 times out of 100 have odds that are 19-to-1 since $Odds_i = ((1-t)*W/w_i) - 1$, where W is the total amount of money bet on all horses (also known as the pool), t is the track takeout, and w_i is the amount bet on horse i among all the n individual horses entered in the race.[2] Make a \$2 bet 100 times on 19-to-1 horses and if their true probability to win is 5 in 100, you will bet \$200 and get \$200 in return (5 win bets that pay \$40 each).[3]

However, this is not the result that is obtained in the literature. Indeed in most studies the coefficient on "odds" is in fact negative and has been called the "favorite-long shot bias". This bias represents an inefficiency in the pricing of horses in parimutuel pools since it implies that a gambler's return should go down as he bets higher odds horses. Yet we

[2] See Harville (1973) for a complete treatment of odds computations.
[3] As in footnote one, horse race gambling would still be a losing proposition even if horses were efficiently priced since the take out would guarantee sizeable loses.

have explained above that is not so if the horse's odds truly reflect his probability of victory.

Explaining this anomaly and identifying factors that either mitigate or magnify this inefficiency have been the main focus of the literature on horse race gambling. See Coleman (2004) for a review of the evidence on the favorite-long shot bias and Sauer (1998) for a comprehensive review of the economics of wagering markets.

For our present purposes, that is looking at whether or not late money has an effect on the favorite-long shot bias (or said differently if late money has an impact on market efficiency by bringing the subjective probabilities closer to or further from the objective probabilities) the work of Ottaviani and Sorensen (2003, 2006), Asch, Malkiel and Quandt (1982), Crafts (1985), and Gramm and McKinney (2009) are most relevant.

As said in the Introduction, almost 40% of the wagering pool is bet within the last minute before the race goes off, and the above cited studies have demonstrated that more informed bettors, "smart money", and insiders tend to bet late. The question is why this is so? In thinking of why a gambler would want to wait until the end of the betting period to place a bet, many people wish to see what the odds will be on a horse they wish to bet on *before* the bet is placed. Many are the gamblers who have put money down on a horse early on after the betting pool opens thinking they have a juicy price on a horse only to see those odds shrink as more and more of the pool gets devoted to their horse that they thought was at such a great price. We must remember that in parimutuel pools, the odds received are not determined until the final computations are made after the race has commenced. Thus waiting has value. But at a deeper level, if an insider has relevant information he does not wish to reveal, he will wait until the end so that the betting public cannot adversely affect the odds received on the "insider" horse. Ottaviani and Sorensen (2003) provides what we think is the most convincing explanation why an informed bettor would wish to wait until the last possible opportunity to place a bet. Given that a bettor is small and privately informed "[i]f the market closes immediately after the informed bets are placed, the market's *tậtonnement* process cannot incorporate this private information and reach a rational expectations equilibrium" (Ottaviani and Sorensen 2003:2). Given we are dealing with parimutuel betting, we cannot think of a better reason to wait. This is obviously not the case in financial markets where the adjustment in the price of an asset could be resumed when the market opens up the next day at 9:30 am. However, in a parimutuel market, when the bell rings the betting stops.

The empirical antecedents of this paper are the works of Asch, Malkiel and Quandt (1982), Crafts (1985), and Gramm and McKinney (2009). Asch, Malkiel and Quandt (1982) examine the impact of an "informed class of racetrack bettors" by comparing the ratio of the final odds to the morning line odds, the ratio of the odds with 8 minutes remaining to bet over the morning line odds and the ratio of the odds with 5 minutes remaining over the morning line odds. They find that "the marginal odds of the late bettors appear to be as good as and perhaps better than the final odds in predicting the order of finish" (Asch, Malkiel and Quandt 1982: 193). Crafts (1985) looked at the effect of late money by examining the contribution of the ratio of the final odds or starting price of horses in the United Kingdom (UK) compared to the morning line "fixed odds" of bookmakers. Remembering that in the UK there are not parimutuel pools and the odds you get on a horse from a bookmaker are the odds you keep, as more money is bet on any particular interest, the odds on that horse will still fall on the marginal bets that bookmakers entertain. The "Crafts Ratio" as it has been dubbed, thus represents the subjective probability of victory determined by the final odds over the subjective probability of victory from the forecasted opening odds. Crafts (1985) found that increases in this ratio, or said differently horses who had the final odds fall from the initial opening odds and thus had an increasing subjective probability of victory, led to increasing returns. This is the same thing as saying that the Crafts Ratio improved market efficiency and reduced the favorite-long shot bias. Gramm and McKinney (2009) approach the question of the efficacy of late money by putting the greatest temporal precision yet on what the definition is of "late money". They look at a modified Crafts Ratio by taking the final percentage of the win pool bet on a certain horse and divide it by the percentage of the win pool the horse had at the last click of the tote board. Thus a value of this ratio greater than one would indicate late money moving toward a particular horse as measured by the last possible update of the betting pools before the race goes off. In a clustered tobit regression of net return on odds and the modified Crafts Ratio, Gramm and McKinney (2009) report that the coefficient on the modified Crafts Ratio is positive and statistically significant across the win, place and show pools for a sample of 1644 races run in the US in 2003 and 2005. The positive coefficient indicates that the modified Crafts Ratio improves market efficiency and that late money is smart money.

III. Methodology and Results

This paper extends the work of Gramm and McKinney (2009) first by improving the econometric specification of the net return equation and second by dramatically increasing the sample size.

Table 1 reports the results of estimating the following equation:

$$NR_{ij} = \beta_0 + \beta_1 \text{Crafts Ratio}_{ij} + \beta_2 \text{Odds}_{ij} + \beta_3 \text{Odds}^2_{ij} + \beta_4 \text{Interactions} + \varepsilon$$

where NR_{ij} is the actual net return to a unit win bet (-1 for a nonwinner and the odds for a winner) on the i*th* horse in the j*th* race, Crafts Ratio_{ij} is the ratio of the percentage of the final pool bet on the i*th* horse in the j*th* race divided by the percentage of the pool bet on the same horse at the last click of the tote board, Odds_{ij} and Odds^2_{ij} are self explanatory, and the interaction terms are factors that interact with odds, such as the size of the pools and the type of race, that can have an impact with odds on the net returns. The results presented in Table 1 show the usual favorite-long shot bias in that $\beta_2 < 0$ and is highly statistically significant. The results also confirm the importance of the Crafts Ratio in promoting market efficiency in that β_1 is positive and is also significant. The positive coefficient indicates that the Crafts Ratio reduces the favorite-long shot bias and thus moves the subjective probabilities closer to the objective probabilities and helps to more correctly price the horses that are running in the race.[4]

Table 1: Regression Results

	Coefficient	Slope	z-stat
Crafts Ratio	4.124	0.275	9.79
Odds	-0.621	-0.041	-11.29
$Odds^2$	0.001	0.0001	17.79
Interactions			
Pool Size	-0.0001		-1.18
Horses	0.009	0.0006	2.02
Maiden	0.020		0.94
Race Distance			
Middle	-0.002		-0.08
Intermediate	0.045		1.35
Long/Extended	-0.137	-0.009	-2.1
Steeplechase	-0.288		-1.93
Course Condition			
Heavy/Slow	0.072	0.005	2.69
Dead	0.015		0.6
Weather			
Overcast	-0.018		-0.77
Showery	-0.001		-0.02
Constant	-24.714		-28.89

Table 2 looks at the impact of late money by computing what happens to the subjective probabilities versus the objective probabilities for the field of horses by breaking the field down into the most favorite horse together with the second most favorite horse all the way down to the tenth favorite horse. Then we observe what happens to the subjective

[4] The results for the interaction terms indicate that the number of horses in a race and a slow course condition increase market efficiency while race distance increases inefficiency as these factors interact with odds.

probabilities at the last click of the tote board, which we call the preliminary probabilities and compare them to the final subjective probabilities when all the computations for the final pool are complete and compare both sets to the objective probabilities. As the results show, in every case but the third favorite (where the results are insignificant) the final probabilities bring the preliminary probabilities closer to the true objective probabilities. Or said differently, the money bet at the last possible moment before the gate opens and the race commences improves the market efficiency of pricing particular betting interests in horse racing gambling markets throughout the entire field of different odds horses. Alternatively, the results of Table 2 are another way to view the favorite-long shot bias. Note the preliminary subjective probabilities for the first and second favorites are below the objective probabilities for these two categories of horses and that the preliminary subjective probabilities for the remaining eight categories of horses are all greater than the objective probabilities.

Table 2: Objective vs. Final vs. Preliminary Probabilities

Favorite Position	Objective Probability	Final Subjective Probability	z-stat	Preliminary Subjective Probability	z-stat	Rate of Return
1	32.59%	31.50%	-2.86	29.65%	-7.72	-12.35%
2	19.63%	19.42%	-0.64	18.19%	-4.41	-14.05%
3	13.71%	14.14%	1.50	13.76%	0.15	-18.42%
4	10.50%	10.48%	-0.09	10.58%	0.31	-15.57%
5	7.33%	7.78%	2.09	8.23%	4.17	-20.35%
6	5.40%	5.82%	2.21	6.40%	5.32	-21.20%
7	4.19%	4.37%	1.06	4.99%	4.70	-23.45%
8	3.16%	3.33%	1.10	3.95%	5.12	-23.44%
9	1.95%	2.55%	4.63	3.13%	9.08	-41.55%
10	1.30%	1.54%	3.56	1.96%	9.75	-33.93%
			56.60		350.79	

Note also that the differences are statistically significant for each of the categories except the third and fourth favorites.[5] Said differently, this is just a different presentation of the favorite-long shot bias in that the preliminary subjective probabilities underestimate the two top favorites' chances of victory while overestimating the longer shots chances of winning. When looking at the final probabilities we see that in each case except the third favorite (where the results are insignificant), the late money that is bet between the last click of the tote board and the ring of the bell reduces the favorite-long shot bias by bringing the subjective probabilities closer to the true objective probabilities and thus improving efficiency. However, in five of the ten different positions there is still a statistically significant difference between the final subjective probabilities and the true objective probabilities. Moreover, Table 2 contains the results of the joint hypothesis test that all of the final subjective probabilities are equal to the objective probabilities and that separately all the preliminary subjective probabilities are equal to the objective probabilities. This is a Chi-Squared test and the statistic is reported on the last row of Table 2. The values of the statistics easily reject the null hypothesis that the subjective probabilities are equal to the objective probabilities for both the final and the preliminary subjective probabilities. The upshot is the final subjective probabilities are closer to the objective probabilities and late money improves efficiency and reduces the favorite-long shot bias…but does not eliminate it.

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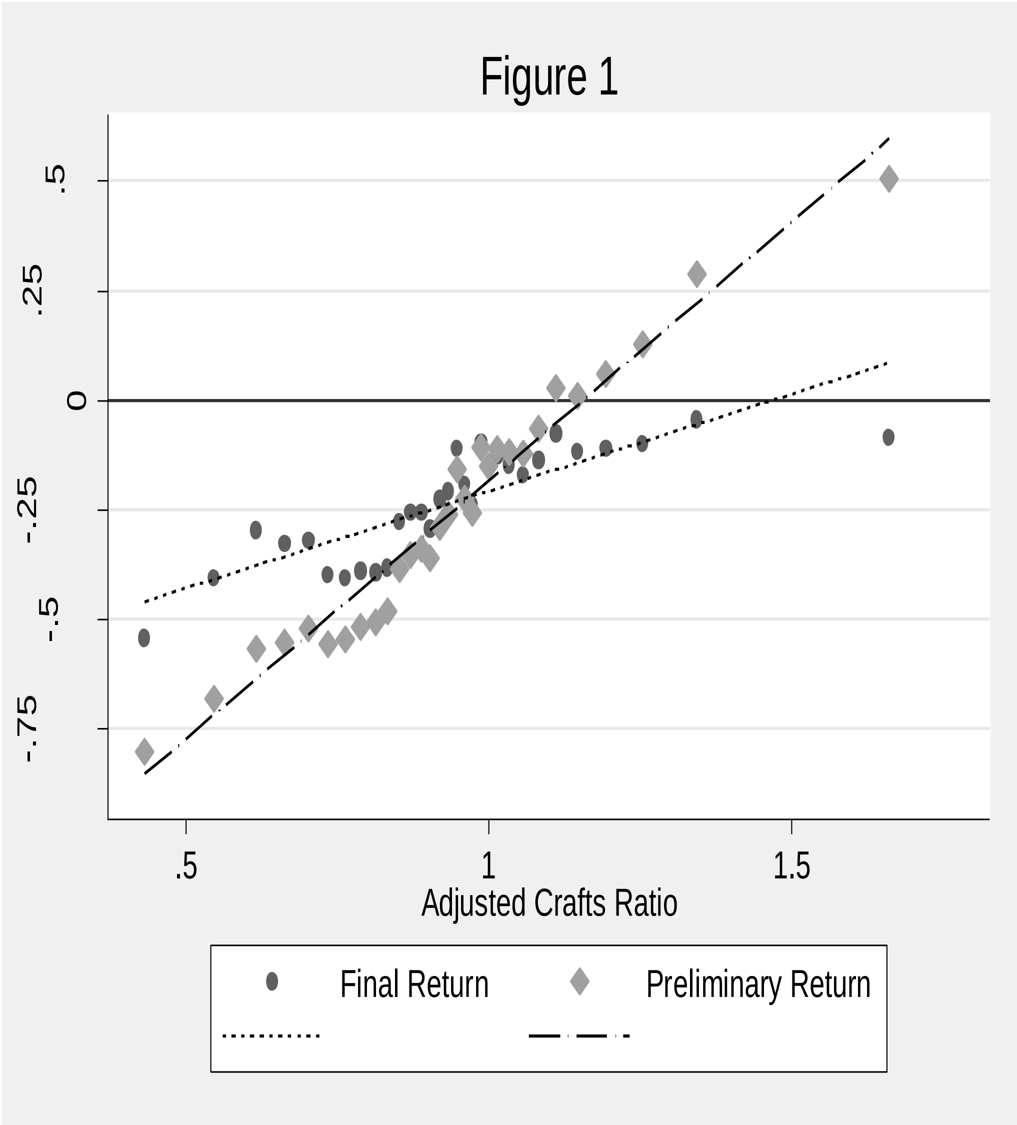
[5] - is the formula used to compute z-statistics where ψ is the subjective probability and ζ is the objective probability as discussed in Busche and Walls (2000).

In the above discussion, it has been confirmed statistically that the final and preliminary probabilities are individually different from the objective probabilities and that the final probabilities reduce market inefficiency relative to the preliminary probabilities. However, we have not tested whether differences between the final probabilities and the preliminary probabilities are statistically different significant relative to each other in a significant way. These results are presented in Table 3. Analogous to the results in Table 2, the final probabilities are statistically different from the preliminary probabilities in every case except the third and fourth favorites. So not only do the final probabilities more closely mirror the objective probabilities than do the preliminary probabilities numerically, but this numeric difference is statistically significant.

Final	Preliminary	z-stat
31.50%	29.65%	-4.90
19.42%	18.19%	-3.79
14.14%	13.76%	-1.33
10.48%	10.58%	0.40
7.78%	8.23%	2.03
5.82%	6.40%	3.00
4.37%	4.99%	3.57
3.33%	3.95%	3.92
2.55%	3.13%	3.90
1.54%	1.96%	5.69
		129.1

Lastly, Figure 1 gives us another alternative look at the interpretation of the results of this investigation. The Crafts Ratio data on all of the approximately 154,000 horses that ran in the 14,854 races in the sample were ranked from highest Crafts Ratio to lowest and then arbitrarily divided into 30 cohorts (or should we say herds?) of approximately 5100 horses each. Figure 1 plots the rate of return on the vertical axis against the value of the Crafts Ratio on the horizontal axis for both the preliminary returns (diamonds) that gamblers would have received if they had locked in the odds that prevailed at the last click of the tote board and the final returns (spheres) they received after the race



commenced and the final odds could be ascertained. Of course, if the Crafts Ratio had no explanatory power we would expect that the scatter plot of these data points would have a zero slope so that late money moving either toward or away from a particular betting interest would have no bearing on the rate of return. But this does not appear to be the case as the slope is decidedly positive for the Crafts Ratios for both the preliminary and final returns. The preliminary returns are what people thought they were going to get right before the bell went off. The final returns graph tells us what they actually received. As we can see, the late money that comes in lowers the slope of the preliminary returns graph so that people that bet money on horses that have money flowing away do not lose as much and people betting on horses that have money flowing toward them do not win as much even though a higher Crafts Ratio tends to increase the (still negative in the case of the final returns) rate of return. This is the same thing as what the information in Table 2 tells us. Late money tends to raise the subjective probabilities of horses that are under bet and lower the subjective probabilities of horses that are over bet. Together Tables 1, 2 and 3 and Figure 1 lead us to this robust empirical observation…late money is smart money and it improves the efficiency of the betting markets in horse race gambling.

IV. Conclusion

The results of this paper strongly support the hypothesis that more informed bettors, insiders, or smart money players appear to be some of the last people to wager in parimutuel betting markets. Not only does late money bring the subjective probabilities one observes in the final minute before the betting closes and the race commences closer to the true objective probabilities, late money also depresses the odds on the most favorite horses and raises the odds on the long shots. That is, late money reduces the favorite-long shot bias and improves market efficiency for the pricing of betting interests in horse race gambling.

References

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

Busche, K. and Walls, W. D. (2000) Decision cost and betting market efficiency, *Rationality and Society*, **12**,477–92.

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

Crafts, N. F. R. (1985) Some evidence of insider knowledge in horse race betting in Britain, *Economica*, **52**, 295–304.

Gramm, M. and Owens, D. H. (2006) Efficiency in pari-mutuel betting markets across wagering pools in the Simulcast Era, *Southern Economic Journal*, **72**, 926–37.

Gramm, M. and McKinney, C.N. (2009) The effect of late money on betting market efficiency, *Applied Economics Letters*, **16**, 4, 369-72.

Harville, D. A. (1973) Assigning probabilities to the outcomes of multi-entry competitons, *Journal of the American Stastistical Association*, **69**, 446–52.

Ottaviani, M. and Sorensen, P. N. (2006) The Timing of Parimutuel Bets http://www.econ.ku.dk/sorensen/Papers/tobaflb.pdf

Ottaviani, M. and Sorensen, P. N. (2003) Late Informed Betting and the Favourite-Longshot Bias, C.E.P.R. Discussion Papers 4092, C.E.P.R. Discussion Papers.

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