THE RACETRACK:
A SCIENTIFIC APPROACH

BY

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THESIS

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Thank You All.

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CHAPTER ONE
INTRODUCTION

"In any case I had decided to watch at first, and not to start in earnest this evening. This evening, if anything did happen, it would be slight and accidental - and that I assumed. Besides, I had to study the actual play; because in spite of the hundreds of descriptions of roulette I had read with so much eagerness, I understood nothing of how it worked until I had seen it for myself."

Dostoyevsky - The Gambler

1.1 Why Research?

Horseracing and its associated activity of gambling invites academic research of a multidisciplinary nature. Economics, psychology, mathematics and statistics are all fields that have investigated the two topics. In 1976 economists discovered a new body of data on which they could test their theories. For many years psychologists have investigated human behaviour in gambling situations. Mathematicians have developed optimal betting strategies. Statisticians have assisted in all the investigations as well as utilised decision theory, probability theory and regression analysis, in their own right, within the discipline.

Why do academics devote their time to this subject? The furthering of knowledge in general in the above fields is important. Also, because the possibility of making money with relatively little work exists, people from all walks of life will be drawn to the intellectual challenge of finding winners. Researchers know that in order to derive money making systems, research on an academic scale is necessary. The amount of data available is phenomenal and although much of it is utilized by the public, some of it is not and that which is, is not always used in a consistent manner.

The research in this work concentrates on all four fields mentioned above. A general overview of the work done in each section is as follows. In chapters two and three, the betting market is examined within the framework of the efficient markets hypothesis. Tests of the three well known forms of efficiency are performed. In chapter four, within the framework of the expected utility hypothesis, the behaviour of gamblers is analysed. The investigation concentrates on behaviour observed at the racetrack, but draws ideas from other gambling situations as well. In chapter five, an investigation is made into horseraces, considering a race to be a sports event. This will consider the competing horses as athletes and will try and identify which fundamental factors are most important in determining the victor of such a race. In chapter six, some statistical theory, which has simple applications in horseracing is examined. In chapter seven, the economics of racetrack management is investigated.

1.2 The History of Horseracing and Gambling

Unlike other sports, horseracing relies on gambling to keep the fans interested. Take away the risk involved in betting and the intellectual challenge of the game, and its aesthetically colourful nature would fade quickly. The sport of kings has had its stars which drew the fans to the track but these are all too few, and 99 percent of the people at the track are there purely for the pleasure of gambling. Money has not always been such an important component of horseracing. Chariot races were held at the Olympic Games during the seventh century B.C. The winners of these races presumably received honour while the fans enjoyed the spectacle of athletic competition at a high level. It may be a little naive to believe that no gambling took place on such races, but it is also reasonable to assume that this activity was not of prime importance with regard to the races.

The evolution of the sport into the sport of kings as we know it today probably occurred most rapidly in England in the twelfth century. At that time English kings were using horses in battle and Richard the Lion-Heart was said to have acquired great respect for the Arabian horse. From this time royalty paid more interest to horses for their speed than before and Charles II, who is known as the father of the British turf, in the 17th century, participated in races as a rider as well as putting up various prizes to be run for. In the early 18th century most races were between just two horses, (the so called match races) with the prize money being put up by the owners, the winning owner taking all the money.

During the middle of the 18th century, open field races became more popular because the private nature of match races did not allow for wide participation at any level. Conditions were laid down with regard to which horses were eligible to race so that horses were raced against similar animals in order to make the races fair and exciting. The horses racing were thoroughbreds which had evolved as a breed from roughly the start of the 18th century. The evolution of such horses was strongly influenced by the importation to England of Arabian stallions which were mated with English mares. The thoroughbred combined the speed of the Arabian horses with the stoutness of the English horses. Today all registered thoroughbreds in any country can trace their heritage back to one of three Arabian stallions.

The modern age of racing is generally considered to have been marked by the inauguration of the English classic races: the St. Leger in 1776, the Oaks in 1779, and the Derby the next year. Only three year old horses are eligible to run in the classics. This pattern of classic races spread throughout the world. The other main type of race was the handicap which is in some sense the opposite of the fixed weight classic races, which supposedly determine the best horse of a particular generation. Handicap races have the specific objective of giving each horse in the race an equal chance of winning. As is to be expected, handicap races are exceptionally popular as betting media. Handicaps do not have restrictions on the age of the competing horses.

The rules of racing, representing as they do centuries of experience, are quite complex in their entirety. Briefly, the race procedure begins when the jockeys weigh out and report to the trainers in the parade ring. After the jockeys mount, the horses enter the track and parade past the public and stewards for inspection. The use of starting gates is virtually universal. During the race, patrol judges and stewards, supplemented by a video film patrol at most tracks, check for rule violations. The result does not become official until the jockeys have weighed in and those that finished in the money are certified as having carried the correct weight. Objections against the pending result must be made at the time the jockeys are weighing in. If a horse involved in an objection finished in the first four, the stewards will view the various films of the race and reach a subjective decision regarding the outcome of the race.

More important than the history of racing as a sport is the history of the betting markets that have grown with racing through the years. We now consider the history of racetrack betting. From the beginning, gambling has been an integral part of horseracing. The built in wagers represented by owners' stakes in match races necessarily were at natural odds (even money for a two horse race, 2/1 for a three horse race, etc.); but betting among spectators quickly developed, in which the odds reflected prevailing opinion as to the horses' relative chances of victory. Man-to-man betting was the original form, but this required that a person who wished to wager, find another person of opposite opinion but similar purse; and it was a natural step to the appearance of professionals who would accept bets of any reasonable amount from all comers.

In addition to the above, as racing among fields of horses became more popular, laying of odds became more complicated, and the bookmaker appeared on the scene. The bookmaker must thus be seen as a middleman offering a service to punters. Clearly a bookmaker must be paid for this service. The theory of bookmaking is simple: the bookmaker sets his odds so that the sum of the probabilities implied in the odds is greater than one. This is called an over-round book. (Note that an over-round book does not necessarily imply profit to the bookmaker). If he then lays each horse to lose the same amount, he will make a profit no matter which horse wins, and this will be his return for the service he provides.

An oversimplified example of the above is a race between 7 evenly matched horses in which a bookmaker would offer 5/1 (a point shorter than the natural odds) on each. Assuming equal amounts wagered on each horse, regardless of which one won the race the bookmakers's profit would be one seventh of the total wagered on the race. In practice however such a situation in which the bookmaker has no financial interest in which horse wins, is very difficult to achieve, and despite constant adjustment of the odds as bets are received, the bookmaker generally stands to win or lose depending on the result of the race.

In 1872 a Parisian shopkeeper devised a system whereby betting tickets, representing one unit each, could be purchased to any value the bettor desired. After the deduction of his commission, the shopkeeper distributed the receipts among the winning ticket holders in proportion to their number of winning tickets. The system, which he called pari-mutuel, (bet among ourselves) proved to be extremely popular, and, although the French government at first frowned on it, the pari-mutuel system was subsequently declared the only legal means of betting in France.

In an 1891 regulation 7 percent of the pool was allocated as follows; 4 percent to the racing clubs, 2 percent to various charities and 1 percent to the Minister of Agriculture for development of horse breeding. This 7 percent, referred to as the takeout, today also includes tax payable to the government, and varies between countries and between betting pools.

The Ekberg totalizator, a machine that mechanically records bets, was first used in New Zealand in 1880. A similar device known as the "Australian tote" became popular in the U.S. Some form of totalizator, now often integrated with sophisticated computer equipment, is used in all pari-mutuel operations. The mutuel system vied with bookmakers for supremacy and in 1940 the last bookmakers were outlawed in the U.S. In most countries today the mutuel system is the only legal form of betting on racehorses. However, England, Australia and South Africa among others, allow bookmakers to compete with the tote.

The equipment used in the mutuel system was sophisticated enough to allow for various types of bets, all with their own pools. Thus place and show betting evolved, and later more complex bets such as exactas and doubles were offered. Off-track totes also made their appearance, thus betting did not require actually going to the racetrack, but rather to the closest tote. The tote was therefore in a strong position to compete with the bookmakers for the public's money.

What is the importance of racing to the society within in which operates? Firstly, it provides entertainment in the forms of gambling as well as a sporting contest to the people of the society. Secondly, it provides an easy to collect tax for the government. The amounts accruing to the state from gambling taxes are substantial and should not be underestimated in reviewing racing's standing in society. Finally, it provides jobs for thousands of people including jockeys, trainers, stable hands, vets, tote operators, officials, news reporters, bookmakers, breeders and others. For these reasons it is important that the overall state of the industry is healthy. In this work we investigate, among other things, whether all is well with racing in Cape Town, and offer suggestions to resolve any perceived problems.

1.3 Horseracing in Cape Town

Horseracing takes place regularly, (usually on a Wednesday and a Saturday) at one of the three racetracks in Cape Town. The Cape Turf Club runs racing at Milnerton and Durbanville, while the South African Turf Club is similarly in charge of racing at Kenilworth. Both clubs operate under the rules of the Jockey Club of South Africa. Race meetings are usually held at one of the main courses (Milnerton and Kenilworth) for a period of about eight weeks before reverting back to the other main course. Durbanville racecourse is only used for midweek racing in winter, in order to protect the grass at Milnerton from over usage. The three courses are shown in diagrams 1.1 to 1.3.

A typical days program, or card, will consist of between 7 and 10 local races. On Wednesdays, 7 races, and on Saturdays 8 or 9 races is the norm. As well as local racing, the feature race of one of the other main racing centres is broadcast live on television to the course. In addition to this, all other races in the other main centres are broadcast live on speakers at the course. The other main centres of racing in South Africa are Johannesburg and Durban. Racing usually starts at 13h00 in Cape Town (14h00 on Wednesday) and races are run at intervals of about 35 to 40 minutes.

KENILWORTH

Kenilworth consists of a 1200m straight course, a new oval course and an old oval course, both lefthanded. The old course is normally only used in winter.

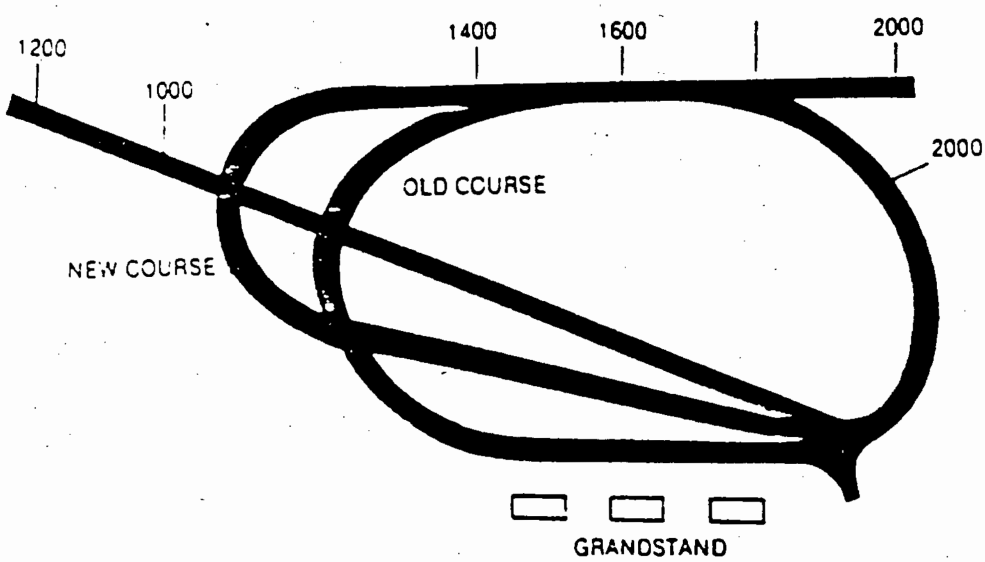


Diagram 1.1 Kenilworth Racetrack

The races that make up the card are usually of different class and distance so as to give owners as wide a choice of race as possible in which to enter their horses. The following is a list of the different classes of race with approximate prize money, as well as the type of horses that would make up the field for the race.

Class of Race	Approximate Stakes	Typical runners
Maiden	R14,000	0 time winners
Novice	R15,000	1 time winners
Graduation	R17,000	1 to 2 time winners
Fillies Handicaps	R22,000	1 to 3 time winners
Progress A	R22,000	1 to 3 time winners
Progress D	R22,000	1 to 4 time winners

MILNERTON

Consists of a 1400m straight course and a lefthanded round course with the choice of a long run-in of 800m (far bend) or a shorter run-in of 600m (near bend).

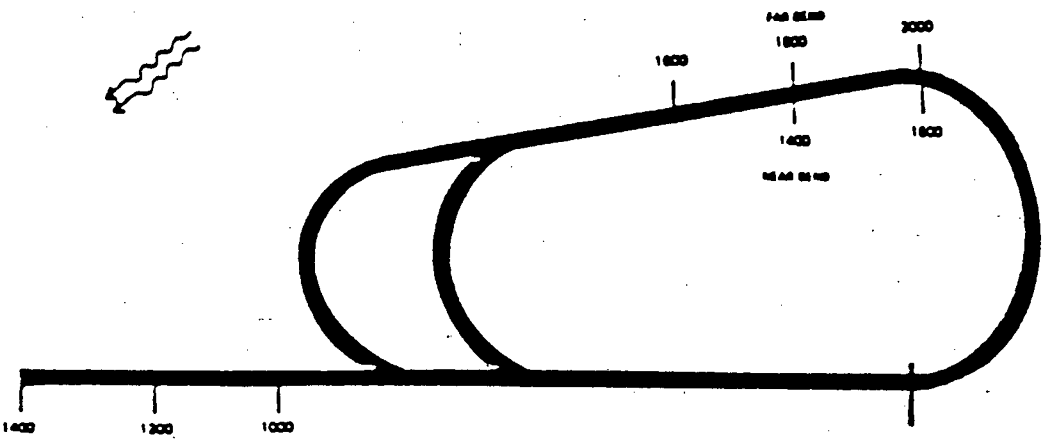


Diagram 1.2 Milnerton Racetrack

Progress E	R22,000	1 to 4 time winners
C Division	R22,000	1 to 4 time winners
B Division	R26,000	3 to 6 time winners
A Division	R30,000	5+ time winners
Major Handicaps	R30,000 to R1,000,000	Handicapper's Discretion
Weight For Age (WFA)	R30,000 to R500,000	Handicapper's Discretion
Classics	R100,000 to R500,000	3+ time winners
2 Year Old	R14,500 to R16,000	0 to 2 time winners

The following are possible further restrictions on the type of runner allowed to compete in races. The Progress races are for the same class of horse, but the D and E races are over longer distances, generally over 2400m or longer. The inferior classes (Maiden, Novice) are sometimes restricted by age and/or sex. The classics are only open to 3 year

DURBANVILLE

Consists of a lefthanded oval track, about 2000m in extent, with a straight run-in of nearly 600m.

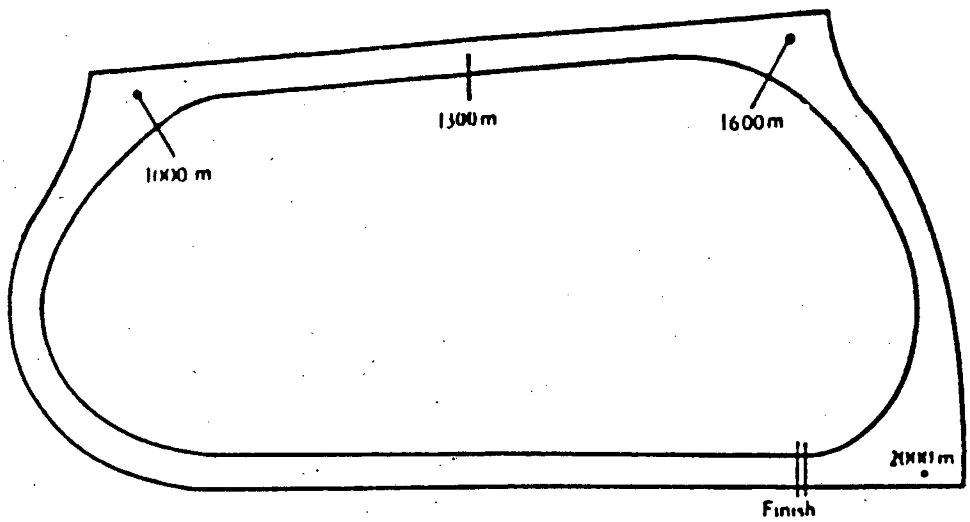


Diagram 1.3 Durbanville Racetrack

old horses, and some are restricted by sex. The 2 year old races are clearly restricted by age and also sometimes by sex.

The stakes are allocated approximately as follows.

Position	% of stakes
1st	64%
2nd	19%
3rd	9%
4th	5%
5th	2%
6th	1%

When nominating a horse to run in a race, the owner or trainer will usually just have regard to the distance of the race. Once the nominations for a particular race are made, each horse is allocated a weight to be carried and a barrier position, (draw) from which it will start if it accepts to run in the race. The trainer then gets a chance to examine all the entrants for the race and to see how his horse has been treated at the weights as well as the horse's luck at the draw. In most cases the allocation of weights is mechanical, through the application of a formula, and therefore there would be no surprises regarding weights. Trainers will normally accept the horse for a race if they feel that it has a chance of beating the other horses entered, from its allocated draw.

If a horse accepts for a race, the trainer must find a jockey to ride the horse. Some jockeys have contracts with trainers and therefore would ride all the trainer's horses. If this is not the case, a jockey will be found that suits the horse's racing style. A further consideration would be the weight allocated to be carried, since if the jockey is much lighter than this, the balance is made up with dead weight, which obviously would not contribute to the job of controlling the horse. Apprentice jockeys, as their name implies, are learning the trade and during this learning period are entitled to a weight allowance, which is either 4kg, 2.5kg, 1.5kg or nothing depending on how many winners they have already ridden. If a trainer accepts two or more horses for a single race, such horses will be viewed as being "coupled". The coupling rule is only important for betting and is discussed later.

Horses normally start their racing careers as late 2 year olds or early 3 year olds, reach their peaks as 5 year olds and can race up until 10 or possibly even older. For racing purposes we distinguish 5 separate categories of horses. A colt is a male horse aged 4 or less. A filly is a female horse aged 4 or less. A gelding is a castrated male of any age. A horse is a male horse aged 5 or more. A mare is a female horse aged 5 or more. The universal birthday of horses born in the southern hemisphere is the 1st of August. Obviously breeders ensure that horses are born near this date. The universal birthday of horses born in the northern hemisphere is the 1st of January.

Information regarding the races can be obtained from either of the daily newspapers

(Cape Times and Argus), the official program of the turf club (race card), or the three professional tipping services (Computaform, Winning Form and Raceform). The cost in 1991 of the newspaper is approximately 70c. The race card costs R1.50. The Computaform, Winning Form and Raceform cost R4.00, R3.50 and R2.80 respectively. The race card can be seen free of charge on the wall at all totes. Figures 1.1 to 1.5 show some typical information available in each publication.

13h15 1 (1000 m)	WIN – PLACE – SWINGER – TRIFECTA	
	PLACE ACCUMULATOR	Closes 14h25
	PICK SIX	Closes 15h05
	QUINPOT	Closes 15h05
	JACKPOT	Closes 15h50

432 **TOPSPORT** *JUVENILE PLATE (Colts and Geldings)* R20 000

(1st R12 800/2nd R3 800/3rd R1 800/4th R1 000/5th R400/6th R200)

Coupled (1 & 2)

1 *Silken Sails* *J G Lightheart* 6 **56,0**
& 2 2 b c Argosy (USA)-Silken Splendour by Quick Turnover (USA) G BASSON (24)
Messrs P Smith, S D Mann, B J Makepeace and J N Farrell
Aquamarine, yellow sash, cuffs and peaked cap
Bred by: Highlands Farm Stud (Pty) Ltd
M364 91.01.05 G MJP 1000 G Basson 56.0 6-9 1 1,25 Aquaquaver 62,00 5-2

2 *Sing Your Love* *J G Lightheart* 3 **56,0**
& 1 2 br c Beethoven (GB)-All Supreme by Contraband (GB) F COETZEE (24)
Messrs G C Ermer, B J Makepeace, N C Evans, D McDiarmid and J P van Rensburg
Black, purple sleeves and cap
Bred by: P Petersen
K346 90.12.29 G MJP 1000 W Ries 54,5 7-7 1 3,50 Haunting Refrain 62,30 10-1
K397 91.01.19 G JPt 1000 W Uys 56,0(24) 3-5 4 6,50 Sectional Title 60,10 8-1

3 *Bambile* *D Coleman* 5 **53,0**
2 ch c Capture Him (USA)-Tagrag (Arg) by Irmak C WILKINSON
Messrs D C Willment, B D Silks and W P Miles
Blue, grey and black checked sleeves, blue cap
Bred by: Maine Chance Farms (Pty) Ltd
Unraced

4 *Rambling Cowboy* *G V Woodruff* 4 **53,0**
2 ch c Mexican Itch-Mount St Helens by Volcanic (Ire) E CHELIN
Messrs C van Dyk, D R Hodgson and Mr and Mrs C P Hopkins
White, black stars, white sleeves, orange collar and cuffs, black and orange quartered cap
Bred by: P R Groenewald
K295 90.12.08 G MJP 800 M Uys 56.0 6-11 8 6,75 Shankaar 50,60 20-1

5 *Twisting Star* *Patrick Kruyer* 1 **53,0**
2 b c Folmar (USA)-Tailors Twist by Big John Taylor (USA) G HATT
Messrs F M Ratner and S C Shub
Magenta, grey hooped sleeves, quartered cap
Bred by: Pharlap Stud
M364 91.01.05 G MJP 1000 E Chelin 56.0 4-9 5 4,50 Silken Sails 62,00 8-1

14

"WELCOME TO RACING AT MILNERTON"

Figure 1.1 Reproduction from the Race Card

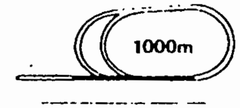
We have thus far examined the racing part of Cape racing. We now look at the

JUVENILE PLATE (C & G)

1

1000 Metres (R20 000)

Course Record: 58,20s Tucaman: 10/85



Average time per metre:
Mil., ,06200 Ken., ,06150
Dbv., ,06090

Average Time: 62,00s

13h15 · 432

Swinger/Trifecta

No.	Name	Rating
1	SILKEN SAILS	37
2	SING YOUR LOVE	36
5	TWISTING STAR	25
6	WINTER STORM	24

Coupled: (1x2).

STAKES:
1st R12 800
2nd R 3 800
3rd R 1 800
4th R 1 000
5th R 400
6th R 200

S.P.	RESULTS		
No.	Win	Place	Swinger
1.	R	R	X R
2.		R	X R
3.		R	X R
4.		R	Trifecta
Doubles	X	R	X X
	X	R	R
	X	R	Time

1 SILKEN SAILS

J.G. LIGHTHEART (M)

2 b.c. Argosy – Silken Splendour
Messrs. P. Smith, S.D. Mann and B.J. Makepeace

Aquamarine, yellow sash, cuffs and peak cap.

Rating	Wet	Blink	Jockey	Mass	Race F	Draw
37			G Basson	56	24	6

Winner's SILKEN SAILS 14/9/88

Date	Course/Going	Ref	Race and Distance	Al.	Race Fig	Jockey	Mass	Draw	Opening Betting	Closing Betting	St	800	400	200	Fin	Lengths Behind	Winning Horse *Second Horse	Var	Time	Adj Time/Metre and Comments	Speed Rating	No of Runs	No of Wins	No of Places	Total Stakes Earned to Date in Rands
5 Jan 91	Mil G	364	Mdn Juv 1000	A		Basson G	56	6-9	3/1	5/2	5	5	4	3	1	1,25	*Aquaquaver	P.	62,00	,06200 Good debut	40	1	1		11 200

2 SING YOUR LOVE

J.G. LIGHTHEART (M)

2 br.c. Beethoven – All Supreme
Messrs. G.C. Ermer, B.J. Makepeace, N.C. Evans, D. McDiarmid & J.P. van Rensburg

Black, purple sleeves and cap.

Rating	Wet	Blink	Jockey	Mass	Race F	Draw
36			F Coetzee	56	24	3

Winner's SING YOUR LOVE 16/8/88

Date	Course/Going	Ref	Race and Distance	Al.	Race Fig	Jockey	Mass	Draw	Opening Betting	Closing Betting	St	800	400	200	Fin	Lengths Behind	Winning Horse *Second Horse	Var	Time	Adj Time/Metre and Comments	Speed Rating	No of Runs	No of Wins	No of Places	Total Stakes Earned to Date in Rands
29 Dec 90	Ken G	346	Mdn Juv 1000			Ries W	56-1½	7-7	6/1	10/1	3	2	1	1	1	3,75	*Haunting Refrain	T	62,30	,06150 Easy debut win	40	1	1		11 200
19 Jan 91	Ken G	397	Juv C,G 1000	A	24	Uys W	56	3 6	4/1	8/1	5	5	4	4	4	6,50	Sectional Title	I	60,10	,06271 Faded steadily	4	2	1	1	12 200

3 BAMBILE

D. COLEMAN (M)

2 ch.c. Capture Him – Tagrag
Messrs. D.C. Willment & W.P. Miles

Blue, grey and black checked sleeves, blue cap.

Rating	Wet	Blink	Jockey	Mass	Race F	Draw
–			C Wilkinson	53		5

Winner's BAMBILE 1/10/88

Date	Course/Going	Ref.	Race and Distance	Al.	Race Fig	Jockey	Mass	Draw	Opening Betting	Closing Betting	St	800	400	200	Fin	Lengths Behind	Winning Horse *Second Horse	Var	Time	Adj Time/Metre and Comments	Speed Rating	No of Runs	No. of Wins	No of Places	Total Stakes Earned to Date in Rands

FIRST RUN

4 RAMBLING COWBOY

G.V. WOODRUFF (M)

2 ch.c. Mexican Itch – Mount St Helens
Messrs. C. van Dyk, D.R. Hodgson and Mr. and Mrs. C.P. Hopkins

Emerald and gold stripes, royal blue sleeves emerald cap.

Rating	Wet	Blink	Jockey	Mass	Race F	Draw
23			E Chelin	53		4

Winner's RAMBLING COWBOY 27/9/88

Date	Course/Going	Ref.	Race and Distance	Al.	Race Fig	Jockey	Mass	Draw	Opening Betting	Closing Betting	St	800	400	200	Fin	Lengths Behind	Winning Horse *Second Horse	Var	Time	Adj Time/Metre and Comments	Speed Rating	No of Runs	No of Wins	No of Places	Total Stakes Earned to Date in Rands
8 Dec 90	Ken G	295	Mdn Juv 800	A		Uys M	56	6-11	14/1	20/1	2	2	2	6	8	6,75	Shankaar	P	50,60	,06492 Good pace, faded	X	1			

5 TWISTING STAR

P. KRUYER (M)

2 b.c. Folmer – Tailors Twist
Messrs. F.M. Ratner & S.C. Shub

Magenta, grey hooped sleeves, quartered cap.

Rating	Wet	Blink	Jockey	Mass	Race F	Draw
25			G Hatt	53		1

Winner's TWISTING STAR 5/9/88

Date	Course/Going	Ref.	Race and Distance	Al.	Race Fig.	Jockey	Mass	Draw	Opening Betting	Closing Betting	St	800	400	200	Fin	Lengths Behind	Winning Horse *Second Horse	Var	Time	Adj Time/Metre and Comments	Speed Rating	No of Runs	No of Wins	No of Places	Total Stakes Earned to Date in Rands
5 Jan 91	Mil G	364	Mdn Juv 1000			Chelin E	56	4 9	6/1	8/1	9	9	8	7	5	4,75	Silken Sails	P	62,00	,06291 Jumped awkwardly	X	1			350

6 WINTER STORM

M. WATTERS (M) *(R45 000)*

2 b.c. Foveros – Wild Winter
Messrs. L.S. Phelps, D.G. Kagan and D M Buda

Pink, black hoop and armband, quartered cap.

Rating	Wet	Blink	Jockey	Mass	Race F	Draw
24			M Khan	53		2

Winner's WINTER STORM 31.8.88

Date	Course/Going	Ref	Race and Distance	Al.	Race Fig	Jockey	Mass	Draw	Opening Betting	Closing Betting	St	800	400	200	Fin	Lengths Behind	Winning Horse *Second Horse	Var	Time	Adj Time/Metre and Comments	Speed Rating	No of Runs	No of Wins	No of Places	Total Stakes Earned to Date in Rands
12 Jan 91	Mil G	380	Mdn Juv 1000			Chelin E	56	1 6	8/1	7/1	2	2	3	3	4	6,50	Roadblock	K	61,60	,06385 Faded steadily	X	1		1	875

Race End

Figure 1.2 Reproduction from Computaform

1 TOPSPORT PLATE

R 20000

JUVENILE PLATE

13.15 — **1000 METRES**

Nominations : 24
Runners : 6

NO	HORSE	LEN BEH	PRED TIME	MASS	OR	B	JOCKEY	TRAINER	WKS	FIN	LBH	DIST	JOCKEY	BETT	TIME	B	A
1	SILKEN SAILS	0.0	61.6	56.0	6		BASSON G	LIGHTHEAR	(4)	1	1.2	1000	BASSON G	5/ 2	61.5		
2	SING YOUR LOVE	1.1	61.8	56.0	3		COETZEE F	LIGHTHEAR	(2)	4	6.5	1000	UYS W	8/ 1	61.9		
5	TWISTING STAR	2.5	62.0	53.0	1		HATT G	KRUYER P	(4)	5	4.5	1000	CHELIN E	8/ 1	62.0		
6	WINTER STORM	4.0	62.3	53.0	2		KHAN M	WATTERS M	(3)	4	6.0	1000	CHELIN E	7/ 1	62.3		
4	RAMBLING COWBOY	7.4	62.9	53.0	4		CHELIN E	WOODRUFF	(8)	8	6.8	800	UYS M	20/ 1	62.9		
3	BAMBILE			53.0	5		WILKINSON	COLEMAN D		*** NO RECENT FORM ***							

COUPLINGS : (1-2)

RESULT	SP	1	2	3	4				Fav
PAYOUT	W	P	P	P	P	Sw	Sw	Sw	Tr

TRIFECTA(Boxed)	TRIFECTA(Win Banker)	SWINGERS(Boxed)
R 2.00: 1 x 2 x 5 Straight	R 2.00: 1 x 2 , 5	R 6.00: 1 x 2 x 5
R 6.00: 1 , 2 , 5	R 6.00: 1 x 2 , 5 , 6	R12.00: 1 x 2 x 5 x 6
R24.00: 1 , 2 , 5 , 6	R12.00: 1 x 2 , 5 , 6 , 4	R20.00: 1 x 2 x 5 x 6 x 4
R60.00: 1 , 2 , 5 , 6 , 4	R20.00: 1 x 2 , 5 , 6 , 4 , 3	R30.00: 1 x 2 x 5 x 6 x 4 x 3

SILKEN SAILS made a proming debut when running on well to beat subsequent winner Aquaquaver at this course four weeks ago and looks well set for the double today. SING YOUR LOVE won very well at the first attempt, but was never in the hunt behind Sectional Title subsequently. He may improve on that here, and certainly makes a formidable Tote coupling with SILKEN SAILS. TWISTING STAR meets SILKEN SAILS on 3 kgs better terms for a 4.5 length beating first time out and will struggle to reverse that result here, but should finish somewhat closer. WINTER STORM showed some promise behind better fancied stable companion Roadblock on his debut and needs some improvement to win it, but he could well make it into the Trifecta.

1 SILKEN SAILS 56.0 6 — 2 y.o. b c by Argosy - Silken Splendour by Quick Turnover
Basson G — Lightheart J G :Cape — Bred by: Highlands Farms

(4)91.01.05 M 364 G MJP 1000 BASSON G 56.0 6- 9 1 1.25 *AQUAQUAVER 62.0 61.6 5/ 2 87
Ran on well to beat a subsequent winner on recent debut, chance.

2 SING YOUR LOVE 56.0 3 — 2 y.o. br c by Beethoven - All Supreme by Contraband
Coetzee F — Lightheart J G :Cape — Bred by: P.Petersen

(3)90.12.29 K 346 G MJP 1000 RIES W 54.5 7- 7 1 3.50 *HAUNTING REFR 62.3 61.8 10/ 1 84
(2)91.01.19 K 397 G MJP 1000 UYS W 56.0 3- 5 4 6.50 SECTIONAL TITL 61.3 61.9 8/ 1 83
Moderate run after easy debut win, might improve.

3 BAMBILE 53.0 5 — 2 y.o. ch c by Capture Him - Tagrag(ARG) by Inmak
Wilkinson C — Coleman D :Cape — Bred by: Maine Chance

* FIRST RUN * Watch betting.

4 RAMBLING COWBOY 53.0 4 — 2 y.o. ch c by Mexican Itch - Mount St Helens by Volcanic
Chelin E — Woodruff G V :Cape — Bred by: P.R.Groenewald

(8)90.12.08 K 295 G MJP 800 UYS M 56.0 6-11 8 6.75 SHANKAAR 51.8 62.9 20/ 1 63
Moderate debut.

5 TWISTING STAR 53.0 1 — 2 y.o. b c by Folmar - Tailors Twist by Big John Taylor
Hatt G — Kruyer P P :Cape — Bred by: Pharlap Stud

(4)91.01.05 M 364 G MJP 1000 CHELIN E 56.0 4- 9 5 4.50 SILKEN SAILS 62.8 62.0 8/ 1 79
Made a fair debut, might improve.

6 WINTER STORM 53.0 2 — 2 y.o. b c by Foveros - Wild Winter by Golden Thatch
Khan M — Watters M :Cape — Bred by: Y B Stud

(3)91.01.12 M 380 G MJP 1000 CHELIN E 56.0 1- 6. 4 6.00 ROADBLOCK 62.7 62.3 7/ 1 74
Showed some promise on debut, might improve.

***** TRAINER/JOCKEY COMBINATIONS FOR RACE 1. PERFORMANCES FOR CURRENT SEASON (1st August to Present) *****

No	Trainer	Jockey	Rns	1st	2nd	3rd	Win%	Plc%
1	Lightheart J	Basson G	24	4	2	1	17	29
2	Lightheart J	Coetzee F	10	0	3	3	0	60
3	Coleman D	Wilkinson C	6	1	0	0	17	17
4	Woodruff G V	Chelin E	82	16	8	13	20	45
5	Kruyer P P	Hatt G	98	25	8	12	26	46
6	Watters M	Khan M	123	14	16	18	11	39

Figure 1.3 Reproduction from Winning Form

CAPE SEVEN 5.20 Graduation 1000m

PA6 BigSix5 JP4

Ratings: a difference of one point equals about 0.5 length.

Nr		*Rating*	*Draw*	*Jockey*	*Weight*	*BL*	*Trainer*
8	Hogerty Hill	87.0	7	Fradd	54.0	bl	RRixon
2	Deep Down	86.0 ?	1	Starkey	57.0		Millard
9	Hurry Herb	84.0	3	Sutherland	54.0		Millard
5	Walk in Space	82.0	11	Roberts	57.0		ASteyn
6	Whale Song	82.0	5	GPuller	54.5		Kannemeyer
3	Harry's Mystery	82.0 ?	10	Lloyd	57.0		Payne
10	Little Harry	81.5	9	St Martin	54.0		Schutt
11	Never Retreat	80.0	8	Hatt	51.5		Snaith
7	Golden Bay	80.0 ?	6	Coetzee	54.0		Stewart
4	Steel Blue	76.5	2	Fortune	57.0	bl	ASteyn
1	Bellinzona	76.5 ?	4	Khan	57.0		Watters

** indicates that the horse is likely to run below best on soft.*
Couplings 2x9
A fair sized field: the pace should be good.

Hogerty Hill hasn't run to his best rating lately and was lame last month; he tries blinkers this time and should do better if fit. *Deep Down* showed plenty of pace last time and should run well. *Hurry Herb* has poor form.

Walk In Space returns from a break and would really have liked it further; he cannot be ignored, though. *Whale Song* returns from a lay-off and should run to his rating if fit. *Harry's Mystery* has performed well upcountry and seems likely to run to form. *Little Harry* ran below best the last times.

Never Retreat was hampered last time and should run to her rating again. *Golden Bay* has good Durbanville form and ought to run to his rating. *Steel Blue* should run to his rating. *Bellinzona* needs it further.

The selection is based on a good pace.

BEST FOUR:	*TRIFECTA/PA:*	*SHORTLIST*
1. Deep Down	Deep Down	(2) Deep Down (c)
2. Hogerty Hill	roving banker	(8) Hogerty Hill
3. Harry's Mystery		
4. Walk In Space		

Figure 1.4 Reproduction from Raceform

associated betting markets. There are two ways of betting in Cape Town, namely with a bookmaker or with the tote. We shall examine the bookmakers first. The 25 to 30 active bookmakers in Cape Town have there rooms in the city and can usually be found there on non racing days. They will usually not do much business except on race days. If another main centre has racing on a day that Cape Town does not, they will be in the rooms taking bets on these away races. Most of their business, however, is done on local racing at the racecourse.

One or two of the larger bookmakers will have a list of odds for all Cape races in the morning of any race day. These odds are also usually those with which all the bookmakers open their betting, on the course. At the course each bookmaker has his

BETTING at Cape Tattersall's yesterday:

BLOODLINE GUINEAS
(Milnerton, 1 600 m, today)

16—10	Star Effort
7— 2	Phantom Robber
6— 1	Spook And Diesel
8— 1	Surprise Attack
12— 1	Empire State
16— 1	Dunbarton, Supersonic Suprise, Bold Chieftain
20— 1	King Kama, Special Squad, Deep Lustre, Jungle Chant
25— 1	Ludwig's Music, In The Saddle
33— 1	Jackies Boy, Captain Marcus

Forecast betting

RACE 1

8—10	Silken Sails
2— 1	Twisting Star
5— 2	Sing Your Love
8— 1	Winter Storm
s/p	Bambile
10— 1	others

1 **1.15: JUV PLT, R20 000, 1 000 m (R2 Swinger/Trifecta):**

1	SILKEN SAILS 2 b c J Lightheart	Basson		1M10	6 56,0
2	SING YOUR LOVE 2 br c J Lightheart	F Coetzee	1K10	4K10	3 56,0
3	BAMBILE 2 ch c D Coleman	Wilkinson			5 53,0
4	RAMBLING COWBOY 2 ch c G Woodruff	Chelin		0K08	4 53,0
5	TWISTING STAR 2 b c P Kruyer	Hatt		0M10	1 53,0
6	WINTER STORM 2 b c M Watters	Khan		4M10	2 53,0

● Coupled: 1 and 2.

16 The Argus, Friday February 1 1991

What the tipsters say...

	DEREK WILSNAGH (The Argus)	GRAHAM POTTER (The Argus)	BARRY HOPWOOD (The Argus)
1	1 SILKEN SAILS 2 Sing Your Love 5 Twisting Star	1 SILKEN SAILS 6 Winter Storm 2 Sing Your Love	1 SILKEN SAILS 5 Twisting Star 2 Sing Your Love

Figure 1.5 Reproductions from The Cape Argus and The Cape Times

own board displaying the current odds available on each horse. The opening betting is usually very cautious, with odds only being offered on the top 3 or 4 horses in the betting. Generally one bookmaker will price up and slowly the others will follow. The initial pricing up is usually 5 to 10 minutes after the end of the last race and about 5 minutes after the initial display of current tote prices for the race. The bookmaker betting period on the course is therefore approximately 30 minutes for each race.

The bookmakers presumably set odds given the information known to them, and within the competitive bookmaker market for bets. After a few minutes, the bookmakers have felt out the market and begin to adjust the odds. Not much money is bet early on, since the public have not had a chance to inspect the horses on their way down to the start. People with inside information, however, may bet in the initial few minutes in order to secure the odds then on offer. If they feel a better price will be on offer later they may haggle with the bookmaker now, or simply wait to get the better odds. Note that once a bet is struck with a bookmaker the odds are fixed for that bet.

Once the horses have run down to the start, with approximately 15 minutes to the off of the race, the bookmakers will start to experience more activity in the betting market. Punters have now had a chance to see their fancies and they must now bet. The bookmaker will now be adjusting his odds through weight of money rather than personal feelings or rumours. At the very end of the betting period there is usually a rush to get bets on and bookmakers will often take bets until the race is half over. Most big money bets struck with bookmakers will be on credit. If a bookmaker accepts bets which he feels to be too large on a particular horse he will lay some of the bets off. This means that he will bet on the horse concerned with another bookmaker, hopefully at odds equal to or greater than those which he has already laid.

Bookmakers will normally only lay win bets, and although some will lay place bets as well, this is rarely seen on course. In 1989 bookmakers as a group had turnover of approximately two thirds of the total tote turnover. The punter gets taxed when he collects winnings from the bookmakers. The tax is currently 10% of the amount won disregarding the amount staked. For example, if a bookmaker lays a bet of 120 to 10 on a horse at 12/1, and the horse wins, the payout will be 120 less 12 tax plus the 10 original stake, or 118. If a horse is scratched within the betting period, a deduction from bets laid before the scratching, is made in accordance with a table which relates the scratched horse's odds to the percentage of the odds laid to be deducted.

The Totalisator Agency Board (the tote) is authorised by the provincial authorities to conduct betting on racing throughout the country. The tote is essentially a medium for dividing the losers' money amongst the winners. All money is placed in different pools, a fee is charged to all bettors, and the remainder of the money is distributed to the winning bettors. The tote offers a variety of bets for which different charges are levied. Some of the charges are paid to the Province as taxes and the rest is given to the racing clubs in order to provide amenities for the racing public, as well as stakes for the races that are conducted on their racecourses. Betting with the tote can take place on the course, or at one of their approximately 50 off-course branches around the province. A telephone betting service also exists.

The following is a description of what is required in order to win each bet offered by the tote.

Win:

Select the winner of a specified race.

Place:

Select a placed horse in a specified race. Dividends are payable in respect of horses placed:

(i) First and second when there are four or five starters;

(ii) First, second and third when there are six to thirteen starters;

(iii) First, second, third and fourth when there are fourteen or more starters.

Swinger:

Select two horses to finish first, second or third in a specified race, irrespective of the order in which they finish.

Trifecta:

Select three horses to finish first, second and third in the exact order in a specified race.

Double:

Select the winners of each of the two designated double races. A consolation dividend is payable to tickets selecting a winner and a second.

Place Accumulator:

Select a horse placed first, second or third in each of the seven designated Place Accumulator races.

Quinpot:

Select the first or second placed horse in the five designated Quinpot races.

Jackpot:

Select the winners of each of the four designated Jackpot races.

Pick Six:

Select the winners of the six designated Pick Six races.

The charges (or takeout) applicable to these bets differ according to their complexity. The following are defined as exotic bets and are subject to a takeout rate of 25% of the total pool for that specific bet; Pick Six, Jackpot, Place Accumulator, Quinpot, Trifecta and Swinger. The Win and Place bets are subject to a takeout rate of 18% of their respective pools, before any distribution to the winning ticket holders.

The total takeout percentage actually exceeds the rates quoted above, because the track is allowed to retain the deduction from winning bettors that results from only paying bets to the lower 10c on a unit bet. This additional amount is generally known as "breakage".

CHAPTER TWO

THE EFFICIENT MARKETS HYPOTHESIS AND HORSERACING

"... and as for profits and winnings, people everywhere, not only at roulette, are always winning or taking away something from one another."

Dostoyevsky, The Gambler

2.1 INTRODUCTION

Efficient Market Definitions

An efficient market is one in which all available information relevant to the market is accounted for immediately in the pricing of the relevant assets. An implication, therefore, of a market that is efficient, is that above normal profits cannot be made by any individual on a systematic basis. Much work has been done by researchers arguing from both sides that stock markets are, or are not, efficient. In recent years (from 1976) some research has concentrated on examining horserace betting markets and subjecting these to tests of efficiency.

Three classes of information were defined by Fama (1970) with regard to stock market information. If an individual held information in the lowest class and could not make above normal profits, the market was said to be weakly efficient. Similarly if an individual held information in the middle or highest classes, (in addition to all the information in the lower classes) and could not make above normal profits,the market was said to be semi-strongly efficient and strongly efficient respectively.

The above three classes were defined by Fama specifically for stock market data and not as generally as listed above. Fama defines the lowest class of information to be past prices and returns of a specific share. Data of this type is used (in stock market studies) to test weak efficiency. The middle class of information is defined as all other publicly available information. Data of this type can therefore be used to test semi-strong efficiency. The highest class of information is defined as knowledge which is only available to very few people who are usually insiders. Data of this type could be used to test for strong efficiency. The three tests are better thought of (from weak to strong) as tests of technical efficiency, fundamental efficiency and efficiency against inside information. This removes to some extent the somewhat arbitrary definitions of weak, semi-strong and strong.

To test for efficiency in the betting market it is necessary to define the information relevant to such markets which fits into each of the three classes. In previous studies, specifically Dowie (1976) and Snyder (1978), this has been done in the following way. The lowest class of information is defined as containing only the odds of the horses. The market is therefore shown to be weakly efficient if profits cannot be made by betting on horses at specific odds. These odds are viewed as the subjective probabilities of the horses winning as determined by the market. Further, if the market is weakly efficient, the rate of return to all odds categories should be equal to 0% (ignoring transactions costs). This would imply that the public's estimates of the probabilities of winning for all horses was in line with empirical probabilities.

The information in the middle class was first defined by Snyder as other data available regarding the race itself but not including subjective opinions on the outcome of the race. Examples of this data would be weight, draw, jockey etc. Losey and Talbot (1980) defined this class of information as incorporating such data, as well as all subjective information available regarding predictions of the outcomes of races.

Snyder defined the highest class as that containing the knowledge of owners, trainers etc. and tipsters' information that is published in various publications. For his tests he uses the latter data since the former is clearly not publicly available. Losey defines this category to contain information held by owners, trainers etc. alone and concludes that the strong form cannot be tested in the absence of this information. The three classes have had no further redefining since Losey's paper in 1980.

In this work we will redefine the three information classes in terms of the data to be contained in them, as well as introduce two new terms. This will of course be relevant to the horseracing information market but will possibly be transferable to stock market analysis. Define the lowest class of information to contain all unprocessed information available to the public. Define the middle class of information to contain all processed information available to the public. Define the highest class of information to contain all information available to insiders such as owners, trainers, jockeys etc. but excluding public tipsters. The middle and highest classes are thus similarly defined to previous studies.

Define unprocessed information as all publicly available information that is elementary (i.e. it is a single data point which is not a function of other data).This data includes jockey, trainer, mass, draw etc. Although odds are a function of all these variables we cannot know without investigating each individually whether their weighting in determining odds has been correctly made. For example, perhaps the market is efficient in accounting for jockey but inefficient in accounting for draw, the odds test may reveal the market to be efficient but inefficiencies may exist in places. Odds although a function of elementary data, can still be used as an overall test of weak efficiency, and therefore for the purposes of the argument we will regard the odds as elementary information.

Define processed information as complex data which is determined as a function of elementary data and concerns subjective opinions regarding the outcome of a race. This would include tipsters' choices, newspapers' forecast betting guides and horses' ratings in tipping and rating guides. Another way of considering the data sets is as follows. Assume the lowest class to contain all technical information or objective information. The middle class then contains all fundamental information or subjective information.

Within the framework of the E.M.H., research other than that concentrating on tests of informational efficiency has been done. Various tests have been performed to examine bettor consistency. It is important to define what is meant by the terms relating to efficiency and consistency used in this work. This is because similar terminology is used to describe differing tests in various papers. When a paper is reviewed the tests will be described using the framework described in the next paragraph. An indication will also be given as to how the author viewed the tests.

The definition of market efficiency which states that profits cannot be made utilising some set of information will be used throughout. The information sets defined above will be used. Consistency in the betting market is defined as the inability of bettors to increase their return, without any additional information, but not necessarily to a level of profitability. Profitability is defined as a positive return after transaction costs have been accounted for.

A further topic which has been mentioned but not researched, is that of betting on local pools at away racetracks. These topics are discussed in depth in the following sections which review the literature on the subject and present ideas and proposals for further research.

2.2 LITERATURE REVIEW

2.2.1 Tests of Weak Efficiency

The Favourite-Longshot Bias

Dowie (1976) is the pioneering paper on the efficiency of horserace betting markets. The paper tests for weak efficiency in the betting markets in England, using elementary information (odds) only. The data are shown in Table 2.1.

The data used are bookmaker Starting Prices (SP's) which are divided into 68 odds categories ranging from 1/11 to 150/1. Actual returns to each category as well as cumulative returns using level staking and staking to return 100 are calculated. The returns shown are all pre-tax of 8%. Level staking means the bet on each horse is the same no matter what the odds, whereas staking to return a fixed amount will obviously mean betting more on horses with lower odds. The weak test is made by examining the rates of return to the different odds categories. A statistically significant positive rate of

1973 FLAT SEASON: RETURN AT EACH STARTING PRICE

Odds	Unit stakes required to return 100	Runners	Winning percentage	Percentage return	Cumulative return	
					Level staking	Staking to return 100
(1)	(2)	(3)	(4)	(5)	(6)	(7)
1–11	91·7	1	100·0	109·0	109·0	109·0
2–13	86·7	1	0·0	0·0	54·5	56·1
1–6	85·7	2	100·0	117·0	85·8	85·8
1–5	83·3	2	100·0	120·0	97·2	96·8
2–9	81·8	4	100·0	122·0	107·1	106·7
1–4	80·0	7	85·7	107·1	107·1	106·9
2–7	77·8	2	50·0	64·5	102·6	102·6
30–100	76·9	1	100·0	130·0	104·0	103·9
1–3	75·0	8	75·0	99·8	102·8	102·9
4–11	73·3	15	66·7	90·7	98·6	98·9
2–5	71·4	18	88·9	124·4	106·2	106·0
4–9	69·2	21	81·0	116·6	108·9	108·7
40–85	68·0	1	100·0	147·0	109·3	109·1
1–2	66·7	24	70·8	106·3	108·6	108·5
8–15	65·2	14	64·3	98·4	107·4	107·4
4–7	63·6	23	60·9	95·6	105·5	105·8
8–13	61·9	24	75·0	121·5	107·8	107·7
4–6	60·0	52	67·3	112·4	108·9	108·7
8–11	57·9	58	37·9	65·6	99·9	100·7
4–5	55·6	76	59·2	106·6	101·3	101·8
5–6	54·5	35	65·7	120·3	103·0	103·2
10–11	52·4	79	46·8	89·5	100·7	101·2
Evens	50·0	116	46·6	93·1	99·2	99·8
11–10	47·6	112	41·1	86·3	97·1	98·0
6–5	45·5	32	25·0	55·0	95·3	96·5
5–4	44·4	134	42·5	95·7	95·3	96·4
11–8	42·1	113	35·4	84·2	94·1	95·3
6–4	40·0	186	37·6	94·1	94·1	95·1
13–8	38·1	123	36·6	96·2	94·3	95·2
7–4	36·4	221	30·8	84·6	92·9	94·0
15–8	34·8	101	32·7	94·1	92·9	94·0
2	33·3	305	24·6	73·8	89·9	91·6
85–40	32·0	43	23·3	72·8	89·5	91·3
9–4	30·8	312	27·2	88·5	89·4	91·0
5–2	28·6	363	26·5	92·6	89·8	91·2
11–4	26·7	342	24·9	93·2	90·2	91·3
3	25·0	538	23·6	94·4	90·8	91·6
100–30	23·1	279	22·9	99·3	91·5	92·0
7–2	22·2	590	18·8	84·7	90·6	91·4
4	20·0	734	21·1	105·6	92·7	92·6
9–2	18·2	656	13·9	76·3	90·8	91·5

Table 2.1 reproduced from Dowie (1976)

5	16·7	855	15·1	90·5	90·8	91·4
11–2	15·4	635	15·6	101·3	91·7	91·9
6	14·3	944	13·5	94·2	92·0	92·0
13–2	13·3	450	17·3	130·0	94·0	93·1
7	12·5	983	9·9	78·9	92·4	92·3
15–2	11·8	288	12·9	109·2	92·9	92·6
8	11·1	1290	8·8	78·8	91·3	91·8
17–2	10·5	36	2·8	26·4	91·1	90·5
9	10·0	621	7·6	75·7	90·3	90·1
10	9·1	1564	7·5	83·0	89·4	89·7
11	8·3	513	4·9	58·5	88·3	89·3
12	7·7	1798	4·8	62·2	85·3	88·0
13	7·1	109	5·5	77·1	85·3	85·9
14	6·7	1700	4·7	69·7	83·8	85·3
15	6·3	56	1·8	28·6	83·6	84·4
16	5·9	1501	2·5	41·9	80·3	83·2
18	5·3	124	0·8	15·3	79·9	83·1
20	4·8	3739	1·1	22·5	70·5	79·9
22	4·4	141	0·0	0·0	70·1	79·7
25	3·8	1913	1·3	34·0	67·4	78·8
28	3·4	70	1·4	41·4	67·3	78·8
30	3·2	115	0·0	0·0	67·0	78·7
33	2·9	3314	0·5	18·5	61·3	77·1
40	2·4	152	0·0	0·0	61·0	77·0
50	2·0	506	1·0	50·4	60·8	77·1
66	1·5	59	0·0	0·0	60·7	77·1
100	1·0	57	0·0	0·0	60·5	77·1
'150'	0·7	6	0·0	0·0	60·6	77·1
		29307				

Table 2.1 cont. reproduced from Dowie (1976)

return, after tax, did not appear in the data and the market is therefore deemed to be weakly efficient.

The data consist of 29 307 horses which ran during the 1973 season. It is noted (as it has been in other studies) that the rates of return are proportional to the probabilities of winning. This means that although profits cannot be made, a smaller loss results from betting on favourites than on outsiders. We call this the favourite-longshot bias which is examined further in chapter four. Evidence of the bias is thus obtained from this fairly extensive data.

Although the market has been noted to be weakly efficient in that profits cannot be made by using odds data alone, bettors are inconsistent in that they could do better than the average loss, simply by betting on horses in certain odds categories, namely horses in the high probability categories (low odds categories). Inconsistency is taken to imply that bettors are capable of increasing returns simply by altering their betting behaviour without reference to any additional information. We shall see other examples of bettor inconsistency in the research.

Snyder (1978) tested for weak efficiency in the horserace betting market by examining 1 730 races in the United States between 1972 and 1974. His data consists of tote, rather than bookmaker SP's. His study also cites data from 5 other studies, 3 of which considered approximately 10 000 races each. A list of these studies is reproduced in figure 2.1, as well as graphs of returns versus odds categories for each study. Overall results are shown in figure 2.2. It was noted by Snyder that the bettor inconsistency is strong and stable over time.

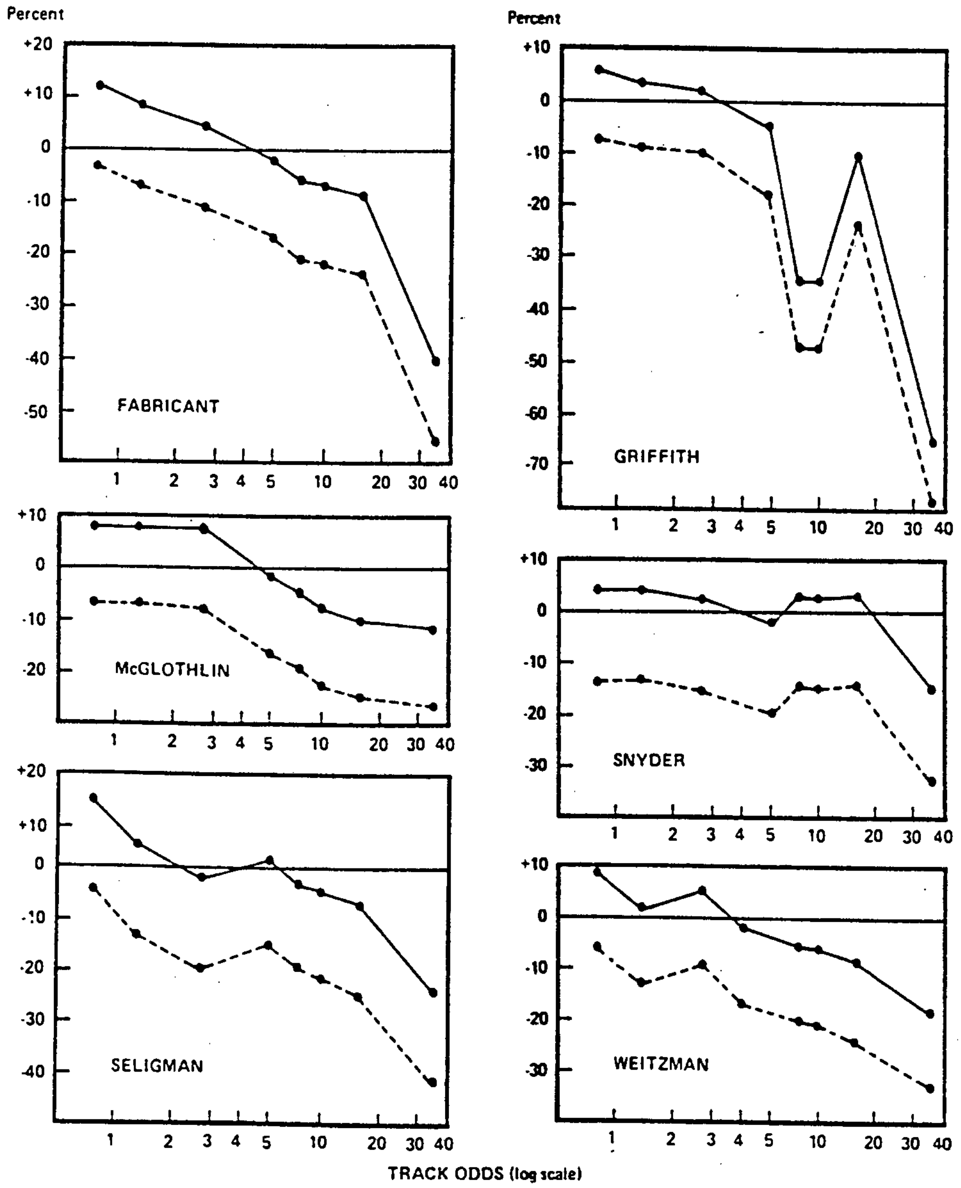
Disregarding transaction costs, t-tests are performed to examine whether the rates of return are significantly different from 0%. It is shown that rates of return are positive for favourites below 3/1 while they are negative for odds greater than 8/1. Taking transaction costs into account there is no category which yields a positive return and the market is thus weakly efficient. This paper also showed the inconsistency of bettors in that returns were higher in the lower odds categories than in the longer odds categories. The tests utilised only elementary data (odds) and is therefore a test of weak efficiency. Snyder viewed the test in the same way. Unlike Dowie's study, Snyder has grouped the odds categories, thereby reducing the number of categories from about 70 to about 10. The tests were then carried out on the returns to these category groupings.

Complementing a point made by McGlothlin (1956) that this bettor inconsistency was smallest in the main race because uncertainty was least then, Snyder noted "evidence that the bettor bias is accentuated at smaller tracks where greater uncertainty exists." Investigations are carried out in this work to find in what situations bettor inconsistency is most marked or almost absent. For example, later races will probably show a more marked form of inconsistency since on average, bettors will be losing about 20% of their

Horse Race Studies: Authors, Dates and Number of Races

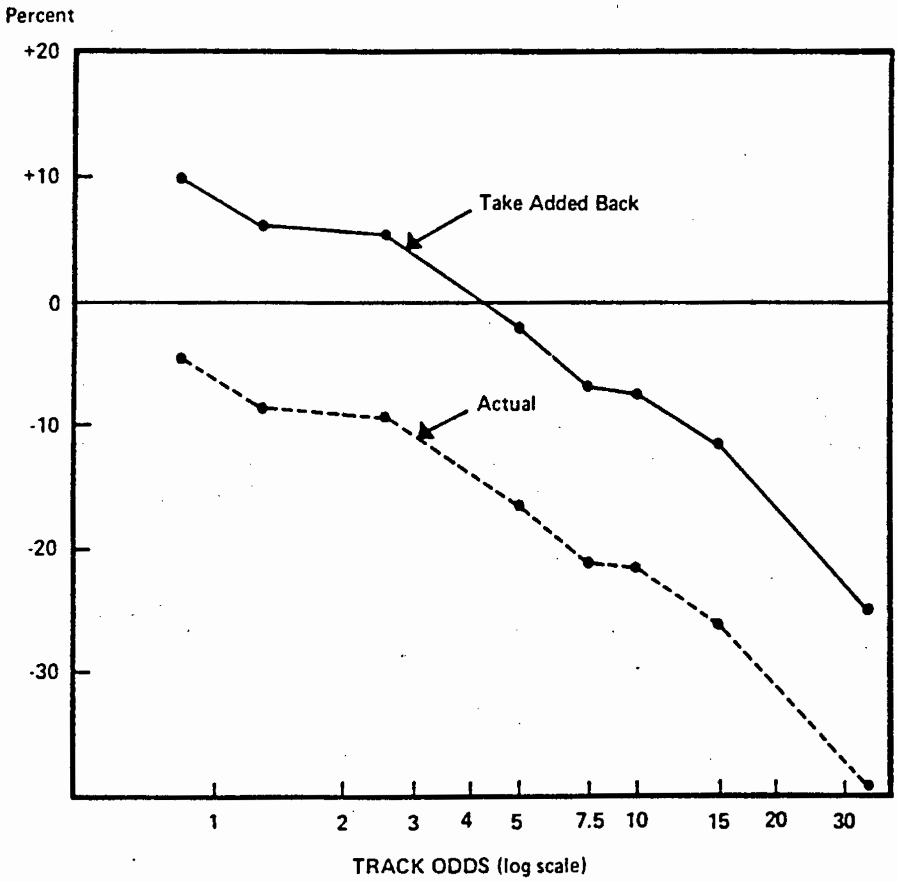
Author	Date Published	Racing Dates	No. of Races
Fabricant	1965	1955–62	10,000
Griffith	1949	1947	1,124
McGlothlin	1956	1947–53	9,248
Seligman	1975	1975	1,183
Snyder	1978	1972–74	1,730
Weitzman*	1965	1954–63	12,000

*Weitzman did not publish his data, but they were used again and published by Rosett (1965).



Rates of Return for Six Studies:
Actual (dotted line) and Take Added Back (solid line)

Figure 2.1 reproduced from Snyder (1978)



Combined Rates of Return

Figure 2.2 reproduced from Snyder (1978)

money and will need to back a winner at a long price to come out ahead for the day. More of this in section 2.2.4.

Kreel (1988) considering data from Cape Town racetracks for 1988 and using 729 races examined his data in 3 different ways. Firstly the data were not grouped and resulted in 37 odds categories. Many of these had too few observations to be analysed statistically so the categories were grouped, firstly, grouping the odds categories so that odds groups with little perceived differences were grouped together, and secondly to obtain a smooth monotonically decreasing curve of observed probabilities versus odds. It was noted that bookmakers made more percentage profit on outsiders than on favourites, which is just another way of reconfirming that bettors as a group tend to lose more on outsiders than on favourites. Again, only odds data were used, resulting in the weak form test. An update of this study is performed during the research. Some of the original results are shown in table 2.2. The original variable names are used, as they are referred to by these names in the new results, which are shown in section 3.1. Specifically, p = price (odds), wp = number of winners, exp = number of runners, obs = observed probability, theo = theoretical probability, and rat = the ratio of the probabilities.

The Affect of the Draw

Canfield et al. (1987) tested for weak efficiency using only one fundamental factor applicable to each horse, namely the horses barrier position, or draw. The hypothesis is that simply by knowing the horse's draw and possibly other external factors related to the meeting as a whole, such as the weather, profits could be made. The hypothesis is based on the assumption that the shape of the track will influence the results of races. The data consist of the results and relevant draw information for 3 345 races run in Canada during 1982, 1983 and 1984. Races were categorised as being on a wet or a dry day at the track as well as being split by the distance of the race. In this case either sprint or route was the classification.

One of the main conclusions of the study was that "...the chance that a typical horse in post position one or two will win a given race is about double that of a horse in post position seven to ten." Some of the results are reproduced in tables 2.3, and 2.4.

Rates of return to each post position were calculated from betting to win on each horse. The only strategy that yielded profits was betting on post position one or two on dry days. The profits were in the range of 10% to 15%. Further betting strategies which utilized the exotic (complex) betting market did not show profits at the 5% level of significance. It is concluded that although a physical track bias does exist at this particular track, it is generally incorporated into the betting behaviour of punters who push the odds down on horses that have a better chance in the race simply because they have a good draw.

P	WP	EXPP	OBS	THEO	RAT
0.1	2	2	1.000	0.909	0.909
0.2	4	6	0.667	0.833	1.250
0.25	3	4	0.750	0.800	1.067
0.333	10	11	0.909	0.750	0.825
0.4	10	16	0.625	0.714	1.143
0.5	11	14	0.786	0.667	0.848
0.6	15	29	0.517	0.625	1.208
0.7	14	20	0.700	0.588	0.840
0.8	11	33	0.333	0.556	1.667
0.9	14	23	0.609	0.526	0.865
1	12	40	0.300	0.500	1.667
1.1	10	17	0.588	0.476	0.810
1.2	6	21	0.286	0.455	1.591
1.3	7	23	0.304	0.435	1.429
1.4	16	30	0.533	0.417	0.781
1.5	16	39	0.410	0.400	0.975
1.6	11	34	0.324	0.385	1.189
1.7	19	41	0.463	0.370	0.799
1.8	20	54	0.370	0.357	0.964
2	32	118	0.271	0.333	1.229
2.2	20	63	0.317	0.313	0.984
2.5	30	135	0.222	0.286	1.286
2.8	10	52	0.192	0.263	1.368
3	57	209	0.273	0.250	0.917
3.3	5	55	0.091	0.233	2.558
3.5	40	201	0.199	0.222	1.117
4	46	307	0.150	0.200	1.335
4.5	25	178	0.140	0.182	1.295
5	52	482	0.108	0.167	1.545
6	52	528	0.098	0.143	1.451
7	47	590	0.080	0.125	1.569
8	24	537	0.045	0.111	2.486
10	23	516	0.045	0.091	2.040
12	34	1785	0.019	0.077	4.038
14	23	910	0.025	0.067	2.638
16	5	244	0.020	0.059	2.871
20	13	1030	0.013	0.048	3.773

Table 2.2 reproduced from Kreel (1988)

Winning Percentages and Rates of Return on Win Bets by Post Position in 2516 Six-Furlong Races Run over Mile Tracks. Source: Quirin (1979)

Post Position	Number of Horses	Number of Winners	Percent Winners	Rate of Return
1	2516	304	12.1	1.08
2	2516	267	10.6	0.80
3	2516	279	11.1	0.73
4	2516	276	11.0	0.71
5	2516	249	9.9	0.63
6	2481	271	10.9	0.89
7	2375	220	9.3	0.71
8	2208	204	9.2	0.79
9	2025	164	8.1	0.94
10	1886	140	7.4	0.52
11	1107	91	8.2	0.72
12	727	51	7.0	0.21
Very Outside	2516	184	7.2	0.53

Table 2.3 reproduced from Canfield (1987)

Movements in the Odds

Tuckwell (1983) examined whether the movements in the bookmaker's odds were random or not. A movement in the odds in one direction should be followed, with equal chance, by another movement (should one occur) in either direction. Thus the probability of further movement in the already noted direction is 50 per cent. Using a Chi-Squared test, the hypothesis of randomness in odds movements is rejected at the 1% level of significance and it is determined that for a given movement in the odds, a movement in the same direction has a probability of approximately 85 per cent.

The above is not a test of weak efficiency in the context of this research. Tuckwell further investigates whether using odds data alone can lead to profitable betting strategies. If this were possible then in our context the market would be weakly inefficient. Instead of betting on horses in every odds category, Tuckwell determines in which odds groups the punter is expected to lose the least amount. He does this by

Table 2.4 reproduced from Canfield (1987).

Winning Percentages by Post Position in 3345 Sprint and Route Races Run Over 332 Days at Exhibition Park in 1982–1984

Post Position	1982 109 days: Number of Winners	1982 109 days: % Winners*	1983 113 days: Number of Winners	1983 113 days: % Winners	1984 110 days: Number of Winners	1984 110 days: % Winners	Average % Winners	Avge. Diff. from Mean % Winners	*t* statistic**
1	173	16.05	146	12.78	162	14.78	14.54	+2.56	4.09
2	192	17.88	139	12.24	149	13.72	14.61	+2.63	2.06
3	152	14.06	132	11.60	144	13.16	12.94	+0.96	2.28
4	124	11.50	141	12.29	123	11.32	11.70	−0.28	−0.46
5	123	11.45	158	13.92	132	12.10	12.49	+0.51	0.46
6	119	11.17	132	11.76	114	10.51	11.15	−0.83	−1.45
7	83	8.19	90	8.43	91	8.74	8.45	−3.53	−6.50
8	60	6.83	91	9.44	82	8.84	8.37	−3.61	−3.00
9	44	6.49	63	7.70	59	7.65	7.28	−4.70	−5.82
10	22	4.44	55	8.61	50	8.39	7.14	−4.84	−2.74
Totals and Averages	1092	12.81	1147	11.47	1106	11.67	11.98		

* These percentages do not necessarily add to one since different post positions have different numbers of starters.

** With two degrees of freedom, using the three-years data, the one-tail cut-off values are 1.89 at the 10% level and 2.92 at the 5% level. So at the 10% level, positions 1–3 have an edge, 7–10 have a disadvantage and 4–6 are average.

regressing the observed losses in each odds category against the starting price odds, converted to probabilities, of that category. He derived the following regression line;

$$\hat{L} = 50.3 - 362.7p^{*} + 978.8p^{*2} - 773.3p^{*3}$$

where $\hat{L}$ is the predicted percentage loss to punters and p* is the probability equivalent of the starting price odds.

The results are reproduced in Table 2.5. Although at the higher odds, the pattern is similar to that seen in other studies, the pattern of losses at the lower odds is not. This derivation of expected losses was first presented in Tuckwell's 1981 paper which dealt with bettor consistency. Further comment can be found in section 2.3.1.

Predicted Percentage Loss ($\hat{L}$) and Starting Price odds (SPO)

SPO	$\hat{L}$	SPO	$\hat{L}$
0.41	8.24	5.00	13.44
0.67	17.15	5.50	14.84
0.73	17.55	6.00	16.20
0.80	17.61	6.50	17.50
0.90	17.21	7.00	18.74
1.00	16.49	7.50	19.91
1.11	15.50	8.00	21.02
1.25	14.20	9.00	23.04
1.38	13.09	10.00	24.84
1.50	12.09	11.00	26.43
1.63	11.21	12.00	27.84
1.75	10.46	14.00	30.24
1.88	9.85	15.00	31.27
2.00	9.37	16.00	32.20
2.25	8.73	20.00	35.17
2.50	8.45	25.00	37.76
2.75	8.45	32.91	40.44
3.00	8.66	40.00	42.03
3.25	9.03	50.00	43.56
3.50	9.51	66.00	45.10
3.75	10.07	98.73	46.76
4.00	10.70	187.30	48.40
4.50	12.04		

Table 2.5 reproduced from Tuckwell (1983)

Tuckwell now tests for weak efficiency by backing all horses in the odds range between 2/1 and 4/1 that firm in the betting market. Horses in this odds range show the smallest loss to punters. Also, since horses that firm in the market are likely to firm again, profit may be possible by betting on horses in this odds range that have already firmed. This is clearly not strictly a test of weak efficiency, although Tuckwell proceeds as if it is. Bets are placed at odds higher than the starting price, but no other details are given. It is assumed that the method of betting is as follows; if a horse is backed from 3/1 to 28/10, a bet is made at 28/10 and the horse then firms further to (say) 5/2. By using this method a profit of slightly above 5% is achieved. Tuckwell concludes that the market is weakly inefficient, and that this is a result of strong inefficiency which had been demonstrated earlier in the paper, and which is discussed shortly. This is the only paper which concludes that the market is weakly inefficient. Comment on this aspect can be found in section 2.3.1.

Odds as Predictors

Asch et al.(1982) asks the questions whether the publicly determined odds are a good predictor of horse performance, and if not where do the discrepancies between empirical probabilities and the subjective probabilities lie? These questions are essentially a formulation of a test of weak efficiency. Horses are grouped by their level of favouritism rather than their actual odds. Once the horses are allocated to categories based on their level of favouritism, the objective probability of a horse in a category winning is simply the number of horses winning in such a category divided by the total number of runners in the category. In this case we may have two horses with the same odds but they may fall into different categories because they have a different level of favouritism. The subjective probabilities are calculated from the actual odds only after allocation to the categories.

The results of the study, shown in table 2.6, indicate that a similar pattern of subjective and objective probabilities emerges to that observed when horses are allocated to categories based on their actual odds. The public overestimate the probabilities of outsiders winning while they underestimate the probabilities of favourites winning.

Subjective and objective probabilities of winning in 729 Atlantic City (NJ) races in 1978 (total number of horses = 5805).

Favorites[a] (1)	No. of races[b] (2)	Obj. prob.[c] (3)	Subj. prob. (4)	(Subj. prob. − obj. prob.)/ st. error of obj. prob.[d] (5)
1st	729	0.361	0.325	−2.119[e]
2nd	729	0.218	0.205	−0.903
3rd	729	0.170	0.145	−1.972[e]
4th	724	0.115	0.104	−0.961
5th	692	0.071	0.072	0.074
6th	598	0.050	0.048	−0.279
7th	431	0.030	0.034	0.480
8th	289	0.017	0.025	1.096
9th	165	0.006	0.018	2.095[e]

[a]Lowest odds horses.

[b]The number of races declines because many races have only a small number of entrants. It should be noted that there are numerous races in which there is a tie for which horse is the first favorite, or second favorite, etc. The pool of first favorites was taken to consist of all horses with the lowest odds, including ties, and similarly for the other positions.

[c]Note that these probabilities are the probabilities for the ith favorite conditional on there being an ith favorite in a particular race. Hence they need not sum to unity.

[d]The standard errors were computed by taking the objective probabilities as the 'true' probabilities and assuming a binomial process. Thus the standard error is $[p(1-p)/n]^{\frac{1}{2}}$ [see Ali (1977)], where p is the objective probability and n the number of races.

[e]Significant at the 0.05 level.

Table 2.6 reproduced from Asch et al. (1982)

As another test of weak efficiency, and now using the more common method of allocating horses to categories, namely by using the actual odds, rates of return were calculated for nine categories. The results, shown in table 2.7, again indicate that the market is weakly efficient after transaction costs but that bettors are inconsistent in their manner of betting. An interesting test was carried out here which indicates that this inconsistency is more marked in the last two races of the day. This was mentioned earlier. The data used were 729 races run during 1978 in the United States. Tote odds were used throughout. Odds data alone were used for the tests which are therefore tests of weak efficiency.

Rates of return from bets on horses with different odds levels for all races and for late races (races 8 and 9).

Odds level *O* (1)	Rates of return: All races (2)	Late races (3)
0≦2	−0.1366	−0.0428
2<0≦3.5	−0.3177	−0.3210
3.5<0≦5	−0.1758	−0.0288
5<0≦8	−0.2242	−0.5238
8<0≦14	−0.1602	−0.1698
14<0≦25	−0.3255	−0.3618
25<0	−0.6372	−0.6858

Table 2.7 reproduced from Asch et al. (1982)

Asch et al. (1984) examines market efficiency from a different point of view. The main thrust of the paper is similar to previous studies in that it attempts to find profits using only odds as information. Instead of comparing empirical probabilities with subjective probabilities on a category by category basis, logit analysis is used. Thus empirical probabilities are thought of as dependent variables, while different types of odds (e.g. SP's and Forecast Prices (FP's)) relating to the races are thought of as the predictor variables.

The paper is difficult to read because the meaning of some terms are not explained. The wording of the paper appears to suggest that empirical probabilities are affected by FP's and SP's. The reverse is clearly the truth. However it is reasonable to use logit analysis if the various odds are used as explanatory variables only. The interpretation is then that the odds help explain the outcome of races but they certainly have no systematic fundamental effect on such outcomes.

The various odds used are the FP's, SP's and marginal odds derived from the final eight minutes of betting. The latter are used to test for inside information and will therefore be discussed later. The paper notes that neither FP's nor SP's alone provide a satisfactory explanation of the empirical winning probabilities. This is consistent with the other studies in that it implies that above normal profits cannot systematically be made on win bets simply by using odds information.

Undeterred by this evidence the paper suggests three betting strategies to be used in conjunction with the predictive model using the FP's and SP's. All three strategies inevitably end up backing the favourites. It is noted that for all strategies using win betting, better results than the average (negative track take) are obtained. This is nothing unexpected if we keep in mind the well known favourite-longshot bias (inconsistency) of bettors.

The horses for win bets as selected by the predictive model were bet on for places and shows. This resulted in fairly substantial profits, although these were shown to be much lower than noted at first, owing to a computer error in the original calculations, two years later by Asch et al. (1986). The following explanation is offered by the paper. "It is possible that the tendency to overbet longshots is accentuated in place and show betting. It is also possible that all the information contained in the win pool may not be efficiently impounded in the place and show pools."

The paper concludes by noting two practical problems. Firstly any predictive model working with SP's as an independent variable will be rendered useless by the fact that SP's are not known until the race is almost over. Secondly, any strategy that could be employed in the place and show pools, would have to be of very limited size as these pools are small relative to the win pool. The data used for all the tests were some form of odds and therefore the tests were of weak efficiency.

Bird and McCrae (1987) in testing for semi-strong efficiency also investigate weak efficiency by ranking horses by their level of favouritism, at four different points in the betting period, and noting rates of return to these categories. The data were collected from Australian racetracks during 1983 and 1984. A total of 1 026 races were used, while bookmaker odds were used in preference to tote odds. The results, shown in table 2.8, indicate that Australian bettors have similar biases in their betting behaviour as bettors from the U.S.A. and Britain. The percentage return to the first favourite was -7.38 while the return to the seventh favourite was -38.96. All returns in between decreased monotonically. The test of weak efficiency used only odds data. This paper is discussed further in the next two sections.

Rates of Return from Placing a $1 Bet on Horses Ranked Both on the Basis of the "Experts" Poll and Their Level of Favoritism.

	Period							
	t_1		t_2		t_3		t_4	
Ranking	Tipsters %	Favoritism %	Tipsters %	Favoritism %	Tipsters %	Favoritism %	Tipsters %	Favoritism %
1	−12.29	−15.28	−7.18	−9.00	−4.50	−5.40	−5.50	−7.38
2	−26.45	−26.57	−22.29	−20.61	−18.06	−13.33	−18.78	−10.81
3	−16.62	−13.38	−12.67	−17.80	−7.79	−11.54	−9.66	−17.99
4	−27.66	−24.40	−25.54	−14.93	−19.18	−22.61	−19.61	−24.45
5	−20.71	−35.72	−15.91	−36.20	−9.23	−33.64	−9.62	−29.16
6	−53.27	−39.95	−52.98	−33.55	−50.05	−20.08	−40.46	−27.12
7	−46.09	−42.49	−44.65	−38.56	−36.92	−41.63	−38.40	−38.96

N.B. None of the differences between the returns where the horses are ranked on the basis of the tipsters' polls and on basis of the level of favoritism prove to be significant at the 0.10 level.

Table 2.8 reproduced from Bird and McCrae (1987)

Figlewski (1979) also had as his main aim the testing of semi-strong efficiency but did test for weak efficiency along the way. His data consist of 189 races run in the U.S.A. in 1977 with the use of tote odds. Logit analysis is used. The dependent variable is the predicted probability of each horse winning. The predictor variable is the tote odds. From the data sample, coefficients for the explanatory variable are estimated so as to maximize the product of the predicted probabilities of the horses that actually won each of the 189 races (maximum likelihood estimation). The conclusion drawn is that the tote odds are a better predictor of races than no information at all (the coefficients of the explanatory variables set to zero). This is hardly useful, but this type of test was not the aim of the paper. A number of papers have thus run tests of weak efficiency in the racetrack betting market. These include results from different times as well as different countries, namely the U.S.A. , England, Australia and South Africa. Different data were also used between studies in that some used tote odds while others used bookmaker odds. Grouping of data was another aspect which differed from study to study. The basic form of the test is to compare empirical probabilities of winning with those subjectively determined. A more complex form of the test uses logit analysis and functions of the odds rather than the odds themselves.

Although the market is weakly efficient in that after transactions costs profits cannot be made simply by knowing the odds of the runners, the market is nevertheless inconsistent. This is because of the betting bias that the public show towards outsiders and against favourites. The public have been shown to be inconsistent in that they could increase their return to above the average simply by betting on favourites.

2.2.2 Tests of Semi-Strong Efficiency

The Subjective Views of the Press

The data for testing semi-strong form efficiency in the stock market consists of publicly available information regarding shares, in addition to the past price information. In the context of horserace betting we will use as data the subjective information of various groups of people regarding the outcomes of races. Snyder was the first to comment on the possibility of a test of semi-strong efficiency. He suggested that a test of semi-strong efficiency had not been reported. We noted in the introduction that Snyder's definition of the semi-strong class has been updated and we therefore just consider his "strong efficiency" test as pertaining with more relevance to a test of semi-strong efficiency.

For his examination of "strong efficiency" Snyder defines newspaper tipsters as being in the class of people who possess inside information. It will be noted here that if such "inside information" was published it would fail to be inside information and could not be used to test strong efficiency anyway!

Snyder's study is thus applicable to an evaluation of tipsters information, which is then a test of semi-strong efficiency. The test is conducted by examining rates of return to tipster "bets" in a similar way to the manner in which the test of weak efficiency was carried out. The data used were odds (FP's) predicted by various newspapers, the official track handicapper and the Daily Racing Form, based on 846 races run during 1975. The odds on all the horses are noted and the horses are grouped into odds categories as in the test of weak efficiency. Rates of return to each odds category are calculated.

Rates of return are analysed without regard of transactions costs. In this hypothetical situation an efficient market is one in which all rates of return are zero. Snyder's weak efficiency test showed the public to be inconsistent in that returns were greater than zero for favourites while they were less than zero for outsiders. It is now shown that the "experts" are also inconsistent and to a higher degree. Rates of return to favourites were higher for the experts than the public, while they were lower than the public's return for outsiders. The only conclusion that Snyder draws from this is that the experts are more biased than the public in determining odds.

Losey and Talbot (1980) also take Snyder to task on his work. They suggest that Snyder's test is relevant only as a test of semi-strong efficiency. They then assume that the FP's obtained from some source (in this case the Racing Form handicapper), are accurate estimates of the true odds, and therefore that any deviation from these FP's in the publicly determined odds, present opportunities for profit.

The test examines the FP's and SP's for 1305 races in the U.S.A. run during 1978. Assuming the FP's to be the true odds, if the ratio of SP to FP is greater than 1 the bet will have positive expected value and so long as we confine our bets to such situations we will make a profit in the long run. The ratios are calculated and split into 3 categories, viz. 1.01-1.32, 1.33-1.72, and greater than 1.72. Level stake bets were made on the 579 horses that qualified for a bet. Horses qualify for a bet if their FP's are 3/1 or less. The resultant losses were 21.6%, 32.8% and 32.7% respectively. The overall loss was 28.4% which was noted to be significantly different from the average bettors loss of 17%. Evidently something is wrong.

It is somewhat difficult to explain the results in the light of two observations already made. Firstly, simply by betting on favourites (say horses at 3/1 or less) we would expect to obtain a rate of return better then the average loss of 17%. Secondly, the odds on favourites as estimated by the Racing Form are assumed to have been overestimated (i.e. the probabilities inherent in the FP's for favourites are less than the empirical probabilities).

The conclusion drawn from the test is that the so called experts do not know more than the public regarding the outcomes of races, and if anything they exhibit less knowledge. No explanation is offered as to why the results of the test were the opposite of what were expected. Using the definition of efficiency that rules out abnormal profits, the final conclusion of the study is that the market is semi-strongly efficient.

Tuckwell (1983) examines semi-strong efficiency very briefly in a paper that is more concerned with strong efficiency. The Australian publication "Computercard" publishes odds for its first three rated horses on a consistent and scientific basis. A bet was made on all horses whose SP's exceeded the estimated odds. This led to a profit of some 6.5 per cent, and the conclusion is that the market is semi-strongly inefficient. It is noted that this occurs in spite of strong inefficiency, and not because of it, as was the case with the weak test.

In addition to testing for semi-strong efficiency, Bird and McCrae (1987) investigate whether the information contained in the tipsters' forecasts is impounded into the odds as determined by the public. In the test, the choices of ten "experts" are noted. Three points are allocated to a horse tipped first, two for second and one for third. This gives an overall view of the information contained in the tipsters' suggestions. Horses are then categorised by their rank, as determined by the allocation of the tipster's points. Level stake bets are placed on all horses with the same rank and the rates of return are calculated. It is noted that the returns are negative for all ranks and that the higher ranks, (strongly fancied by the tipsters) performed better in terms of returns than the lower ranks, as shown in table 2.8. The conclusion drawn is that the market is semi-strongly efficient.

As seen in the section on weak efficiency the horses were also grouped on the basis of their level of favouritism as determined by the public. Rates of return were calculated and t-tests performed to see if there were any differences between the returns to the public and those to the "experts". No significant difference was found and the conclusion drawn was that the odds determined by the public, incorporate the tipsters information. Discussion on this conclusion can be found in section 2.3.2.

Figlewski (1979) attempted to connect the track odds and the tipsters' information in a more complex way. His method has been discussed in the previous section although in this section we consider the model for prediction to include tipsters' information as well as the track odds as explanatory variables. The test shows that at the 5% level of significance, the two models explain as much as one another and therefore the tipsters are not adding any additional information to the predictions. It is concluded that the information held by the tipsters is discounted in the track odds determined by the public. All the studies thus indicate that possessing the knowledge of a racing tipster will not yield profits and the market is therefore semi-strongly efficient.

Gabriel and Marsden (1990) compared payouts to winning tote bets with the corresponding SP's available from the bookmakers. They hypothesised that if the market was semi-strongly efficient, the returns to both bets would be the same. Data were collected from the racing season of 1978 when electronic tote boards were not available, so that tote punters in fact did not know what their return would be until after the race. If tote odds were consistently above bookmaker odds, surely the punters would back with the tote rather than the bookmakers? If they did not, this would indicate a lack of information on their part which would mean that the market was semi-strongly inefficient. It is shown that tote returns for the season were consistently higher than bookmaker SP's even when eliminating the higher (10/1 and above) tote payouts. The conclusion drawn is that the market at that time was semi-strongly inefficient.

2.2.3 Tests of Strong Efficiency

Correlation Between Different Sets of Odds

Since 1976 a few papers have examined betting markets for strong efficiency. The first of these was Dowie, whose paper has already been mentioned in connection with weak efficiency. The strong form is tested by hypothesising that if the odds set well before the race (FP's), are as highly correlated (or more highly correlated) with the observed probabilities of winning , as the SP's are, then this would be an indication of a strongly efficient market with no inside information. This is because of the assumption that persons possessing inside information would exploit it until the "off" thereby causing the odds to move into line with the odds suggested by the superior information. Odds set well before the race would supposedly not have been adjusted for the inside information.

The tests reveal that for the 1973 racing season the correlation between the FP's and the observed probabilities was as high, if not higher, than the correlation between the SP's and the observed probabilities. The conclusions drawn from the tests are therefore that the betting market is strongly efficient. This view is generally not taken by racegoers. Please note further comments in section 2.3.3.

Inside Information

Crafts (1985) commented on Dowie's paper and went on to define a different method for testing strong efficiency. His data were FP's and SP's collected over a four month period involving 16,769 runners. He calculated the ratios of FP's to SP's and categorised runners showing a "marked difference" between FP and SP as follows:

(1) $1.5 \leq FP/SP < 2.0$
(2) $FP/SP \geq 2.0$
(3) $1.5 \leq SP/FP < 2.0$
(4) $SP/FP \geq 2.0$

A total of 2 280 runners fell into one of these categories, and the other runners were regarded as not having shown a marked change in odds. Each horse in these categories was then "bet" on at both FP and SP. Categories (1) and (2) yielded profits of between 65% and 140% of the stake, when backing at FP although bets on the same horses at SP yielded a loss of between 1% and 9%. Categories (3) and (4) yielded losses of approximately 65% when backing at FP and losses of between 13% and 38% when backing the same horses at SP.

It is noted that certain bets will yield profits in the long term. These are on horses whose SP is markedly shorter than its FP. Such bets would have to be made at FP in order to be profitable. The conclusion drawn is that SP odds are a better guide to true winning probabilities than the FP's are and thus Dowie's result is in question.

A similar test is performed but instead of using FP's, LP's are used. These are defined as the longest price at which a bet was transacted on the course. The results are similar to those above in that no profit can be made by backing supported horses at SP, but substantial profits can be achieved by backing such horses at LP. The conclusion drawn is that, at the start of the betting period, the punters had a better idea of the supported horses chances of winning than the bookmakers did. The betting market is thus found to be strongly inefficient. People who follow the information when it is revealed in the prices do not have opportunity for profits. Examples of marked changes in the betting markets are shown in table 2.9.

In their 1982 paper Asch et al. examine marginal odds produced by bettors in specific periods within the whole betting period. They calculate the marginal odds produced by bettors in the final 8 minutes of betting as well as those produced during the final 5 minutes. They obviously also have the final odds and compare these 3 different odds to the morning line odds (FP's). It is hypothesized that bettors with inside information would prefer to bet late in the betting period thereby giving as little time as possible to the public in which to follow such information. The data they have permit an investigation of such an hypothesis.

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Date	Course	Horse	Form and betting description
16/9/82	Yarmouth	"Compound"	"dropped to 7/2 after visiting 7/1 from 5/1 (bets of £10,000-£1400, £2750-500 twice, £2250-500)". In previous race only 4th at 10/11 beaten 9 lengths by another horse again in opposition who was on this occasion more favourably weighted.
30/9/82	Brighton	"Rana Pratap"	"dropped dramatically from 12/1 to 7/2". In previous races had managed no better than 4th place.
1/12/82	Newton Abbot	"Mister Lucky"	"following some 8/1 and 6/1 was reduced from 4/1 to 11/4 favourite". In six previous races had not reached the first four.
7/12/82	Newcastle	"Mossmoran"	"feature was the run on Mossmoran who hardened through all rates from 5/1 to 2/1". In two previous races the horse had been unplaced.

Note: In each these cases the horse concerned won the race. All details are taken from relevant copies of *Sporting Life*, and the betting market descriptions are quoted verbatim.

Table 2.9 reproduced from Crafts (1985)

It is shown that for horses that finished first, the ratios of the SP's to the FP's are greater than the ratios of the marginal odds to the FP's. This is interpreted as implying that the marginal odds are better predictors of finishing position than SP's and therefore if the assumption regarding the betting behaviour of inside information holders is correct, then inside information does exist. Another way of thinking about it, is that winning horses, in general, are especially favoured by late bettors.

Tuckwell (1983) uses as the basis for his test an, examination of the adjustment of the bookmaker odds during the betting period. His testing procedure, however, is somewhat different to that of Crafts. Tuckwell notes that from empirical observation, (various economic studies into gambling) the gross (net of tax) profit margin on turnover for bookmakers is 5 per cent. In addition to knowing what bookmakers win, the average loss of punters at different odds levels is calculated using a regression model. The model uses the probability equivalent of the starting price odds as a predictor variable, to estimate the percentage loss to punters at any specific starting price level. The results of the regression are shown in Table 2.5. Since bookmakers win what punters lose, any deviation from the expected 5%, occurring in punters losses would require further investigation. As seen in Table 2.5, the percentage loss to punters varies considerably from 5%. In fact the loss is around 16% at the odds level of 1/1, gradually falling as the odds lengthen, to about 9% at odds around 3/1. Thereafter the loss increases with increasing odds level, reaching almost 50% at the longest odds. The paper then sets out to find where the discrepancy, between the expected 5% loss and the observed losses, lies.

The answer is to be found in the adjustment of the odds. It is assumed that the movement of the odds during the betting period is associated with weight of money. Consider two horses with a starting price of 9/2. One that was backed in from 6/1, while the other drifted from 3/1. Table 2.5 suggests that the profit margin to bookmakers laying bets on these horses is about 12%. However, because the two horses were laid at different prices earlier in the betting, the overall average margin of horses at the starting price of 9/2, may well be different from 12%. Since the first horse was laid at odds longer than 9/2, the profit margin to bookmakers on those bets, is going to be less than the expected margin of 12%, and it may even be negative. On the other hand, bets taken on a horse that eventually has a starting price 9/2, at an earlier price of 3/1 (say), will necessarily yield a greater profit margin to the bookmaker than the expected 12%. Empirically it is known that horses that firm in the betting, have relatively more money placed on them than horses that drift in the betting. It is thus concluded that because more money was taken by bookmakers on the first horse, its profit margin will dominate, and the resultant average profit margin to bookmakers, laying horses at starting price odds of 9/2, will be less than the expected 12%. Evidently the adjustment of the odds during the betting period was cutting the bookmakers expected margin at all starting price odds levels.

A reason was now sought as to why the odds adjusted the way they did. If bookmakers were capable of accurately assessing a horses chances, the "correct" odds would be on offer at the start of the betting period, and the systematic firming and drifting of horses in the odds would not occur. It is suggested, that since it is unlikely that bookmakers will generally have less knowledge than punters at the outset of the betting period, that some new information must have been introduced. Since it is unlikely that new information becomes publicly available during the betting period, the only possible remaining explanation, is that inside information, not available to the public or bookmakers, causes the odds to adjust and squeezes the bookmakers' margins.

It is suggested that because of the inequity associated with inside information, that it should be eliminated. This inequity is not from the side of the bookmakers, but from the point of view of punters who do not have access to inside information. If inside information did not exist, bookmakers would be not faced with squeezed margins, but competition amongst them would most likely cut profit margins back to their original levels when inside information still existed. The implication of a decrease in bookmakers' margins in the absence of inside information, is a lengthening of odds on all horses, at all times, during the betting period. This would clearly be of considerable benefit to the average punter, at the expense of the insiders.

Ethical considerations alone are sufficient to require the elimination of inside information, but Tuckwell presents another reason why insiders should be stopped. Racing is essentially a form of entertainment, and much of the pleasure is derived from exercising one's judgement, and then witnessing the results of any decisions made, in a short period of time. This pleasure can only be detracted from by an imperfect flow of information, as putting together a puzzle without all the pieces is no fun at all since the picture will never be clearly visible. Too much unpredictability, such as exists, if inside information plays a large role, tends to reduce the interest in betting. It is thus quite likely that many paying customers will be lost to the sport because of the existence of inside information.

The nature of inside information is examined and various alternative forms are presented. These are reproduced verbatim, below. In addition an explanation of the mechanics of each alternative is given, and these too are reproduced directly from the text of Tuckwell's paper.

" (a) An imperfect flow of information from the stable to the public, but no interference with race outcomes.

(b) Indirect interference by the stable in the outcome of races.

(c) Direct interference in race outcomes which is either stable inspired or to which the stable is a party.

(d) Outside interference in race outcomes - that is, interference which does not involve the stable in any way."

These alternative forms of inside information are explained more fully as follows;

" (a) Here there is no attempt to interfere in any way with the outcome of the race, but there exists an inadequate flow of relevant information. The type of information would usually relate to the precise nature of the horse's physical condition, its likes, dislikes and other idiosyncrasies and perhaps more importantly, the extent to which things are improving or deteriorating. The stable and its connections are in a privileged position in making accurate assessments of these factors. Not infrequently, a relevant piece of information, known to the stable before the race, only becomes public after the race. This does not necessarily mean that the information was deliberately withheld. It may well be a reflection on the quality of the communication channels.

(b) This category is similar to (a) in that an inadequate flow of information exists, but in this case the horse's condition is deliberately manipulated by the stable in order to accomplish a successful betting coup for either the stable itself and/or its confidants. For example, the horse's training schedule may be eased slightly before one race, so that it runs two or three lengths below its best, and then stepped up again before the race in which the horse is financially supported. This is a case of deliberate interference in the outcome of races and, consequently, the stable has a much stronger incentive to obstruct the flow of information compared with (a). The interference, in nature, is indirect and, because of this, is virtually impossible to detect. Trainers can claim they were doing what appeared best for the horse at the time, but that in retrospect a slight error of judgement was made. What the real intentions were is more a matter of opinion than demonstrable fact. For practical purposes, therefore,categories (a) and (b) are indistinguishable.

(c) This direct interference, involving the stable, takes the form of not allowing the horse to run on its merits and, consequently, requires the jockey's cooperation. Without going into practical details, jockeys can achieve the desired result in a variety of ways and, unless it is very badly and ostentatiously executed, it is extremely difficult to be sure of the intentions. The authorities ask questions from time to time, but in the majority of cases there is little alternative but to accept the explanations offered.

(d) This category refers to interference in races which is unassociated with the stable, that is, outside interference. It may take the form of obtaining the cooperation of jockeys or of the administration of drugs to the horse. As in the case of (c), there are the same problems in directly detecting complicity on the part of the jockeys. However, in this case it does seem possible that all contact between jockeys and the outside elements seeking their cooperation could be severed, given sufficient resolution on the part of the relevant authorities.

The problem of drug detection is a technological one. While rapid advances have been achieved in this area, there may always be some doubt whether the technology of drug administration is still one step ahead. In this respect, prevention, in the form of stringent stable security, would be an essential, parallel aim."

The importance of these problems cannot be overstated, as it is widely recognized that the declining financial state of racing, (specifically in Cape Town) is a result of the existence of inside information.

Bookmaker Odds

Bird and McCrae (1987) use bookmaker, as opposed to tote prices, and examine the adjustment of the odds during the betting period. This is similar to Crafts' analysis although it only examines the bookmaker odds from the opening of the betting period and does not consider the morning prices at all. The paper also introduces the concept of "consumption benefits" that may be derived from racing other than the chance of a positive rate of return. This leads to a discussion on why gamblers are at the racecourse at all, and is dealt with in chapter three. It is worth noting though that incorporating this concept into our idea of an efficient market will change what is meant by such a market. It may now be possible to say that the market is efficient, even if returns to all odds categories are not zero percent (excluding transactions costs).

The data used are from 1 026 races run in Australia during 1983 and 1984. The justification for using bookmaker odds is that the greater portion of win bets are struck with bookmakers. This means that we can get a better idea of the movement of the odds from the bookmakers, because large sums are virtually always wagered with them. The data consists of bookmaker odds at four time points during the betting period, namely, at the start of betting, five minutes later, thirteen minutes before the start and the final odds.

The test is as follows. If we observe a certain movement in the price (probability) of a horse, we will bet on that horse. The size of the predefined movement was varied and numerous tests using different " filters " were performed. Probabilities were used instead of prices. The probabilities used were the standardised type as first defined by Dowie. The test was conducted in both directions, thus examining horses that both firmed and drifted in the betting. The filters used were 0.025, 0.05, 0.075, 0.1, 0.125 and 0.15. These are clearly arbitrary, but a good starting point.

The paper identifies only three possible times, (and odds) when the bets could actually be placed. The "bet at end" strategy places a bet at the call of odds at which the horse was first observed to satisfy the movement criterion (filter). It is possible that a horse may have satisfied a particular filter before the it is first observed to do so, in which case it should in theory be bet on at the first price at which it satisfies the filter, not at the price which is conveniently available through the data. In order to use a "bet as soon as possible" strategy, a continuous series of prices was simulated. A problem here is that prices in reality are not continuous and thus we may necessarily have to accept slightly lower odds than we would like, given the satisfaction of our filter. Using the continuous prices would obviously tend to overstate the rate of return to this strategy.

An example may clarify the method used. Suppose the opening betting on a particular horse is 5/1. At the second call, the horse is 4/1, thus satisfying one of the various filters. The "bet at end" strategy would bet at the odds of 4/1, while the "bet as soon as possible" strategy would bet at some theoretical odds level, which is derived at through the simulation of continuous prices. Both bets are relevant to the same filter.

The final betting strategy is the one which has implications for strong efficiency. This is the so called "bet at beginning" strategy. The bets for this strategy are placed at the odds prevailing before the horse was identified as having satisfied a filter. If we assume that the changes in prices are owing to the utilization of inside information not available at the opening of betting, then if profits can be made with prior knowledge of these price movements (equivalently, knowledge of inside information), the market is strongly inefficient. The results of the tests are shown in Table 2.10.

Rate of Return from Placing a $1 Bet at "Beginning" Odds on Horses that Satisfy Various Filter Strategies and Horses Designated to Control Groups

Bet at Beginning					
Filter (no. of bets)	Filter strategy %	Control group %	Filter (no. of bets)	Filter strategy %	Control group %
+0.025 (1923)	+8.16†	−25.62	−0.025 (1532)	−46.03†	−21.47
+0.05 (696)	+18.41‡	−15.19	−0.05 (277)	−43.74†	−16.79
+0.075 (243)	+28.01†	−52.16	−0.075 (54)	−47.50	−20.37
+0.1 (77)	+42.66†	−37.34	−0.1 (9)	−80.00	−38.89
+0.125 (26)	+52.31	−27.88	−0.125 (3)	−100.00	−100.00
+0.15 (10)	+196.10	−100.00	−0.15 (0)	—	—

Difference between rate of return on filter strategy and control group:
† Significant at 0.05 level.
‡ Significant at 0.10 level.
N.B. Significance tests only applied where the sample size exceeds 30.

Table 2.10 reproduced from Bird (1987)

It can be seen that knowledge of the price movements is not sufficient for profits to be made. The knowledge of such price movements must be held prior to the occurrence of the movement, i.e. inside information not already impounded in the odds is necessary for profits.

Two other interesting points discussed in the paper are the effect of the staking system used on the rates of return, and the use of control groups as a check on the results. The latter point checks if a group of horses at similar starting prices, that do not have a decreasing price history, will perform differently to a group of horses that do have a decreasing price history. The results of these tests are shown in Tables 2.11 and 2.12 and are noted to be consistent with the previous observation that profits cannot be made by knowing the price history of the horses. A similar check was made using the "bet at beginning" odds, and this showed that profits can be made with prior knowledge of price movements.

Rate of Return from Placing a $1 Bet at "End" Odds on Horses that Satisfy Various Filter Strategies and Horses Designated to Control Groups

Bet at End					
Filter (no. of bets)	Filter strategy	Control group	Filter (no. of bets)	Filter strategy	Control group
+0.025 (1923)	−11.85	−16.52	−0.025 (1532)	−23.21	−11.06
+0.05 (696)	−8.28	−6.94	−0.05 (277)	−10.11	−28.07
+0.075 (243)	−4.33	−5.10	−0.075 (54)	−9.96	−21.30
+0.1 (77)	0.52	18.83	−0.1 (9)	−66.67	83.33
+0.125 (26)	−15.50	14.42	−0.125 (3)	−100.00	208.33
+0.15 (10)	47.40	−12.50	−0.15 (0)	—	—

N.B. The differences between the rates of return for the filter strategy and the control group for all positive and negative filters are not significant at either the 0.05 and 0.10 level.

Table 2.11 reproduced from Bird (1987)

In order to investigate the effect of the staking system used, similar strategies were used but instead of betting one unit, an amount was staked to win one unit. The latter system usually performs better than the former because proportionately more money is put on favourites. This is noted to be the case for the " bet at end " strategy but not for the " bet at beginning " strategy, where it is better to bet one unit on each horse. This is probably because the probability of an outsider winning given that he is the subject of an inside information tip, is very much higher than if he was not. The rate of return to the odds categories containing such outsiders is probably more than that for similarly tipped favourites. In this case a system which put proportionately more money on outsiders would perform better, and this is what we have observed. The results shown in Table 2.13 should be compared with Table 2.10.

Rates of Return from Placing a Bet to Win $1 on Horses that have Been Identified as Having Satisfied Various Filter Strategies

Filter (no. of bets)	Bet at beginning %	Bet at end %	Bet "as soon as possible" %	Filter (no. of bets)	Bet at beginning %	Bet at end %	Bet "as soon as possible" %
+0.025 (1923)	+3.07	−8.11‡	−6.93‡	−0.025 (1532)	−38.22†	−16.21†	−30.66†
+0.05 (696)	+10.31	−7.24	−6.03	−0.05 (277)	−42.24†	−12.94	−30.59†
+0.075 (243)	+18.81‡	−3.32	−2.82	−0.075 (54)	−46.70†	−10.48	−32.16‡
+0.1 (77)	+20.64	−5.49	−4.77	−0.1 (9)	−68.97	−47.55	−60.60
+0.125 (26)	−2.65	−29.54	−27.95	−0.125 (3)	−100.00	−100.00	−100.00
+0.15 (10)	+42.52	+42.71	+53.72	−0.15 (0)	—	—	—

† Significant at 0.05 level.
‡ Significant at 0.10 level.
N.B. Significance tests only applied where the sample size exceeds 30.

Table 2.12 reproduced from Bird (1987)

2.2.4 Tests of Bettor Consistency

Place Probabilities Estimated From Win Probabilities

We have seen in tests of weak efficiency that bettors can increase their return (although not to a level of profitability) by betting consistently on favoured horses. The additional information required for such a system is zero, since the odds information on all horses is available. By consistently betting on outsiders which over the long term offer a lower return than favourites, bettors are demonstrating what we have defined as inconsistent

Rates of Return from Placing a $1 Bet on Horses Identified as having Satisfied Various Filter Strategies

Filter (no. of bets)	Bet at beginning %	Bet at end %	Bet "as soon as possible" %	Filter (no. of bets)	Bet at beginning %	Bet at end %	Bet "as soon as possible" %
+0.025 (1923)	+8.16	−11.85†	−8.30	−0.025 (1532)	−46.03†	−23.21†	−38.04†
+0.05 (696)	+18.41†	−8.28	−5.52	−0.05 (277)	−43.74†	−10.11	−30.48†
+0.075 (243)	+28.01†	−4.33	−2.56	−0.075 (54)	−47.50†	−9.96	−32.09
+0.1 (77)	+42.66‡	0.52	2.73	−0.1 (9)	−80.00†	−66.67	−75.56
+0.125 (26)	+52.31	−15.50	−6.46	−0.125 (3)	−100.00	−100.00	−100.00
+0.15 (10)	+196.10	47.40	62.30	−0.15 (0)	—	—	—

† Significant at 0.05 level.
‡ Significant at 0.10 level.
N.B. Significance tests only applied where the sample size exceeds 30.

Table 2.13 reproduced from Bird (1987)

behaviour.

To examine bettor consistency we need to examine actual returns to similar bets which have identical probabilities of success. In addition to these tests we can construct probability relationships between different bets that we believe should hold and test to see if in fact they do hold. The first test along these lines was proposed by Harville (1973). He produced a formula giving place probabilities in terms of the win probabilities. The formula relies on accurate estimates of the win probabilities being available, and that these are sufficient information to assign probabilities to other finishing positions.

The formulae are as follows:

If Q_i is the probability that horse i wins the race, then the probability that i is first and j is second is

$$Q_i \times \frac{Q_j}{(1-Q_i)}$$

and the probability that i is first, j is second and k is third is

$$Q_i \times \frac{Q_j}{(1-Q_i)} \times \frac{Q_k}{(1-Q_i-Q_j)}$$

In order to obtain these simple formulae to estimate the place probabilities, the assumption was made that the probability of a horse beating any subset of horses in the race is the same no matter where the other horses, not in the subset, finish.

Further analysis of estimating place probabilities can be found in chapter 6. Harville uses 335 races to examine the differences between observed frequencies and the frequencies expected on the basis of the publicly determined odds. This is done for finishing first, second and third. His winning frequency comparison again reveals the favourite-longshot bias, and he notes that bettors overrate the chances of longshots and underestimate the chances of favourites and near favourites.

The second and third place frequency comparisons indicate a tendency to overestimate the probability of finishing second or third for horses with high theoretical probabilities of such finishes, and to underestimate the chances of those with low theoretical probabilities. It is noted, however, that in the frequency of placing (finishing in the first two) table, the observed frequencies are very close to the expected frequencies. This is explained as follows; horses that have a high (low) probability of finishing second also have a high (low) probability of finishing first, so that the effects of overestimation (underestimation) of their chances of finishing second are cancelled out by the underestimation (overestimation) of their chances of finishing first.

Finally, horses are categorised with regard to their expected return from place and show bets. The expected return is simply the final actual "payoff" amount multiplied by the theoretical probability of placing/showing as derived from the win probabilities. The results indicate that profits cannot be made simply by making bets that have an expected return of greater than one.

Tuckwell (1981) examines the apparent irregularities between the win and place (finishing in the first three) betting markets in Australia. He uses the Harville formulae to calculate expected place probabilities, but uses a different method for calculating estimates of the win probabilities. A regression line is calculated such that the win probability for a given horse is a polynomial function, of degree four, of the bookmaker SP of the horse. The data used are 3 849 horses from 286 races run in Australia in 1975.

Estimates of the place probabilities for all horses are calculated from the calculated win probabilities and are divided into one of ten different probability ranges. For seven of the probability categories the observed probability of placing exceeded the estimated probability, although the difference was only significant in the category of horses that had an estimated place probability of between 0.05 and 0.08. This implied that backing horses in this category would result in long term profits. The other three categories had observed probabilities of placing lower than those expected and thus losses would result by betting such horses for a place. Of these "loss" categories, only the category containing horses with estimated place probabilities of between 0.6 and 0.8 had a significant difference between observed and expected.

It is thus clear that backing horses for a place will result in widely varying returns depending on the odds category that such horses fall into. By backing horses that have a low probability of placing, a greater return will be realized than by backing horses that have a high probability of placing. This in itself renders the market inconsistent. The fact that profits can be made at a certain odds level means that the market is also inefficient. It is shown that backing all horses that had an expected return of greater than one, yielded a return of about 20 per cent. This is in contradiction to Harville's study.

Systematic Profits

Hausch et al. (1981) have examined betting market efficiency in the context of the place (first two) and show (first three) markets. The paper devises a technical system for place and show betting. The data consist of 1 065 races involving 9 037 horses run during

1978 in Canada, as well as 627 races involving 5 895 horses run in 1974 in the U.S.A. Estimates of place and show probabilities are calculated via the Harville formulae, although it is clearly stated that there is no unique method of determining such probability estimates.

Actual versus theoretical probabilities are compared for win, place and show finishes. The results for the win probabilities indicate again the favourite-longshot bias. The results for place and show probabilities differ somewhat from Harville's results in that significant differences appear in twelve of the probability categories. Using the theoretical probabilities and the actual "payoffs" to each horse, an expected return per $1 bet is calculated for all horses. The "payoffs" are those amounts which would have been paid had the conditions for a winning bet been satisfied.

Horses were then classified according to their level of expected return, and a $1 bet on each horse in each category was made. The results are shown in table 2.14. Note that as expected the actual return increases with the expected return, even if it does not equal it. It is now assumed that the investor wishes to maximize his long run asset growth, and so the Bernoulli capital growth model is introduced. This model involves calculating bets in order to achieve the above objective. The expression below, reproduced from Hausch

$$\underset{p_l,\ s_l}{\text{Maximize}} \sum_{i=1}^{n} \sum_{\substack{j=1 \\ j\neq i}}^{n} \sum_{\substack{k=1 \\ k\neq i,j}}^{n} \frac{q_i q_j q_k}{(1-q_i)(1-q_i-q_j)} \log \left[\begin{array}{c} \dfrac{Q(P+\sum_{l=1}^{n} p_l)-(p_i+p_j+P_i+P_j)}{2} \\ \times \left(\dfrac{p_i}{p_i+P_i} + \dfrac{p_j}{p_j+P_j} \right) \\ + \dfrac{Q(S+\sum_{l=1}^{n} s_l)-(s_i+s_j+s_k+S_i+S_j+S_k)}{3} \\ \times \left(\dfrac{s_i}{s_i+S_i} + \dfrac{s_j}{s_j+S_j} + \dfrac{s_k}{s_k+S_k} \right) \\ + w_0 - \sum\limits_{\substack{l=1 \\ l\neq i,j,k}}^{n} s_l - \sum\limits_{\substack{l=1 \\ l\neq i,j}}^{n} p_l \end{array} \right]$$

where q_i = the probability that horse i wins
Q = the take out rate
P = the place pool
S = the show pool
P_i = amount bet on horse i to place
S_i = amount bet on horse i to show
p_i = our bet on horse i to place
s_i = our bet on horse i to show
w_0 = our wealth level.

$$\text{s.t.} \sum_{l=1}^{n} (p_l + s_l) < w_0, \qquad p_l > 0, s_l > 0, l = 1, \ldots, n,$$

Results of Betting $1 to Place or Show on Horses with a Theoretical Expected Return of at Least α

Exhibition Park

	Place			Show		
α	Number of Bets	Total Net Profit ($)	Net Rate of Return (%)	Number of Bets	Total Net Profit ($)	Net Rate of Return (%)
1.04	225	5.10	2.3	612	33.20	5.4
1.08	126	− 10.10	−8.0	386	53.50	13.9
1.12	69	11.10	16.1	223	40.80	18.3
1.16	40	5.10	12.8	143	26.30	18.4
1.20	18	5.30	29.4	95	21.70	22.8
1.25	11	−2.70	−24.5	44	11.20	25.5
1.30	3	−3	− 100.0	27	10.80	40.0
1.50	0	0	—	3	6	200.0

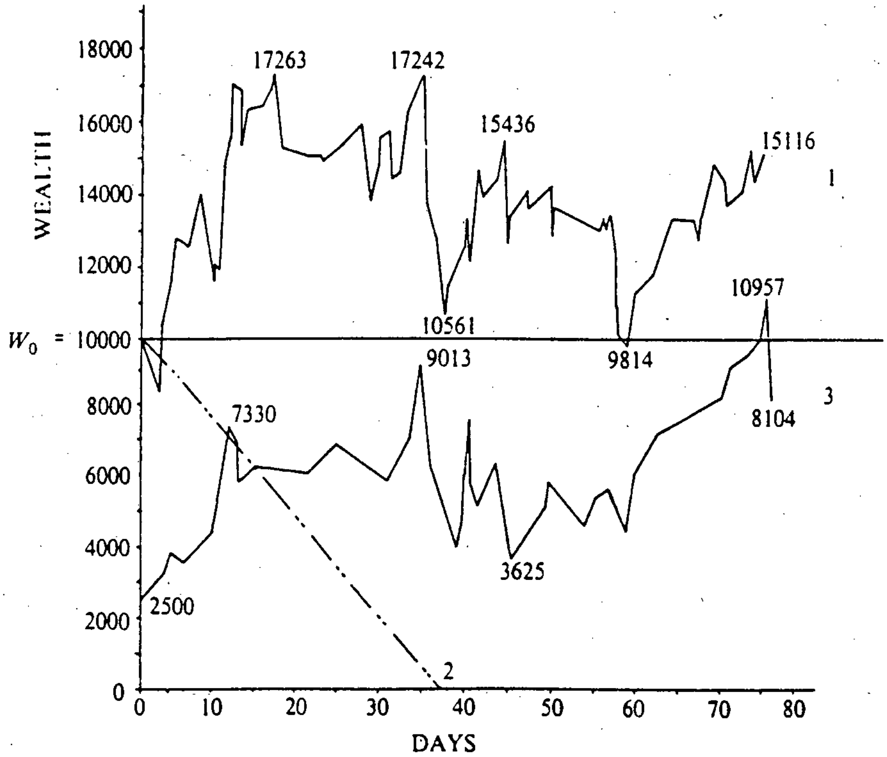
Santa Anita

	Place			Show		
α	Number of Bets	Total Net Profit ($)	Net Rate of Return (%)	Number of Bets	Total Net Profit ($)	Net Rate of Return (%)
1.04	103	12.30	11.9	307	− 18.00	− 5.9
1.08	52	12.80	24.6	162	6.90	4.3
1.12	22	9.20	41.8	89	3.00	3.4
1.16	7	2.30	32.9	46	12.40	27.0
1.20	3	− 1.30	−43.3	27	6.20	23.0
1.25	0	0	—	9	6.00	66.7
1.30	0	0	—	5	5.10	102.0
1.50	0	0	—	0	0	—

Table 2.14 reproduced from Hausch (1981)

et al. (1981), is maximized subject to wealth constraints, and the optimal amounts to bet on each horse are thereby calculated. Results of the betting system using an initial wealth level of $10 000, and an expected return cut-off of 1.16 are shown in Table 2.15.

The above system could not be used in practice because of the large number of inputs required in a very short space of time before the off of a particular race. The practical system involves identifying the horse most likely to have the highest expected return by inspection of the tote board, and then using a regression equation to calculate the expected return. If this is sufficiently high a further regression equation is used to



[1]Results from expected log betting to place and show when expected returns are 1.16 or better with initial wealth $10.000.

[2]Approximate wealth level history for random horse betting. Total dollars bet is as in system 1 ($116.074). Track payback is 82.5%. therefore final wealth level is $10.000 − 0.175($116.074) = −$10.313 (Note: breakage is not taken into consideration)

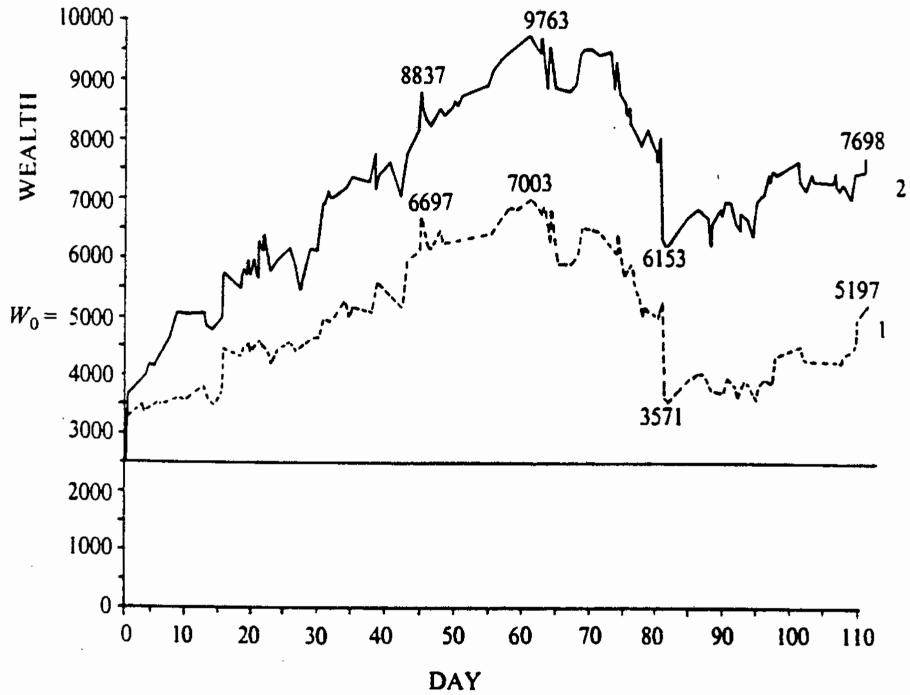
[3]Results from using the Exhibition Park approximate regression scheme (with initial wealth $2.500) at Santa Anita.

Wealth Level Histories for Alternative Betting Schemes: Santa Anita: 1973/74 Season.

Table 2.15 reproduced from Hausch (1981)

calculate the optimal amount to be bet on the horse. The regression equations obviously give approximations to the expected returns and optimal bet amounts that would have been produced via the above formulae.

The results of the betting system using the regression equations are shown in Table 2.16. A further problem with implementation was that one was not able to bet at the final odds, but rather the odds prevailing with approximately two minutes to the off time. Thus all calculations would practically have to use information at this time. The authors ran a further test using only such information and the results are reproduced in Table 2.17. It thus appears that profitable exploitation of the inconsistencies inherent in the place and show betting markets is possible, and the conclusion is therefore that the



[1]Results from expected log betting to place and show when expected returns are 1.20 or better with initial wealth \$2,500.

[2]Results from using the approximate regression scheme with initial wealth \$2,500.

Wealth Level Histories for Exact and Approximate Regression Betting Schemes: Exhibition Park: 1978 Season.

Table 2.16 reproduced from Hausch et al. (1981)

market is inconsistent as well as weakly inefficient.

Hausch and Ziemba (1985) extended their 1981 paper by deriving approximate regression schemes for the following possible variations from his original equation. Firstly the size of the pools that the bettor was faced with was considered. Three different place and show pools were used. These were \$2 000, \$10 000 and \$150 000 for place, and \$1 200, \$6 000 and \$100 000 for show. Formulae for each of these pool sizes were derived for each of four initial wealth levels, namely \$50, \$500, \$2 500 and \$10 000. Nineteen new optimal-bet regression equations were derived, and it was suggested that for intermediate values for pool size or wealth, that interpolation be used.

All the derived regression equations are now adjusted for differing track takes, breakage, *Results from Summer* 1980 *Exhibition Park Betting*

Date	Race	Regression estimate of expected return per dollar, 2 minutes before end of betting	Regression estimate of expected return per dollar, at the end of betting	Regression estimate of optimal bet 2 minutes before end of betting	Finish	Net return based on final data with consideration of our bets affecting odds	Final wealth
							$2500
July 2	9	120	122	$19,SHOW ON 4	5-6-7	− $19	2481
"	10	120	123	72,SHOW ON 8	8-1-2	72	2553
July 9	7	121	110	292,SHOW ON 1	2-7-1	131	2684
"	10	135	122	248,PLACE ON 1	1-6-2	260	2944
July 16	6	131	122	487,PLACE ON 9	9-8-6	536 } 682	3626
		139	117	292,SHOW ON 9		146	
"	7	125	127	7,SHOW ON 1	5-2-8	− 7	3619
July 23	3	149	149	30,SHOW ON 2	2-10-7	92	3711
"	4	139	134	573,SHOW ON 10	6-10-4	201	3912
July 30	8	121	111	215,PLACE ON 4	4-1-5	129	4041
"	9	123	125	591,SHOW ON 6	8-1-5	− 591	3450
Aug 6	6	128	112	39,SHOW ON 4	4-3-1	59	3509
"	9	124	103	51,SHOW ON 2	4-1-3	− 51	3458
Aug 8	1	121	132	87,SHOW ON 1	1-10-4	139	3597
"	3	127	111	635,SHOW ON 3	3-4-7	127	3724
"	4	126	113	126,SHOW ON 2	2-7-1	82	3806
Aug 11	8	121	112	94,SHOW ON 8	8-6-2	113	3919
"	9	131	130	688,SHOW ON 5	5-3-4	138	4057
Aug 13	3	128	106	33,SHOW ON 2	1-6-7	− 33	4024
"	6	131	122	205,SHOW ON 5	5-8-4	144	4168
"	7	134	133	511,SHOW ON 6	8-5-9	− 511	3657
"	10	123	109	108,SHOW ON 5	3-5-1	59	3716

Table 2.17 reproduced from Hausch (1981)

coupled horses and multiple bets on one race. The effect of changing the track take on long run profits is examined. One specific example shows that an increase in the track take from 14 per cent to 15 per cent led to a decrease in profit of 17.4 per cent, while the track take increasing from 15 per cent to 17 per cent led to a decrease in profit of 32.5 per cent. The effect of breakage is also investigated and it is found that on average bettors lose 1.79 per cent of the total payoff to 5c breakage, while they lose 3.14 per cent to 10c breakage, using the betting system. A summary of the results obtained using the betting system is given in Table 2.18.

It is noted that virtually all the bets were on favoured horses that were underbet to place or show.

Exotic Betting

Ali (1979), examined bettor consistency at the racetrack by comparing the returns to two identical bets, i.e. the same events had to occur in order to win both bets. He compared returns from winning double bets with a corresponding return derived by placing a bet on the winner of the first leg of the double, and then placing the return from this win bet on the winner of the second leg of the double. It is noted that the win pools for each race are separately determined from the pool for the daily double, which thus comprises a separate bet altogether. Actual returns should only differ to the extent that the transactions costs involved in placing two win bets are greater than those involved in placing one double bet. Any greater discrepancy would indicate an inconsistent use of information.

The test of consistency is made by examining the differences

$(1-\alpha)D_t - P_t$ for $t = 1$ to n

and testing whether they differ significantly from zero, where

α = % transactions costs per bet (win and double)

D_t = return to double t

P_t = return to parlay t

and n = number of doubles examined.

The observed double payoff is thus decreased by the percentage additional transactions costs involved in betting the parlay. If the differences are not significantly different from zero, the implication is that identical probabilities are being attached to the winning horses in both pools, and therefore that bettors are consistent in their use of information. The data for the test consisted of 1 089 double observations made in the U.S.A. and Canada during 1975. The mean difference (as calculated above) is found to be not significantly different from zero and the inference drawn is that the market is consistent in its use of information.

Table 2.18 reproduced from Hausch (1981)

Summary Statistics on System Bets Made at Aqueduct in 1981/82, Santa Anita in 1973/74, Exhibition Park in 1978 and 1980, and at the Kentucky Derby Days 1981/82/83 with an Initial Betting Wealth of $2500

Track and Season	Number of Days	Number of Races	Track Take	Expected Value Cutoff	Number of System Bets	Number of Bets Won	Percent of Bets Won	Percent of Bets Won Weighted by Size of Bet	Total Money Wagered	Track Take	Total Profits	Average Payout Per $2 Bet	Rate of Return on Bets Made
Aqueduct 1981/82	43	380	15%	1.14	124	68	55%	65%	$42,686	$6,403	$3,792	$3.33	8.9%
Santa Anita 1973/74	75	627	15%	1.14	192	114	59%	69%	$51,631	$7,745	$2,837	$3.16	5.5%
Exhibition Park 1978	110	1,065	18.1%	1.20	174	97	56%	72%	$49,991	$9,048	$5,198	$3.08	10.4%
Exhibition Park 1980	10	90	17.1%	1.20	22	16	73%	77%	$ 5,403	$ 924	$1,216	$3.18	22.5%
Derby Days* 1981/82/83	3	30	15%	1.10	19	17	89%	96%	$12,766	$1,915	$5,462	$2.97	42.8%
Totals and Weighted Averages	241	2,192	—	—	531	312	59%	71%	$162,477	$26,035	$18,505	$3.12	11.4%

Asch et al. (1986) test for consistency in the double and exacta pools. When the tests reveal inconsistencies, they make a case for the existence of inside information that led to such inconsistencies. The data used for the exacta study comprised 510 races run in 1984 in the U.S.A. Exacta payoffs were categorised by size into 11 categories and rates of return were calculated for each category. It is noted that the returns exhibited no systematic tendency. Two of the 11 categories yielded profits of 5 and 10 per cent. The results are reproduced in table 2.19.

In order to test consistency, Asch examines the subjective probabilities implicit in two separately determined pools, viz. the win pool and the exacta pool. The subjective probability of the exact finish (i first, j second) determined from the exacta pool is $S_{ij} = B_{ij}/B$

where B_{ij} = the amount bet on the (ij) exacta

B = the gross exacta pool.

Rates of Return on Exacta Bets: Constant Class Inverals

Payoff range	No. of pairs in sample	No. of winners in category	Rate of return
0–16·00	1896	162	−0·11
16·01–32·00	3653	110	−0·30
32·01–48·00	3139	68	−0·13
48·01–64·00	2676	38	−0·26
64·01–80·00	2317	34	0·05
80·01–96·00	1866	18	−0·13
96·01–112·00	1757	17	−0·04
112·01–128·00	1469	11	−0·24
128·01–144·00	1347	5	−0·54
144·01–160·00	1188	8	0·10
160·01–∞	19938	39	−0·46

Table 2.19 reproduced from Asch et al. (1986)

The subjective probability of winning the (ij) exacta determined from the win pool probabilities, is denoted S_{ij}^{*} and is calculated as follows. Horses are allocated to one of 20 probability categories on the basis of their subjective winning probabilities (i.e. their odds). Observed winning probabilities are determined for each category. An average relationship between objective and subjective probabilities is derived by regressing the one on the other. The objective probabilities of winning the (ij) exactas are calculated using the above calculated observed winning probabilities and the Harville formula for exact finish probabilities. From these objective probabilities of winning the (ij) exacta, the required subjective probabilities S_{ij}^{*} are derived. Comment on this method of obtaining the probabilities required for the test can be found in section 2.3.4.

A regression of S_{ij}^{*} on S_{ij} is performed in order to determine the relationship between the two. The analysis rejects the hypothesis that $S_{ij}^{*} = S_{ij} + e_{ij}$. This means that the probabilities associated with horses in a particular race are inconsistently determined.

Given that inconsistent betting is occurring in the exacta pool, Asch now tries to find out why. He compares the actual exacta payoffs with those that are expected on the basis of the odds from the win pool. The comparison is made for 41 246 exacta pairs which includes winning and losing exactas. The hypothesis is made that if people possess inside information they would rather use it in the exacta pool than the win pool so as not to signal their information to the public. This is tested by examining the difference between the actual and expected returns to winning and losing exactas. It is found that the differences between actual and expected payoffs is significantly different for winning and losing exactas in the direction that implies the existence of inside information; i.e. it is found that the actual payoffs for winning exactas are depressed compared with the expected payoffs but this is not true for losing exactas.

Asch also examines daily double betting for consistency. The data consisted of 122 double pairs. It is found that the average payoff to the double is greater than that to the corresponding parlay. This, however, does not mean that the probabilities are inconsistently determined. The difference is in fact completely accounted for by the differing transactions costs involved in the bets. When an adjustment is made for the higher transactions costs involved in betting the parlay, the payoffs (and therefore the implicit probabilities) are equivalent. The results observed here are similar to those of Ali's study.

Cross Track Betting

Hausch and Ziemba (1990) presented the first examination of cross-track betting. This involves betting on races other than at the local track. Since the pools at the different tracks are kept separate, the opportunity is available to study the differences and similarities between two different betting populations. In the past, the study of bettor consistency has been confined to one betting group, or intra group consistency. This paper examines inter group consistency.

Cross-track betting in the U.S.A. is generally available only on the major races of the year. Examples are given of the disparity of the payoffs to identical bets at different racetracks. Specifically, it is shown that in order to be guaranteed a return of $1, it is only necessary to wager approximately 93c, provided that all bets can be placed at the track (one of several) that offers the best odds for each specific horse.

The paper, in a similar vain to the authors' other papers, attempts to estimate the probability of an event, and to compare this estimate with the public's estimate. If the two differ sufficiently then profits can be made. In their past papers the "event" has been the placing of certain horses. In this paper the event is the victory of certain horses, and the estimates of the probabilities of such events are derived from the away racetracks, and compared with the local public's estimates of the probabilities of the same events. The optimal growth model that was used in their previous papers is used here again.

The "true" probability of a horse winning is taken as the probability as defined subjectively by bettors at the track where the horse is actually running. Optimal bets are calculated by the system when the expected return from a bet is greater than a cut-off level. An important point is made in that the "true" odds as observed at the home track are adjusted for the favourite-longshot bias before using the probabilities as input to the betting model. The model was tested on 11 races. The return was 15 per cent profit on the amount wagered. With so few races though, this is clearly not statistically significant. Two reasons put forward for discrepancies in the odds at different tracks are, firstly that bettors generally bet on local horses where-ever the race may be taking place, and secondly that bettors at different tracks have differing access to information regarding horses that are running at any given track.

The practical problems involved in implementing a system to take advantage of such bettor inconsistencies are insurmountable. This is because all the data is needed before the off of the race in order to place the bets optimally. Unfortunately the data is not available until the race is over. Add to this that it is unlikely that we would be the last to wager (which is a further requirement of the system) and it is clear that approximate schemes will have to be derived. Since the costs involved with betting at many tracks are extensive the approximate scheme should ideally involve only one track.

The one track model involves viewing the odds at one away track on the on course television monitor and comparing these with the odds available at the home track. The expected returns can be quickly calculated (probably by inspection) and one optimal bet can be isolated. The optimal growth model, now with very few inputs will generate the amount to bet. This is done in the same manner as the approximate schemes in the authors' two other papers. The profit from such a method was 9.2 per cent, although this was from only 11 races. The conclusion was that further work is necessary in order to demonstrate significant profits.

2.3 COMMENTS, FURTHER IDEAS AND PROPOSALS

2.3.1 Tests of Weak Efficiency

Transformed "Sum To One" Probabilities

Dowie's 1976 paper appears to represent an attempt at applying theories to an area in which the author has little practical experience. Dowie's lack of insight into the racing world is evident from his assumption that the predicted odds as published in the newspapers 24 hours before the race, can be taken as accurate estimates of the probabilities of winning the race for each horse. The problems of using FP's (forecast prices) is discussed in detail later.

Except for the elementary investigations into weak efficiency the paper is of little practical interest and further research based upon it is unnecessary. The paper does however make two good points relevant to the data. Firstly the odds data are transformed into probabilities so that the total probability of winning for all horses sums to one. This would obviously not be the case with the bookmakers odds.

As an example, consider the odds from two races run at Milnerton in 1990.

Race One		Race Two	
No.	Odds	No.	Odds
1	17/10	1	17/10
2	6/1	2	7/2
3	10/1	3	7/2
4	12/1	4	5/1
5	20/1	5	10/1
6	20/1	6	10/1
7	20/1	7	16/1
8	20/1		
9	20/1		
10	20/1		
11	20/1		
12	20/1		
13	20/1		

In both of the above races the favourite is at odds of 17/10 but this does not tell us anything about the other horses in the race It is a connection between each horse and all the other horses in a particular race that is established with the use of Dowie's transformation. In race one the total probability sums to 1.11 while that in race two sums to 1.22. Thus although both favourites would be allocated to the same odds category, this may not be the most accurate method of allocation. From the total probability of both races it seems that the favourite in race one is up against less than the favourite in race two, and therefore logically MORE likely to win than its equally priced counterpart in race 2.

This assumes that the estimation of the odds of all horses is fairly accurate. This is not usually true for the rank outsiders. If, however, we remove the rank outsiders from the analysis, the sum of the probabilities of the remaining horses in race one is only 0.68 while it is 0.98 for race two. This is a clear example of why it is necessary to group horses by their probabilities of winning, calculated with reference to the rest of the field. It is surprising that the academic literature that has followed this pioneering 1976 paper has largely ignored this useful transformation of the raw data. In this thesis we shall use the raw data as well as the transformed data for similar tests of weak efficiency.

Dowie uses every odds group that had a runner at those odds in his analysis, i.e. he uses no grouping of odds categories. A problem with this is the statistical validity of tests if the number of observations in some of the categories is small. The advantage of using this approach is that a very high degree of homogeneity is achieved. The number of odds groups to use should be determined so as to achieve accuracy and reliability in estimates of the probabilities derived from such groups. This will usually be done after considering the form and volume of data available and possibly the purpose for which the estimates will be used. In order to test efficiency in specific areas of the market, a large number of odds groups will be required. This research will use groupings as appropriate to the data. The groupings will be motivated at that time.

Dowie had the opportunity to use tote or bookmaker data. He uses bookmaker data, and it is his discussion of the various merits and demerits of both data sources that makes the paper more valuable. The points mentioned have been noted and will be pointed out where relevant in the various tests when the data is defined and discussed. Further comment on this paper can be found in section 2.3.3.

Grouping of Odds Categories

Snyder's paper in 1978 similarly shows little knowledge of the horseracing field. His lack of insight is apparent when testing for what he calls strong efficiency. This is discussed in the next section. Tests of weak efficiency similar to those of Dowie are performed. The number of odds groups tested was 10, and the odds categories were grouped for convenience. This again brings up the problem of how to group the odds categories. It may be that using only 10 groups is too few, resulting in too low a degree of homogeneity within the groups.

Consider the following idea of "barrier odds". Punters may decide that they will back a horse if they can obtain a certain price. For example they may decide to back a horse if they can get 2/1 or 1/1 or maybe 15/10, but it is unlikely that they would have as a barrier to betting the "odd" price of, say, 17/10. It makes sense therefore to group horses together that fall between certain "barrier odds". Thus 16/10 and upwards to 2/1 would be grouped together. The main point of this idea is to group together odds categories which are perceived by the punters as having very close empirical winning probabilities, i.e. a punter would give the same real world probability of winning to a 16/10 shot as he would a 2/1 shot. When using this idea it is still important not to have too wide a range within groups thereby reducing the homogeneity within the groups.

Asch's 1982 paper also examined weak efficiency in a way which used an inadequate method of grouping the odds categories. Horses are assigned to a category defined by their level of favouritism for the race. For example, the favourite is assigned to category one, the 2nd favourite to category two and so on for 9 categories. The observed probability of winning is compared with the subjective probability for each category, calculated from the odds of the horses in the category.

The above method of grouping horses with different odds allows for too much variation of the odds within one group. For example, the favourite in one race may be 4/10 with the 2nd favourite at 6/1, while in another race the favourite may be 3/1 with the 2nd choice at 33/10. The 4/10 shot and the 3/1 chance will fall into the same group. Homogeneity of horses with respect to their odds is clearly violated in this group. If we accept that the actual odds are a better indicator of performance than a simple measure of favouritism, then we should have no place for this method of grouping. The research in this work will not examine the performance of horses based on their level of favouritism except to give an indication for reference purposes of the percentage of favourites (1st favourites) that win and place, and returns to such favourites.

Logit Analysis

Asch's 1984 paper is the nadir of the research that we have uncovered to date. Not only is the paper poorly worded and badly structured in terms of its arguments, but it also lacks a logical basis and it utilizes inappropriate statistical techniques. Consider, "In particular, we reject the null hypothesis that the morning line odds contain no information not already accounted for by the track odds." The triple negative used in this sentence only serves to further confuse the reader as regards the thin logic that is proposed in the paper. Further, crucial terms appear to mean one thing in one reference and something different elsewhere. Few of the terms are defined.

The essence of the paper, is that Asch is trying to model the empirical probability of winning using only odds data as independent variables. Thus the only variables used are the same as those used in testing weak efficiency. Given the overwhelming evidence from past studies, that profits cannot be made simply by utilizing odds information, it is our suggestion that the relatively sophisticated techniques of logit analysis are misplaced here. Clearly, no further research along these lines will be done in this work.

It seems possible that the reason for using logit analysis may have been that it is the "correct" method for performing "regression" analysis on percentages or odds data. Thus the researchers may simply have been "trying it out". The problem was that they were doing so in a very well researched area where the analysis had nothing new to add. Logit analysis would be better used in cases where data on many variables is available and the aim of the exercise is to predict empirical odds. Thus although using odds data alone may have seemed a logical place to start with logit analysis, we believe it to have been inappropriate.

Canfield et al. (1987) is the only paper that we have seen that tests for weak efficiency using data other than the odds of the horses. As we proposed in the introduction, weak efficiency tests should be formed by using elementary data points. The data that Canfield uses is the draw of the horses which is clearly elementary and therefore a logical test of weak efficiency. Similar tests to those performed in Canfield's paper will be done in this research. This will include "blocking" to remove the effects of factors such as the track, (Milnerton vs. Kenilworth) and the weather (wet vs. dry). Tests using other elementary data points such as jockey, trainer etc. will also be performed.

Tuckwell's approach (originally 1981, but reproduced in 1983) to estimating future rates of return at various odds levels seems inappropriate. He uses regression analysis to derive estimated returns at each odds level. He derives a trinomial function whereby the expected return at any odds level can be calculated. Firstly, let us note that we do not require rates of return to any odds level, but only those that are available on the bookmakers's board. Secondly, it is noted that the results of the regression are not in line with previous studies on the topic which utilised over 50,000 races. It is clearly more reasonable to use observed rates of return as estimates of future rates than to use Tuckwell's trinomial function which appears to have no logical basis.

A further problem with this paper is that no details are given regarding his betting strategies, other than to say that they yielded a 5 per cent profit. It must also be noted here that it is possible to interpret the test as a strong form test since odds data are being used in conjunction with information regarding the adjustment of the odds.

The following further study of weak efficiency is undertaken. An examination of all races run in Cape Town between June 1990 and December 1991 which incorporated approximately 1100 races. An analysis is made of empirical and subjective probabilities as well as checking to see if meaningful profits can be made at any odds level. The data is split up to analyse different classes of race separately as well as split in order to analyse external factors such as the weather and the "number of race on the card" factor. Together with this investigation is an analysis of bettor bias since it is only the through the biases of the public that make it possible for individuals to make above normal profits.

2.3.2 Tests of Semi-Strong Efficiency

Problems With Forecast Prices

Snyder's test of strong efficiency, in the framework of this work, is actually a test of semi-strong efficiency. Using newspaper tipsters (or any group which publish forecasts about races), as the basis of a strong form test has the following problems. Firstly if it is assumed that they do not have access to inside information (which is probably closer to the truth than any other argument), then their predictions cannot be used as a test of inside information. Secondly and more importantly, if it is assumed that they do have access to inside information, are they likely to publish this information in the newspaper?

Snyder's examination of tipster performance is riddled with problems. Firstly, the rates of return were calculated using the experts predicted odds as if they were the actual payouts. This is clearly going to distort the rates of return. Secondly, Snyder notes that the experts do not necessarily try to estimate winning probabilities, but rather the odds that the public are likely to set through their betting. This in itself is a violation of the so called strong efficiency test as the experts are not using their information anyway, but rather,are using their knowledge of the public's betting habits. It also however plays havoc with any semi-strong test that we might think of applying since we are trying to test whether profits can be made by using "expert" information and now we are told that the experts are not using their information but rather estimates of what they believe will happen at the track!

Thirdly, it is noted that expert predictions must be made some time before the race and they may change their views by the off time of the race. This point probably only introduces minor inaccuracies into the rates of return. Fourthly, it is noted that experts have to publish odds for all races. The problem here is that they would not normally have an actual bet on every race on which they may have an opinion.

Finally, and it is this point that makes all tests which use FP's virtually worthless, is that in setting odds, the experts are, consciously or sub-consciously, assigning ranks to the horses rather than probabilities. It is surprising that this extremely important point has only been made in one of about 10 relevant papers, and only as a footnote at that. Asch et al. (1982) noted "...this results because the professional handicappers are really providing a set of rankings rather than a set of odds consistent with potential payoffs...".

This problem consistently leads experts to overestimate the odds on favourites while underestimating the odds on outsiders. The reason for this is probably conservatism when it comes to rating favourites and a "couldn't care" attitude towards assessing outsiders. Typically a horse that will start at 5/10 is quoted in the paper at 8/10. Snyder relates that one of the newspaper experts explained to him that "we don't want to point the finger too clearly at a horse's winning chances." It is also typical for the horses lower down in the betting (high odds) to be grouped in a category called "others" at 10/1 or 20/1 (say). It should be clear that the expert does not regard these horses as being serious contenders and has probably not devoted much time to analysing their real chances. It should also be obvious that in a race with 20 horses, it is highly unlikely that the 8 horses (say) at the bottom of the betting board have in reality identical probabilities of winning. Given the above arguments, Snyder's conclusion, that the experts are more biased in determining odds than the public, was to be expected.

Losey deserves similar comment regarding his analysis of FP's as Dowie received. He too assumes that the FP's can be taken as reflecting the true winning probability for each horse. We suggest this is owing to a lack of insight into the racing world on his part. He also does not offer any explanation as to why the results he obtained were contrary to his hypothesis. What of the significant negative returns where positive returns were being sought? One explanation is that horses that drift in the betting from FP (assuming this is close to the opening call) to SP is that they are doing so on overriding and usually inside information. For example, a horse does not eat his food the night before a race and is therefore not backed by the stable or its connections for this reason alone. This piece of information has overridden any other factors which may have been in the horses favour. Such horses invariably do not perform at their best but are allowed to start at a high price which would qualify them for a bet under the above test. Further analysis along the lines of Losey's test may reveal other reasons for the apparent anomaly. Such tests are performed during the research.

Tuckwell (1983) found that following the tips given by Computercard yielded a positive return of 6.5 per cent. The only conclusion that we can draw from this is that Computercard are genuinely superior to the market at finding winners at the necessary odds. This is because of the manner in which the test was set up. Horses were only backed if they had an SP greater than that estimated by Computercard. In general this would mean that the horse must have drifted from lower odds. Other studies have shown that such horses perform relatively poorly compared to their odds, yet profits were still made by backing these horses. This would imply that Computercard are consistently selecting those horses that drift but still manage to do better than their odds would imply. A major problem here is that, as in the case of weak efficiency, no details regarding the procedure are given.

Bird's test of semi-strong efficiency was followed by the conclusion that the publicly produced odds incorporated all the information supplied by the tipsters. It was also implied that the odds as determined by the public were largely dependent on the tipster selections. We do not believe that this is interpretation is sound. It is probable that bettors come to their conclusions regarding the outcome of races independently of the experts. The test would then only show that the experts are as bad at selecting winners as the public are. This has already been established.

The only way to test whether subjective information was being incorporated into the public's odds, would be to suggest bets that the average punter would not make unless he had read such tipster's suggestions. This would entail consistently suggesting bets on fundamental outsiders and seeing if this led to substantial public betting on such horses. If the public consistently ignored such advice , we could possibly conclude that the tipsters information is not important in determining the public's odds. The point to note here is that it is unlikely that the public are influenced by the tipsters to any large degree, in that they would back certain horses at certain odds whether they suggested by the tipsters or not. The test is relevant although the interpretation of it is incorrect. The connection between the publicly produced odds and the experts information is a lot more subtle than the conclusion "These findings suggest that the information supplied by the experts is incorporated into the bookmaker odds." seems to imply.

Figlewski, using logit analysis comes to the same conclusion as Bird, and also implies that the publicly determined odds are dependent largely on the tipster's choices. It is our hypothesis that the information in the tipster's suggestions is accounted for in the track odds, but the reason for this is that both the public and "experts" are using the same pool of factual information. We therefore agree with the results of the test, which are that the market is semi-strongly efficient, meaning that profits cannot be made simply by using tipster information and odds information. We do however believe that the interpretation of the results, which states that the public determines the odds based solely on tips available in the newspapers, is incorrect.

We have suggested a possible method for testing the incorporation of subjective information into the publicly determined odds. This was evidently quite impractical. We now suggest another impractical test although it would certainly test for such incorporation correctly. We would need to examine odds determined by two independent groups of bettors, one using only factual information and the other using both factual information and subjective information. If these groups determined the odds identically (highly unlikely) we could conclude either that the tipsters determine their selections in an identical manner to the public or that the tipsters information is not used by the public. If the odds differed for the two groups then we could conclude that the public does incorporate the tipsters information into their choices. The degree of importance attached to such tipster information could be gauged by examining the deviation between the two separately determined odds.

It is obvious that severe practical difficulties make it impossible for such a test to work in practice. Firstly, we would need two large groups of bettors with highly similar characteristics with regard to determining odds so that any detected differences would not be owing to the groups chosen. Secondly, it is unlikely that the test could be carried out in a closed off room and therefore it is possible that inside information might reach the groups. It is obviously also possible that the group only allowed to observe factual information may well note some subjective information. Tests of semi-strong efficiency are pretty simple to perform and interpret. Analysis of the determination of odds is difficult to perform and given that any results from tests are likely to be misleading anyway, this work will not consider this type of analysis.

Bookmaker Versus Tote Odds

Gabriel (1990) used data from a period when electronic tote boards were not available. This supposedly suited his hypothesis. Since such data is unavailable, identical tests will not be performed. The hypothesis assumed that a difference between tote and bookmaker returns would imply a semi-strongly inefficient market. The possibility does exist, however,that tote returns are higher than bookmaker returns for all horses simply because of the manner in which the bookmaker sets his odds. Thus a similar test might show that tote returns for losing horses are also higher than bookmaker returns and this would simply mean that the profit margin of the tote is smaller than that of the bookmakers.

If bookmakers generally offer shorter odds than the tote, why would anyone bet with them? The reason is that the bigger punters know that they will receive a fixed return after betting with a bookmaker, while the tote odds are not fixed until the off of the race. The fact that tote returns are consistently higher than bookmaker SP's should not be interpreted as an implication of semi-strong inefficiency. The reason is that this information alone cannot lead to a profitable betting strategy. The tests in this paper are inappropriate to the topic of market efficiency. Similar tests, comparing bookmaker and tote returns, are performed in section 3.4 with regard to bettor consistency, but no inferences are drawn regarding the efficient markets hypothesis.

Analysis of semi-strong efficiency should simply concentrate on the selections of professional tipsters, the official race card and form guides. Six newspaper tipsters will be examined, three of the Cape Times and three of the Argus. The official race card (program) is published by the race clubs and includes, for the information of patrons, the selections of an "independent pundit". These selections will be similarly examined. The form guides also provide a tipping guide supposedly using some method to consistently arrive at their selections. These are the Computaform, Winning Form and Raceform. Their performances are examined.

2.3.3 Tests of Strong Efficiency

Inequity in the Gambling Market

Examination of the possibility of the existence of inside information in a market is what is meant by testing the market for strong efficiency. In recent years the market for shares has been rocked by scandals involving insider trading despite strict legislation prohibiting such behaviour. There is currently no legislation prohibiting trading on inside information at the racetrack. We believe therefore, that the tests of strong efficiency made in this work have implications for legislation at governmental level as well as for further investigation into probable "illegalities" and immoralities that occur at South African racetracks.

It is necessary to note that any test of strong efficiency is in fact only a close approximation to the only real test of strong efficiency. This was defined by Vannebo (1980). He suggested that the alleged holder of the inside information be taken to the track, his bets observed and his rate of return calculated. If this was in excess of the average rate for bettors on a consistent basis we could conclude that the market were strongly inefficient. Approximate tests have been performed by Dowie, Crafts, Bird and Asch.

These tests which will be described shortly all tend to underestimate the returns to inside traders and therefore if any of them are significant, they are actually more significant than they appear. This removes the problem of only being able to test approximately for strong efficiency. A discussion of why it is important to have a strongly efficient betting market (in particular), is not out of place here. If the market were found to be weakly or semi-strongly inefficient, this would only have implications of an inconsistent (as previously defined), but UNPREJUDICED pool of bettors. This means that such bettors DO have the opportunity to alter their betting patterns by using freely available information, in order to make the market efficient. If the market is found to be strongly inefficient, this would imply that bettors are being prejudiced against by a small group of people who should have no more right to cheat at the track than they have at the stock exchange. This means that the vast majority of bettors are NOT in a position to bring about market efficiency although they would undoubtedly prefer to be in a position to do so.

Why is the above so important and what would be the implications of an efficient horserace betting market in South Africa? Conversely, what would be the implications for a strongly inefficient market in South Africa? In an introduction to South African racing at the start of the Form Stallion Register Vol.3, Faull (1986) examines these questions. Using an exceptionally accurate and insightful approach, he describes the current situation in South Africa as well as giving suggestions for the future.

The main points of the above reference are recounted here. The most essential point to note is that the mainstay of the racing industry, which includes both racing and gambling aspects, is the punter. Without the betting public, people such as trainers, jockeys, breeders and thousands of others who derive their livelihood from the industry, would be looking for other work. This is shown diagrammatically in Diagram 2.1, which is reproduced from the Form Stallion Register.

The importance of the punter should be obvious to anyone. A second important point to come out of Faull's discussion is that in order for the tote to observe extra turnover it is necessary either (1) for existing punters to bet more or (2) for new punters to be drawn into betting. The only way in which either of these two requirements for greater turnover can occur is through effective marketing of horseracing. It should be clear that greater turnover would naturally be better in the LONG RUN for everybody concerned with racing. Consider diagram 2.2 which is also reproduced from the Form Stallion Register Volume 3. The important connections to note are those between public goodwill, tote turnover and stake money.

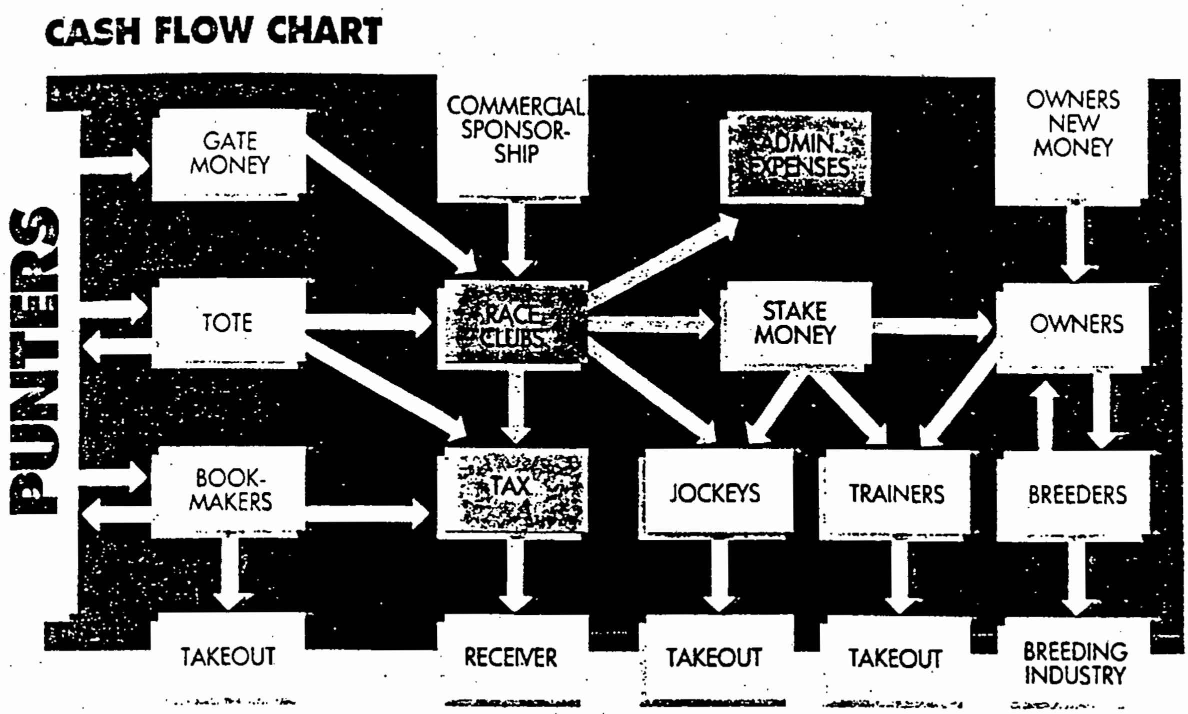


Diagram 2.1 reproduced from The Form Stallion Register Volume 3

The problem exists in South Africa that a small minority with substantial power are letting racing stagnate possibly for the SHORT RUN benefit of the few. (There can be little argument regarding this when one looks at statistics regarding racecourse attendances). By this we mean that not much is seen to be done regarding apparent irregularities in betting markets. This in turn reflects a strong negative image of racing to the general public and of course to the racing public themselves.

The betting market is the obvious place to look for reasons regarding the extremely poor public image of racing. Two "hypothetical" examples are reproduced from the Form Stallion Register Volume 3, in diagram 2.3.

Given that it is possible that such situations may arise in practice, (and go by with hardly even any press comment), is it any wonder that in recent years many people have left

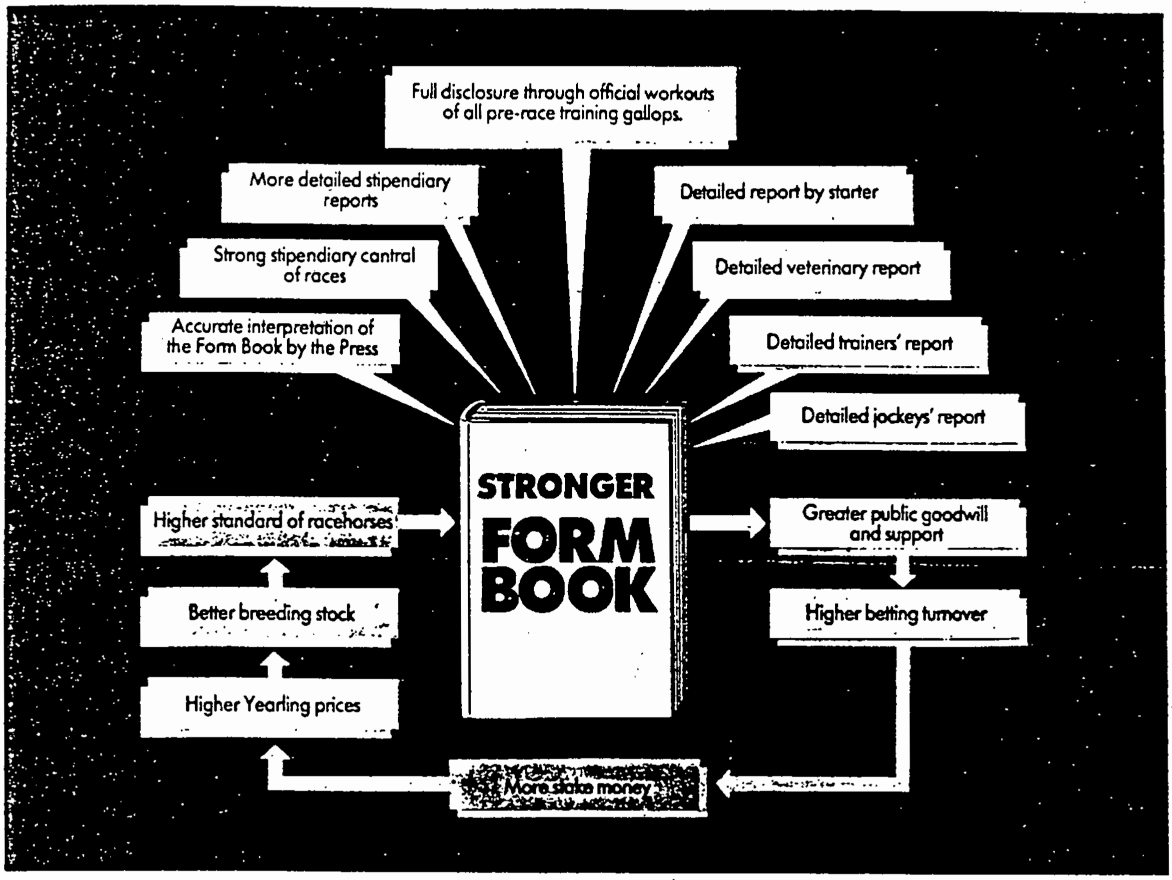


Diagram 2.2 reproduced from The Form Stallion Register Volume 3

racing while relatively few have been attracted to the sport. In the U.S. and Australia the existence of inside information is acknowledged and has been dealt with in a practical (if not perfect) manner. Horses that have not run recently are subjected to public training workouts. Australia even has a system whereby horses competing for the first time run in races on which no legal betting may be held. We believe that because of the relatively backward state of the information market in this country, it may be necessary to introduce such trials, if not legislation regarding the use of inside information akin to that regulating the stock market.

Hypothetical Betting Move A

Mr X, a leading breeder who also enjoys the pleasures of racehorse ownership and betting, decides to retain a certain yearling filly whose pedigree and conformation suggest that she might be a talented runner and consequently a valuable breeding prospect.

Having decided to trade the profits of successful breeding for the pleasures of ownership he commissions leading trainer Mr Y to condition the filly for her racetrack career. Much to their delight the filly shows exceptionally brilliant ability in her training and trial workouts. Mr X instructs Mr Y to set her up for a betting coup on her debut and to ensure that the price is right. Mr Y, well versed in the art of hiding an unexposed crackerjack, waits patiently for the right field.

First time out he takes on a large field of fillies, half of which haven't raced before, the other half of which includes five fillies that were narrowly beaten on their debuts. When the betting opens for the race on-course, only eight people know the full strength of this filly – the trainer, his two stable jockeys, two grooms who ride the stable's work, the owner, and the owner's brother and son who have accompanied him to the racetrack to assist with the execution of the betting coup.

An unsuspecting group of on-course fans, guided solely by the bare record of some inconclusive form, lay their bets in the hope that three of the five fillies with placed form will contest the finish. As the field starts to enter the pens Messrs X and Y and their assistants move in to lay their bets with the bookmakers and tote.

A few minutes later their filly has crushed her rivals to land a substantial coup for her connections, leaving a large band of helpless and disappointed customers, and of course a whole entertainment industry, poorer and betrayed for the experience.

Hypothetical Betting Move B

Racehorse owner, Mr A, imports from England a three-year-old filly named Hevon Caires and puts her into training with Mr B. From five starts as a two-year-old her form, four places in maiden races and a respectable fifth in a minor stakes, had been fairly promising but nothing to suggest that she would be out of the ordinary.

Given the warmer South African climate Hevon Caires improves in leaps and bounds and after nine months is working like a real champion. Mr B enters her for her first race, which due to restrictions on imported horses, has to be a B Division event. In order to ensure a good price in the betting the maiden filly is pitted against a strong field of in-form runners. The race chosen is also one of the jackpot legs. Judged on her English form Hevon Caires can be given very little chance of winning, so is ignored by the Press and the vast majority of jackpot punters.

Backed from 14/1 to outright favourite Hevon Caires romps home by 5 lengths. Messrs A and B, their jockey and a handful of chosen friends have a field day scooping over half the jackpot pool at the expense of a large number of disregarded punters. Is this not a surefire way to alienate the customers in the marketplace?

Diagram 2.3 reproduced from The Form Stallion Register Volume 3

The foregoing paragraphs have been necessary to set the scene so that the implications of the tests of strong efficiency can be more fully understood. To answer the questions posed earlier, it would seem that the main implication of an efficient market in racetrack betting is the long term prosperity and growth of the industry and all associated with it. The converse situation would seemingly imply the decline of the industry.

It thus seems that the most important of the three tests of efficiency is the test of strong efficiency. Since 1976 a few papers have examined betting markets for strong efficiency. The first of these was Dowie, whose paper has already been mentioned in connection with weak efficiency. Dowie's main problem is the faith he places in the reliability of the FP data that he uses. His test examines the correlation between the observed winning probabilities and the FP's/SP's and checks to see which set of odds data has the higher correlation with the empirical probabilities.

The above is certainly not a good approach to take since the FP's could theoretically be set by someone who has consistent access to inside information. This is highly unlikely, but we include the example to illustrate a point. Far more serious problems with the test are as follows. The odds set by the newspapers are normally within some tacit constraints. This point has already been discussed. Thus favourites are not quoted "too short" and outsiders are not quoted "too long". This will clearly have a distorting effect on the tests. Secondly, newspaper odds are set by one or two people with biases, who determine the odds not with money but with probably not more than what they would consider a thorough investigation of the data. Remember that the odds in the paper are predicted by people who are not going to lose any money if their winning probability estimates are wrong. Do their odds really reflect all public information the day before the race and exclude only privately held information? We think not! Dowie's test therefore seems shortsighted.

The topic of Dowie's paper was taken up by Crafts (1985) who suggested that Dowie's tests were not appropriate. It appears from the paper that Crafts has a much better understanding of the horseracing scene than Dowie. He suggests that any test of strong efficiency should examine "the process of adjustment of the odds in the market from those forecast in the morning (FP's) to those returned at the track (SP's)". This approximate test is reasonably close to a real test of strong efficiency, although problems still exist. The use of FP's in tests have been shown to be fraught with problems. A way around the problem in this test is to only use prices as available from bookmakers from 30 minutes before a race. If we detected that horses whose odds moved down sharply from 30 minutes before to lower SP's, won a greater number of races than expected we could possibly conclude that inside information exists. The problem here is that a decrease in the odds can occur for various reasons and not only because of the bets of people with inside information. This approach is carefully utilized and the situation in Cape Town investigated.

There are 3 possible scenarios regarding FP's and SP's. Firstly the SP can be greater than the FP for a favoured horse, e.g. FP = 1/1 and SP = 2/1. Secondly, the SP can be less than the FP for a favoured horse, e.g. FP = 2/1 and SP = 1/1. Thirdly, the SP can be greater than the FP for an outsider, e.g. FP = 10/1 and SP = 33/1. It is extremely rare to have the reverse of the last situation and it is therefore not considered. For tests of strong efficiency the most important movements are those of type 2, i.e. where a horse is backed from a high FP to a lower SP. Note that from observation the FP's should be lower for favoured horses and higher for outsiders. Thus a change as in scenario 1 is actually more marked than we observe. A change as in scenario 2 is actually less marked than we observe, and a change as in scenario 3 is generally much less marked than we observe.

Crafts did attempt to tackle the problem of the predicted FP's. Unfortunately he made what appears to be an incorrect assumption in trying to connect the two sets of odds. He first notes that no fine distinction is made between the outsiders and concludes that often the SP of such horses will exceed there FP for this reason alone. He then goes on to say that "the compilers' implied probabilities are sometimes very conservative in the sense that they sum to a considerably larger total than those implied in the SP." This however is not true of favourites as we have seen. For example, a horse that will have an SP of 5/10 is often quoted by the press as an 8/10 shot. In this case the papers are being conservative but not in the sense suggested by Crafts!

The reason for Crafts' observation then is that he is using all the horses to calculate the total probability. Consider the following example. A race has 5 runners and the betting is as follows:

	FP	SP	FP prob	SP prob
Horse A	1/1	5/10	0.500	0.667

Horse B	2/1	2/1	0.333	0.333
Horse C	10/1	50/1	0.091	0.002
Horse D	10/1	50/1	0.091	0.002
Horse E	10/1	50/1	0.091	0.002
Total Probability			1.106	1.006
Total Probability (excluding "others")			0.833	1.000

The reason that the FP probabilities sum to more than the SP's is normally because of the incorrect assessment of the outsiders. If we exclude the "others" category we usually find that in fact the SP probabilities sum to more than the FP's.

One of Crafts' conditions for using a horse in the analysis is if SP > FP then the horse is used only if the sum of the FP's is larger than the sum of the SP's by less than 0.01 per horse after excluding the outsiders. The other condition is that either the SP or the FP must be less than or equal to 10/1. These conditions will ensure that for scenarios 1 and 3 discussed above using the FP's will not be a problem. However it is neither of these scenarios that is most important for tests of strong efficiency. We will use Crafts' formulation of his conditions although our initial requirement of the first condition will be that the FP must be higher than the SP.

A similar investigation is feasible which looks at the rankings of the horses in the morning as per some odds prediction and compares these with the rankings as determined by the SP's. Clearly some information is lost using a test such as this, but it will avoid the possible error in using the seemingly "arbitrarily" determined FP's. (These prices are obviously not arbitrary but are possibly random within small bands of prices).

Crafts cites some examples of betting "coups" from which one may easily conclude that inside information did exist although it was quickly transformed into public information when the bettors holding it made their bets. These "coups" were on horses that had no fundamental reason to win, but did win after being backed at long odds and obviously starting shorter than their FP's. The logic behind the test is thus fine but as we have already noted, it is not easy to interpret the newspaper prices. Crafts also tests the reverse of the above by examining horses that drift in the betting from low FP to higher SP. This is similar to Losey's test of semi-strong efficiency. This may however also have meaning in a strong form context, because such horses would be expected to perform poorly in the long run relative to their SP's.

This paper is one of the best in academic research on horseracing and with slight adjustments all of its ideas and tests can be applied to the South African racing scene. We believe that the most important section of Crafts' paper comes at the end, when he discusses the implications of his tests. We reproduce some of his work here verbatim and in capitals to imply the importance thereof.

"ARGUMENTS FOR THE TIGHTER REGULATION OF THE HORSE RACE BETTING MARKET CAN PRESUMABLY ONLY BE STRENGTHENED BY THESE FINDINGS. EQUALLY, THE EXISTENCE OF THE INEFFICIENCIES REVEALED IN SECTION TWO WOULD PRESUMABLY CONFLICT WITH THE ROYAL COMMISSION ON GAMBLING'S PHILOSOPHY THAT THOSE WHO GAMBLE SHOULD KNOW AS MUCH AS POSSIBLE ABOUT THE ODDS AGAINST THEIR WINNING. THE JOCKEY CLUB'S OWN COMMITTEE OF INQUIRY ARGUED THAT "THE PUBLIC IS ENTITLED TO BE SATISFIED THAT EVERY PRECAUTION IS TAKEN TO ENSURE THAT RACING IS FAIRLY CONDUCTED AND THAT MALPRACTICES ARE REDUCED TO A MINIMUM." IF THIS VIEW IS ACCEPTED BY THE JOCKEY CLUB, THEN IT MAY WELL BE THAT THEIR OFFICIALS SHOULD ENQUIRE MORE FREQUENTLY INTO HORSES SHOWING IMPROVED FORM WHERE THE BETTING MARKET INDICATES THE POSSIBILITY OF SIGNIFICANT INSIDER INFORMATION, AND THAT THE JOCKEY CLUB SHOULD CONSIDER WHETHER IT IS ENFORCING ITS RULES OVER "NON-TRIERS" STRICTLY ENOUGH. IN PARTICULAR, PUBLIC CONFIDENCE WOULD SURELY BE ENHANCED IF CASES SUCH AS THOSE RECORDED IN TABLE 3 HAD BEEN ENQUIRED INTO BY THE STEWARDS WITH A VIEW TO ESTABLISHING THE REASONS FOR THE IMPROVEMENT IN FORM AND THE PREVIOUS INFERIOR PERFORMANCES."

In his 1982 paper Asch tested for strong efficiency by examining the marginal odds produced by bettors in the last few minutes of the betting period. The idea of using marginal odds is a logical one, but unfortunately he also uses FP's. We think that using the FP's in this test is unnecessary and that only the SP's and the marginal odds could have been used. Ratios of SP's to marginal odds of greater than one would indicate betting support in the marginal period and we could examine the finishing position records of all horses. If the assumption of betting behaviour holds and we observe significant differences between performance records of horses with differing ratios then we could conclude that inside information may exist and is being utilized in the final minutes of betting. Another test would be to examine the finishing positions of horses that changed their level of favouritism in the marginal period. Tests using these ideas will be carried out using bookmaker data (already available) as well as tote data.

Tuckwell (1983) used the adjustment of the odds as the basis for his test. The author is very insightful and has some useful comments related to the equatability of the betting market. These were covered in some detail in section 2.2.3. His tests however, rely on knowledge of bookmakers' profit margins which are not available in South Africa, and therefore no similar tests could be performed.

We now get to a paper that does not use FP's in its tests. In the clearest, most ingenious and logical paper in racing literature, Bird and McCrae (1987) propose tests of strong efficiency that are closest to Vannebo's optimal test. These were carefully set out and explained in section 2.2.3. All the points made in this paper are relevant to tests of strong efficiency. As mentioned above we will test using bookmaker odds and possibly using tote odds as well. We suggest that any test of strong efficiency be performed along the lines set out in this paper. This would include consideration of the new concepts introduced, namely, consumption benefits, control groups and the effect of the staking system used. Bird noted that "...(bookmaker data) is the only data which provide a meaningful series of prices throughout the course of betting. In addition, bookmaker odds provide the best means to gauge the advent of information onto the market since the largest and most knowledgeable gamblers concentrate their betting activities via bookmakers." Bird's test still has one problem in that the bookmaker prices that he uses are reported as an average of a few bookmakers prices. No indication is given if bets are actually struck at these prices. This research solves this problem as outlined below.

The essential element of any test of strong efficiency, in the absence of the ability to view the bets of real insiders, (trainers, owners etc.) is to analyse the adjustment of the odds through the betting period. It is therefore essential that the data used (odds) is representative and relevant for the purpose it is being used for. We have seen that using FP's is not relevant to such tests. This is clearly because the process of adjustment examined must only be of one set of odds, for example those odds set by bookmakers (FP's are set by newspapers while SP's are set by bookmakers). The odds must however also be representative of what is happening at the track as well as being accurate.

By representative is meant that if the reported opening price of a horse was 2/1, that means that the first bet struck on the course on that horse was at 2/1. This is clearly not the case with the reported odds. Further, this research places in doubt the recording accuracy of publications like Computaform for recording the odds as reflected on bookmakers boards at various times in the betting period. Tote odds at any time are relevant, representative and accurate but the same cannot be said of reported bookmaker odds. Since it is the adjustment of bookmaker odds that is more important, (if we assume the big punters bet with the bookmakers) we have obtained from a bookmaker his actual record of every bet struck on the racecourse over a two year period. This data will thus fulfil the above requirements. Details of the testing procedure are set out in section 3.3. Tote odds are also used in a specific test using the marginal odds idea, although this data source is more limited.

2.3.4 Tests of Bettor Consistency

Inefficiency and Inconsistency

In this section we shall examine the consistency of the bettors in the betting market. By consistent we mean that bettors cannot raise their rate of return above the average without access to more information. In our case more information would be inside information. Consistency within one betting pool, e.g. win bets, has been examined and has revealed the well known favourite-longshot bias. Consistency between two or more betting pools, e.g. place and swinger bets, is examined. Finally, consistency between identical pools at different tracks is examined.

The difference between inconsistency and inefficiency in the betting market should be noted again. Inefficiency, (i.e. the achievement of long run profits) is a result of the inconsistencies of bettors. Thus inefficiency implies inconsistency of some form, but the reverse is obviously not always true. We will examine this topic in chapters two and three. In this chapter we obtain insight into what actually goes on in the market and whether any inconsistencies can be exploited profitably. In chapter three we will ask why bettors behave the way they do in creating such inconsistencies.

Bettor consistency is concerned with examining the probabilities implied by the bettor determined odds on various types of bets. Bets fall into two categories, namely simple and exotic. The simple bets are win and place. Exotic bets involve bets on more than one horse simultaneously and these are swinger, trifecta and daily double. The pools for each type of bet are separate. There should be some fairly obvious relationships between the probabilities implicit in the various pools. If these relationships are violated for whatever reason, profitable exploitation may be possible.

Profitable systems to exploit bettor inconsistencies do not necessarily require that we have our own estimates of the empirical probabilities, (which presumably would be a better predictor of results than the publicly determined probabilities) but any system would probably give better returns if we were able to calculate more accurate estimates of winning probabilities than the public.

A simple example of a logical relationship between implicit subjective probabilities is that the probability of winning should be less than the probability of placing. At extremely high probabilities, (0.9+) it has been observed that the opposite is possible. For example a horse with bookmaker odds of 1/10 could be paying R1.10 for a win but R1.20 for a place! This is clearly a case of bettor inconsistency that could be exploited profitably in theory. In practice it would be more difficult as we would have to be one of the last bettors, and note as well that our bet would affect the final odds.

The above is a very simple example of inconsistency and it probably only occurs once a year offering a profit of maybe 1% on outlay of up to R100 with virtually no risk. It is therefore not of much use to be able to observe such situations. We need to investigate other situations where inconsistencies may exist. Firstly, we should examine the relationship between win and place probabilities. For example, if two horses are paying R10 for a win, but one is paying R2 for a place while the other is paying R4, we may regard the win and place odds on the former to be consistent with each other, which would imply that we believe the odds of the latter are inconsistent. Note that the problem could arise either from false win odds or false place odds on the latter horse. If we assume that the win odds are fairly close approximations of the empirical odds, we could say that the place odds on the second horse are too high. The connection between win probabilities and place probabilities was first examined by Harville (1973).

We have still only considered relationships between single probability bets. We must also examine relationships between single and compound probability bets, as well as those between two compound probability bets. For example, a relationship should exist between the probabilities implicit in daily double bets and the probabilities implicit in the win pools corresponding to the daily double races. An analysis of payoffs to daily doubles and payoffs to the corresponding "parlay" bet will be made. A parlay involves backing each horse in a specified double combination separately in the win pool for each of the two races. If the first horse wins, the total return from the winning bet is placed on the selected horse in the second race. The payoffs should be close, since the events that must occur for both bets to be successful, are the same.

In Cape Town, however the daily double pool is not divided only between the ticket holders predicting the winners of both races. Eighty percent of the pool is divided between such tickets while ten percent each is divided between ticket holders a winner and a second in the two races. This makes comparison along the lines of the above analysis more difficult since psychological factors may be involved. Do bettors consider the likely consolation payoffs at all when they bet on the double? For testing consistency we shall have to assume that consolation payoffs are not considered. We can then increase the observed double payoffs by twenty percent to obtain the public's implicit winning probabilities. Adjustments to this percentage added back can be made if the twenty percent appears unrealistic. This adjustment to our original adjustment may be needed because of the fact that double returns are displayed and this will affect the number of tickets bet on each combination. Clearly a fairly complex relationship exists between implicit win probabilities in the win pools and the corresponding implicit win probabilities in the double pool in Cape Town.

A relationship simpler to examine is that between implicit place probabilities in the place pool and implicit place probabilities in the swinger pool. For example, given that we have probabilities of placing from the place pool, we will be able to calculate expected payoffs from the corresponding swinger bet assuming the market is consistent in pricing both bets. Clearly if actual returns on swinger bets just before the off are higher than expected, profits could be made in the long run. This will depend on the implicit probabilities in the place pool being close approximations to the empirical place probabilities. We would do better still, if we were able to obtain more accurate estimates of the empirical probabilities, but these are not necessary for profitable exploitation.

Examination of the trifecta payouts would require knowledge of win probabilities from the win pool as well as probabilities of placing second and third from the place pools. The trifecta is a very complex bet to analyse using probabilities and it is virtually certain that inconsistencies exist between the pools. Lack of data regarding all (as opposed to winning) trifecta combinations meant that no study was made of this bet. Analysis of winning trifectas could have been made, but it was thought that such analysis would not lead to any useful or meaningful results. Examination could also be made of the even more complex exotic bets, namely the jackpot and the pick-six, but this would be unlikely to reveal anything meaningful. It is surely meaningless to try and establish a logical relationship between probabilities implicit in six separate win pools and compare these with win probabilities implicit in the pick-six pool when people are choosing their horses for the pick-six with the help of their phone numbers!

Harville (1973) was the first paper to examine relationships between probabilities in respect of horseracing. He developed formulae based on certain assumptions. Further discussion on this topic of probability, permutations and order statistics can be found in section chapter five. Harville's examination of actual versus theoretical frequencies of finishing second and third as well as placing will be similarly used in this work.

Two papers appeared almost simultaneously in 1981. These were from Hausch et al. (U.S.A.) and Tuckwell (Australia). Both papers extended Harville's investigation into frequencies of placing (first three) and tried to find a profitable strategy that could take advantage of the bettor inconsistencies that were noted in the preliminary investigations. The main thrust of each paper was to identify situations where a positive expected return existed (given the assumption that the win pool was "true") in the place pools.

Tuckwell's paper is simpler and uses an inappropriate method to derive estimates of win probabilities given an odds level. This has been discussed in section 2.3.1. The betting system used when profitable opportunities were identified was a simple unit staking system, i.e. betting the same amount on every horse that qualified for a bet. Hausch, on the other hand, developed a very sophisticated betting model which took into account many factors before arriving at an optimal amount which should be bet on a specific horse. Thus the main difference between the papers is their implementation of a betting strategy. Our approach shall be to follow Hausch's methods precisely, except that we shall either use a level staking system which is far easier to implement than Hausch's system, or devise our own system which is also simple to implement, but which does follow the notion of optimizing the amount bet on particular horses in some sense. The complexity of Hausch's staking system is considerable, and its economic applications and implications, seem beyond the scope of this work.

Ali (1979) made a useful study of bettor consistency, although he implied that it was actually a study of market efficiency. In the context of our work, he only examined consistency. There are two problems with his approach. The first is that he only examined consistency with regard to winning doubles. How do the bettors evaluate the probabilities associated with losing horses? This question is addressed in this work.

The other problem is that congruence between double probabilities and parlay probabilities does not necessarily imply consistent behaviour by the betting public. The reason for this is that the double probability is a compound probability which we do not decompose into its two components, so that we cannot know how it was arrived at, and therefore we cannot compare it with the two individual win probabilities derived from the win pool. We get around this by building a second compound probability estimate of the double event and comparing this with the probability from the double pool. This assumes, however that bettors are not "wildly" inconsistent or that at least one of the two horses in the double is "fairly" consistently bet on by the public.

Consider the following example. Ignore transactions costs.

Double return = 100 (bettors subjective probabilities for both horses = 0.1)
Parlay return = 100 (bettors subjective probabilities for the horses are .05 and .2 respectively)

This scenario over many observations would imply that bettors are consistent, although we can see that they are in actual fact wildly inconsistent. We shall assume that this type of scenario does not occur, and we can therefore safely continue to test consistency along the lines of Ali's test. The test will be adjusted slightly, as described above, to allow for the specific conditions prevailing in Cape Town.

Asch et al. (1986) examined exacta and daily double betting with a view to testing for consistency among bettors as well as testing for inside information. There are three major problems with the paper which demonstrate a lack of insight into racing. The techniques used are also somewhat inappropriate. Firstly, the derivation of the subjective probability of winning the (ij) exacta, using the win probabilities from the win pool, uses regression analysis which brings in observed probabilities. The observed probabilities are totally unnecessary in this context as is the regression analysis. Such probabilities should be derived directly using the subjective win pool probabilities and the Harville formulae.

Secondly, it seems inappropriate to attempt a test of inside information in the complex world of exotic betting. Since their are no bookmakers in the U.S.A. it may seem logical that this is a sound way to test for inside information. However, the factors affecting the payoffs to exotic bets are numerous and trying to isolate one (inside information) is difficult, and the results of tests are unlikely to be meaningful.

Asch also examines consistency and inside information in daily double betting. He found that the double is not consistently priced and is in fact underbet (i.e. the return to the double is higher than that to the corresponding parlay). The reason for this is probably because the money is tied up for two races as well as the fact that the transactions costs for the double are lower. Thus, thirdly, Asch's explanation as to why he could not show the existence of inside information in double betting is somewhat suspect. He states that holders of inside information will not bet the double since this signals the information to the public, as "will-pays" are displayed after the running of the first leg. Our point against this explanation, is that the assumption that inside information is so freely available so as to affect every double payout under discussion, is false.

Hausch and Ziemba (1990) examined the application of their optimal betting model to cross-track betting. Since it is a relatively new form of gambling, not much research has been done regarding it, and data tended to be sparse. In South Africa, however, cross-track betting forms a significant part of the total amount bet at a single track. Unfortunately, we were only able to obtain data from one racing centre, and that only applicable to the local tracks. Tests will be performed to examine bettor consistency using winning bets only, as these are published weekly for all racing centres in the newspaper. The bets examined will be win and trifecta. The results can only be of theoretical interest, since the implementation problems involved are insurmountable.

CHAPTER THREE
E.M.H RESULTS AND CONCLUSIONS

"It is true that only one person in a hundred wins. But what do I care about that?"
Dostoyevsky - The Gambler

Chapter two covered the literature review regarding the Efficient Markets Hypothesis. This chapter presents the results of our own tests which are based entirely on South African data.

3.1 Weak Efficiency

The method of systematically selecting horses using a single piece of unprocessed information, is so simple that it is virtually always overlooked by bettors. For example, most punters would not bet on a horse solely because the horse had a good draw or solely because a top jockey was aboard. Bettors will rather assimilate all the information regarding the horses in a race before making a decision to bet, and if so, on which runner. If bettors do not attempt to systematically analyse all the available information, they would probably combine their prior perceptions/beliefs with advice provided by newspaper tipsters or tipping guides, (processed information) in the belief that such tipsters have analysed the available information sufficiently.

The betting market is weakly inefficient if profit can be made by using only unprocessed information pertaining to the race. This would entail betting on the horse in each race with the best draw, (say). Paradoxically, since the method is so simple, it is generally not employed by any punters for that reason. They would demand a more complex method of determining betting opportunities. For this reason it may be possible to find a simple system whereby profit can be made.

The simplest way of trying to find winners systematically is to find horses with a certain characteristic whose observed probability of winning any given race, (frequency interpretation) over a long enough period of time, exceeds the expected probability of a horse with that characteristic doing so. Alternatively, the observed return from betting on such horses must be greater than the expected return of the bets. For example, a horse at odds of 1/1 is expected to win one every two races, i.e. for any particular race, the theoretical probability of winning is 0.5. If we observe enough 1/1 horses over an extended period and we see that they win on average more than once in two races, we should back any horse running at 1/1, since whatever factors go into determining the odds, they are on average understating the true probability of such horses winning.

If we examine the draws of winning horses, and we assume that each draw leads to an equivalent chance of winning, we expect to find an even distribution of the draws among the winning horses. In this case it would not simply be enough for one draw to have a greater observed probability of winning than expected, because this may still not lead to profit. In this case we need the observed return of backing horses with a particular draw to be greater than the expected return.

The first test is to group all horses by their starting price (SP) and note the number of winners from each category. Initially we will ignore the tax of 10% applicable to winning bets. The Computaform reports the SP's of all horses. These were transformed for each race, such that the probabilities of winning summed to 1 for the race. The first data set was then grouped by odds category. The transformed data set was grouped by probability category. The data used were of 1141 races run in the Cape Province from 9 June 1990 to 28 December 1991. There were 13 560 runners in total. The odds categories ranged from 1/10, (probability of winning 0.909) to 20/1 (probability of winning 0.0476). The probability categories ranged from .025 to .575 (these being the mid range values of the categories). The winners of the 1 141 races were similarly divided into odds/probability categories.

Observed rates of winning for each category were then calculated. These were compared to the expected rates implied by the odds, or the average expected probability for the transformed data. The expected rates are calculated as follows. If the odds are n/m i.e.

invest m to get back m+n, then the theoretical probability of winning is m/(n+m). If the range of probability is x to y, then the theoretical average probability of winning is (x+y)/2. The data, rates and graphs are shown in Tables 3.1 to 3.3 and Figures 3.1 to 3.3. In Tables 3.1 to 3.4 and 3.6 to 3.9 an asterisk (*) means there exists a significant difference (at the 5% level on a two sided alternative) between the expected and actual probabilities of winning at that probability level. Where the number of observations is less than thirty, the results of the test cannot be reasonably accepted, and should be treated with caution.

The variables in the following tables and graphs are defined as follows:

P = odds category expressed as the return to 1 unit.
WP = number of winners in each odds category.
EXPP = number of horses running in each odds category.
OBS = WP/EXPP = observed rate (probability) of winning for each odds category.
THEO = theoretical rate (probability) of winning for each odds category.
RAT = THEO/OBS = ratio of expected rate and observed rate.

The results are comparable with Dowie (1976) and Kreel (1988) in that profit can be made in some odds categories, although no pattern is discernable. The question as to why profit can be made in these categories, and not similar surrounding ones, remains unanswered. Given the small number of observations in some categories, and the strange results that emerged, it was necessary to group the odds categories and investigate further. The categories were grouped in two ways. Firstly in order to create a smooth, decreasing curve of observed rates, which is what we expected in the initial study. Secondly, the categories were grouped so that, each odds category within a group, was perceived by the betting public as having approximately the same winning probability as the other categories in the group. The "equal perception" groups were derived, based on the author's personal observations of gamblers at the track.

P	WP	EXPP	OBS	THEO	RAT	
0.1	1	1	1.000	0.909	0.909	
0.2	2	2	1.000	0.833	0.833	
0.25	1	1	1.000	0.800	0.800	
0.33	7	9	0.778	0.752	0.967	
0.4	6	6	1.000	0.714	0.714	
0.5	9	13	0.692	0.667	0.963	
0.6	9	23	0.391	0.625	1.597	*
0.7	23	46	0.500	0.588	1.176	
0.8	30	57	0.526	0.556	1.056	
0.9	19	40	0.475	0.526	1.108	
1	15	62	0.242	0.500	2.067	*
1.1	11	22	0.500	0.476	0.952	
1.2	34	63	0.540	0.455	0.842	
1.3	13	29	0.448	0.435	0.970	
1.4	10	47	0.213	0.417	1.958	*
1.5	21	51	0.412	0.400	0.971	
1.6	19	40	0.475	0.385	0.810	
1.7	8	61	0.131	0.370	2.824	*
1.8	27	80	0.338	0.357	1.058	
2	59	165	0.358	0.333	0.932	
2.2	31	110	0.282	0.313	1.109	
2.5	44	211	0.209	0.286	1.370	*
2.8	13	60	0.217	0.263	1.215	
3	45	241	0.187	0.250	1.339	*
3.3	24	91	0.264	0.233	0.882	
3.5	65	292	0.223	0.222	0.998	
4	74	414	0.179	0.200	1.119	
4.5	49	306	0.160	0.182	1.135	
5	103	718	0.143	0.167	1.162	
6	85	723	0.118	0.143	1.215	
7	68	919	0.074	0.125	1.689	*
8	65	1066	0.061	0.111	1.822	*
10	53	1216	0.044	0.091	2.086	*
12	46	2500	0.018	0.077	4.181	*
14	25	1437	0.017	0.067	3.832	*
16	13	870	0.015	0.059	3.937	*
20	14	1453	0.010	0.048	4.942	*
33	0	115	0.000	0.029	N/A	

Table 3.1 Theoretical and observed probabilities for all odds categories

PS	WPS	EXPS	SOBS	STHEO	RATS	
0.45	107	198	0.540	0.690	1.276	*
1.1	60	147	0.408	0.476	1.167	
1.4	44	127	0.346	0.417	1.203	
1.7	54	181	0.298	0.370	1.241	*
2.1	90	275	0.327	0.323	0.986	
2.65	57	271	0.210	0.274	1.303	*
3.15	69	332	0.208	0.241	1.159	
3.75	139	706	0.197	0.211	1.069	
4.5	49	306	0.160	0.182	1.135	
5	103	718	0.143	0.167	1.162	
6	85	723	0.118	0.143	1.215	
7	68	919	0.074	0.125	1.689	
8	65	1066	0.061	0.111	1.822	*
10	53	1216	0.044	0.091	2.086	*
12	46	2500	0.018	0.077	4.181	*
14	25	1437	0.017	0.067	3.832	*
16	13	870	0.015	0.059	3.937	*
20	14	1453	0.010	0.048	4.942	*
33	0	115	0.000	0.029	N/A	

Table 3.2 Theoretical and observed probabilities after smoothing

The grouping of categories were as follows;

Smooth Curve

Group 1: 1/10 to 9/10

Group 2: 1/1 to 12/10

Group 3: 13/10 to 15/10

Group 4: 16/10 to 18/10

Group 5: 2/1 to 22/10

Group 6: 5/2 to 28/10

Group 7: 3/1 to 33/10

Group 8: 7/2 to 4/1

Thereafter the groups concided with the original categories as no further grouping was

PE	WPE	EXPE	EOBS	ETHEO	RATE	
0.25	17	19	0.895	0.800	0.894	
0.7	90	179	0.503	0.588	1.170	*
1.2	83	223	0.372	0.455	1.221	*
1.65	75	232	0.323	0.377	1.167	
2.233	134	486	0.276	0.309	1.122	
3.15	147	684	0.215	0.241	1.121	
4	74	414	0.179	0.200	1.119	
4.5	49	306	0.160	0.182	1.135	
5	103	718	0.143	0.167	1.162	
6	85	723	0.118	0.143	1.215	
7	68	919	0.074	0.125	1.689	*
8	65	1066	0.061	0.111	1.822	*
10	53	1216	0.044	0.091	2.086	*
12	46	2500	0.018	0.077	4.181	*
14	25	1437	0.017	0.067	3.832	*
16	13	870	0.015	0.059	3.937	*
20	14	1453	0.010	0.048	4.942	*
33	0	115	0.000	0.029	N/A	

Table 3.3 Theoretical and observed probabilities after equal perception smoothing

necessary.

Perceived Equal Probability

Group 1: 1/10 to 4/10

Group 2: 5/10 to 9/10

Group 3: 1/1 to 14/10

Group 4: 15/10 to 18/10

Group 5: 2/1 to 5/2

Group 6: 28/10 to 7/2

The groups now, again, coincided with the categories.

The results are shown in Tables 3.2 and 3.3, with an S as a suffix or prefix to variable

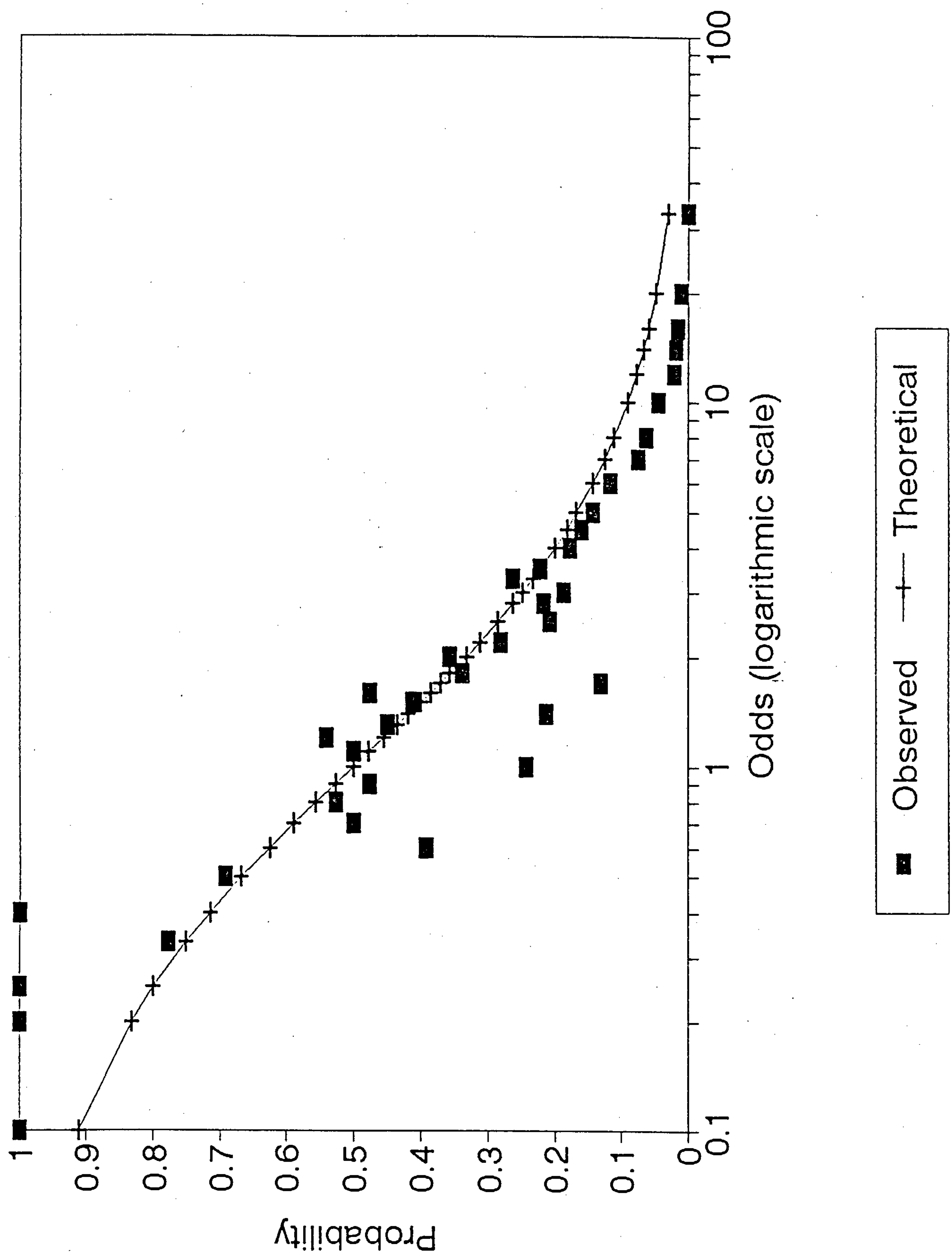


Figure 3.1 Theoretical and observed probabilities for all odds categories

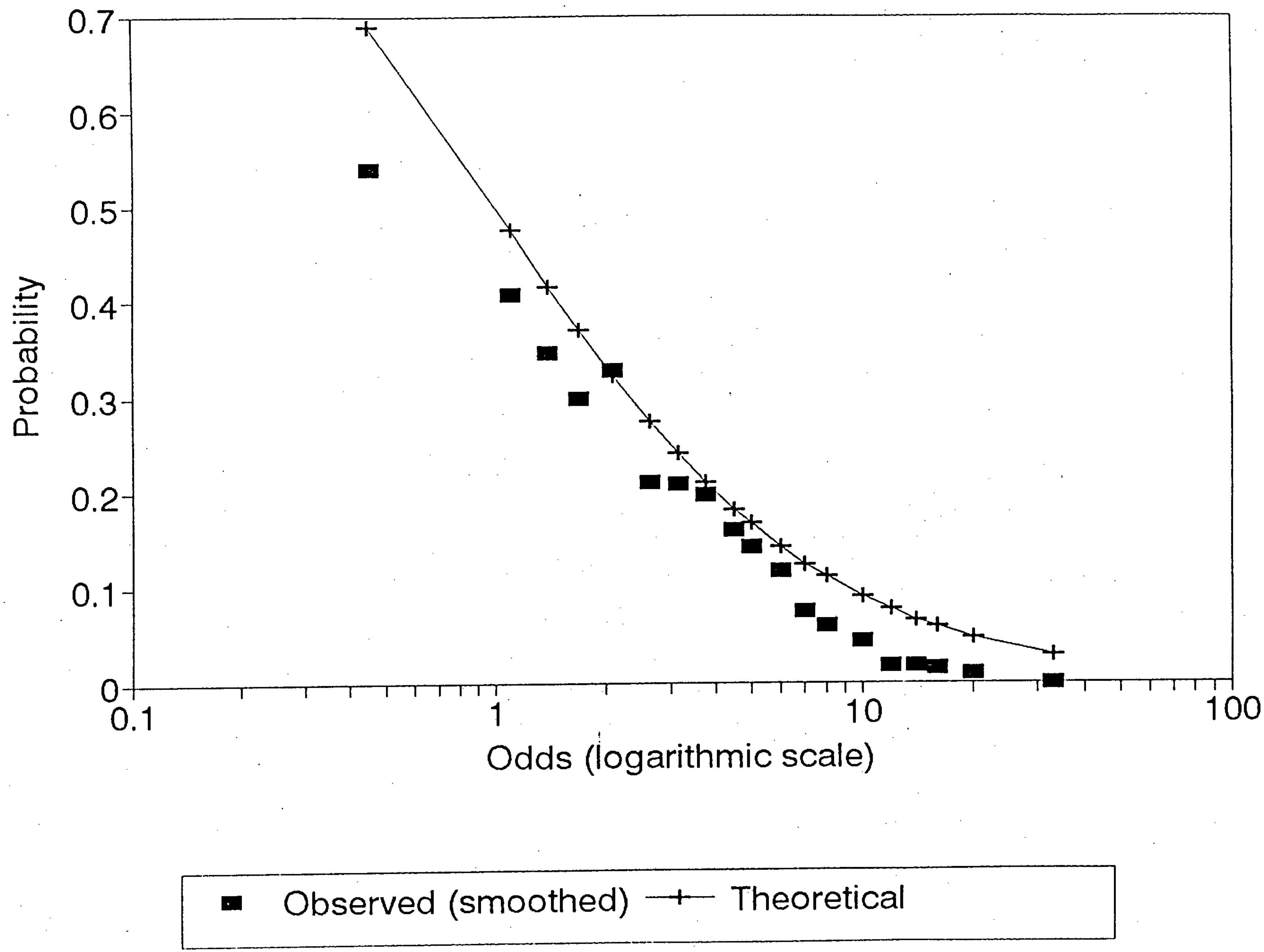


Figure 3.2 Theoretical and observed probabilities after smoothing

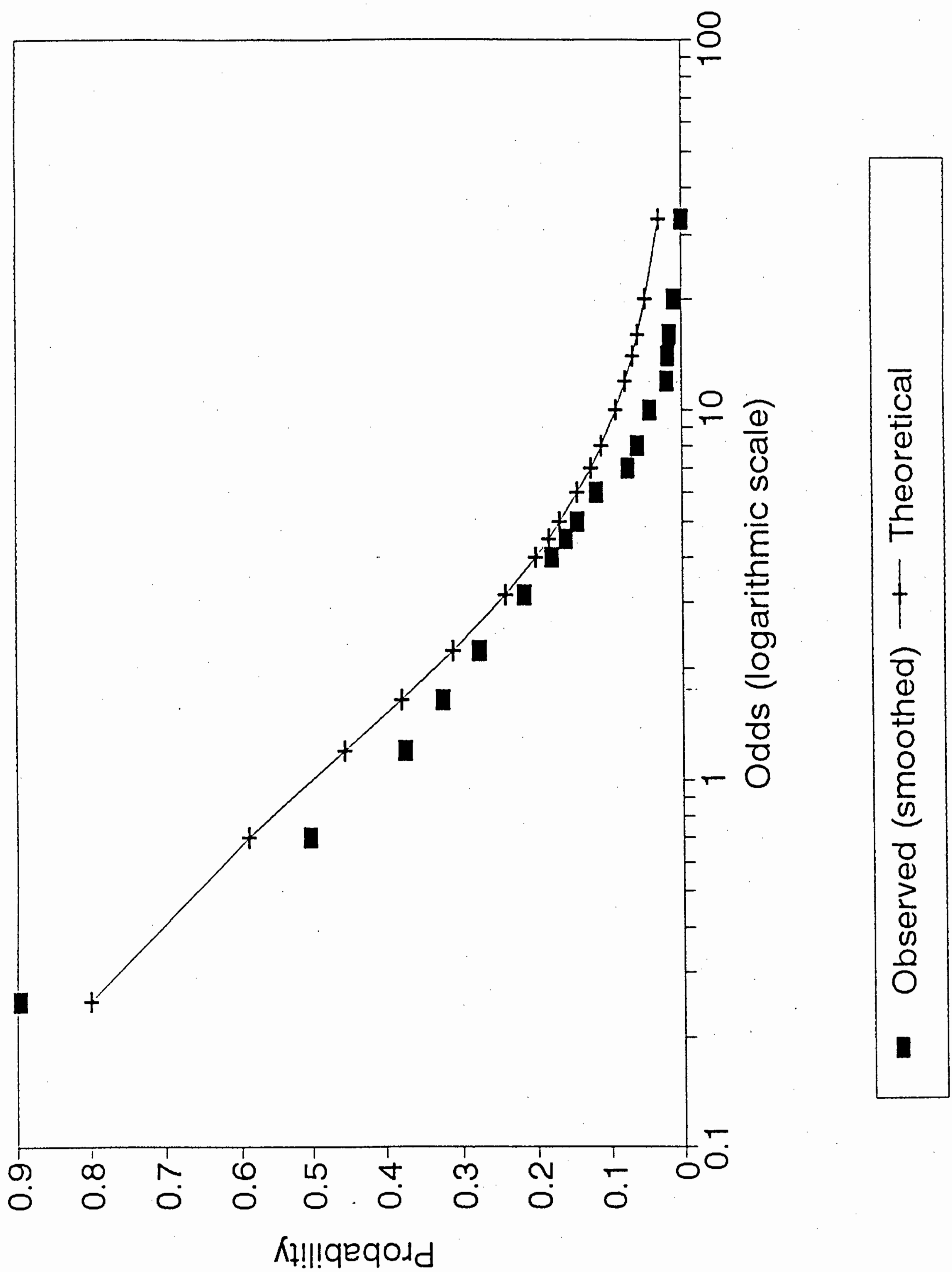


Figure 3.3 Theoretical and observed probabilities after equal perception smoothing

names, to indicate the Smooth groups, and an E to indicate the Equal Probability groups. In the smooth groups we now almost have a monotonically decreasing smooth curve of observed probabilities. This results in profit only being possible in one group, namely 2/1 to 22/10. The profit is small, is not significant at any conventional testing level, and there does not appear to be a fundamental reason why profit should be realized in this group. Taking tax of 10%, on winning bets into account, would remove this profit.

A profit is also made in the highest probability category (lowest odds) when odds categories are grouped by the Equal Perception criterion. The numbers in this group are small and therefore no statistical statements can be made regarding the profit. We note, however, that even taking tax into account, a small profit is possible.

The probability categories whereby horses were grouped for the investigation using transformed probabilities were as follows.

(1) 0.5 to 0.65
(2) 0.4 to 0.499
(3) 0.3 to 0.399
(4) 0.25 to 0.299
(5) 0.2 to 0.249
(6) 0.15 to 0.199
(7) 0.125 to 0.149
(8) 0.1 to 0.1249
(9) 0.08 to 0.099
(10) 0.06 to 0.079
(11) 0.04 to 0.059
(12) 0.03 to 0.039
(13) 0.02 to 0.029

The results are shown in Table 3.4. The variables are defined as follows.

APROB = average theoretical probability of winning

APROB	WINS	RUNS	ARATIO	PRATIO	
0.575	11	54	0.204	2.823	*
0.45	55	117	0.470	0.957	
0.35	134	262	0.511	0.684	*
0.275	71	241	0.295	0.933	
0.225	138	465	0.297	0.758	*
0.175	187	760	0.246	0.711	*
0.1375	137	781	0.175	0.784	*
0.1125	122	1032	0.118	0.952	
0.09	65	1167	0.056	1.616	*
0.07	63	1975	0.032	2.194	*
0.05	93	3398	0.027	1.827	*
0.035	47	2655	0.018	1.977	*
0.025	18	653	0.028	0.907	

Table 3.4 Theoretical and observed probabilities using "sum to one" transformed probabilities

WINS = number of winners in each category

RUNS = number of runners in each category

ARATIO = WINS/RUNS = actual percentage of winners to runners

PRATIO = APROB/ARATIO = ratio of theoretical to actual winning probability.

The results confirm the existence of the favourite-longshot bias. Low odds runners are underbet, while high odds runners are overbet. Exceptions are the shortest and longest odds categories. The shortest odds category is overbet, while the longest odds category is slightly underbet. Since these actual probabilities are based on transformed odds, (i.e. odds that would make the game fair) any profitable categories can obviously not be exploited. We have seen, however, that even if the odds were completely fair, (to the extent that the probabilities of winning sum to one) the bias of overbetting short odds horses still exists.

The odds reflected by the tote are determined in a different way to those of the bookmakers. All the money is placed in a pool, the take out is removed, and the remainder is paid to the holders of tickets on the winner. There is no need to transform the tote odds, because the required relationship between all horses in the race already exists, i.e. the probabilities of the horses sum to one. The data was available in the form of win bets placed on all runners. From this, the win probability for each horse and the equivalent odds were calculated as follows. (An example of the data is shown in Table 3.5.)

Win probability = win bets / total pool.
Odds = (1 / win probability) - 1.

All horses were grouped by odds into the nearest recognized bookmaker odds category. Winning horses were noted and similarly allocated. Observed and expected rates were calculated as before. The data was supplied by the Cape Racing Computer Division from 10 November 1990 until 30 November 1991. This included 787 races in which 8 883 runners participated. The analyses were the same as those used for the bookmaker odds investigation. The letter T was used as a suffix or prefix to the variables previously used, to indicate that tote odds were being considered. The results are shown in Tables 3.6 to 3.8.

There is a similarity in these results when compared with the bookmaker odds results, in that profits are possible in certain categories, but with no evident pattern to such profits. The main difference is that profit appears possible at the longer odds categories as well as the shorter ones. This is in contradiction of the favourite-longshot bias so evident in other studies. The odds categories reflected here do not take account of the 18% take out on win bets (whether the bets win or lose). Taking the take out into account and affixing a 1 to the variable name to indicate the difference, we notice that almost all the profits disappear, table 3.9.

Profit is still possible at prices around 25/1 (after take out) on the tote. The reasons for these odd patterns of profit, and isolated categories returning profit, are not known. It should be noted that the tote tends to reflect the odds set by the bookmaker. Another point is that the tote odds indicate the return after tax and charges, whereas the bookmaker odds are shown before tax. The reasons for betting biases are investigated

Table 3.5 Example of data used to calculate tote odds

DATE: 30-NOV-91, TIME: 18:06:42, SESSION: 1584, CAPE RACING

C O L L A T I O N S   R E P O R T

W I N

RACE 2, LOCATION 1 : CAPE TOWN PERFORMANCE 80

RUNNERS ENTERED	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
CURRENT RUNNERS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19

RUNNER	SELL-PAY	TOTAL
1	195.00	195.00
2	140.00	140.00
3	4,670.00	4,670.00
4	3,557.00	3,557.00
5	147.00	147.00
6	749.00	749.00
7	667.00	667.00
8	103.00	103.00
9	175.00	175.00
10	967.00	967.00
11	403.00	403.00
12	37.00	37.00
13	458.00	458.00
14	428.00	428.00
15	62.00	62.00
16	95.00	95.00
17	7,727.00	7,727.00
18	485.00	485.00
19	1,022.00	1,022.00
TOTAL	22,087.00	22,087.00

TP	TWP	TEXPP	TOBS	TTHEO	TRAT	
0.6	1	3	0.333	0.625	1.875	
0.7	10	28	0.357	0.588	1.647	*
0.8	1	6	0.167	0.556	3.333	
0.9	6	17	0.353	0.526	1.491	
1	15	25	0.600	0.500	0.833	
1.1	14	34	0.412	0.476	1.156	
1.2	17	35	0.486	0.455	0.936	
1.3	12	24	0.500	0.435	0.870	
1.4	22	39	0.564	0.417	0.739	
1.5	2	22	0.091	0.400	4.400	*
1.6	8	13	0.615	0.385	0.625	
1.7	4	20	0.200	0.370	1.852	
1.8	14	38	0.368	0.357	0.969	
2	50	103	0.485	0.333	0.687	*
2.2	31	100	0.310	0.313	1.008	
2.5	45	108	0.417	0.286	0.686	*
2.8	20	95	0.211	0.263	1.250	
3	28	132	0.212	0.250	1.179	
3.3	28	102	0.275	0.233	0.847	
3.5	33	144	0.229	0.222	0.970	
4	41	172	0.238	0.200	0.839	
4.5	26	182	0.143	0.182	1.273	
5	54	251	0.215	0.167	0.775	*
6	62	344	0.180	0.143	0.793	*
7	29	285	0.102	0.125	1.228	
8	39	417	0.094	0.111	1.188	
10	15	431	0.035	0.091	2.612	*
12	13	348	0.037	0.077	2.059	*
14	6	358	0.017	0.067	3.978	*
16	32	455	0.070	0.059	0.836	
20	25	442	0.057	0.048	0.842	
25	21	561	0.037	0.038	1.027	
33	39	674	0.058	0.029	0.508	*
50	23	1077	0.021	0.020	0.918	
100	1	1798	0.001	0.010	17.802	*

Table 3.6 Theoretical and observed probabilities using tote odds

TPS	TWPS	TEXPS	TSOBS	TSTHEO	TRATS	
0.75	18	54	0.333	0.571	1.714	*
1.1	46	94	0.489	0.476	0.973	
1.4	36	85	0.424	0.417	0.984	
1.7	26	71	0.366	0.370	1.011	
2.1	81	203	0.399	0.323	0.808	*
2.65	65	203	0.320	0.274	0.856	
3.15	56	234	0.239	0.241	1.007	
3.75	74	316	0.234	0.211	0.899	
4.5	26	182	0.143	0.182	1.273	
5	54	251	0.215	0.167	0.775	*
6	62	344	0.180	0.143	0.793	*
7	29	285	0.102	0.125	1.228	
8	39	417	0.094	0.111	1.188	
10	15	431	0.035	0.091	2.612	*
12	13	348	0.037	0.077	2.059	*
14	6	358	0.017	0.067	3.978	*
16	32	455	0.070	0.059	0.836	
20	25	442	0.057	0.048	0.842	
25	21	561	0.037	0.038	1.027	
33	39	674	0.058	0.029	0.508	*
50	23	1077	0.021	0.020	0.918	
100	1	1798	0.001	0.010	17.802	*

Table 3.7 Theoretical and observed probabilities using tote odds and smoothing

further in chapter four.

All horses were also categorised by the ratio of their tote odds, (excluding charges) to their bookmaker odds (excluding tax). In general in Cape Town, tote odds are higher than bookmaker odds at bookmaker prices of 10/1 and below, and virtually always higher at bookmaker odds of greater than 10/1. The ratio ranged from about 0.5 to 20. A split of the data was made, so that horses with bookmaker odds of less than 10/1 were analysed separately. Horses were divided into four categories as follows.

(1) Ratio 0.5 to 0.999

(2) Ratio 1 to 1.499

TPE	TWPE	TEXPE	TEOBS	TETHEO	TRATE	
0.75	18	54	0.333	0.571	1.714	*
1.2	80	157	0.510	0.455	0.892	
1.65	28	93	0.301	0.377	1.253	
2.233	126	311	0.405	0.309	0.763	*
3.15	109	473	0.230	0.241	1.046	
4	41	172	0.238	0.200	0.839	
4.5	26	182	0.143	0.182	1.273	
5	54	251	0.215	0.167	0.775	*
6	62	344	0.180	0.143	0.793	*
7	29	285	0.102	0.125	1.228	
8	39	417	0.094	0.111	1.188	
10	15	431	0.035	0.091	2.612	*
12	13	348	0.037	0.077	2.059	*
14	6	358	0.017	0.067	3.978	*
16	32	455	0.070	0.059	0.836	
20	25	442	0.057	0.048	0.842	
25	21	561	0.037	0.038	1.027	
33	39	674	0.058	0.029	0.508	*
50	23	1077	0.021	0.020	0.918	
100	1	1798	0.001	0.010	17.802	*

Table 3.8 Theoretical and observed probabilities using tote odds and equal perception smoothing

(3) Ratio 1.5 to 1.999

(4) Ratio 2 and greater.

Winners and placed runners were similarly divided. The results are seen in tables 3.10 to 3.13. Chi-squared tests of association were performed and all tests showed a highly significant relationship between the ratio category and the probability of winning or placing. The interpretation of this is simply that given that a horse has won or been placed, it is more likely that it was in ratio categories 1 or 2. An interpretation that implies winning probabilities are determined by ratio category is clearly illogical. Table 3.13, where the expected value of one of the cells is less than 5 should be treated with caution.

A further investigation was made to see whether profit could be made by backing certain

TP1	TWP	TEXPP	TOBS	TTHEO1	TRAT1	
0.312	1	3	0.333	0.762	2.287	
0.394	10	28	0.357	0.717	2.009	*
0.476	1	6	0.167	0.678	4.065	*
0.558	6	17	0.353	0.642	1.819	*
0.64	15	25	0.600	0.610	1.016	
0.722	14	34	0.412	0.581	1.410	*
0.804	17	35	0.486	0.554	1.141	
0.886	12	24	0.500	0.530	1.060	
0.968	22	39	0.564	0.508	0.901	
1.05	2	22	0.091	0.488	5.366	*
1.132	8	13	0.615	0.469	0.762	
1.214	4	20	0.200	0.452	2.258	*
1.296	14	38	0.368	0.436	1.182	
1.46	50	103	0.485	0.407	0.837	
1.624	31	100	0.310	0.381	1.229	
1.87	45	108	0.417	0.348	0.836	
2.116	20	95	0.211	0.321	1.524	*
2.28	28	132	0.212	0.305	1.437	*
2.526	28	102	0.275	0.284	1.033	
2.69	33	144	0.229	0.271	1.183	
3.1	41	172	0.238	0.244	1.023	
3.51	26	182	0.143	0.222	1.552	*
3.92	54	251	0.215	0.203	0.945	
4.74	62	344	0.180	0.174	0.967	
5.56	29	285	0.102	0.152	1.498	*
6.38	39	417	0.094	0.136	1.449	*
8.02	15	431	0.035	0.111	3.186	*
9.66	13	348	0.037	0.094	2.511	*
11.3	6	358	0.017	0.081	4.851	*
12.94	32	455	0.070	0.072	1.020	
16.22	25	442	0.057	0.058	1.027	
20.32	21	561	0.037	0.047	1.253	
26.88	39	674	0.058	0.036	0.620	*
40.82	23	1077	0.021	0.024	1.120	
81.82	1	1798	0.001	0.012	21.710	*

Table 3.9 Theoretical and observed probabilities using tote adds with tax and charges deducted

VARIABLE: ODDS <=10/1

OBSERVED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
WON	74	345	155	77	651
LOST	362	1584	919	913	3778
TOTAL	436	1929	1074	990	4429

EXPECTED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
WON	64.09	283.54	157.86	145.52	651
LOST	371.91	1645.46	916.14	844.48	3778
TOTAL	436	1929	1074	990	4429

DEGREES OF FREEDOM = 3

TEST STATISTIC = 55.30

CHI-SQUARE (5%) = 7.81
CHI-SQUARE (0.5%) = 17.73

CONCLUSION: SIZE OF WIN/PLACE RATIO AND PROBABILITY OF WINNING ARE HIGHLY CORRELATED.

Table 3.10 Chi-Square test of association between ratio category and probability of winning where odds were less than or equal to 10/1

VARIABLE: ODDS <= 10/1

OBSERVED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
PLACED	239	974	435	248	1896
UNPLACED	197	955	639	742	2533
TOTAL	436	1929	1074	990	4429

EXPECTED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
PLACED	186.65	825.78	459.77	423.81	1896
UNPLACED	249.35	1103.22	614.23	566.19	2533
TOTAL	436	1929	1074	990	4429

DEGREES OF FREEDOM = 3

TEST STATISTIC = 202.05

CHI-SQUARE (5%) = 7.81
CHI-SQUARE (0.5%) = 17.73

CONCLUSION: SIZE OF WIN/PLACE RATIO AND PROBABILITY OF PLACING ARE HIGHLY CORRELATED.

Table 3.11 Chi-Square test of association between ratio category and probability of placing where the win odds were less than or equal to 10/1

VARIABLE: ODDS > 10/1

OBSERVED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
WON	6	19	23	33	81
LOST	77	355	323	2905	3660
TOTAL	83	374	346	2938	3741

EXPECTED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
WON	1.80	8.10	7.49	63.61	81
LOST	81.20	365.90	338.51	2874.39	3660
TOTAL	83	374	346	2938	3741

DEGREES OF FREEDOM = 3

TEST STATISTIC = 72.92

CHI-SQUARE (5%) = 7.81
CHI-SQUARE (0.5%) = 17.73

CONCLUSION: SIZE OF WIN/PLACE RATIO AND PROBABILITY OF WINNING ARE HIGHLY CORRELATED.

Table 3.12 Chi-Square test of association between ratio category and probability of winning where the odds are greater than 10/1

VARIABLE: ODDS > 10/1

OBSERVED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
PLACED	13	97	74	223	407
UNPLACED	70	277	272	2715	3334
TOTAL	83	374	346	2938	3741

EXPECTED TABLE

RATIO CATEGORY

	1	2	3	4	TOTAL
PLACED	9.03	40.69	37.64	319.64	407
UNPLACED	73.97	333.31	308.36	2618.36	3334
TOTAL	83	374	346	2938	3741

DEGREES OF FREEDOM = 3

TEST STATISTIC = 161.59

CHI-SQUARE (5%) = 7.81
CHI-SQUARE (0.5%) = 17.73

CONCLUSION: SIZE OF WIN/PLACE RATIO AND PROBABILITY OF PLACING ARE HIGHLY CORRELATED.

Table 3.13 Chi-Square test of association between ratio category and probability of placing where the win odds are greater than 10/1 horses based on their ratio category. Where bookmaker odds were less than 10/1, a loss of approximately 20% was made in categories 1 and 2 for both bookmaker and tote odds, after adjusting for charges and tax. This is about what is expected from betting at random. Where bookmaker odds were greater than 10/1, a profit of 46% and 15.5% was made in category 1 for bookmaker odds and tote odds respectively, after all charges. This was mainly owing to the presence of three horses winning at bookmaker odds of 20/1, out of only 6 winners. These numbers are small and should be interpreted with caution. In category 2, losses of 18% and 17% were made by bookmaker odds and tote odds respectively.

A slightly more sophisticated approach to testing weak efficiency is to introduce one or two other elementary factors by which to group horses. The factor used thus far has been the odds. We now consider a specific group of horses, namely the favourite in each race. The second factor we are concerned with is therefore postion in the betting, and we shall consider only those which are first. We therefore first examine the return to favourites grouped by their SP's. Other factors will then be introduced to further subdivide the data. The factors which we considered might have an influence on the return to betting on favourites were;

a) the course
b) the distance
c) the going
d) the number of the race
e) the size of the field.

If any of these factors consistently affect the outcomes of races enough, profit may be possible, even though betting on all favourites leads to losses. The reasons these factors were considered are as follows. Firstly, note that any negative factor affecting most of the horses in a race makes it more likely the the result will be an upset (defeat of the favourite). This is because it is likely that the favourite will be one of the majority of the horses affected. Horses race throughout the year and are exposed to wet conditions during the minority of meetings. Most horses do not adapt to such conditions when they do occur. Therefore we might expect favourites to fare relatively poorly on wet days since they are likely to be one of the many, (but not all), horses affected by the conditions.

A similar line of logic applies to the course the race meeting is held at. Some courses are more difficult for most, (but not all), horses to negotiate and we might expect a greater number of upset results at such courses. The distance of the race is possibly only important with regard to whether the race is being run on the straight course (sprints) or the turn (distance). Races around the turn where jockeyship will count more are more liable to upsets than straight sprints where the jockey simply needs to sit on the horse and keep it on a straight path.

The number of the race on the card is thought to affect the return to favourites, because of the tendency of bettors to bet proportionally less on favourites as the day progresses. The reasons for this will be examined in detail in chapter three, but the obvious one is that collectively bettors have lost 18% (the take out) of their stakes at any time, while absolutely the amount grows with each race. Bettors therefore need to back horses at ever lengthening odds in order to just break even for the day. The favourites, (horses with the shortest odds in the race) are thus avoided more and more as the day progresses. The size of the field influences results in that there may be inteference to some of the runners in larger fields. Also it is intuitive that it is easier for a favourite to beat 5 horses than 15.

The results of the analyses are shown in Tables 3.14 to 3.21. The tote return excludes the original stake. The bookie return has been adjusted for 10% tax on winnings. This makes the two returns comparable since the tote return is calculated from actual tote returns from which 18% take out has been deducted. The average winning SP is calculated using the tote return. The average SP is calculated using the total bookie odds for all favourites (winners or not).

OVERALL ANALYSIS OF FAVOURITES	
RACES	1603
WINNERS	568
% WINNERS	35.43
TOTE RETURN	793.3
BOOKIE RETURN	797.62
LOSING BETS	1035
PROFIT OR LOSS	-241.7
% P OR L	-15.08
AVERAGE WINNING SP	1.40
AVERAGE SP	1.66
PLACES	1067
% PLACES	66.56
TOTE RETURN	382.4
LOSING BETS	536
PROFIT OR LOSS	-153.6
% P OR L	-9.58

Table 3.14 Overall analysis of favourites

The observed winning percentage for favourites is 35.43% which is in line with the commonly held belief that one third of favourites win. The loss incurred by backing all favourites is 15.08% which is slightly better than the expected loss of 18% which should result by backing at random. This result is significant at the 1% significance level using a two sided alternative. Following from this, it was noted that virtually all subdivided categories of favourites also performed significantly (at either the 1% level or stronger) better than betting at random. As The average price for favourites was 1.66 to 1 or almost 17/10 in bookmakers terms. The average price of winning favourites is somewhat lower at 14/10. The percentage of favourites placed was 66.56, which is also about that expected. Backing all favourites to place, yielded a loss of only 9.58%.

Examining table 3.15 we note the percentage winners decrease with increasing odds which is expected. We may compare the observed percentage of winners in each category with that expected on the basis of the average winning odds in the category. In the first category the actual winning percentage is 58.16% while the expected percentage is 59.17%. The actual and expected percentages for the other three categories are, 41.88 (A) and 44.84 (E), 28.37 (A) and 37.45 (E), 24.30 (A) and 30.58 (E) respectively. The larger these differences, the larger is likely to be the loss incurred by betting on favourites in the specific odds category. Thus we note the loss for category one is 1.6%, while for category three, the loss is 24.33%. This means bettors are avoiding short priced favourites and showing a preference for longer priced favourites. This confirms the well known favourite-longshot bias even when examination is restricted to favourites.

The comparison of returns from bookmakers and the tote shows that short priced favourites are backed to a larger extent with the bookmakers than the tote, while the reverse is true of long priced favourites. The percentage of placed favourites decreases from category 1 through 4 which is expected. Note that a small profit was made by backing very short priced favourites for a place. This is because the favourite-longshot bias operates more strongly in the place pool, since the probabilities of winning money are high while the absolute returns are very low, and bettors avoid such bets. The positive return of almost 1% was achieved in about 2 years, and therefore such a route to profit does not seem practical.

ANALYSIS OF FAVOURITES BY ODDS				
	< 1/1	11/10 TO 15/10	16/10 TO 2/1	22/10 TO 5/1
RACES	294	351	423	535
WINNERS	171	147	120	130
% WINNERS	58.16	41.88	28.37	24.30
TOTE RETURN	118.3	180.2	200.1	294.7
BOOKIE RETURN	103.36	169.92	198.00	326.34
LOSING BETS	123	204	303	405
PROFIT OR LOSS	-4.7	-23.8	-102.9	-110.3
% P OR L	-1.60	-6.78	-24.33	-20.62
AVERAGE SP	0.62	1.17	1.64	2.58
AVERAGE WINNING SP	0.69	1.23	1.67	2.27
PLACES	248	257	260	302
% PLACES	84.35	73.22	61.47	56.45
TOTE RETURN	48.6	79.6	95	159.2
LOSING BETS	46	94	163	233
PROFIT OR LOSS	2.6	-14.4	-68	-73.8
% P OR L	0.88	-4.10	-16.08	-13.79

Table 3.15 Analysis of favourites by odds category

Examining table 3.16 we note little difference in returns to favourites at Milnerton and Kenilworth. This is what was expected since there is no difference between the courses. The differences between these two courses and Durbanville, is however, the opposite of what was expected. Given that Durbanville is a more difficult track to run and ride at, (very sharp turns), we expected to find a lower return to favourite betting. The returns for win and place betting are better than at both other courses. The reason for this seems to be that the public and the bookmakers are already under the impression that Durbanville is a course where more upsets occur than usual. This is reflected in the average SP, as well as average winning SP figures. In both cases these are higher at Durbanville than the other courses. The public are thus biased even more against betting on favourites at Durbanville.

ANALYSIS OF FAVOURITES BY COURSE			
	MILNERTON	KENILWORTH	DURBANVILLE
RACES	595	803	205
WINNERS	203	293	72
% WINNERS	34.12	36.49	35.12
TOTE RETURN	284.9	385.2	123.2
BOOKIE RETURN	287.51	389.68	120.42
LOSING BETS	392	510	133
PROFIT OR LOSS	-107.1	-124.8	-9.8
% P OR L	-18.00	-15.54	-4.78
AVERAGE SP	1.68	1.60	1.85
AVERAGE WINNING SP	1.40	1.31	1.71
PLACES	370	553	144
% PLACES	62.18	68.87	70.24
TOTE RETURN	130.3	192.4	59.7

LOSING BETS	225	250	61
PROFIT OR LOSS	-94.7	-57.6	-1.3
% P OR L	-15.92	-7.17	-0.63

Table 3.16 Analysis of favourites by course

A similar scenario exists when we differentiate between good and and heavy (wet) going. We expected a higher return to favourites when the going was good, while the return to win betting is better when the going is heavy. Betting for a place is more profitable when the going is good. The reason again, is that bettors and bookmakers alike also perceive that favourites will have a more difficult time in the rain. Therefore the average SP for such favourites was 1.91 to 1, whereas for favourites on good going it was 1.57 to 1. The average winning SP's show similar differences. The results show that the difference between the winning percentages is small, and there is therefore no reason to price favourites differently given a difference in weather.

ANALYSIS OF FAVOURITES BY GOING		
	GOOD	WET
RACES	1158	445
WINNERS	416	152
% WINNERS	35.92	34.16
TOTE RETURN	549.2	244.1
BOOKIE RETURN	540.58	257.04
LOSING BETS	742	293
PROFIT OR LOSS	-192.8	-48.9
% P OR L	-16.65	-10.99
AVERAGE SP	1.57	1.91
AVERAGE WINNING SP	1.32	1.61

PLACES	797	270
% PLACES	68.83	60.67
TOTE RETURN	274.2	108.2
LOSING BETS	361	175
PROFIT OR LOSS	-86.8	-66.8
% P OR L	-7.50	-15.01

Table 3.17 Analysis of favourites by the state of the going

The analysis of favourites by distance shows results that were expected. The percentage of favourites winning, is higher down the straight, as are the return to win and place betting. The public and bookmakers also seem aware of this, as the average SP for turn races is higher than for straight races.

ANALYSIS OF FAVOURITES BY DISTANCE		
	TURN	STRAIGHT
RACES	939	664
WINNERS	308	260
% WINNERS	32.80	39.16
TOTE RETURN	454.4	338.9
BOOKIE RETURN	444.82	352.80
LOSING BETS	631	404
PROFIT OR LOSS	-176.6	-65.1
% P OR L	-18.81	-9.80
AVERAGE SP	1.72	1.58
AVERAGE WINNING SP	1.48	1.30

PLACES	606	461
% PLACES	64.54	69.43
TOTE RETURN	222.9	159.5
LOSING BETS	333	203
PROFIT OR LOSS	-110.1	-43.5
% P OR L	-11.73	-6.55

Table 3.18 Analysis of favourites by distance of the race

The analysis of favourites by race number, gives some strange results, in that there appears no pattern of betting through the afternoon. The percentages of favourites winning and placing also show no consistency which is what was expected (for the first 4 races at least). A profit was made, betting on all favourites in first races, as well as betting for places on favourites in the sixth and ninth races. Further analysis and discussion on this topic can be found in section 4.2.

ANALYSIS OF FAVOURITES BY RACE NUMBER			
	ONE	TWO	THREE
RACES	201	200	200
WINNERS	92	64	76
% WINNERS	45.77	32.00	38.00
TOTE RETURN	114.1	85.7	106.3
BOOKIE RETURN	128.03	86.22	105.30
LOSING BETS	109	136	124
% P OR L	2.54	-25.15	-8.85
AVERAGE SP	1.58	1.55	1.68
AVERAGE WINNING SP	1.24	1.34	1.40

PLACES	149	152	135
% PLACES	74.13	76.00	67.50
TOTE RETURN	41.5	45.5	49.6
LOSING BETS	52	48	65
PROFIT OR LOSS	-10.5	-2.5	-15.4
% P OR L	-5.22	-1.25	-7.70

Table 3.19 Analysis of favourites by race number

ANALYSIS OF FAVOURITES BY RACE NUMBER			
	FOUR	FIVE	SIX
RACES	199	199	199
WINNERS	62	55	79
% WINNERS	31.16	27.64	39.70
TOTE RETURN	77.3	73.1	113.2
BOOKIE RETURN	75.72	83.57	110.75
LOSING BETS	137	144	120
PROFIT OR LOSS	-59.7	-70.9	-6.8
% P OR L	-30.00	-35.63	-3.42
AVERAGE SP	1.70	1.81	1.70
AVERAGE WINNING SP	1.25	1.33	1.43
PLACES	110	125	150
% PLACES	55.28	62.81	75.38
TOTE RETURN	38.7	52.8	59.8
LOSING BETS	89	74	49

PROFIT OR LOSS	-50.3	-21.2	10.8
% P OR L	-25.28	-10.65	5.43

Table 3.19 Analysis of favourites by race number

ANALYSIS OF FAVOURITES BY RACE NUMBER			
	SEVEN	EIGHT	NINE
RACES	199	150	56
WINNERS	65	55	20
% WINNERS	32.66	36.67	35.71
TOTE RETURN	98.5	93.7	31.4
BOOKIE RETURN	93.10	81.99	32.95
LOSING BETS	134	95	36
PROFIT OR LOSS	-35.5	-1.3	-4.6
% P OR L	-17.84	-0.87	-8.21
AVERAGE SP	1.65	1.61	1.54
AVERAGE WINNING SP	1.52	1.70	1.57
PLACES	112	94	40
% PLACES	56.28	62.67	71.43
TOTE RETURN	39.9	36.6	18
LOSING BETS	87	56	16
PROFIT OR LOSS	-47.1	-19.4	2
% P OR L	-23.67	-12.93	3.57

Table 3.19 Analysis of favourites by race number

The analysis of favourites by class is shown in Table 3.20 and a reproduction of similar analysis from Kreel (1988) is shown in Table 3.22. A profit was made, betting on all favourites in Juvenile races. This might have been expected, because in such races there is little or no exposed track form for any of the runners. The favourite is often the horse with the most potential. This information is usually inside information and not known by the public until shortly before the off when the particular horse is backed to favourite by its connections. This generally results in public betting on the horse which leads to a very short priced favourite. Note the average winning SP of Juvenile favourites is the lowest of all the classes at about 11/10. Owing to the high percentage of such favourites that win, however, profit appears possible.

The Classic and A Division categories resulted in a small loss and no loss respectively. This is probably because the horses competing in such events are high quality, and usually have a good deal of consistent exposed form on the track. These races are therefore easier to analyse and once a favourite has been determined, it is likely to do well, barring any mishaps. Profit was also made by betting on Classic favourites for a place. Note that the sample of Classic races is small and that the results in general, differ somewhat from the similar study undertaken four years ago.

ANALYSIS OF FAVOURITES BY CLASS				
	MAIDEN	NOVICE	PROGRESS	B DIVISION
RACES	470	359	337	132
WINNERS	177	104	111	33
% WINNERS	37.66	28.97	32.94	25.00
TOTE RETURN	245.7	155.5	161.8	61.1
BOOKIE RETURN	244.70	154.80	165.06	57.66
LOSING BETS	293	255	226	99
PROFIT OR LOSS	-47.3	-99.5	-64.2	-37.9
% P OR L	-10.06	-27.72	-19.05	-28.71

AVERAGE SP	1.63	1.72	1.83	1.76
AVERAGE WINNING SP	1.39	1.50	1.46	1.85
PLACES	338	212	228	53
% PLACES	71.91	59.05	67.66	40.15
TOTE RETURN	99.5	77.5	89.2	49.2
LOSING BETS	132	147	109	79
PROFIT OR LOSS	-32.5	-69.5	-19.8	-29.8
% P OR L	-6.91	-19.36	-5.88	-22.58

Table 3.20 Analysis of favourites by class of race

ANALYSIS OF FAVOURITES BY CLASS			
	A DIVISION	CLASSIC	JUVENILE
RACES	100	54	151
WINNERS	44	24	75
% WINNERS	44.00	44.44	49.67
TOTE RETURN	56	27.6	85.6
BOOKIE RETURN	55.62	25.49	94.29
LOSING BETS	56	30	76
PROFIT OR LOSS	0	-2.4	9.6
% P OR L	0.00	-4.44	6.36
AVERAGE SP	1.45	1.24	1.46
AVERAGE WINNING SP	1.27	1.15	1.14
PLACES	75	45	116

% PLACES	75.00	83.33	76.82
TOTE RETURN	24.5	12.9	29.6
LOSING BETS	25	9	35
PROFIT OR LOSS	-0.5	3.9	-5.4
% P OR L	-0.50	7.22	-3.58

Table 3.20 Analysis of favourites by class of race

Analysis of favourites by field size, (table 3.21) shows results that were not expected. The winning percentage increases with increasing field size. This, together with the increasing average SP of favourites with increasing field size, leads to a profit of 2.52% by backing favourites in large fields. Similar results are obtained for place betting, and a small profit is made betting on favourites for a place in large fields.

ANALYSIS OF FAVOURITES BY FIELD SIZE			
	4 - 9	10 - 14	15 - 20
RACES	533	808	262
WINNERS	173	295	100
% WINNERS	32.46	36.51	38.17
TOTE RETURN	182.7	442	168.6
BOOKIE RETURN	191.86	439.02	166.74
LOSING BETS	360	513	162
PROFIT OR LOSS	-177.3	-71	6.6
% P OR L	-33.26	-8.79	2.52
AVERAGE SP	1.45	1.71	1.95
AVERAGE WINNING SP	1.06	1.50	1.69

PLACES	354	521	192
% PLACES	66.42	64.48	73.28
TOTE RETURN	98.1	211.4	72.9
LOSING BETS	179	287	70
PROFIT OR LOSS	-80.9	-75.6	2.9
% P OR L	-15.18	-9.36	1.11

Table 3.21 Analysis of favourites by field size

The following are categories where profit was made; (since a loss was not made in A Division races, its results are included here)

Win Betting Category	Profit
Race Number One	2.54%
Class A Division	0.00%
Class Juvenile	6.36%
Field Size 15-20	2.52%

Place Betting Category	Profit
Odds $<$ 1/1	0.88%
Race Number Six	5.43%
Race Number Nine	3.57%
Class Classic	7.22%
Field Size 15-20	1.11%

The above profits suggested further investigation. In addition, the two areas where profit was shown possible in Kreel, (1988) namely Maiden favourites at 2/1 or better, as well as Juvenile favourites at less than 1/1 were also considered for further investigation. The results are shown in Table 3.23.

Table 3.22 Reproduced from Kreel (1988)

CLASS OF RACE

	Maiden	Progress	B Div	A Div	2-7-0	Overall
						*
Races	231	202	85	76	98	692
Favourites Winning	92	76	29	26	40	263
% Favourites Winning	39.83%	37.63%	34.12%	34.21%	40.81%	38.00%
Return on FW	144.42	102.50	52.10	35.30	47.04	381.36
Tax	14.44	10.25	5.21	3.53	4.70	38.14
Net Return	129.98	92.25	46.89	31.77	42.34	343.22
Losing Bets	139	126	56	50	58	429
Profit or Loss	-9.02	-33.75	-9.11	-18.23	-15.66	-85.77
% P or L on turnover	-3.90%	-16.71%	-10.72%	-23.99%	-15.98%	-12.36%

ANALYSIS OF FAVOURITES BY TWO FACTORS				
	1	2	3	4
RACES	31	201	133	44
WINNERS	16	91	39	26
% WINNERS	51.61	45.27	29.32	59.09
TOTE RETURN	27.3	116.1	92.1	17.3
BOOKIE RETURN	26.50	128.00	96.60	15.50
LOSING BETS	15	110	94	18
PROFIT OR LOSS	12.3	6.1	-1.9	-0.7
% P OR L	39.68	3.03	-1.43	-1.59
AVERAGE SP	2.02	1.58	2.56	0.61
AVERAGE WINNING SP	1.71	1.28	2.36	0.67
PLACES	22	148	90	35
% PLACES	70.97	73.63	67.67	79.55
TOTE RETURN	7.7	42	39.2	8.4
LOSING BETS	9	53	43	9
PROFIT OR LOSS	-1.3	-11	-3.8	-0.6
% P OR L	-4.19	-5.47	-2.86	-1.36

Table 3.23 Analysis of favourites by two factors

Categories:

1) = Class Juvenile, Field Size 15-20

2) = Race Number One, Field Size 15-20

3) = Class Maiden, Odds > 2/1

4) Class Juvenile, Odds < 1/1

The analysis shows a substantial profit is made through backing Juvenile favourites in large fields. The number of races that had such favourites, was however small at only 31. This result is significant at the 1% level of significance. Betting on favourites in race number one in large fields also yielded a profit of just over 3%, which is significant at the 10% level.

An analysis of Juvenile favourites in race one was not made, because over 90% of the time, race one was a Juvenile event. Further analysis of A Division races was not pursued as splitting this category further, resulted in very small numbers of races. Analysis was made of two categories which yielded profits in a previous investigation. Unfortunately both of these categories now yielded small loses. Neither of these losses were statistically different from a 0% return at the 5% level of significance.

Further examination of returns to place betting was not carried out. The two race numbers which yielded profit, appeared to have no logical basis and were discounted as anomolies. Combining any of the other three categories and subdividing the data, resulted in the number of races becoming too small too use.

An interesting test of weak efficiency which also has implications for strong efficiency, is an examination of the ratio of win payoffs to place payoffs, approximately 30 minutes before the off of the race. This is when the odds are publicly displayed by the tote for the first time. About 10% to 20% of the final pools have been bet at that time. Our hypothesis is that win betting, prior to the display of the odds, is more indicative of winning probabilities than place betting. The data used were collected by hand from the tote display board at the racetrack, and included 59 races and 678 horses. Ratios of win to place payoffs were calculated and split somewhat arbitrarily into 2 categories, namely where the ratio was between 0.5 and 1.999, and where the ratio was greater than or equal to 2. The results are shown in Table 3.24. They may be interpreted as supporting our hypothesis. Owing to the limited data, no examination of returns was made.

VARIABLE: WIN/PLACE RATIO

OBSERVED TABLE

CATEGORY	FINISHING POSITION 1	2	3	UNPLACED	TOTAL
0.5 - 1.999	24	22	24	115	185
2 upwards	35	37	35	386	493
TOTAL	59	59	59	501	678

EXPECTED TABLE

	FINISHING POSITION 1	2	3	UNPLACED	TOTAL
0.5 - 1.999	16.10	16.10	16.10	136.70	185
2 upwards	42.90	42.90	42.90	364.30	493
TOTAL	59	59	59	501	678

DEGREES OF FREEDOM = 3

TEST STATISTIC = 18.38

CHI-SQUARE (5%) = 7.81
CHI-SQUARE (0.5%) = 17.73

CONCLUSION: SIZE OF WIN/PLACE RATIO AND PROBABILITY OF PLACING ARE HIGHLY CORRELATED.

Table 3.24 Chi-Square test of association between the ratio of the win to place odds at the opening of betting, and the probability of winning

3.2 Semi-Strong Efficiency

The purpose of all tests of semi-strong efficiency is to attempt to detect areas of the betting market, which may be exploited for profit, using subjective publicly available information. Before any tests are done, it is proposed that this is the area of information that is least likely to yield any opportunity for profit. The reason for this is that such information is the starting point of any public investigation into systematic betting techniques. The prospective punter would first ask himself, " How good is the information provided by this tipster? " rather than, " What is the true probability of, a horse at odds of 2/1, winning? " which is a question relating to weak efficiency.

In respect of weak efficiency and semi-strong efficiency, the betting market and the stock market present the opportunity to examine the opposite approaches taken by investors in these markets. In the betting market, fundamental information, such as tips offered by tipsters, (assuming such tips to be an assimilation of the majority of publicly available fundamental information) is more easily understood, analysed and acted upon than elementary technical information, such as the percentage of horses at odds of 2/1 that have won in the last year (say).

This scenario is the opposite of that existing in the stock market, where it is easier to understand and act upon technical buy/sell information, such as an observation that the previous days volume traded in a particular share was 5 times greater than an average of the past 3 weeks trade in that share, than it is to interpret and act upon stockbrokers reports on companies. Bottom line advice (tips) are given along with detailed analysis of companies, and this is obviously easy to understand, but it is still far more difficult to quantify in investment terms than a tip on a horserace. Note also that experts on the stock market often base their advice on technical information whereas in the betting market this is not the case.

In some sense, therefore, publicly available information offered by experts in the betting market is equivalent to the technical (price/volume etc.) information available in the stock market, since they may both be the starting point for investment decisions within their particular markets. Given this and the above comments, as well as the fact that much research has shown stock markets to be weakly efficient, it is highly likely that the betting market is semi-strongly efficient. Even if inefficiencies could be detected, it is unlikely that they could be exploited because of the easy access of the information that would be used for such exploitation.

We start with an analysis of newspaper tipsters. Of all the information available to the public, that obtained from the newspaper is the cheapest, most easily accessible and possibly the easiest to understand. Research has shown that the most read page of a newspaper is its racing page. How do these newspaper tipsters perform relative to a random betting system, and a system that simply bets on the favourite in each race? Is the market efficient with respect to the tips contained in the various newspapers racing pages?

These questions can be answered after some simple (but tedious) analysis of the tipsters selections and the race results. The data used were the tips contained in the racing pages of the Argus and the Cape Times. The Cape Argus tipsters were Derek Wilsnagh, Graham Potter and Barry Hopwood, while the Cape Times tipsters wrote under the pen names Pioneer, Intuition, Recondite and Sceptre. The newspaper pages (which were used for various purposes) were collected from 17 December 1990 until 8 December 1991.

Every first selection of each tipster was noted and a R1 win bet was placed on all such selections. It was then noted whether the horse won or not. If a horse tipped did win, the bookmaker odds at the end of the betting period as reflected in the Computaform results, were used to calculate the return to the tipster. These odds are the official SP's. The results are shown in Table 3.25. Note that because each tipster did not give selections every week, the number of selections differs between tipsters.

	NEWSPAPER TIPSTERS			
CAPE TIMES				
	PIONEER	INTUITION	RECONDITE	SCEPTRE
RACES	718	679	583	745
WINNERS	231	203	172	196
% WINNERS	32.17	29.90	29.50	26.31
RETURN	318.4	288.5	249.8	323.9
LOSING BETS	487	476	411	549
PROFIT OR LOSS	-168.6	-187.5	-161.2	-225.1
% P OR L	-23.48	-27.61	-27.65	-30.21
CAPE ARGUS				
	WILSNAGH	POTTER	HOPWOOD	
RACES	511	429	466	
WINNERS	182	147	145	
% WINNERS	35.62	34.27	31.12	
RETURN	216	178	197.3	
LOSING BETS	329	282	321	

PROFIT OR (LOSS)	-113	-104	-123.7	
% P OR (L)	-22.11	-24.24	-26.55	

Table 3.25 Returns and winning percentages of newspaper tipsters

Notably, none of the tipsters show a profit using the system of betting a level stake on their first selections for a win. In addition, all the tipsters showed significantly (at 5% or stricter) larger losses than the expected loss of 18%, which being the take out from the win pool, results from random betting. The Cape Argus tipsters seem to perform consistently better than those of the Cape Times. Analysis of betting on the favourite in each race, shows that such a system yields a loss of only 15%. The results obtained here are similar to those of industry surveys as well as other local academic literature. The results of a similar analysis done by Lipshitz (1986) show losses, resulting from betting R1 on all newspaper tips, of between 15% and 30%. A tipsters competition in a magazine called Racing Digest, show the losses incurred by each tipster range from 15% to 50% over a similar period.

The other sources of subjective racing information are the Computaform, Winning Form and the official Race Card. It is not the job of the Race Card to offer subjective information, but rather to inform the public of the program on offer for the day. None the less, a short comment is given on the expected performance of each horse, and a selection as to the winner and placed horses is also made. The business of the other two publications is to offer subjective information so that it can be used for profitable ends.

The Race Card is about twice as expensive as a newspaper, while the other publications are approximately twice as expensive as the Race Card. The Computaform offers two first selections, one being called the Compataform selection, and the other called the speed rating selection. An analysis identical to that used for the newspapers was used for the two Computaform tips, the Winning Form selection and the Race Card selection. Computaform and Winning Form data was examined from 2 June 1990 until 23 November 1991. The Race Card was examined over the same period as the newspapers.

The results are shown in Table 3.26.

TIPPING GUIDES				
	COMPUTAFORM	SPEED RATING	WINNING FORM	RACE CARD
RACES	916	910	1035	723
WINNERS	294	206	252	193
% WINNERS	32.10	22.64	24.35	26.69
RETURN	319.7	274.5	509.2	301.1
LOSING BETS	622	704	783	530
PROFIT OR LOSS	-302.3	-429.5	-273.8	-228.9
% P OR L	-33.00	-47.20	-26.45	-31.66

Table 3.26 Returns and winning percentages of tipping guide tips

Again we note that none of the tipping guides offer a profit to a bettor backing each of their selections with a level stake. The difference between their returns and the average expected return is significant at the 1% level. These publications in fact perform more poorly than the newspapers. Why should the more expensive, supposedly more knowledgeable publications fair worse than the newpapers, and in turn, why should the newspaper tipsters, who are full time journalists, perform worse than the public?

Firstly, the tipping guides are published 3 or 4 days prior to any race meeting. Thus their selections are made earlier than the newspapers (24 hours prior) and the public, who make final decisions minutes prior to individual races. The advantage the public has over the tipsters is that they can observe the weather conditions, the condition of the horses and the betting market which may reflect inside information. Such inside information is usually only released into the market in the last minutes of the betting period.

The second problem is that the tipsters are forced to make a selection regarding every horserace, whereas they might only bet on 1 or 2 horses at any meeting. Bettors, of course, bet only when they want to. The Computaform publish a best bet for the day based on the Computaform rating as well as a best bet based on speed rating. If they believe that their is nothing worth betting on, they state that there is no best bet for the day. Examining such tips is certainly a more suitable test of semi-strong efficiency. Winning Form publish four best bets for any meeting, regardless of how many races are on the card. They seem to force a second selection, i.e. choosing the most likely winners from the tips already given. Examining such bets still yields a more suitable test of semi-strong efficiency than those already performed. Such tips were examined over the same period as before, for each publication, and the results are shown in Table 3.27.

TIPPING GUIDES BEST BETS			
	COMPUTAFORM	SPEED RATING	WINNING FORM
RACES	118	115	510
WINNERS	51	39	128
% WINNERS	43.22	33.91	25.10
RETURN	52.3	51.9	247.2
LOSING BETS	67	76	382
PROFIT OR LOSS	-14.7	-24.1	-134.8
% P OR L	-12.46	-20.96	-26.43

Table 3.27 returns and winning percentages of best bet tips of the tipping guides

Firstly, note that the Computaform data set here is relatively small, so the results must be interpreted with some caution. The t-test on this data set shows a significant difference at the 5% level, which suggests that the Computaform Best Bet selections perform better than a random betting system. Profit is still not possible and therefore the market is efficient with respect to subjective public information. The Winning Form best bets perform almost as poorly as the Winning Form selections, probably because of the compulsory nature of announcing their best bets as well as the fact that they publish four best bets instead of just one. The difference in return to these bets is significantly (1% level) different from the average.

Figlewski noted that subjective information (i.e tips from newspapers or tipping guides) could not be used to enhance the accuracy of the odds as a predictor of race results. We have shown similar results with respect to our local betting market and publicly available subjective information. This confirms Figlewski's observation that in a market where pricing is taking place, the determined price will include the market participants views of subjective information efficiently. This means that no profit can be made by using tipsters' selections.

3.3 Strong Efficiency

The importance of strongly efficient markets is well documented and has been discussed in length earlier in this work. The advantage that this work has over previous research is that actual bookmaker data was used as opposed to the usual average bookmaker prices that abound in other studies. Before proceeding to the test using bookmaker data, a test was performed using tote data, although this data source was very limited. The data consisted of tote odds 30 minutes before the off of the race as well as the final tote odds for each runner. The data incorporated 59 races and 650 horses.

The ratio of final odds to opening odds was calculated for all runners. The data was then divided into one of three categories depending on this ratio. Category 1 includes horses that were backed (ratio = 0.5 to 0.999), category 2 horses that drifted (ratio = 1 to 1.999) and category 3 horses that drifted a lot (ratio = 2 to 9). The results are shown in Table 3.28.

Examination of table 3.28 reveals a significant relationship between finishing position and ratio category. In overall terms we see that more horses were placed than expected,

VARIABLE: WIN/OPEN RATIO

OBSERVED TABLE

CATEGORY	FINISHING POSITION 1	2	3	UNPLACED	TOTAL
0.5 - 0.999	23	35	32	197	287
1 - 1.999	32	13	17	184	246
2 - 9	4	11	9	93	117
TOTAL	59	59	58	474	650

EXPECTED TABLE

CATEGORY	FINISHING POSITION 1	2	3	UNPLACED	TOTAL
0.5 - 0.999	26.05	26.05	25.61	209.29	287
1 - 1.999	22.33	22.33	21.95	179.39	246
2 - 9	10.62	10.62	10.44	85.32	117
TOTAL	59	59	58	474	650

DEGREES OF FREEDOM = 6

TEST STATISTIC = 20.10

CHI-SQUARE (5%) = 12.59
CHI-SQUARE (0.5%) = 18.85

CONCLUSION: SIZE OF WIN/OPEN RATIO AND PROBABILITY OF PLACING ARE HIGHLY CORRELATED.

Table 3.28 Chi-Square test of association between the ratio of the final odds to the opening odds, and the probability of winning when these horses were backed, whereas more horses were unplaced then expected when such horses drifted a lot in the betting. This evidence is clearly not conclusive in any direction owing to the small numbers used.

The main test of strong efficiency is conducted along the lines of the tests of Bird and McCrae (1987). As pointed out, their tests suffered from the problem of using average prices instead of actual bets laid. This problem was solved for this work by obtaining a bookmaker's actual betting sheets. The bookmaker's clerk records all bets for a particular race, horse by horse using columns on the page. More often than not it was found that only 25% to 50% of the field attracted any bets at all, while usually only 4 or 5 runners (at most) in any race attracted any significant support. Significant support is a somewhat arbitrary term, but for the purposes of this work, we define it to mean either, that in excess of R1 000, or more than 10 individual bets were placed on the horse considered. Only horses attracting such support were investigated further.

This eliminated the problem of apparent large drifts in the odds. For example, the Computaform may report the opening betting on a horse to be 3/1, and its closing odds to be 10/1. On examination of the bookmaker's betting sheet, however, horses with such patterns inevitably showed no betting activity. In addition it may be found that if there was any betting activity, it first occured at 7/1 and then later at 10/1. This is an example of a horse drifting in the betting, but not to the extent that would be assumed from the Computaform data.

The data covered 1 442 races from 2 Aug 1989 to 28 December 1991 and included 16 852 horses. Each betting sheet was examined and horses to be included for further investigation were determined by the criterion regarding significant betting activity described above. Horses were then grouped according to the change in probability from their first recorded odds to their final recorded odds. A filter test identical to that of Bird was performed. The results shown in Table 3.29 should be compared with Table 2.10.

Filter	No. of bets	Bet at beginning	Bet at end
+0.025	1260	+12.20%	-8.18%
+0.05	541	+19.67%	-4.52%
+0.075	233	+28.57%	+5.71%
+0.1	153	+32.01%	+8.24%
+0.125	61	+28.11%	+7.44%
+0.15	12	-33.33%	-50.00%
-0.025	844	-35.83%	-19.35%
-0.05	256	-48.70%	-26.99%
-0.075	120	-49.74%	-25.04%
-0.1	45	-73.39%	-56.17%
-0.125	16	-48.45%	-42.43%
-0.15	4	-100.0%	-100.0%

Table 3.29 Rates of return from placing R1 on all horses satisfying a filter requirement.

Note that the positive returns for the filters +0.025, +0.05,+0.075, and +0.1 are significant at the 5% level of significance. This certainly indicates profitable betting opportunities for those who know which horses to bet on at the start of the betting period. The profit is greatly reduced for those following horses that have their odds cut during the betting period. In fact a loss results if the cut in odds from the opening bet was not large enough. If we assume that the bookmakers know at least as much as the punters in terms of available information, and can assess such information as well as punters, then the change in the original bookmaker odds must be owing to private information which is not widely available. The above returns are certainly indicative of private information which was not available to bookmakers when they initially set the odds on their boards. The negative aspects of such a conclusion have been discussed earlier.

The interpretation of the negative filters is more difficult. Since we know that bookmakers are generally conservative in their initial pricing of all horses, we would expect some negative movements in the horses probabilities of winning. The horses considered here, however, are all backed to some significant extent. We must therefore conclude that the private information held in respect of such horses is somehow imparted to the bookmakers during the betting period and they are therefore prepared to lay such horses at lengthening odds. The information may not be overt, but maybe indirectly signalled to bookmakers via betting patterns on other runners.

One further test was carried out using the idea of a control group obtained from Bird's paper. This is a check to see if a group of horses at similar prices that don't have a decreasing price history, will perform differently to the group of horses whose odds have decreased during the betting period. Only betting at the end of the period was considered. The results shown in Table 3.30 should be compared with table 2.11.

Filter	No. of bets	Filter Strategy	Control Group
+0.025	1260	-8.18%	-17.77%
+0.05	541	-4.52%	-10.54%
+0.075	233	+5.71%	-19.14%
+0.1	153	+8.24%	-20.41%
+0.125	61	+7.44%	-35.35%
+0.15	12	-50.00%	-80.00%
-0.025	844	-19.35%	-23.66%
-0.05	256	-26.99%	-22.97%
-0.075	120	-25.04%	-14.55%
-0.1	45	-56.17%	-30.50%
-0.125	16	-42.43%	-44.29%
-0.15	4	-100.0%	-100.0%

Table 3.30 Rates of return from placing R1 at final odds on horses that satisfy a filter strategy and horses designated to a control group.

The control group performance should in general, not be far from the average loss which results from betting at random of 18%. Significant differences (at the 5% level where a t-test is appropriate) were detected between the positive filter strategies and the control group in all instances. This evidence again suggests the existence of private information which is not impounded in the odds on offer at the commencement of betting. It should be noted here that the inefficiencies exhibited here are more than likely contributing to the decline of racing in general at the Cape.

3.4 Bettor Consistency

The examination of bettor consistency in the win and double pools will consider possible payoffs to the double and equivalent parlay rather than the probabilities involved. Implicit in using this approach is the assumption that bettors are reasonably consistent in their estimates of winning probabilities from pool to pool. This was discussed in more detail in section 2.3.4. The test is thus based on that of Ali (1979). Ali's test is not directly applicable because of the dividend structure of the local double bet. Eighty percent of the available pool is divided among ticket holders naming the winners of both races, while ten percent each is divided among those naming a winner and a second placing. The test of consistency is thus to examine the differences;

$$X = 0.8 \times D - (1 + a_i) \times (1 + b_j)$$

where a_i = odds of horse i of leg 1 of double

b_j = odds of horse j of leg 2 of double

D = possible return of the double

P = $(1+a_i)*(1+b_j)$ = return to the parlay.

This clearly ignores any benefit, gained by bettors of the double, relating to consolation payoffs as described above. Note that a, b, and D are determined from distinctly different betting pools and hence D and P are separately market determined. The data involved 5 054 double observations. Estimates of the mean and variance of the difference between double and parlay were computed. The mean difference for the sample was 16.40 while the standard error of the mean was calculated as 4.31. The difference is significant at the 1% level (two sided alternative). This means that the return to the double is significantly more than that to the equivalent parlay.

The difference is simply explained by the fact that the parlay involves two separate charges whereas the double involves only one charge. Adding back the extra charge of 18%, applied to the win pool, to the parlay yields different results. The mean difference is now only 6.07 while the standard error of the mean is 5.80. The computed Z statistic is 1.04 and indicates that there is no significant difference between the two returns. This result simply explains the differences that in reality do exist. The conclusion is that bettors are inconsistent in their pricing of the two bets. This observation does not imply inefficiency of the market. The results here imply that if a bettor bets on both winners in the races comprising the double, he would do better by betting the double instead.

The test of bettor consistency relating to swinger and place betting is based on the probabilities involved in each bet. As with the double and win pools, the swinger and place pools are separate. The test is based on the following difference for each possible swinger combination in the race;

$$X_{ij} = S_{ij} - P_i P_j$$

where S_{ij} = the probability of winning a swinger involving horses i and j

and P_i = the probability of horse i placing.

Both these probabilities are publicly determined. Note that not only winning combinations are used, but all possible combinations for a particular race.

The data used were from 100 races and included 4 668 possible swinger payoffs. Place probabilities were calculated as 1/(place payoff), while swinger probabilities were calculated as 1/(swinger payoff). In order to win a swinger it is necessary for both selected horses to finish in a place (first 3). Therefore equivalent swinger probabilities can be calculated by multiplying the place probabilities of any two horses. Thus the term $P_i P_j$ represents the equivalent swinger winning probability, derived by using estimates of place probabilities from the place pool.

The average difference in equivalent swinger probabilities and actual swinger probabilities was 0.088, with a variance in the difference of 0.0088. The standard error of the mean was 0.0046 and the computed z value was 19.20 which is highly significant. The reason for the difference cannot be explained by additional charges in the swinger pool as these are the same as in the place pool. The difference can possibly be explained by noting that the swinger involves betting for a place on 2 horses in the same race whereas place betting involves betting on only one horse.

Analysis was made of returns to win and trifecta bets at different racing centres, but on the same races. We are looking for a significant difference in return to these bets. Our hypothesis prior to investigation was that returns should be lower in the centre where the event is actually being held, the information relevant to the race being more easily available there. This hypothesis can be tested even if we only have data on winning bets, and not all bets, as we have had for some of the above tests. This is indeed the case for this test.

Data were collected as follows. The win and trifecta payouts for races in the Transvaal and Natal were collected and these were regarded as the "home" payouts, as they were the payouts from courses in their particular centres. In addition the Cape payouts on these bets were collected and designated the "away" payouts. The data were subdivided by size of the payout. In the case of win bets the two categories were as follows; (i) either "home" or "away" payout being less than R4.00, or (ii) similarly, below R10.00 but greater than R4.00. Payouts greater than R10.00 were ignored. The categories for the trifecta were similar, but the cut off values were R100 and R1000 respectively, higher payouts again being ignored.

One hundred payouts for each bet and centre were collected randomly. The results are as follows.

Win Bets (payouts < R4)

Centre	Cape (Away)	Natal (Home)
mean	2.60	2.26
std. dev.	0.217	0.160

Centre	Cape (Away)	T'vaal (Home)
mean	2.37	2.26
std. dev.	0.380	0.321

Win Bets (R4 <= payouts < R10)

Centre	Cape (Away)	Natal (Home)
mean	5.34	5.15
std. dev.	2.774	1.746

Centre	Cape (Away)	T'vaal (Home)
mean	4.81	4.53
std. dev.	2.504	1.630

Trifecta Bets (payouts < R100)

Centre	Cape (Away)	Natal (Home)
mean	57.2	56.3
std. dev.	26.3	24.2

Centre	Cape (Away)	T'vaal (Home)
mean	51.8	55.6
std. dev.	23.0	25.9

Trifecta Bets (R100 <= payouts < R1000)

Centre	Cape (Away)	Natal (Home)
mean	435.2	359.3
std. dev.	334.5	249.9

Centre	Cape (Away)	T'vaal (Home)
mean	425.2	402.5
std. dev.	298.4	228.2

The hypothesis was strongly supported against a two sided alternative, for win bets in the short odds (< R4) category in both Transvaal and Natal. The interpretation is that for these short priced favourites, the information relating to their true probability of winning is not as well impounded in the "away" odds as in the home odds. This is what we had expected on logical grounds. Both differences were significant at the 1% level. The only other category to show a significant difference, but here only at the 10% level, was that of trifecta bets paying between R100 and R1000 for Natal races. This can be similarly explained by the above line of reasoning.

The papers of Tuckwell (1981) and Hausch et al. (1981) investigated the inconsistencies of bettors forming the win and place pools. Both indicated that systematic profit was possible implying not only an inconsistent market but an inefficient one as well. The findings of both studies were similar despite the difference in gambling law applicable in the two countries of investigation. Tuckwell is based in Australia while Hausch used United States data. In addition to the tote, Australia also has legal bookmaking, so their situation is much like that of South Africa.

Although the hypothesis, (market efficient or not) was the same in both papers, the methodology differed somewhat. In our work, we follow both approaches to testing the efficiency of the local market. Our results shown in Table 3.31 should be compared with those reproduced from Tuckwell, which are shown in Table 3.32. Our results were obtained in an identical manner to those of Tuckwell.

The data consisted of 2 534 horses for which place probabilities were estimated. These probabilities were then subdivided into ten different ranges and the average probability of placing within each range was compared with the proportion of horses running a place. This was done for all horses within each probability range and also for two classes, (1) where the odds-equivalent of the predicted place probability was exceeded by the place odds on the tote, implying a positive expected return, and (2) where the odds-equivalent of the estimated place probability exceeded the tote place odds and the expected return was negative.

Range of Estimated Place Probability		Positive Expected Return	Negative Expected Return	Combined
0.0 and under 0.03	x	n/a	0.0201	0.0201
	y	n/a	0.0368	0.0368
	n	0	244	244
0.03 and under 0.05	x	0.0427	0.0397	0.0397
	y	0	0.0406	0.0399
	n	4	246	250
0.05 and under 0.08	x	0.0630	0.0641 **	0.0640 **
	y	0	0.1319	0.1280
	n	7	235	242
0.08 and under 0.013	x	0.1016	0.1041 **	0.1040 **
	y	0	0.2000	0.1949
	n	7	270	277
0.013 and under 0.2	x	0.1781 *	0.1634 **	0.1641 **
	y	0.3125	0.1909	0.1973
	n	16	288	304

Range of Estimated Place Probability		Positive Expected Return	Negative Expected Return	Combined
0.2 and under 0.3	x	0.2563	0.2474	0.2481
	y	0.2307	0.2571	0.2548
	n	26	280	306
0.3 and under 0.4	x	0.3544	0.3467 *	0.3477 *
	y	0.3226	0.3184	0.3189
	n	31	201	232
0.4 and under 0.6	x	0.5075 **	0.4871	0.4925
	y	0.5744	0.4513	0.4842
	n	94	257	351
0.6 and under 0.8	x	0.7005	0.6659	0.6843
	y	0.7096	0.6788	0.6951
	n	124	109	233
0.8 and under 1.0	x	0.8649 **	0.8879	0.8271 **
	y	0.7846	0.8666	0.8104
	n	65	30	95

Table 3.31 Comparison of estimated place probabilities with actual proportion placing

x = average estimated place probability in range

y = proportion of horses actually running a place

n = number of horses in sample

** = significant at 5% or lower

* = significant at 10%

The hypothesis being tested is for a difference between actual and average estimated place probabilities. The range of probabilities refers to those place probabilities as estimated from the win probabilities.

As can be seen, the results differ in some categories and are quite congruent in others.

Profit is theoretically possible in all categories where the the observed proportion of horses running a place is significantly higher than the average place probability estimated from the win probabilities.

Comparison of estimated place probabilities with proportion placing

Range of estimated place probability		Positive expected return	Negative expected return	All
0·0 and under 0·03	x	0·019	0·017	0·017
	y	0·0	0·025(0·006)	0·025(0·005)
	n	30	829	859
0·03 and under 0·05	x	0·042	0·039	0·040
	y	0·087(0·059)	0·054(0·015)	0·057(0·014)
	n	23	239	262
0·05 and under 0·08	x	0·066	0·064*	0·064*
	y	0·136(0·073)	0·108(0·017)	0·110(0·017)
	n	22	324	346
0·08 and under 0·13	x	0·100	0·102	0·102
	y	0·114(0·048)	0·127(0·018)	0·125(0·017)
	n	44	355	399
0·13 and under 0·20	x	0·165	0·163	0·163
	y	0·181(0·045)	0·191(0·020)	0·190(0·018)
	n	72	397	469
0·20 and under 0·30	x	0·240	0·248	0·248
	y	0·231(0·044)	0·291(0·025)	0·278(0·022)
	n	91	323	414
0·30 and under 0·40	x	0·352	0·343	0·346
	y	0·337(0·046)	0·360(0·034)	0·352(0·027)
	n	104	200	304
0·40 and under 0·60	x	0·497	0·484	0·492
	y	0·438(0·032)	0·456(0·033)	0·447(0·024)
	n	235	226	461
0·60 and under 0·80	x	0·698*	0·667*	0·690*
	y	0·604(0·037)	0·452(0·063)	0·564(0·032)
	n	174	62	236
0·80 and under 1·00	x	0·888	0·867	0·884
	y	0·873(0·037)	0·750(0·097)	0·849(0·036)
	n	79	20	99

x = average estimated place probability in range
y = proportion of horses running a place (standard errors in parentheses)
n = number of horses
* denotes a significant difference at the 5 per cent level

Table 3.32 reproduced from Tuckwell (1981)

As mentioned above, Hausch's method was slightly different from that of Tuckwell. The estimates of the place probabilities were made in the same way and these were then used to calculate an expected return for each $1 bet on the particular horse. The formula used to calculate the expected return, EX_l, is more complicated for the American bettors because the return to successful show (first three) bettors on horse i depends on which horses finish with i in the first three positions. In South Africa the pool is divided equally among the three (or sometimes four) horses that finish in the places and therefore the return to successful bettors of horse i for a place can be determined at the start of the race rather than after it has been run.

The formula for the expected return in the South African context is,

$$EX_l = [\frac{1}{10} \times INTG(\frac{Q \times (P+1)}{3 \times (P_l+1)} \times 10)] \times R_l$$

where Q = (1 - the track take) = 0.82 for South Africa

P = the place pool in rands

P_l = the amount in rands bet on horse l to place

R_l = the probability that horse l places derived from the win probabilities.

If there are 14 or more horses in a race, the 3 is replaced by a 4 in the formula. An adjustment is made in order to allow for the rounding down of all dividends to the lower ten cents. The same data sample as used for the tests relating to Tuckwell's paper was used here. For each horse the expected return from a R1 bet was calculated. The expected returns ranged from about 2.5, implying an expected profit of 150% to about 0.4, suggesting an expected loss of around 60%. A theoretical R1 bet was placed on horses having an expected return of 0.8 or more, and the results were tabulated after being split by ranges of expected return. The following results in Table 3.33 be compared with the results of Hausch's original investigation which are shown in Table 2.14.

$\alpha > 1$

α	Number of Bets	Return	Profit	% Profit
1.04	68	68.1	0.1	0.1
1.08	72	78.5	6.5	9.0
1.12	47	47.4	0.4	0.8
1.16	45	43.4	-1.6	-3.5
1.20	18	16.3	-1.7	-9.4
1.25	31	33.0	2.0	6.4
1.30	27	34.6	7.6	28.1
1.50	35	36.9	1.9	5.4
2.00	19	40.0	21.0	110.5
2.00+	9	29.2	20.2	224.4

$\alpha < 1$

α	Number of Bets	Return	Profit	% Profit
0.95	113	96.2	-16.8	-14.8
0.90	136	117.3	-18.7	-13.7
0.85	148	128.6	-19.4	-13.1
0.80	115	104.9	-10.1	-8.80

Table 2.33 Results of betting R1 to place on horses with a theoretical expected return of at least α.

As is evident from the above table, profit is certainly possible as long as the expected return is high enough, (greater than 1.2, say). The cutoff point for bets in Hausch's paper was 1.2, a figure which our results also suggest as a value of EX, above which we should bet. As has been noted already, the inputs required to calculate EX, are not available until the race is already being run and no further betting is allowed. In order to make the system operational, it is therefore necessary to use information available just before the off of the race, and to be able to process it very quickly, in order to place a bet.

The method used by Hausch was followed here. It was noted that a requirement for a bet under the system conditions implied that the horse in question would have attracted a larger proportion of the win pool than the place pool. The variable $(w_i/W) / (p_i/P)$ was constructed for all horses. Here w_i is the amount bet on horse i to win, W is the total win pool, p_i is the amount bet on horse i for a place, and P is the total place pool. These values were calculated using the final odds on offer. To make the system operational, the values used will have to be those available with approximately two minutes to the off of the race.

The above variable was used as the independent variable, to predict the variation in the dependent variable EX. The results of the regression analysis are shown here. The coefficient of the variable, (here called B) is positive and significant. The value of R^2

LS // Dependent Variable is ER
Date: 6-24-1993 / Time: 13:38
SMPL range: 1 - 2513
Number of observations: 2513

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	0.1995391	0.0048734	40.944536	0.000
B	0.6300575	0.0047808	131.78982	0.000

R-squared	0.873689	Mean of dependent var	0.707969
Adjusted R-squared	0.873639	S.D. of dependent var	0.419925
S.E. of regression	0.149272	Sum of squared resid	55.95050
Durbin-Watson stat	1.039161	F-statistic	17368.56
Log likelihood	1214.895		

Table 3.34 Regression results

is 0.873, which implies a good correlation between EX (here called ER) and B. Clearly EX cannot be calculated for all horses just prior to the off of the race as time is limited. EX is therefore estimated shortly before the off, for the horse that by inspection has the largest value of (w_i/W) / (p_i/P). If the value of EX is sufficiently large, then a bet is placed on the horse in question.

We tested our derived regression model in theory and in practice. Firstly we estimated EX using the odds on offer at the end of the betting period for a further 557 horses. In 31 of these cases EX was observed to be greater than 1.2 with a maximum of 1.84. The return from backing each of these horses would have been 40.8 or a profit on turnover of 31.6%. We then visited the track for 5 consecutive race meetings and applied the model to the odds on offer as displayed by the tote approximately 2 minutes before the off of the race. We actually placed bets on 18 horses (all in different races) whose value of EX was estimated to be greater than 1.2. The maximum value we estimated for EX was 1.50. The return to the 18 bets was 19.6, or a profit on turnover of 8.9%.

Back home, with the final odds available to us, we ran our model on these data (some 481 horses in 44 races). We now found that our estimated EX exceeded 1.2 for 31 horses, and betting on these yielded a profit of some 25.1% on turnover. The difference can generally be explained by the appearance in the second group (final odds), of horses whose EX values were just below 1.2, shortly before the off and greater than 1.2 at the end of betting. Evidently most of those horses did indeed place. However, there was one instance of a horse whose EX based on final odds was 1.47, and whose EX shortly prior to the off was unlikely to have been below 1.2. This horse also placed, and we can therefore ascribe some of the difference in returns between the two groups to an over pressurised experimenter.

CHAPTER FOUR

RATIONAL DECISION MODELS

"But I, with strange perversity, deliberately went on staking on red after noticing that it had turned up seven times running. I am sure vanity was half responsible for this; I wanted to astonish the spectators by taking senseless chances and - a strange sensation! - I clearly remember that even without any promptings of vanity I really was suddenly overcome by a terrible craving for risk."

Dostoyevsky - The Gambler

4.1 Introduction

This chapter concerns itself with the decision making process as observed under certain conditions. These conditions are those applicable to gamblers (decision makers) at the racetrack. For example, we note that the decision makers have chosen to be in their situation, which may be untrue for decision makers in other situations. We investigate the decision makers goals by examining their actual decisions at the track and also attempt to explain the process whereby such decisions were made. In other words, what do gamblers do once at the track, and why do they do it.

Gambling is the betting or staking of something of value, with consciousness of risk and hope of gain, on the outcome of a game or uncertain event, the result of which may be determined by chance, strategy or a combination of both. Many activities involve elements of risk and hope of gain, and may depend on the outcome of an uncertain event or events - business ventures, buying and selling stock and military strategies for example; indeed, participation in such enterprises is often referred to as gambling or taking a chance.

In the seventeenth century, Galileo and Pascal were approached by gamblers who had lost money at games of dice, and wanted to know why. Their investigations, among others, led to the theory of probability. Is it possible that a study of gamblers' behaviour, can lead to acceptable theories regarding utility and choice? One of the factors influencing decision making is surely, the reasons for being in such a decision making position in the first place; i.e. in our case, are decisions related to gambling affected by the reasons for gambling? Anthropologists have tried to discover whether or not gambling was distributed among the cultures of the world in systematic patterns that might reveal a general association between gambling and other cultural traits. The studies showed that no consistent association between gambling and characteristics of the economy, the system of wealth or the type of religion could be found.

A substantial problem in the way of deriving a model of human behaviour is the general lack of understanding of, and belief in, elementary probability theory. Theories of decision making have to assume some level of sophistication as far as people's knowledge of probability goes. This knowledge need not be conscious, as long as individuals act as if they have an understanding of probabilities. In the past people have been taught that everything happens for a reason and therefore that chance has no role. It is these traditional beliefs that hold people back from believing that any event on earth can occur purely by chance. The idea of purely random activity is basic to the comprehension of the relationship between chance and probability.

In this work we shall attempt to discover, using analysis of racetrack gamblers, the reasons that people take chances. Given that we are successful in this attempt, the next question becomes; are these findings regarding human behaviour transferrable to activities other than gambling on horse races? Such questions will not be the subject of this work but speculation, suggestions and possible direction for further research will be offered.

Decision making with reference to horseracing basically comes down to deciding which horse to bet on (if any) and how much to bet on it. Another decision would involve deciding on the type of bet to make (e.g. win or place). Decision analysis is concerned with quantifying the decision procedure and its consequences. By studying people making decisions in a natural environment we can gain some idea of human behaviour in certain situations. From these observations we can predict behaviour in similar situations and can offer advice on behaviour modification if our quantified model of the decision process indicates that optimal decisions are not being made.

Decision analysis thus involves the consideration of the goals of the decision maker, the alternative courses of action available, the risks and uncertainties relevant to such courses of action and the consequences of taking each course of action.In order to quantify the goals and consequences we shall need to assume some function which attributes value to such goals and outcomes for the decision maker. In the past an expected value approach was used, but did not cover decision making with regard to gambling and insurance. Thus utility theory was introduced to cope with problems which expected value theory could not explain. In gambling situations, utility functions, which assign utility values to monetary amounts, are often used to quantify the value of outcomes of an event to a decision maker.

Risk and uncertainty, where they occur in the decision making process, are quantified in terms of probability models. A model can give the likely value of a dependent variable for certain values of some independent variables and predetermined parameter values. Thus, quantification of the decision process involves the specification and estimation of probability models for unknown variables as well as utility (or other) functions which attach "value" to goals and outcomes. It is generally expressed in current literature that such models are inadequate to predict human behaviour, (assuming this to be the model's goal) and other approaches such as heuristic modelling are now finding favour with researchers.

A point on terminology that may cause confusion needs to be cleared up here. When referring to subjective probabilities in this section, we mean those probabilities which are derived from the actions of bettors (i.e. from the observed odds), and not from questioning bettors regarding their degree of belief in the probabilities of the outcomes of an event.

4.2 Literature Review

Since much of the analysis related to decision theory is connected to psychology, it is appropriate that we initially analyse the subject from the psychological point of view. An original paper that is referred to in some later works, is that of Preston and Baratta (1948). The ideas of value of outcome, and probability of outcome, are connected by the concept of mathematical expectation. This expectation is used to define "rational" human behaviour. It is observed that if the player of a game pays more than the mathematical expectation to play the game, he will lose systematically. This behaviour is called irrational, although it is further observed that people are in fact prepared to play such games.

Reasons for such irrational behaviour is considered. The parameters involved are i) the probability of winning, ii) the value of the prize, and iii) the price to play the game. The following options are suggested as to why people are prepared to play the game if the price is greater than the expected return. Firstly, people overstate the probability of winning. Secondly, they may overvalue the prize, and thirdly and similarly they may undervalue the price they have to pay.

In previous work, economists had proposed utility theory which essentially, at that time, stated that the objective scale of money differed from its subjective value. They therefore believed that irrational behaviour was owing to misjudgements regarding the monetary amounts involved. They gave no regard to the possibility that it may have been the probabilities that were being misjudged, (or any other factor for that matter). Peculiarly, this 1948 paper gave little space to the consideration of the subjective scale for money, but pursued instead a psychological scale of probabilities.

The experiments conducted had as their aim to show among other things, i) the existence in a game situation of a scale of psychological probability and its functional relationship to the scale of mathematical probability, and ii) the lack of existence in a game situation of scales of psychological prize value and price as distinct from the numerically defined prize values and prices. Two other interesting goals, were the attempt to determine the extent to which psychological probability was independent of formal experience with mathematical probability, and the determination of existence and location of a point of indifference in the scales of psychological and mathematical probability.

The results of the experiments revealed mathematical probabilities greater than psychological probabilities at very small mathematical probabilities, while the opposite was true for mathematical probabilities greater than about 0.25. This observation is consistent with the favourite longshot bias observed at the racetrack. The point of indifference occurred at about 0.2 on the mathematical scale. The observations were noted to be the same for those who possessed considerable knowledge of mathematical probability, (mathematicians, statisticians and psychologists) as for those who were relatively naive of the topic (students). Lack of consistency in the results forbade a clear-cut conclusion regarding the existence of a subjective scale of money, and further research was recommended.

Further research was indeed carried out by Ward Edwards, and the results published in a series of papers during 1953 and 1954. The first of his papers (Edwards 1953) builds on the experiments of Preston and Baratta. The question "how do people actually go about making decisions in gambling situations?" is posed. It is noted that experiments up to that point only dealt with a limited set of situations and much further research was needed to clarify such questions. Edwards defines the "objective model" of the decision making process as that which predicts the subject will choose the bet with the highest expected value. The problem of determining why people make decisions that violate the objective model, is tackled by requiring subjects to make decisions in circumstances in which the objective model is inapplicable. This situation arises when all choices (bets) offered to the subjects have equal expected values.

Eight possible bets were formulated for each of three levels of expected value, namely positive, zero and negative expected value. Each bet was paired with all others at the same EV level. Subjects were then asked to choose among the two bets, after which a pinball machine determined whether they won or lost on that particular bet. If subjects preferred bet A to B, B to C and C to A, the set of such preferences was called an" inconsistent triad". Kendall's "coefficient of consistency" showed that subjects were in general consistent in choosing among bets.

It was found that two factors contributed to decision making between bets of equal EV.

The first relates to the conditions of the gambling situation. If gambling for real money, subjects preferred long shots much more than if they played for fun. Thus the taking, or avoidance of big risks depended on the experimental conditions.The second factor affecting choices was existence of preferences for some probability levels over others. The analysis centred on the probabilities of winning or losing rather than the amounts of money won or lost. This was owing to the belief that monetary utility curves are not the best way of accounting for the results. The most important probability preferences were found to be a preference for the probability of winning 4/8, and an avoidance of the probability of winning 6/8.

Some important final comments are made in the paper. These are that if probability preferences do indeed exist, they present a serious stumbling block to the utility curves proposed by von Neumann and Morgenstern. Choices among bets can be only be used to determine such utility curves, if the probabilities entering the equations upon which the curves are calculated are the same as the probabilities used by the subjects when making their choices. If these objective and subjective probabilities differ, (specifically if subjects prefer some probabilities to others), the results derived from any utility analysis is likely to be untenable. It is further noted that the decision making process is influenced by (at least) two variables, namely the probability and the value as seen by the subject. These two (and others) interact in a certain way to produce a decision. It would be wrong to measure one of the variables unless it were known that the other was being held constant. This was deemed impossible by Edwards.

Edwards' following experiment was designed to capture similar information regarding the decision making process, but this time each of the eight bets in the three categories of EV had slight differences in their expected value (Edwards 1954(i)). Bets in the positive EV category had EV's ranging from 60c to 85c, while bets in the negative EV category had identical negative EV's. The EV's in the zero EV category ranged from -13c to 13c. The method of pairing each of the bets with all the others in their category, was used as in the constant EV experiment. The experiment is thus designed to identify which variables determine choices among bets with differing expected values.

The results of the experiments showed that subjects do not consistently prefer bets with higher expected value to those with a lower expected value. For bets with positive EV, it was found that the major determinant of choices was the differences in EV and not the preferences for certain probabilities. However, in the zero EV category it was found that the major determinant of choices was indeed probability preferences rather than differences in EV. This may have been because of the small absolute size of the EV for each bet. For the case of negative EV, it was found that both EV differences and probability preferences played a role. The mathematical model provided by utility theory thus remains problematic.

The last paper in the series continues in the same manner as the previous ones (Edwards 1954(ii)). The aim of the new experiments is to determine whether subjects exhibit preferences for certain variances of return, when choosing between bets. The theoretical model that is currently used for prediction is that which states that subjects will act as to maximize subjective expected utility. This is equivalent to the objective EV model, except that the variables in the equation are the subjective probabilities and values as seen by the subject. If it can be shown that subjects prefer certain variances, the model (if it could be derived), would seem unsuitable for prediction of choices.

The method of testing for variance preferences is the same as that used in the previous experiments. All bets have zero EV but different variance of return. The variance is naturally the objective variance; $\sigma^2 = pq(A-B)^2$, where p is the probability of winning, $q = 1-p$, A = amount won if you win, and B = amount you pay if you lose. Two categories of variance are considered, namely high variance, in which the variances of the bets range from 1.1 to 2.52, and the low variance category in which the variances range from 0.275 to 0.63.

The main finding of the experiment was that although variance preferences are useful in predicting behaviour under certain conditions, probability preferences are still the major determinant of betting behaviour. When probability preferences were held constant, the existence of variance preferences could be detected. Some subjects preferred bets of high variance while others preferred bets of low variance, and an attempt to construct a utility curve based on several subjects proved impossible. This seems to imply that people are too different in this respect. It is suggested that the existence of variance preferences will not have an effect on the subjective utility model, since they are only secondary in predictive ability to probability preferences. Whether they are also secondary to utilities, was posed as an experimental question for further research. The introduction of conditions into the experiment, making high variance desirable, produced more bets of high variance, but similar conditions making low variance desirable did not produce more low variance bets. This indicates that people tend to change their habits when they lose money, but not when they win.

Rosett (1970) attempted, through a series of five laboratory experiments, to verify theories proposed by Yaari (1965) and those of utility theory proposed by von Neumann and Morgenstern. All the hypotheses tested rely on the assumption that subjects faced with a choice under uncertainty will implicitly calculate the expected utility of each and choose the one with the greatest expectation.

Some comments on Yaari (1965) are needed here. He states that to explain the co-existence of insurance and gambling, we must either assume that the decision maker exaggerates the utility of large monetary gains, or that he exaggerates the probability of rare events. Since utility and probability are two theoretical components of an integrated decision process, choosing between the two hypotheses is a matter of taste. Yaari states however that empirical data do discriminate between the two hypotheses.

The set of all bets that a decision maker is prepared to accept, on a given event, is examined. The concern will be the convexity or otherwise of this set. A set is said to be convex if it contains every line segment whose end-points are in the set. It is noted that if the set of accepted bets is indeed convex, then a theory of choice under risk is deficient if it implies that the set of accepted bets is not convex. One such theory is that under which the decision maker acts to maximize his expected utility.

Experiments were carried out in the probability range of about a half as well as for extremely unlikely events where the probability was 0.001. In virtually all cases convexity of the acceptance set was satisfied. It is concluded that a general psychological law exists that exaggerates low probabilities and diminishes high probabilities.

Rosett's first two experiments examined how accurately subjects were able to estimate probabilities involved in simple gambles and whether these were then used to calculate expected utilities. The results were inconclusive, as the answers to identical questions put to subjects, 20 times, varied greatly. The third experiment confirmed Yaari's findings that acceptance sets are convex.

The fourth and fifth experiments indicated a relationship between the probability of an event and the proportion of responses that were consistent with the expected utility hypothesis. Consistency with the hypothesis was more likely when the probability was around 0.5 than when it was about 0.025. It is suggested that at low probabilities, subjects become unsure of what they actually prefer and therefore their bets become more nearly random. Quite unfortunately for the researcher, it is noted that the results seemed to depend heavily on the experimental conditions. The tests regarding the expected utility hypothesis also proved inconclusive.

Brady and Lee (1989) provided a literature review of the topic of subjective probability. They discussed many of the papers covered in this work, as well as some others. Assuming the expected utility hypothesis to be insufficient in providing an explanation for decision making under risk, the argument of the paper was that up until then, no explanation had been offered for the observed differences between objective and subjective probabilities. Brady notes that many experiments performed by various of the authors support the same conclusion. This is that the quality, relevance, reliability, type and amount of information upon which the probability is calculated, influences decisions as well as the probability itself.

It is pointed out that Keynes had in 1921, arrived at the same conclusions as the more recent investigators, and had also provided an explanation for the convex shape of the subjective probability curve. A conclusion drawn is that the underweighting of subjective probabilities is owing to the fact that such probabilities are not based on "perfect" information. This paper is important in that it considers the problem of decision making between gambles to be hardly one just of money and probabilities, but rather one which involves many other possible factors.

All the above papers have dealt with the topics of decision making and gambling, but not horseracing. Quite a few papers have been published since 1949 which examine similar topics in decision analysis but approach the subject from the point of view of the "natural gambler". The advantage of these experiments is that they are carried out in a natural surrounding (the racetrack), and are carried out by subjects (punters) who don't even know that they are part of an experiment at all.

The first paper to consider horserace betting useful for the study of human behaviour and decision making was Griffith (1949). He noted that the odds as reflected by the tote were socially determined, and therefore could cast light on the field of the psychology of probabilities. An important comment regarding different forms of gambling is made. This is that not all forms of gambling are psychologically equivalent. Thus the conative predictions of the fall of a dice, contrast strongly with the cognitive factors involved in predicting the winner of a horserace.

The data for the tests consisted of the winners and runners at each of 30 odds categories, from 519 races at three specific racecourses, as well as this information on seventeen selected odds categories for a further 867 races, which were run at all other tracks in the U.S.A. The odds are defined as the actual return for a $1 bet, which includes the $1 originally staked. A posteriori odds of winning are calculated for each odds category by dividing the number of runners in the category by the number of winners in the category. If these a posteriori odds equal the psychological odds determined by the public, then the product of these psychological odds and the number of winners would equal the number of runners in that odds category. Such calculations are made and the results are compared to the actual number of runners at each odds level.

The results show that the product of the winners and the odds is less than the total runners for all odds categories. When the tax and track take are added back, however this is only true at long odds (low probabilities), while at the short odds the product exceeds the total runners. The point of indifference calculated by interpolation, is 6.1/1 or 5.1/1 (which are the odds the bettors react to), if the actual odds are used. This corresponds to a probability of 0.16 or 0.2, which is noted to be close to the results of Preston and Baratta, which were derived in a laboratory environment. The results also show that too much money is wagered on longshots and not enough on favourites. This is the first evidence of the favourite-longshot bias reported in many racing studies in later years.

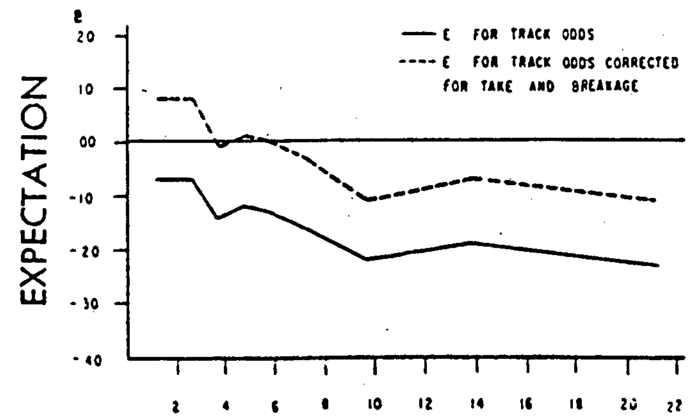
McGlothlin (1956) extended the paper of Griffith, using more detail as well as some new ideas. The primary purpose of the paper in fact, was to examine the stability of risk-taking behaviour over a series of events. The data consisted of 9 605 races run between 1947 and 1953 in the U.S.A. Odds categories were defined as in the Griffith study and horses were allocated to the categories depending on their starting prices. In this study subsamples of data were also considered. Thus the data was split according to the position (race number) of the race through the racing day. The expected returns at each odds level are calculated for each race number, and the results are shown in Table 4.1. Note that the odds categories are quoted from the actual returns payable, while the expected returns have been calculated by adding back the track take and breakage.

The overall results are consistent with those of Griffith and previous laboratory experiments. At odds of less than 3/1 we note positive expected returns while at odds of greater than 6/1 we note expected losses. When the odds used are actual, instead of those adjusted for take and breakage, losses are observed at all odds categories. The indifference point occurs between the probabilities 0.15 and 0.22, which is also in agreement with other experiments.

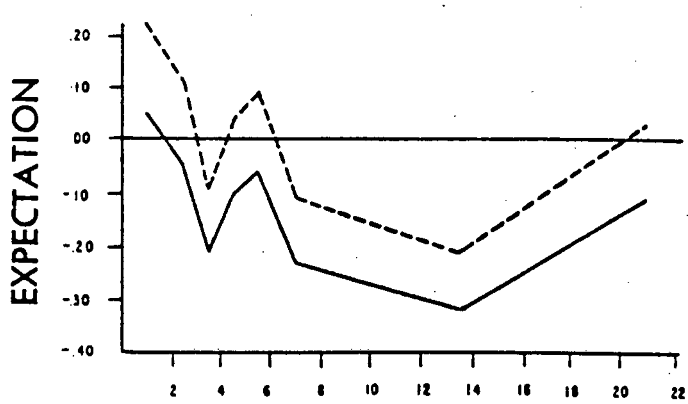
It is noted that the patterns of expected returns versus odds category for race numbers seven and eight, are markedly different to the patterns observed for races one to six. It is unlikely that this has to do with changing behaviour patterns through the day as neither of the adjacent races in the program show similar features. The differing pattern for race seven is explained by noting that race seven is the feature race for the day and

EXPECTED VALUES OF ONE DOLLAR BETS AS A FUNCTION OF TRACK ODDS

Position of Race	Number of Races	Track odds 0.05–1.95	2.00–2.95	3.00–3.95	4.00–4.95	5.00–5.95	6.00–7.95	8.00–10.95	11.00–15.95	16.00–25.95
1	1156	.08	.04	.05	−.11	−.06	.04	−.10	.12	−.11
2	1156	.14	.13	−.05	.02	.08	−.06	−.21	−.08	−.05
3	1156	.05	.09	.06	.08	−.07	.01	−.12	−.13	−.07
4	1156	.05	.10	.04	.12	−.05	−.12	−.06	−.03	−.10
5	1156	.03	.10	−.02	−.07	.02	−.07	−.02	−.02	−.14
6	1156	.11	.03	−.01	−.05	−.06	−.07	.01	−.05	−.20
7	1156	.01	.00	.00	.08	.03	.19	−.17	−.13	−.32
8	1513	.22	.11	−.09	.04	.09	−.11	−.15	−.21	.03
1–8	9248	.08	.08	−.01	.01	.00	−.03	−.11	−.07	−.11
$(\sigma E)_{1-7}$		.048	.064	.077	.091	.108	.086	.095	.114	.121
$(\sigma E)_8$		.053	.056	.057	.069	.089	.073	.071	.082	.121
(σE) Total		.017	.022	.026	.032	.038	.031	.033	.039	.044



ODDS, RACES 1-8 (N = 9248)



ODDS, EIGHTH RACES (N = 1513)

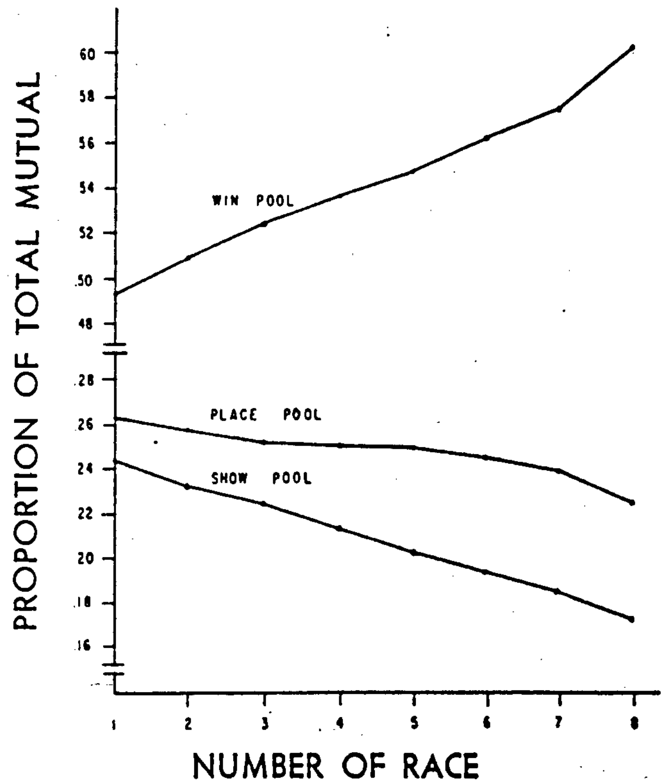
EXPECTED VALUES OF ONE DOLLAR BETS AS A FUNCTION OF ODDS.

Table 4.1 reproduced from McGlothlin (1956) receives a lot more press coverage than the other races. The public are also more aware of the horses running in such races, as they are normally of a higher quality than other races.

Two interesting results were obtained from the subsample of eighth (and final) races. Firstly the expected return of horses in the lowest odds category is much higher than for any of the other races. This indicates that short priced favourites which are avoided in general, are avoided even more so in the last race of the day. Secondly, a marked dip in return at odds of about 7/2 is observed. Bettors are thus wagering larger quantities than usual on horses in this odds category. Since the eighth race does not differ in type from several of the races run earlier in the day, it is postulated that the difference in return patterns, is owing to a change in the bettors behaviour through the day.

It is conjectured that bettors have up until the last race, lost three times what they plan to wager on the last race, and therefore have to resort to backing horses at approximately 3.5/1 to break even or show a moderate profit. The greater avoidance of short priced horses indicates that bettors are not prepared to bet on horses that, if successful, will still leave them as losers for the day.

An examination of the possibility of probability preferences was performed. Three types of simple bets are available to bettors, namely win, place and show, with odds typically ranging from 2/1 to 50/1, 1/1 to 20/1 and 5/10 to 6/1 respectively. Thus the proportion of total money wagered on each pool gives a measure of preference for probability ranges among alternatives with approximately equal expected values. The proportions split by race number are shown in Figure 4.1. A test was performed to indicate whether there was a difference in behaviour between winners and losers. This as done by comparing the relationship between the odds of the winning horse, and the amount bet per person in the following race. An assumption is made that each person at the track bets the same amount. From this assumption the proportion of winning bettors is given by $Q = 0.87/(a_1+1.025)$, where 0.87 is the track take, a_1 are the odds-to-win for the horse finishing first in the previous race, and 1.025 adjusts for breakage, (rounding down of the dividend). This measure was used to test the correlation between winning



PROPORTION OF TOTAL MUTUEL BET IN WIN, PLACE, AND SHOW POOLS AS A FUNCTION OF NUMBER OF RACE
(Data from the 50-day meet at Hollywood Park, 1953.)

Figure 4.1 reproduced from McGlothlin (1956)

bettors and amount bet in the following race. Since there are eight races per day there were seven pairs of variables to be correlated. The seven coefficients ranged from -0.1 to -0.47, indicating that bettors increased their bets more after having lost than after having won.

The betting behaviour of the group is to increase the variability of their assets through the day. This is achieved by increasing the amount bet per person as well as choosing a higher proportion of win category wagers, in preference to place and show betting. Despite the fact that size of wagers and preference for low probability bets are increasing, the pattern of returns for races one through six is constant. This suggests that the utility scale of money is equivalent to the dollar scale, and the more important psychological variable is subjective probability. It appears that variance preferences are of some importance in determining decisions of the type involved in these experiments.

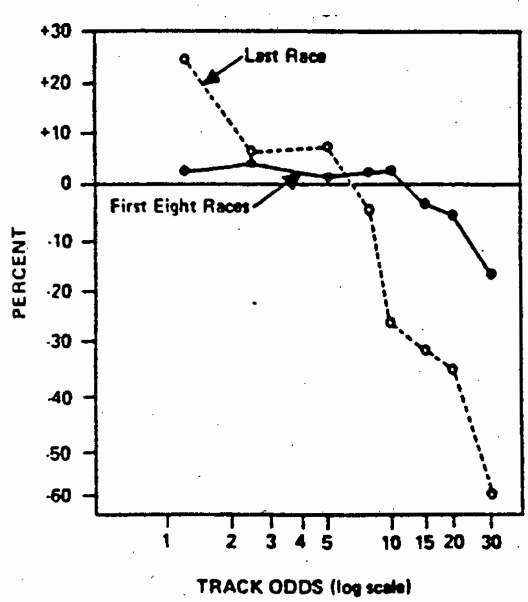
Rosett (1965) investigated the relationship between the observed probability of winning, (given the odds category that the horse belonged to) and the average actual return that would have been paid, had all the horses in that category won. The question, "Are gamblers rational?" is posed. The observation that gamblers pay more than the "fair" amount to play the game, is explained by Rosett, not by utility analysis, but rather by suggesting that either the gambler misunderstands the game or that he has all the information required but cannot perform the calculations involving probabilities.

A theoretical model is constructed whereby gamblers are assumed to be sophisticated, in that they know which factors affect a horses winning chances, as well as knowing how to calculate such probabilities. If gamblers are rational, in the sense that they will not accept bets with lower expected value than some alternative, their betting behaviour should yield a specific relationship between probability and return. This function will differ, depending on whether the majority of bettors are risk seeking or risk averse, and is defined in the paper. The empirical relation between return and probability was investigated under both scenarios (risk averse and risk seeking). The equations derived giving the relationships were unsatisfactory for the purpose of describing the data in the context of the assumed model. Thus the model assuming rationality and sophistication does not hold.

The main deviance of the observed situation from the model was that at very low probabilities, the returns were too low to be accounted for by the model. Explanations which are consistent with rationality are offered. The first is that some bettors want bets of such low probabilities, (parlays of the lowest probability horse in each race) that the lowest probability horse in each race attracts too much money. The second is that some bettors bet nearly at random, which results again in low probability horses attracting too much money (relative to their offered return). It is pointed out that irrational behaviour of several types would also explain the observed deviation.

The conclusion of the paper is that rational decisions can be expected from bettors, except where the decisions concern horses with probabilities of winning of less than about 0.03. An important point regarding the sophistication of bettors is also made. This is that although the tools of statistics are hardly available to the vast majority of track gamblers, they still act as though they are sophisticated, and are well versed in probability theory and calculus among other topics. The conclusion drawn is that we would expect people in other fields, faced with risk and uncertainty, to act as if they are sophisticated, and respond appropriately, merely after having had sufficient experience with the situation.

Snyder (1978) investigated the favourite-longshot bias for the public as well as for the official track handicapper and four newspaper handicappers. The task of the handicappers is to provide a guide to the public as to likely starting odds (publicly determined) of each horse on the card. The data comprised 94 race meetings and 7657 horses. The rates of return were adjusted for the take so as to make the results comparable with other studies. Rates were also calculated for the last race of each



Rates of return, take subtracted

Figure 4.2 reproduced from Snyder (1978)

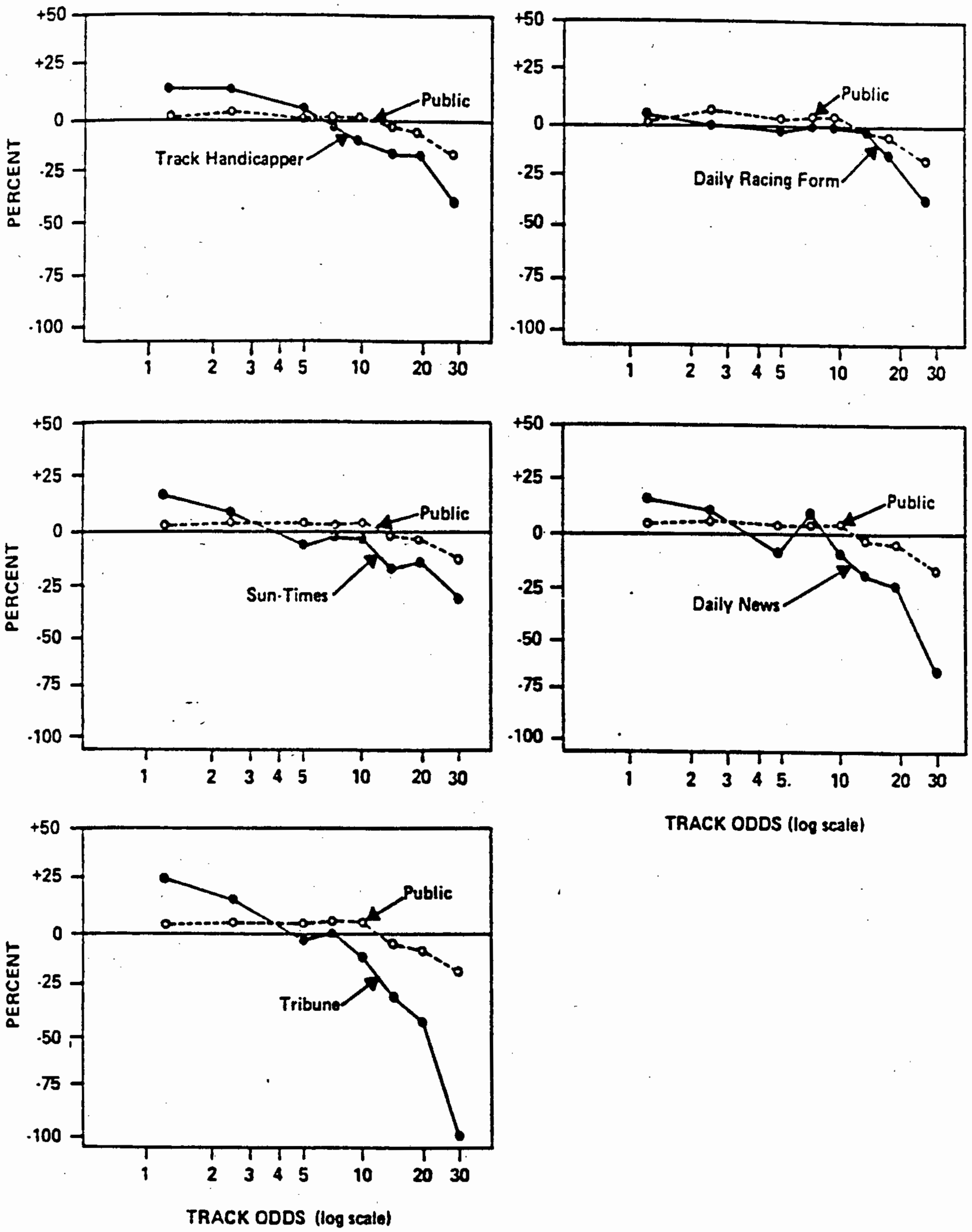
meeting separately. The results are shown in Figure 4.2.

The results confirm the findings in the other studies. It is noted that the possible profit available by backing short odds horses in the final race, disappears when associated costs (transportation, entrance fees and appropriate cost for time involved) are taken into account. In addition the number of betting opportunities are few, and even a moderate bet would push the odds lower, which might well reduce the profit level to zero when the take is taken into account.

The main aim of the paper is to test whether the so called "experts", the handicappers, are less biased than the public with regard to the odds. If the experts had no biases of their own, returns to their predictions would be randomly distributed around the returns observed for the public. The results shown in Figure 4.3, indicate that the "experts" tended to accentuate the public's betting bias. The public therefore do not set odds which closely resemble those predicted by the newspapers, usually on the morning of the meeting. The pattern is similar for last races on the card. The reason for the discrepancy is likely to be the unwillingness of the handicappers to point a finger too clearly at horses with strong or weak chances of winning. The problem with such morning line odds has been discussed at some length in section two.

Weitzman (1965) used racetrack data to derive a utility of money curve for an average bettor at the track. His approach differed from previous studies along these lines in that it was not conducted using the laboratory approach. Further he did not restrict himself to deriving the utility curve for individuals and then try and aggregate, but rather derived a utility curve based on an aggregation of individuals behaviour. The basis of the analysis is the expected utility model rather than the subjective expected utility model, which means that subjective probabilities were taken to coincide with their objective counterparts throughout. The reason for this is that it would have been too difficult to incorporate subjective probabilities into the study. Further, expected utility is only dependent on probability and money, all other possible influences are taken as static.

The expected utility hypothesis implies that maximising U(p,m) is equivalent to maximising p*u(m), where U(p,m) is the utility attached to the risk situation consisting of the possibility of winning m dollars with probability p, and u(m) is the utility of m



First eight races' rates of return, take subtracted: public compared with five experts

Figure 4.3 reproduced from Snyder (1978) dollars. It was found experimentally that the probability of a horse's victory could be expressed as a smooth function of the return which it paid. Each horse in the data set was classified according to the return it would have paid had it won. An empirical probability of winning (number of winners over number of runners) was than associated with each value (level) of return. A function relating p and m, where m is the return for horses with probability of winning p is derived, and from this the curve u(m) can be derived exactly. It is necessary here, to quote from Weitzman, who explains the usage of the term function in this context. "The reader may be confused at this point by the usage of the word "function". It is being employed here in its strict mathematical sense; a function of a variable x is a unique association of a number f(x) with each number x in the domain of the definition. No causality in the physical sense is meant to be implied by this definition. Thus it is not being maintained that the crowd-determined return *causes* the objective probability of a horse's victory - more likely it is the other way around and the crowd's estimation of the horse's probability of victory sets the return. The existence of probability as a function of return in the mathematical, not the causal, sense is under investigation." The data used to derive the relationship between the probability of winning and the return required by bettors to bet at that probability level, consisted of over 12,000 races involving over 110,000 horses.

The best fitting curve turned out to be in the form of an adjusted hyperbola, i.e. such that,

$$p(x)=\frac{A}{x}+\frac{B\log(1+x)}{x}$$

where x is the return to $1 and p(x) is the empirical probability of winning associated with that return.

This gives a supposed indifference curve for the average bettor in the sense that he doesn't mind at which probability level he bets at, as long as the return is in accordance with the above formula for specific A and B. It is noted that under the expected value hypothesis, the resulting indifference curve would be a hyperbola of the form p(x)*x = constant. The conclusion is that the expected value hypothesis gives a good indication as how the average bettor behaves.

It is assumed that the average bettor gambles $5 per race. This is close to the observed amount actually wagered per person at the tracks surveyed. We thus have m = 5x, as well as a functional relationship between p and m. By assuming that the average bettor obeys the expected utility hypothesis, we have p*u(m) = K, where K is the constant utility of an indifference curve for the bettor. In addition we have p=p(m), and therefore K = p(m)u(m). To set the utility scale, let u(5)=5 utiles. Then K = 5*p(5), where p(5) is the probability related to the return of $5. Now u(m) = K/p(m), which can be derived for dollar values within the range considered.

It is noted that a vast quantity of data was used to derive theoretical probability function upon which the utility curve was based. This stands in contrast to the usually indeterminate nature of experimentally derived utility functions. The final point is that the derived utility curve is similar to the one derived on theoretical grounds by Markowitz as an amendment to the Friedman-Savage hypothesis.

Ali (1977) investigated subjective and objective probabilities of winning, and from the relationship between the two, attempted to characterize bettors' behaviour. The data considered were 20 247 harness races run in the U.S.A. at three different race tracks from 1970 to 1974. To derive the objective and subjective probability estimates, horses were grouped according to their level of favouritism. It is argued that the variation in the winning probabilities of the horses most likely to win the races may not be substantial. Similar arguments are put forward for horses second most likely to win and so on. It is therefore decided to group horses based on their level of favouritism rather than their actual odds as determined by the public.

The results are in accordance with other studies which have compared subjective and objective probabilities. Thus we see that horses at short odds, (high probabilities) have probabilities of winning underestimated by the public, with the opposite true for horses with long odds. Instead of explaining these differences using the psychological make up of the bettors, Ali explores the possibility that the differences are owing to a specific form of utility function applicable to them. It is suggested that if bettors are assumed to be sophisticated in the sense that the objective probabilities of winning are completely known to them, then the relationship between the objective and subjective probabilities can be explained by the expected utility hypothesis. Bettors are then characterized as risk seekers.

An alternative suggestion is that if bettors are not wholly sophisticated, then the data are consistent with bettors who are risk neutral and are unable to estimate objective probabilities exactly. The following assumptions are made, by Ali, regarding a typical bettor in order to derive his utility function from the data. He is a utility maximizer, sophisticated and acts as if his betting opportunities are limited to a single race. In addition his utility is assumed to be a function of wealth alone. His utility function is derived and its shape implies that he is a risk seeker who takes more risk as his level of capital declines.

A new measure of risk is defined and used to further investigate the behaviour of bettors. The risk factor was computed separately for the three tracks for which data was available. The track which showed bettors taking most risk was that which had substantially lower betting per person per race than the other two tracks. This was taken as further evidence that bettors' risk attitudes increase when their capital decreases. Risk factors are also calculated for the first, second and last races of the day. These show risk attitudes to be about equal for the first two races but higher for the last race. Since bettors have less capital at the end of the day than at the start, (owing to the track take) this also suggests that as capital declines so bettors are prepared to take higher risks.

Metzger (1985) examined laboratory established biases from optimality, in the natural setting of the racetrack. Two separate experimental findings were tested. Firstly, the gambler's fallacy, where bettors bet less (more) on favourites after a series of favourites have won (been beaten). Secondly, variation in the reference points for the framing of outcomes lead to variations in the acceptability of risk. In particular, the status quo at the start of the day is changed continually through the racing day, and outcomes are framed increasingly in terms of getting back to the status quo rather than on winning for the day. This should lead the public to increasingly avoid favourites through the day.

The data consisted of 11 313 races run in the U.S.A. during 1978. The public's subjective probabilities, p, were calculated for each horse. In addition, after all horses were assigned to an odds class, the objective probability, P, of a horse in each class winning was calculated as the ratio of the number of winners to the number of horses in each class. The public's accuracy in estimating the winning probabilities is then given by $a=p/P$. For the investigation of the gamblers fallacy, a was classified by odds class and the result of the two previous races. An F and S indicate that the race was won by the favourite or second favourite respectively, while an L indicates that another horse won the race. The results are shown in Table 4.2.

ACCURACY OF PUBLIC ESTIMATIONS OF PROBABILITIES I*

Public Estimate‡	Outcomes of Pre-previous and Previous Race†								
	LL	SL	FL	LS	SS	FS	LF	SF	FF
				First Choice					
51 (46—77)	104	98	91	85	91	96	94	86	85
	244§	122	189	98	55	94	209	83	145
35 (31—46)	103	109	100	109	92	97	100	97	97
	792§	347	561	394	166	242	540	235	469
27 (25—31)	96	108	113	113	108	90	100	87	96
	423§	168	265	181	67	124	295	130	187
24 (17—25)	98	93	115	100	159	87	89	106	89
	454§	172	288	200	87	114	312	142	201
				Second Choice					
25 (22—35)	96	96	93	100	114	119	96	104	108
19 (17—22)	106	95	127	119	66	90	95	173	100
	774§	349	586	383	173	252	557	250	463
15 (14—17)	100	104	99	94	88	88	150	115	89
	744§	307	479	331	131	197	494	223	355
	395§	153	238	159	71	125	305	117	184

*Ratio (× 100) of average public estimate to true probability of winning for runners in each odds range. †Example: SL means the pre-previous race was won by the second choice (S) and the immediately previous race was won by a long shot (L). L is any other than the first (F) or second choices. ‡Mean percent of win pool wagered on runners in each odds range. Ranges in parentheses. §Number of observations in each row below ratios.

Table 4.2 reproduced from Metzger (1985)

Table 4.2 shows that the public are influenced by the results of the most recent races. For example, for horses categorised as F, note that the value of a, for horses in the shortest odds class, after two favourites have won the last two races is 85 indicating a large underestimation of the favourites chances in the following race. For horses categorised as F, there are 8 overestimations of favourites chances, (a > 100) when a favourite has not won one of the two preceding races, while there is only one overestimation when the favourite either won the last race or won the penultimate race and the second favourite won the last race. For horses categorised as S, the analogous comparison was not significant.

The results relevant to the second investigation are shown in table 4.3. In this table a has been categorised by the number of the race on the card and by odds class. For first choices, races 1 and 9 show consistent underestimation of the horses' chances no matter

ACCURACY OF PUBLIC ESTIMATIONS OF PROBABILITIES II*

Public Estimate‡	Ordinal Number of Race								
	1	2	3	4	5	6	7	8	9
				First Choice					
51 (46—77)	96	100	100	94	91	91	91	93	93
	106§	84	206	137	173	164	228	275	56
35 (31—46)	97	97	106	100	109	103	106	90	97
	523§	458	593	526	547	515	595	599	371
27 (25—31)	96	129	100	100	104	117	96	93	93
	279§	327	251	286	269	276	225	190	343
24 (17—25)	86	131	108	96	87	111	112	110	92
	349§	388	207	308	267	302	207	192	487
				Second Choice					
25 (22—35)	109	100	100	114	100	96	93	96	104
	372§	379	569	540	563	552	569	664	330
19 (17—22)	106	106	95	100	112	100	119	112	100
	542§	576	464	489	472	457	448	402	531
15 (14—17)	115	97	107	104	87	92	125	92	116
	343§	302	224	228	221	248	238	190	396

*Ratio (× 100) of average public estimate to true probability of winning for runners in each odds range.
‡Mean percent of win pool wagered on runners in each odds range. Ranges in parentheses.
§Number of observations in each row below ratios.

Table 4.3 reproduced from Metzger (1985) what the odds class. The second choices show no consistent pattern. It is suggested that the unexpected finding of similar betting patterns on the first and last races, may be explained by the generally larger fields in these two races, or the availability of exotic betting on the first and last races, which is not be available on other races.

Busche and Hall (1988) undertook to replicate previous studies of the favourite-longshot bias using data from Hong Kong racing. The data consisted of 2 653 races run between 1981 and 1987. Two methods of grouping horses are used, namely, by odds class and by level of favouritism. The odds classes were chosen, subject to the constraint that no class have zero winners, to maximise between-group (minimize within-group) variation. A regression of subjective odds on empirical odds was performed for the Hong Kong data and separately on U.S.A. data available from previous studies.

The derived regression lines were as follows,

U.S.A Subjective Odds = 1.144 + 0.747*Observed Odds $R^2 = 0.993$

Hong Kong Subjective Odds = -2.908 + 1.251*Observed Odds $R^2 = 0.99$

A slope of the regression line of less than one implies risk seeking behaviour, while that of greater than one implies risk averse behaviour. The results from grouping by level of favouritism are shown in Table 4.4 along with the results from two similar studies using U.S.A. data. Column three gives the objective probabilities of winning, while column four gives the subjective probabilities. The tendency to overbet long shots evident in the U.S.A. studies is not apparent in the Hong Kong data. No explanation is offered for the results other than to note that the betting volume in Hong Kong is far in excess (approximately 10 times as much per race) of that in the U.S.A.

Vannebo (1980) commented on Snyder's paper that had appeared two years earlier. He stated that the tests of the E.M.H that Snyder had carried out were not actually tests of efficiency. He suggests that it may be quite rational for bettors to bet on long shots which have a lower expected return, as long as the skewness of the returns are

Hong Kong Betting Data Classified by Favorite Position

Rank (1)	No. of Races (N) (2)	Win Fraction (ζ) (3)	Fraction of Money Bet (ψ) (4)	Standard Errors ($\psi - \zeta$) (5)	Ali 1977 (6)	Asch, Malkiel, and Quant 1982 (7)
1	2,653	.276	.284	.92	−10.29	−2.119
2	2,653	.190	.187	−.39	.99	−.903
3	2,651	.151	.142	−1.29	−.52	−1.972
4	2,647	.0985	.1104	2.05	3.45	−.961
5	2,638	.0835	.0862	.46	3.49	.074
6	2,598	.0627	.0662	.74	3.01	−.279
7	2,509	.0483	.0498	.35	5.80	.480
8	2,346	.0473	.0370	−2.35	6.20	1.096
9	1,992	.0336	.0277	−1.46	...	2.095
10	1,620	.0209	.0209	.0	...	...
11	969	.0227	.0175	−1.09	...	...
12	726	.0138	.0133	−.12	...	...
13	411	.0098	.0103	.10	...	...
14	233	.0129	.0078	−.69	...	...

Table 4.4 Reproduced from Busche (1988)

sufficiently large to compensate for the lower return. People in his scenario have a trade off between expected return, variance of the return and skewness of the return. In all the studies considered thus far, only two moments were considered. In a sense, this single paper negates all weak form tests of efficiency, (i.e. comparing expected returns for different odds levels) that have been performed in previous papers. The difference between his paper and others is that he does not explain the differences between objective and subjective probabilities using utilities or psychological misconceptions, regarding the probabilities, but rather with the aid of a third variable.

Only one other paper to our knowledge, examined the existence of skewness of returns using horseracing data. This was Bird (1987). The data consisted of bookmaker odds at four points in time prior to each race. The races considered were run in Australia in 1983 and 1984. All horses were grouped by their level of favouritism. Each horse had its odds adjusted so that the sum of the probabilities for each race added to one. This implies a zero take by the bookmaker. Subjective probabilities were calculated by adding the "sum to one" probabilities for each level of favouritism and dividing by the number of runners at that level. Objective probabilities were calculated by observing the number of winners at each level and dividing this by the number of runners at each level.

The results shown in table 4.5, are consistent with the findings of similar studies. In particular the favourite-longshot bias is clearly evident. To investigate this bias further, a $1 bet was placed on all horses and average rates of return were calculated for each level of favouritism. Actual odds as well as "sum to one" odds were used. The results shown in table 4.6 reconfirm the favourite-longshot bias in that rates of return decrease with increasing level of favouritism. Note that the market is weakly efficient if charges are included in the returns. Since the variance of the return, (risk) increases as the level of favouritism decreases (and thus returns decrease), the results indicate risk taking behaviour under a two moment (mean, variance) model.

Estimates of Objective and Subjective Probabilities by Level of Favoritism

	Period							
	t_1		t_2		t_3		t_4	
Favorite (Sample Size)	Subj. Prob.	Obj. Prob.	Subj. Prob.	Obj. Prob.	Subj. Prob.	Obj. Prob.	Subj. Prob.	Obj. Prob.
1(1026)	0.2567	0.3000**	0.2598	0.3060**	0.2732	0.3171**	0.2806	0.3179**
2(1026)	0.1686	0.1700	0.1693	0.1733	0.1728	0.1810	0.1740	0.1890
3(1026)	0.1296	0.1540**	0.1301	0.1404	0.1288	0.1378	0.1296	0.1283
4(1026)	0.1017	0.1014	0.1020	0.1104	0.1008	0.0940	0.1003	0.0933
5(1026)	0.0811	0.0705	0.0809	0.0661*	0.0793	0.0644*	0.0793	0.0666*
6(1024)	0.0635	0.0540	0.0647	0.0570	0.0629	0.0632	0.0626	0.0607
7(1009)	0.0524	0.0440	0.0520	0.0435	0.0548	0.0390**	0.0495	0.0403
8 (985)	0.0421	0.0311**	0.0415	0.0369	0.0399	0.0277**	0.0385	0.0334
9 (937)	0.0340	0.0236*	0.0333	0.0214**	0.0318	0.0219*	0.0303	0.0206*
10(874)	0.0274	0.0284	0.0267	0.0273	0.0250	0.0305	0.0239	0.0266
11(791)	0.0225	0.0180	0.0218	0.0220	0.0200	0.0174	0.0189	0.0144
12(690)	0.0186	0.0095**	0.0180	0.0101*	0.0163	0.0098	0.0149	0.0116
13(545)	0.0162	0.0117	0.0157	0.0131	0.0141	0.0121	0.0126	0.0115
14(414)	0.0138	0.0099	0.0135	0.0078*	0.0118	0.0060*	0.0105	0.0060
15(274)	0.0125	0.0063	0.0122	0.0069	0.0105	0.0085	0.0091	0.0091
16(193)	0.0111	0.0043	0.0109	0.0041*	0.0088	0.0069	0.0075	0.0052

** Difference between subjective and objective probabilities significant at 0.05 level

* Difference between subjective and objective probabilities significant at 0.10 level

Table 4.5 reproduced from Bird (1987)

Favorite (Sample Size)	t_1 Actual Odds	t_1 "Sum to One" Odds	t_2 Actual Odds	t_2 "Sum to One" Odds	t_3 Actual Odds	t_3 "Sum to One" Odds	t_4 Actual Odds	t_4 "Sum to One" Odds
	%	%	%	%	%	%	%	%
1(1026)	-15.28**	14.08**	-9.00**	16.42**	-5.40	13.97**	-7.38*	11.66**
2(1026)	-26.57**	-1.13	-20.61**	1.72	-13.22**	4.31	-10.81*	7.56
3(1026)	-13.38**	-17.83**	-17.80**	5.46	-11.54*	7.50	-17.99**	-0.24
4(1026)	-24.40**	1.31	-14.93**	9.08	-22.61**	-6.79	-24.45**	-9.05
5(1026)	-35.72**	-13.43	-36.20**	-18.36**	-33.64**	-19.81**	-29.61**	-14.39
6(1024)	-39.95**	-19.72**	-33.55**	-14.85	-20.08**	-3.92	-27.12**	-11.39
7(1009)	-42.59**	-22.73**	-38.56**	-21.43**	-41.63**	-29.68**	-38.96**	-25.36**
8 (985)	-51.11**	-32.54**	-53.51**	-39.53**	-53.43**	-43.80**	-41.76**	-29.37**
9 (937)	-52.30**	-35.85**	-53.34**	-39.67**	-43.56**	-31.62**	-47.92**	-35.82**
10(874)	-32.17**	-7.93	-28.59**	-8.27	-6.73	13.24	-8.42	9.77
11(791)	-44.70**	-25.37	-31.95**	-12.35	-38.38**	-25.73	-41.21**	-27.54
12(690)	-64.92**	-52.09**	-68.15**	-58.43**	-59.48**	-51.17**	-49.05**	-37.61**
13(545)	-56.54**	-39.61**	-43.87*	-27.74	-37.53	-24.05	-39.82	-26.75
14(414)	-66.12**	-52.97**	-70.65**	-62.04**	-72.62**	-66.61**	-71.44**	-64.67**
15(274)	-80.27**	-71.97**	-77.43**	-70.00**	-61.74**	-53.37**	-56.84**	-48.13**
16(193)	-86.70**	-80.84**	-86.20**	-81.86**	-67.70**	-60.35**	-75.78**	-70.36**

** Significant at 0.05 level

* Significant at 0.10 level

Table 4.6 Average rates of return to a $1 bet by level of favouritism reproduced from Bird (1987)

Bird notes that well informed, risk averse stock market investors take account of skewness of the returns when choosing between risky investments. Thus there exists a precedent for investors to consider more than just the mean and variance of the returns. The standard measure of skewness is calculated for each level of favouritism, and this is noted to increase as the level of favouritism decreased. The relative preference for variance and skewness were evaluated using regression analysis. The returns were regressed against a constant and terms for variance and skewness. The coefficients of these variables were significant and the variables themselves explained a large proportion of the variation in the rates of return. The variance term has a positive coefficient, indicating that gamblers needed a larger return to compensate them for accepting higher variance. The skewness term has a negative coefficient, suggesting that gamblers are willing to accept a lower return in order to have an opportunity of winning unusually large returns.

The results and conclusions of the regression, stand in contrast to the two moment interpretation, that suggests that gamblers are in fact risk taking individuals. In all the regressions, (at different time points before the races) the return and the variance of return were positively related, indicating risk averse behaviour.

Even if gamblers are risk averse, participation in a game that promises negative returns must surely be viewed as risk seeking in an intuitive sense. This is considered as a further question within the framework of the expected utility hypothesis. Utility of wealth models have been criticised for not accounting for non-wealth benefits derived form gambling. Among others, those mentioned are excitement, recognition, status seeking, demonstration of skill and having a good time. It is suggested that these non financial benefits are aligned with the pursuit of skewness of returns. It is also suggested that gamblers do not believe that individually, they are faced with a game of negative returns. The final conclusion is that racecourse gamblers are risk averse individuals who derive particular pleasure from certain non-wealth factors associated with gambling.

4.3 Comments, Further Ideas and Proposals

Griffith (1949) performed a similar investigation, to that undertaken by later researchers who investigated the Efficient Markets Hypothesis. Whereas their emphasis was on the returns available, Griffith concentrated on the probabilities, objective and subjective, of the events concerned. Later researchers thus considered the results of the data, while Griffith considered the reasons for arriving at those results. He was looking for evidence of psychological misconceptions related to probabilities. The results of the data analysis were similar. In the E.M.H section of this work, we have performed a similar investigation to that of Griffith. We concentrated on the returns, rather than the probabilities involved. In an investigation conducted at the racetrack, subjects were asked questions which would relate their views regarding probabilities without them having to bet. The findings and conclusions from the investigation, reported later in this work, provide some answers to the questions posed by Griffith as to why the observed pattern of probabilities emerged the way it did in his study.

McGlothlin (1956) conducted a similar study to that of Griffith. In addition he investigated the probabilities involved for the last race on each card separately. The possibility exists that favourites in the last race are avoided more strongly than usual. In South Africa where bookmakers compete with the tote for the bettors funds, an additional aspect of this idea is the following. Consider a bettor who has a "live" pick-six ticket on the favourite in the last leg (which is the last race of the day). Assume the price of the horse at opening betting, which generally reflects a conservative estimate of the horses winning chances as set by the bookmakers, is 1/1. Assume further that our bettor is one of only a few that have a "live" ticket on the horse, (not an unlikely scenario) and stands to win R50 000, say. His outlay may have been anything from R100 to R10 000. He may now approach a bookmaker and offer him odds of 15/10 on the horse for a bet of say 15 000 to 10 000. Then if the horse wins, he collects R50 000 and pays the bookmaker R15 000, and if the horse loses he gets R10 000 from the bookmaker. The bookmaker agrees to this since he can "sell" the horse to the public at odds shorter than 15/10 and therefore can make a profit on that particular horse, whether the horse wins or loses.

Such bookmaker facilities are not available in the U.S.A, so we would expect the results obtained by McGlothlin in regard of final races to be more pronounced in South Africa. A similar investigation will be carried out using South African data. An investigation of risk taking behaviour through the racing day will also be undertaken using South African data. Use will be made of the size of the pools on win, place, swinger and trifecta betting for each race, as these reflect different levels of risk, as defined by the variance of the return.

Rosett (1965) proposed a model of parimutuel betting behaviour based on three questionable assumptions. These are (i) that the factors involved in determining winning probabilities are known to bettors, (ii) that bettors use this knowledge to correctly forecast these probabilities, and (iii) that bettors know how to calculate both the probability of winning a combination of simple bets (win bet on a single horse) and the corresponding payoffs to such combinations. Since the data conform to the model, it is assumed that the assumptions (which effectively imply rationality and sophistication of bettors) are correct in practice. However, this conclusion is not intuitively appealing as it is very difficult to disentangle the data in such a way as to be able to say which of the three assumptions is most often violated in practice. Simply because the results are in concordance with the model, does not say anything regarding the process whereby such results were achieved. The differences between analysis that concentrates on results as opposed to that which centres on processes is discussed later in this section.

Ali (1977) also makes questionable assumptions regarding human behaviour as well as some doubtful comments on the grouping of data for analysis purposes. The problems with grouping horses for the purpose of investigation by odds class, probability or level of favouritism have already been discussed. Ali suggests that the variation of winning probability within a group determined by level of favouritism is likely to be small. This is clearly not so, as a favourite could start at 1/2 or 5/1, (say). The range of probability here is 0.167 to 0.667! If groupings were based on probabilities or odds such variation would never occur as the maximum length of a probability group would be, say, 0.1. The variation in probability of horses most likely to win from race to race is thus far too large in Ali's study.

Ali discards the psychological analysis of differences in objective and subjective probabilities and derives a utility of wealth function under the assumption that the objective and subjective probabilities are equal. The assumption that bettors are sophisticated, in the sense that the objective probabilities are known to them, is highly suspect. The observed differences may be owing to the misconception of probabilities, rather than to a difference in peoples subjective and objective scales of money. Further dubious assumptions are necessary in order to derive the utility function itself. In addition to assuming sophistication, bettors are assumed to be utility maximizers and to behave as if betting opportunities are limited to a single race.

Although it is unlikely that people are so simple as to be described as utility maximizers, we shall not argue the point here. We are in serious doubt, however, regarding the view that bettors only consider one race at a time and in total isolation to other races on the day or even other races at meetings to be held in the near future. For example, a bettor may bet on a race early in the day simply to try and win enough money so as to increase the size of an exotic wager (jackpot, pick six) to come later in the day. It is very unlikely that the possible payoffs from a particular race are not included in any plans for betting later in the day, implying that bets may be struck with a view to future opportunities. The derived utility function of Ali, must therefore be looked upon with caution.

Snyder (1978) examined newspaper tipsters predictions and compared these with returns to the public. The methodology of the examination is the best way of analysing such a situation, but as has been discussed at some length in section 2.3.2, many problems exist with the use of forecast price information. Similar analysis using South African data would yield meaningless results.

In keeping with the high standard of his other research paper, Bird (1987) makes a significant contribution to the understanding of human behaviour in gambling situations. A similar investigation is conducted to Griffith's original, but an additional variable, namely skewness of returns, is considered to explain bettors preferences. Mention should also be made of Vannebo (1980) who was the first to suggest that bettors preferred positive skewness of returns, and that this was reflected in their betting behaviour.

Following the conclusions of his own study, Bird suggests methods of analysis of human behaviour that could be used in the future. Of particular importance, is the suggestion of models which make no underlying assumptions of rationality or maximizing behaviour. These models are concerned with cognitive mechanisms, simplifying heuristics and information processing strategies that people make use of before making decisions.

The early papers of Preston and Baratta (1948), Edwards (1953), Edwards (1954(i)) and

Edwards (1954(ii)), being by psychologically inclined experimenters, all concentrated on the probability variable as opposed to the money variable in the gambling situation. They were all conscious of the process leading to the results, rather than in the results themselves. The papers concerned themselves not with horseracing, but with laboratory experiments designed to elicit information about subjects behaviour under risk. This seems to be the only drawback of these works, in that a natural setting of decision making is not used, and the results of the laboratory experiments could not really be generalized until it was later shown that the results obtained, were reproduced in the natural setting of the race track. These papers are of considerable importance, although they have not found favour with researchers such as economists who have tended to concentrate on the monetary aspect of the problem of gambling.

4.4 Results and Conclusions

An investigation was made into the winning probabilities of horses with specific odds running in the last race of the racing day. The odds categories were grouped in the following way:

1) 1/10 to 9/10
2) 1/1 to 2/1
3) 22/10 to 33/10
4) 7/2 to 9/2
5) 5/1 to 6/1
6) 7/1 to 8/1
7) 10/1
8) 12/1
9) 14/1
10) 16/1
11) 20/1

The data were from 189 last races involving 2 487 horses. The observed probabilities were compared against the expected probabilities as determined from the average odds of the group.

The results are shown in Table 4.7.

Average odds in group	Wins	Runners	Expected	Observed
0.45	15	22	0.689	0.681
1.46	27	60	0.406	0.450 **
2.76	34	118	0.266	0.288
4	31	162	0.200	0.191
5.5	19	185	0.154	0.102 **
7.5	16	217	0.117	0.073 **
10	13	225	0.091	0.057 *
12	15	492	0.077	0.030 **
14	8	361	0.067	0.022 **
16	10	259	0.058	0.038 *
20	1	386	0.047	0.002 **

Table 4.7 Expected and observed probabilities of winning for runners in the last race of the day.

* = significant at the 10% level

** = significant at the 5% level

The results show that there exists a significant difference between the actual probability and that expected on the basis of the odds, in the short odds categories. The direction indicates that these horses are underbet (leading to odds that are to high/probabilities that are too low) relative to their real chances of winning. Comparison was now made between the observed probabilities in categories two and three with the observed probabilities of similar groups of horses, which had been based on all races, (not simply the final race). The tests showed a significant difference at the 1% level between the observed probabilities of the two samples (the first sample is made up of horses that ran in any race, whereas the second is made up of those horses that ran in final races only). It therefore appears that punters do avoid betting on short priced horses in the final race, and turn rather to longshots in what seems to be a final desperate attempt to even out their losses of the day.

In order to further investigate a change in bettor behaviour through the day, we analysed the proportion of the total amount bet on each of the following bets; Win, Place, Swinger and Trifecta, for each race during the day. Owing to the fact that the number of races varied from 7 to 10, the following adjustments were made. Firstly the data was analysed by the original number of the race concerned. This inevitably meant that race 7 on a Wednesday (the last race on the card) was grouped with race 7 on a Saturday (which is usually the third last race of the day). So that we could see what was actually happening during the last race of the day, the data were regrouped, this time adjusting all Wednesday races 7 to a notional race 9 with the problem now that race 1 on a Wednesday becomes race 3 on a Saturday. The two data sets taken together should however give an indication as to what differences exist between betting on the opening races of the day and the final races. The results are shown in Tables 4.8 and 4.9. Tests to compare the average percentages bet in the first and last races for each bet type, indicated that there was no significant shift in the proportion wagered for any of the four bets. Further analysis of this data would require specific questioning of bettors at the track regarding their bet preferences through the day.

4.5 Decision Analysis: A Psychological Approach

The value of the Expected Value Hypothesis and the Expected Utility hypothesis, lies in their simple mathematical nature, as well as their natural and intuitive appeal. In addition the Expected Utility Hypothesis correctly describes human behaviour in many areas of observation. A problem exists, however, in that although human behaviour often conforms to the suggested model, this does not mean that the assumptions underlying the model are correct.

In many instances, the axioms underlying utility theory are "proven" to be true through some set of data, and the conclusion that follows, is that humans therefore have these axioms consciously or unconsciously in their minds and behave so as to satisfy them.

RACE NO.	RACES	WIN	PLACE	SWINGER	TRIFECTA
1	57	15.55	5.99	26.64	51.81
2	57	13.85	7.04	27.97	51.13
3	57	13.56	6.5	26.57	53.35
4	57	15.21	7.02	27.61	50.15
5	57	15.7	6.99	25.64	51.65
6	57	15.84	6.41	23.43	54.31
7	57	15.42	6.04	24.32	54.21
8	53	15.64	6.18	24.66	53.51
9	30	15.98	6.28	24.16	53.55

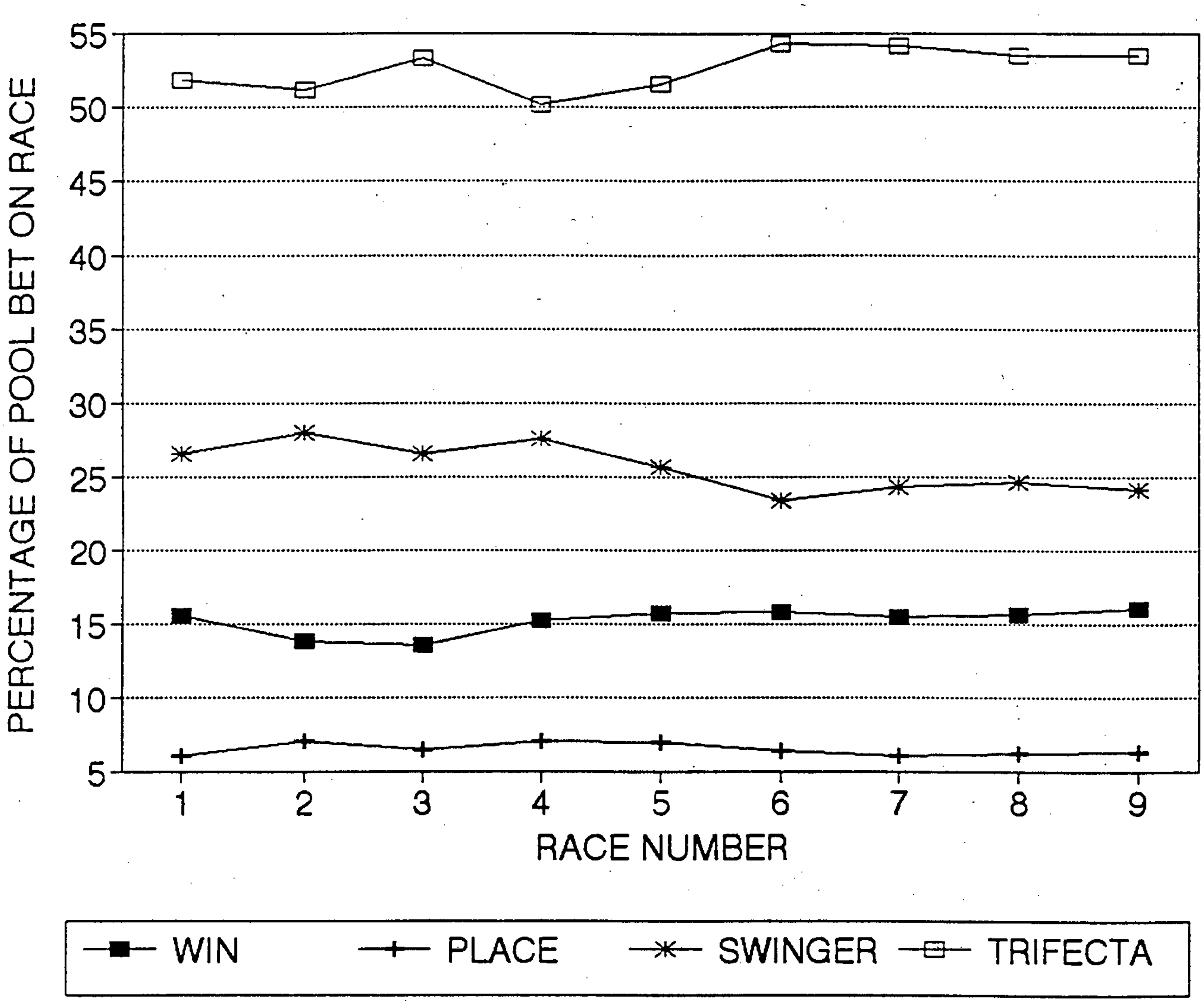


Table 4.8 Percentage of total amount bet per race split by bet type, where race number was taken as the actual number of the race.

RACE NO.	RACES	WIN	PLACE	SWINGER	TRIFECTA
9	57	14.45	5.6	24.71	55.23
8	57	16.29	6.14	23.8	53.76
7	57	16.24	6.15	23.61	53.98
6	57	15.44	6.7	24.81	53.05
5	57	15.1	7.15	26.42	51.31
4	57	14.52	6.92	27.88	50.67
3	57	14.08	6.83	27.98	51.09
2	53	14.45	7.11	27.51	50.91
1	30	16.05	5.75	25.14	53.05

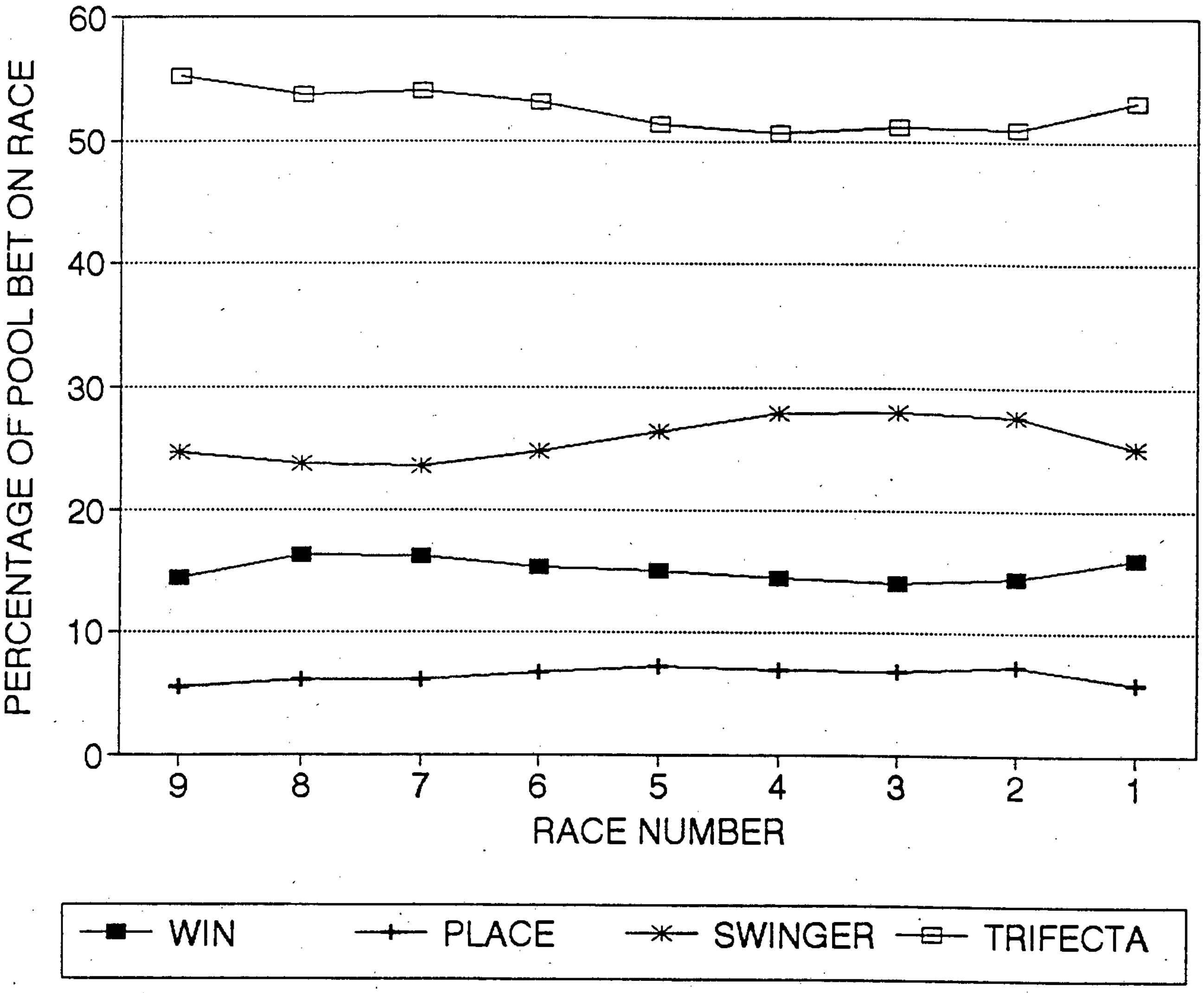


Table 4.9 Percentage of total amount bet per race split by bet type, where race 9 represents the last race of a particular day, and not necessarily races which are the ninth race.

Clearly, causal relationships between behaviour and any proposed axioms are very difficult to prove, but the fact that some correlation exists between predicted and actual behaviour cannot mean that the axioms underlying the predicted behaviour are actually responsible for the observed behaviour.

Although the most commonly used models of human behaviour have the considerable advantage of mathematical simplicity, it is our opinion that models need to be developed using a more general approach (incorporating factors other than the usual money and probability variables). This would not be so that the models could be generalized to many areas, but rather that they might apply with a higher degree of accuracy to one or two specific instances. This approach would obviously then have to be repeated every time a new situation required description or explanation.

We are also of the opinion that the Expected Utility Hypothesis has been accepted so widely because it is used by economists who, in our experience, pose the question "What?" far more often than the questions "How?" or "Why?". In contrast to this, psychologists, who generally eschew the Expected Utility Hypothesis in favour of more complex explanatory models, or at least take the view that money is not the variable that should be concentrated on, in any decision analysis, are more concerned with the process behind the results, rather than what the results actually were.

Consider the following from Reder (1986), "Finally, both the challenges and difficulties of fruitful coexistence of economics and psychology are encapsulated by the reductio ad absurdum cited by Arrow: "There cannot be any money lying in the street, because someone else would have picked it up already". For the economist operating within the rational choice paradigm, this statement can be taken to mean that, for all practical purposes, the world behaves as if there were no money lying in the street. The psychologist, however has no reasons to accept this statement as a working hypothesis. Instead, he would accept the possibility that some money may be lying in the street and would consider it worth learning who finds it and why".

In this work we shall concentrate on the approach taken by psychologists, and pursue an understanding of the process whereby people make decisions. We shall disregard to a large extent the mathematical formulations of the decision making process and start anew. We suggest that people do not consciously act so as to maximize anything, and that if on the whole they do so, there are other forces at work which lead to such observed behaviour. We shall include the influence of non-wealth variables if we find that they applicable to describing actual decision making. Most importantly we shall consider how, and why, decisions are actually made, i.e. the process of decision making.

Consider Reder (1986) again, "...economic explanations involve showing that outcomes (i.e., what agents decide to do) are consistent with the maintained hypothesis of the rational choice paradigm. For psychologists, on the other hand, explanation requires specifying the process by which choices are made. Moreover, for an economist, the process explanation of the psychologist is, at most, of incidental interest unless it leads to outcomes at variance with the maintained hypothesis". Psychologists on the other hand are not threatened by unexpected empirical results. The challenge to the psychologist is to construct a theory of the observed process, which may include any number of contradictions to the suspected hypothesis, and to see whether this might generalize to domains other than choices as in the given experiment. For the gambling process at least, this too is our challenge.

Before we begin investigating the alternative approaches suggested above, we briefly review the most commonly used and easily understandable mathematical models that have been proposed as either descriptive or prescriptive of the decision making process.

The Expected Monetary Value (EMV) hypothesis assumes people will maximize the expected value of their return when making decisions. This implies they will be prepared to pay the expected value of a game, in order to participate in the game. If p_i = the probability of outcome i and X_i is the payoff resulting to the bettor if the outcome of the event is i, then by the EMV hypothesis, the amount a bettor will pay to play the game is

$$E(X)=\sum_{i=1}^{i=n} p_i X_i$$

Note that it is assumed in the model that the objective scales of money and probability are equal to the respective subjective scales.

We next consider the von-Neumann/Morgenstern Expected Utility Hypothesis, which incorporates the Bernoullian Expected Value criterion. Under such an hypothesis, the aim of the decision maker is to maximise his expected utility. Consider u(X), a function of the value of money. This function, generally called a utility function, can take any form, but specific shapes, often used, represent different attitudes towards risk. In this case a bettor would pay the monetary amount which he equated with the utility worth of

$$\sum_{i=1}^{i=n} p_i u(X_i)$$

to play the game. Note under this hypothesis the objective and subjective scales of money differs, but the subjective scale of probability is assumed equal to the objective scale.

Under Certainty Equivalence Theory, the reverse is true. Thus the objective and subjective scales are assumed equal for money, while the scales are assumed different for probability. This subjective or personal school of probability was primarily developed by Frank Ramsay (1931), Bruno de Finetti (1937), Leonard Savage (1954) and Pratt, Raiffa and Schlaifer (1964). In their view, probabilities are degrees of belief, applicable to both repetitive and unique events.

If f(p) represents a function of probability, then under this hypothesis, the amount a bettor will pay to play the game is,

$$\sum_{i=1}^{i=n} f(p_i) X_i$$

Under Non-linear Expected Utility Theory, both probability and money have subjective scales differing from their objective scales. It should be noted that in order to derive a subjective scale of money it is necessary for subjects (at least) to be completely aware of the objective probabilities of all outcomes of the event. In addition, subjects should not prefer betting at certain probabilities to others. Similar problems exist when subjective scales of probability are determined. Under such a scenario the bettor should pay the monetary equivalent of the utility worth of

$$\sum_{i=1}^{i=n} f(p_i)u(X_i)$$

to play the game.

Under Prospect Theory, the function of probability $f(p_i)$ is replaced by a Decision Weight function, $w(p_i)$. Decision weights are not probabilities, and do not obey the mathematical constraints of probabilities. In addition they cannot be interpreted as a measure of belief. They are generally lower than the corresponding probabilities , except in the range of very low probabilities. Another key aspect of Prospect Theory is that utility values are attached to gains and losses, rather than final wealth states, as in Expected Utility Theory.

How should we go about determining how and why people make certain decisions when faced with risky outcomes? We suggest that the best manner is to investigate the subject's psychological state close to when the decision is being made. There will be many variables which affect such a state and the difficult part lies in determining which of these gains the upper hand at the time of the decision ,and thereby play a larger then expected role in the decision making process.

Examples of these could be the reliability and availability of information regarding the bettors subjective probability estimate of a particular horse winning a race. A most important consideration which needs particular attention, is the timing of events that are likely to affect decisions. In this regard it is highly probable that events having occurred most recently, give rise to factors having a stronger hold, (in order to gain the upper hand described above) than events that have occurred in the more distant past. This will be discussed in more detail shortly.

As we have stated above the key to such analysis is through the psychological processes of the subjects. We therefore looked into some relevant psychological literature, before coming up with our own suggestions regarding why people make certain decisions. The literature relates to gambling in general as well as to broader topics of decision analysis, while our suggestions are based on observations of, and discussions with gamblers at the racetrack. In addition a field study was undertaken to shed more light on the psychology of bettors at the race track.

4.5.1 Literature Review And Comments

McCauley et al. (1973) investigated the difference in behaviour between groups and individuals using subjects at the race track. In previous laboratory studies, groups had sometimes shifted towards more risk than the individuals that comprised the group, but on others the reverse was observed. The paper was the first to study this phenomenon in a natural setting.

The riskiness of a bet was defined by the odds, with long odds indicating risk and short odds, caution. Subjects were approached at the track after having made a bet. They were then offered money with which to have another bet, if they would participate in the experiment. The odds of the horse that the subject had originally bet on were recorded as the pretest riskiness level. Four such subjects were brought together in a group and three were randomly chosen to make a group decision as to where to bet their sponsored money, while the fourth made his decision alone. The group had to come to a unanimous decision as to which horse to bet on within about three minutes. The odds of the individuals choice was recorded as the individual posttest riskiness level, while the odds of the group's choice was recorded as the group posttest riskiness level. Initial riskiness for the group was taken as the average of the odds that the groups members had bet on originally.

A shift in risk was measured by the difference in pretest and posttest odds. A positive difference indicated a shift to shorter odds or a cautious shift, and vice versa.

The results were as follows.

Condition	Cautious Shifts	Zero Shifts	Risky Shifts
Group	16	1	5
Individual	6	13	3

The chi- squared value associated with the table is 12.4, which indicates significance at the 1% level. It is however not pointed out that the numbers within the table are small (<5 for some of the cells). The conclusion is that group discussion and the requirement of a unanimous decision produced a shift towards caution. This result is surprising if examined in the light of the fact that these subjects have actually paid an entrance fee to the track in order to take risks with their money. The assumption from this, is that risk is valued more than caution, which is in contradiction to the observed behaviour.

Leopard (1978) investigated risk preference in consecutive gambling, using laboratory experiments. Previous studies of this idea, had produced mixed results. As discussed in section 4.2, McGlothlin (1956) analyzed bettors behaviour, in the real world setting of horseracing. He suggested that risk, as indicated by variance, was greater in subsequent bets when bettors were losing than when they were winning. However, other studies had failed to show any effects of prior outcomes on variance preferences, or found them to be in the opposite direction from those reported by McGlothlin. In Leopard, changes in risk preference over a series of consecutive decisions were related to outcome history and financial state. The alternative gambles available to subjects, differed in risk as defined by variance and skewness.

Risk was assumed to be monotone with variance, but no a priori assumptions were made regarding the relationship between risk and skewness, implying that such a relationship has no fundamental basis. Initial tests of the results showed that subjects were indeed influenced by whether they were ahead or behind, in making their decisions. Two possible reasons are suggested for such behaviour. Firstly, bettors preferences for the amount of risk changed with their status within the game, and secondly, bettors perceptions of the amount of risk involved in the choice of a particular gamble changed with their changed status. The results were examined by subject, on an individual basis.

The first explanation accounts for the observation that some bettors chose higher risk gambles when they were behind. The second explanation accounts for the observed behaviour of those bettors, who chose higher variance after a run of losses, and were expecting a win owing to the gamblers fallacy. In addition, subjects whose behaviour implied a belief in runs of luck, by choosing higher variance gambles when winning and low variance gambles when losing, is also explained by the second point above. Leopard suggests that both preferences, and altered perceptions are simultaneously present, when making decisions on consecutive gambles.

Skewness was adjusted using a trade off between amount to lose and probability of loss. Since risk increases with both of these, there was no reason to believe that one factor would dominate the other. Such non domination would result in no obvious risk ordering between gambles with equal expectation and variance, but differing skewness. It was therefore surprising to the researcher, the extent to which agreement between subject's choices, was noted. This is because she had expected random results since no a priori reason existed, to suspect that the results might be in a specific direction. It was apparent that subjects viewed the probability of loss as the more important risk factor at low levels of variance, while the amount that could be lost was the major risk factor at higher levels of variance.

Wright and Ayton (1986) examined what, how and why psychological factors affect people's estimates of probabilities regarding future events. Desirability and perceived controllability are two psychologically determined variables that affect probability estimation. Other variables are also discussed, but are not relevant to the horserace bettor.

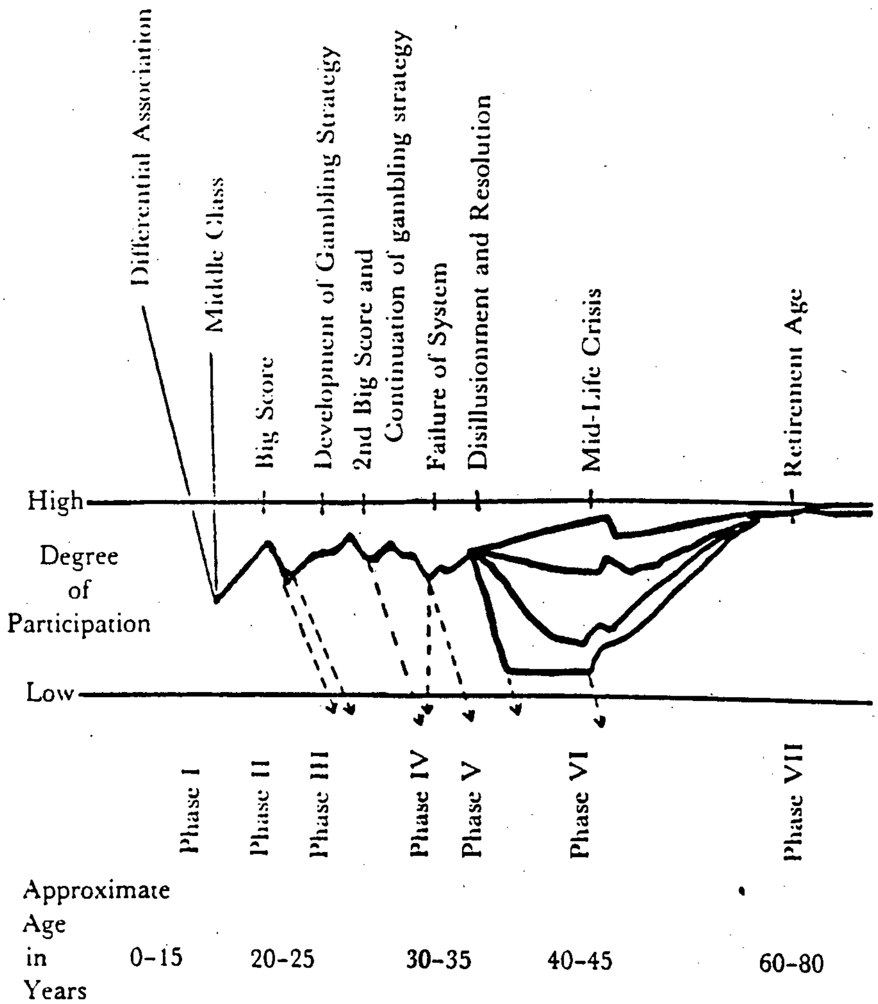
An example of the possible operation of the "availability" heuristic, whereby easily recalled instances are given too high a probability, is given. Subjects are asked to assess the probability of positive (lottery win) and negative (involvement in a car accident) events, occurring to them and someone identical to them in terms of certain social and cultural factors. It was found that subjects believed that desirable events were more likely to occur to themselves, and that negative events were more likely to occur to someone else. The availability of many instances of negative events occurring to others, explains the belief, for negative events, but no explanation is given for the overestimation of the positive event probability. The pattern of responses was termed an optimistic bias. It is quite possible that similar questions asked of subjects on the racecourse would yield a pessimistic bias, especially if the "availability" heuristic was playing a part.

Rosecrance (1986) investigated gambler's behaviour by examining a number of inveterate gamblers at the racetrack. He found that almost all the subjects had similar stories to tell regarding their gambling careers, and through this he was able to put together a general picture of an inveterate gambler. The work therefore regards the question; "Why are gamblers at the track at all?", as opposed to "Why do gamblers exhibit certain behaviour once they are at the track?" Our interest in the first question is based on the belief that much can be learnt regarding the second question by examining the results of psychological analyses of the first question.

Rosecrance defines inveterate gamblers as those persons that attend the races at least twice per week and who consider themselves regulars. The behaviour of these gamblers is then analysed within an historical framework, beginning when they first start to gamble until past retirement age. Interviews with more than 30 subjects were conducted. Seven distinct phases were identified as common to all the participants in the study. These are shown in figure 4.4. Of importance to us and our investigation into bettor behaviour in gambling situations, are the first three phases.

The first phase is the acquisition of the behaviour pattern known as playing the horses. In our view this is the most important phase, since given that someone has acquired such behaviour, it is likely that they have experience of risky situations which will allow them to make rational decisions within their own framework of risk, that may appear irrational to most other people, including researchers, who are not gamblers, and are therefore assumed never to have been provided with sufficient stimulus to acquire gambling

Career Lines of Horse Players



The career lines of inveterate horse players are fairly similar until the disillusionment and resolution phase is reached. Then there is a considerable branching due to the various life styles of the participants. Broken lines indicate drop outs.

Figure 4.4 reproduced from Rosecrance (1986)

behaviour and alternate attitudes towards risky situations.

Two factors were present in almost all the serious players interviewed. These were the exposure to gambling before age 21, and the winning of a large amount, (usually in excess of 10 times their average winning) shortly after having started gambling. (From a personal viewpoint, both Rosecrance and this researcher can testify to being serious gamblers and to satisfying both the above conditions). The early big win is vitally important in determining future behaviour, since those that are rewarded early, begin to believe that winning at the track is possible. This would certainly not be the attitude of another person of similar background to the gambler in question.

The power of the first big win may partly explain why bettors avoid favourites and pursue long-shots with such consistency. Consider the following from Rosecrance; "Almost all serious horseplayers can vividly recall their first big score, how much they made, the name of the horse, the flush of excitement when their horse won, and their wonder and surprise at such an occurrence. The big score often becomes such a significant part of gamblers' memory systems that mere recall of the event provides sensory stimulation." If a repeat performance of this event is of any importance to the bettor, it is likely that he will be observed to make decisions contrary to those predicted by a utility function that was derived for him while away from the racetrack environment.

The other factor of importance in acquiring gambling behaviour is sufficient exposure to gamblers, as well as gambling situations, such as horseracing, which usually occurs through the media. It was found that gamblers with middle class upbringings did not usually have contact with gamblers in their early years, and were generally introduced to horseracing through exciting accounts of the sport in the media. They then associated horseracing and gambling with a colourful and unorthodox life style, which was appealing when contrasted with their own mundane middle class environment. People of such character are almost certain to have different attitudes towards risk than their more "mundane" counterparts and therefore, their behaviour may include examples of apparent irrationality at the racetrack.

Consider the following real life example of one of the subjects in Rosecrance's study. "The life of the race gambler was so different from my own - so much more stimulating, it really turned me on. When I heard on the radio that horse racing was opening in my town, I got a couple of buddies - almost on a dare- to go to the track. When I got there, the crowd, the noises, the charged atmosphere - Man, it blew me away. I bet $5.00 on the first race. The horse actually won. I couldn't believe it! I said to myself, 'This is for me!'".

It appears, therefore, that gamblers are easily capable of separating their worlds into two, boring and exciting, say. It would surely not be assuming too much to believe that they could, in addition, separate their financial accounts into two different worlds as well; an account for the exciting world and an account for the boring world. They could then act completely differently as far as financial decisions are concerned because the money being used is in its own specific situation where the person may assume a totally different psychological outlook on that specific world. We believe that this point is also very important in explaining gambler's so called irrational behaviour at the track.

Phases two and three in the gambler's career are the recognition of the difficulties of sustaining a gambling trait, and the development of a gambling strategy. In the second phase it is quickly acknowledged that simplistic methods of betting are not rewarded and this leads to the third phase, in which a complex gambling strategy is developed. Figure

---

Do not wager on a horse unless:
1) it previously raced within twenty-one days;
2) it was at least third in its last race;
3) it had a workout within five days of today's race;
4) it is ridden by a leading jockey (in the top ten);
5) it is trained by a leading trainer (in the top ten);
6) it has won at least twenty percent of its races;
7) it was no worse than third at the first quarter mile in its last race;
8) it is no more than eight to one in the betting.

Figure 4.5 reproduced from Rosecrance (1986)

4.5 shows a betting system devised by one of the subjects in the study.

The key point to note about the system is that it is a rule based, or heuristic system. The individual and collective effects of these rules need to be learned, and incorporated into the gambler's psychology. We believe that apparent irrational actions of bettors are based on the inadequate application of system heuristics. For example, assume that the above eight rules were sufficient to suggest winners to a high degree of accuracy, and that owing to this fact, our bettor had been very successful in his betting. In addition, assume that following the heuristics rigidly will lead to what observers would call rational behaviour, according to Expected Utility, (say). The bettor's mind will soon most likely associate one or two specific heuristics with his victories, and soon he will bet on the basis of these alone, rather than on the collective effect of all the rules.

A specific example of this, may be a memorable late dash by the jockey aboard his last winning bet. Although the bet was made on the basis of much more information than the jockey alone, the bettor is so impressed by the jockey, that the next time he bets, he weights the jockey far too highly, at the expense of the other variables. This easily recalled instance, (which may be recalled for years ahead) is biasing the bettor away from optimality and so called rationality. Thus, we may well observe an irrational choice owing to one specific heuristic playing too great a role in the decision making process. If we assume that bettors DO in fact devise some system that allows them to make rational decisions (and this is evidenced empirically), then we must assume that eventually decisions are made using only part of that system (probably owing to the effects of the above, or even just plain laziness in the analysis of the available data) which inevitably results in both sub-optimal, but also apparently irrational choices.

The favourite-longshot bias apparent in so much of the economic literature, is easily explained from a psychological standpoint. Consider the following from Rosecrance; "Inveterate race gamblers frequently indicate that winning a large bet generates an incredible high. Gamblers report that when their conviction is verified and the ensuing payoff is substantial, they feel a sense of exhilaration and omniscience." These feelings are almost certainly those sought by gamblers who select high risk and lower return bets (longshots) in favour of those with lower risk and higher return (favourites).

We have attempted to explain why gamblers behave the way they do. Having read many papers on the relevant topics we have come to the conclusion that gambler's behave they way they do BECAUSE they ARE gamblers. Thus the Expected Utility Hypothesis which may be applicable to "normal" people would not approximate gambler's behaviour even remotely, because gamblers, having experienced gambling, have had their psychological outlook changed to the extent that they are not "normal" anymore.

4.6 A Field Study

4.6.1 Background

The failure of Expected Utility Theory as both a predictive and descriptive model, most likely stems from an inadequate recognition of the various psychological factors which are used in the judgement of choices. Many problems with the Expected Utility Theory approach to decision making have been reported in the literature. We wanted to know which of the observed violations of the theory were taking place at the racetrack. In the following paragraphs we have made a summary of some of the observed problems with utility approaches to decision making, as well as citing examples of how these would manifest themselves at the track. We then present the results of the study.

1) Utility models generally consider only rewards, not regrets.

At the racetrack a bettor may violate the rational decision according to the utility model, of say, betting on a particular horse for a win, by choosing rather to bank that horse in a Jackpot or Pick-6 bet. This means that only one horse is selected as the possible winner of one of the legs and the bet cannot be won if this horse (the "banker") does not win. These high risk, high return bets offer a large amount of regret if they could have been won by betting them rather than the win. A return to the win bet is more likely but offers a far lower return with concomitant lower regret at not having bet for a win, assuming that the Jackpot bet is lost, while the win bet would have been successful.

Let us consider a specific example. Our bettor is convinced he has a winner for the day, and the horse's odds are approximately 4/1. He has, say, R400 to spend on the day. If he backs the horse for a win he will receive R1 600 less tax plus his stake back if the horse wins. If he takes a Jackpot with his selection as a banker, his return if successful could range from R100 to R10 000 (say). Note that a successful Jackpot bet implies a successful win bet, but the converse is not necessarily true. Since it is far more likely that the return to the Jackpot will be in the region of R300, utility theory would suggest, given the subjects utility for money curve, that he would bet on the horse for a win. The observed behaviour is likely to be otherwise, however, since the fear (regret), of missing out on the possible R10 000 Jackpot weighs more heavily than any other factor on the bettors mind.

2) Utility models conventionally attach utility values to final wealth levels, not to gains or losses occurring within the specific decision making environment. This point requires the introduction of the concepts of reference points and aspiration levels.

The racetrack bettor may violate his expected behaviour, according to Expected Utility, because he attaches an "irrational" value to a certain return that at other times he may not do. In addition he may bet irrationally because he is attempting to achieve a specific target and he attaches an "irrational" value on this target. It is likely that these two scenarios would occur at different points in the racing day.

Let us consider an example of the second point first. Suppose that our bettor will only be satisfied if he wins at least R5 000 on the day. He will therefore only bet on the high risk, high return bets available. These would be the Jackpot, Pick-6 and Trifecta. This scenario would likely take place early in the racing day. Now assume that our bettor has lost all except 10% of his money. He does not have enough to win R5 000 anymore but he does have enough to get his money back that he has lost during the day. He now looks for those bets which will provide him with this return and attaches special value to them. This scenario most likely occurs at the end of the racing day. Clearly, the risk taking behaviour in both these cases depends both on where you are as well as where you want to be financially.

3) Single attribute utility models do not consider the non wealth factors associated with making a bet.

Besides the potential monetary gain, any bet also includes the utility derived from making the bet. These include, the analyzing of the relevant information, pitting one's predictions against one's contemporaries at the track in order to seek status, and probably most important of all, excitement. These factors are largely absent if one selects the known favourite. Thus even though utility theories would suggest that bettors would bet on such favourites, observed behaviour is likely to differ owing to the derivation of utility other than that derived from money.

4) Utility theories assume a holistic approach, whereby multidimensional alternatives are each assigned a separate level of utility before a decision is made. Thus decision makers are required to take a portfolio perspective before making any decision.

Decisions are more likely made in decomposed fashion, whereby each alternative is compared against a standard and eliminated if it does not measure up. It is also possible for alternatives to be compared against each other directly, without preset standards, and the choice is that which has the most favourable aspects. In both of these approaches the comparisons are made on a piece-meal basis, i.e. one dimension at a time. Suppose one is offered an insurance policy, Expected Utility Theory assumes that the decision regarding the policy will be made taking account of all other risks that you face. It is far more likely that people do not approach decisions in this comprehensive manner and rather treat such problems in isolation.

The following points all relate to the psychology of probability judgements. Subjective probabilities commonly violate basic statistical principles thereby invalidating the axioms of utility theories.

5) Easily recalled instances which are memorable and have also occurred in the recent past have too great an effect on the assessment of the probabilities involved in the decision making process. This is generally known as the availability bias.

Let us consider a specific example that could occur at the racetrack. Assume our bettor wants to bet on the Jackpot, which is his regular form of bet. Assume last week that he bet on the Jackpot, and was knocked out by a horse that he considered to have no chance, because the horse was eight years old and he could not remember the last time an eight year old won a race of any description. In one of the legs of the Jackpot today he is faced with a field of 10, of which two are eight year olds. In this instance he is likely to include these two horses which last week, according to him have been no-hopers. The reason for there inclusion is not only that the instance of an eight year old winning occurred in the recent past, but also that it was a memorable (if not happy) occurrence, which had caused him to lose money the previous week.

6) In attempting to determine true probabilities, initial estimates are often made close to a median value, and then adjusted. This leads to an underestimation of the variance of the probabilities involved and is generally known as the anchoring bias.

Assume our bettor is faced with a race involving twenty runners. Approximately 10 of these will fall into the bookmakers betting class of "others" as the rank outsiders of the race. Clearly they all do not have the same true probability of winning but owing to the subtle prompting of the bookmakers the bettors will deem this to be so. Assignments of probabilities to these horses are likely to be incorrect because of the initial estimates which rank all these horses at some basic level.

7) Any alternative which displays certain characteristics which are typical of previous occurrences will most likely be assigned a probability which is overestimated. This is generally known as the representativeness bias.

Punters in general will have a perception of what characteristics a typical winner possesses. On this basis, a horse with such characteristics will be deemed a likely winner, irrespective of the number of losers that also have such characteristics.

Given this large number of possibilities for failure, it is likely that at an individual level, expected utility maximization is the exception rather than the rule as regards observed behaviour. As a descriptive model of the decision making process, Expected Utility Theory fails firstly, because people do not structure problems as holistically and comprehensively as the theory suggests. Secondly, they do not process information regarding probabilities according to the theory's rules, and thirdly it is highly unlikely that Expected Utility can be used as a general descriptive model, since it barely describes behaviour in controlled laboratory situations.

4.6.2 Procedure

In order to gain some insight into gamblers' behaviour we thought it necessary not only to investigate their group behaviour via aggregate tote and bookmaker data, but also to approach individuals at the track and ask them how they went about betting and how they would react to certain situations. A questionnaire was devised to extract information in such a way as to be able to easily identify subjects' biases, which had been observed in previous aggregate data work.

At the time the field study was being undertaken, we were approached by a student investigating racing from a marketing point of view, and it was decided to group our resources and to have one questionnaire for both topics. The questionnaire is shown here. The first three pages of questions relate to the marketing section of the investigation, while the final two pages concern the decision analysis section of the work.

People were approached at random at the racecourse and asked whether they would be prepared to fill in the questionnaire. They were told that it would only take a few minutes, although some of the subjects got quite engrossed and took up to forty five minutes to complete it. Both Wednesday and Saturday race meetings were attended by the researchers when there joint schedules permitted. Up to four hours at a time were spent at the racecourse, and approximately ten visits were required to collect the sample of eighty six respondents.

The researchers sat with some of the subjects while they completed the questionnaires, in order to explain some of the questions but were careful not to prompt any specific type of answers. The majority of subjects took the questionnaires away and returned them later in the racing day. A brief check was made to see if all the questions had been answered. If some had not, the researchers asked the subjects to please complete the questionnaire. This was often the situation in the case of question twenty in the decision making section of the questionnaire.

The questionnaire is shown on pages 4-55 to 4-59. For the purposes of this work we need have no regard for the marketing section of the questionnaire and it is only shown so that an idea can be obtained of what the subjects had to go through before answering the questions which do concern us. It is likely that about two thirds of the time spent on the questionnaire was spent on this section and it is quite possible that by the time subjects proceeded to the decision making section they were already tired of answering questions. In addition, the more complex nature of the questions on the final page may have elicited an attitude of apathy in the subjects, who may then have answered without much thought in order to get on with what they had come to the races to do. Overall however, we believe that sufficient thought went into the answering of the questions to make the results of the investigation meaningful. The data was transferred to computer by professional data capturers and random checking indicated that the transfer was accurate.

QUESTIONARE

Good afternoon, my name is ...., I am presently completing my thesis at UCT. I would appreciate it if you would answer a few questions with respect to racing. All answers are stictly confidential, and are only used for research purposes.

DEMOGRAPHICS.

1.CLARIFY : Member ☐
Non member ☐

2.AGE: 1.16-34 ☐
2.35+ ☐

Reach limit = close interview.

3.How often do you attend the races.

1.	Basically every racemeeting.	
2.	More than once a month.	
3.	Once a month.	
4.	Twice or more in this past year.	
5.	Once in the past year.	
6.	Less often.	

If attend less than once a year in the past year, close interview.

4. For what reason did you decide to come to the races?

1.	An interest in Racing as a sport.	
2.	To gamble	
3.	It was a feature day , ie. the J&B Met.	
4.	You were invited as a guest.	
5.	I am an owner/trainer/ breeder.	
6.	Other please specify.	

5. Thinking back on your first racemeeting, please tell me your reason why you decided to attend it.

1.	For purely monetry gain.	
2.	A friend/family member encouraged me to go.	
3.	A genuine interest in racing as a sport.	
4.	I was inquisitive.	
5.	Other, please specify.	

6. What do you enjoy about coming to a race meeting. Read the list below and rank the first three in order of preference. (eg. 1 = most important; 2 = 2nd and 3 = 3rd most important)

1.	Make money.(profitable)	
2.	The challange of gambling.	
3.	Relaxing.	
4.	The anticipation of the big win.	
5.	Sociable.	
6.	Friendly racing atmosphere.	
7.	Enjoyment of racing (as a sport)	

7.Listed below are statements concerning the racing industry. The scale rates the statements from STRONGLY AGREE to STRONGLY DISAGREE. Place an X in the box that you feel accurately rates the statement in your opinion.

		ST. AGREE	AGREE	NIETHER	DISAGREE	S. DISAGREE
1.	Horse racing is a game of skill.					
2.	I enjoy watching the horses run.					
3.	Most horse races are rigged.					
4.	Horse racing is well advertised.					
5.	Horse racing is the most enjoyable form of gambling.					
6.	" A day at the races" would be fun .eg. The Met;Durban July					
7.	Restaurant facilities are pleasant and comfortable.					
8.	The racecourse is an undesirable place that attracts the wrong type of person.					
9.	I enjoy gambling at casinos, rather than on the horses.					
10.	I would like to own a racehorse if I had the choice.					
11.	The different types of betting on the course totally confuse me.					
12.	Racing is a sport frequented by the wealthy, upper class.					
13.	Bar facilities are accessible and comfortable.					
14.	Parking is convenient and safe.					
15.	R7 is a acceptable entrance fee to pay considering the facilities.					
16.	Food is overpriced.					
17.	They could improve facilities for the spectators.					
18.	Food and drink are easily accessible at the track.					
19.	The raceclub caters for the whole family.					

		S. AGREE	AGREE	NIETHER	DISAGREE	S. DISAGREE
20.	I would rather bet at the racetrack than bet through the tote.					
21.	Attending a racemeeting is my idea of a good Saturday afternoon entertainment.					
22.	Other than gambling Horse racing is boring.					
23.	I prefer to watch horse racing on T.V. than actually attending racing.					
24.	Bookmakers are generally honest.					

8. What, in your opinion are the major problems with racing in the Cape?

____

9. Read the list below and then give me in your opinion what the three most important improvements needed in Cape racing. Rank the first three in order of preference.

1.	Better racecourse amenities.	
2.	More tote facilities.	
3.	More pre-race information on the horses, jockeys and trainers.	
4.	New types of betting,	
5.	More accessible parking.	
6.	Serious punishment for offenders who manipulate the betting.	
7.	More information on how to bet.	

DECISION MAKING (CIRCLE THE ANSWERS TO THE RIGHT OF THE QUESTION.)

1) Do you generally bet on favourites or outsiders? FAV O/S

2) Which of these three favourites would you prefer to bet on;

1) 6/10 1 2 3
2) 2/1
3) 4/1

3) Which of these three outsiders would you prefer to bet on;
1) 7/1
2) 20/1 1 2 3
3) 66/1

4) Do you bet on horses that you have backed before? Y N

5) Do you bet on newspaper selections? Y N

6) Do you bet on Computaform/Winning Form selections? Y N

7) In which of the following betting categories do you spend most money;
A) Pick Six
B) Jackpot
C) Trifecta
D) Win
E) Quinpot/PA/Swinger/Place

WRITE YOUR TOP THREE IN ORDER.
1)
2)
3)

8) Do you generally listen out for "inside information"? Y N

9) If you obtain "inside information" would you act on it? Y N

10) Is your decision to bet influenced by how much you have lost on the day? Y N

11) Is the amount you bet influenced by how much you have lost on the day? Y N

12) Do you generally consider the possible win from your bet or the possible loss? WIN LOSS

13) Do you bet more on feature races than any other single race? FEAT OTH

14) Do you bet more on late races than early races? L E

15) Do you prefer backing horses in large or small fields? L S

16) Do you follow market movements? Y N

17) Which of the following horses that firm in the market would you bet on if you could only back them at Starting Price?

	Opening Price	Starting Price
1)	2/1	15/10
2)	3/1	15/10
3)	4/1	15/10
4)	3/1	2/1
5)	4/1	3/1
6)	4/1	2/1
7)	5/1	1/1
8)	16/10	15/10

CIRCLE THE NUMBERS YOU WOULD BET ON. CHOOSE AS MANY AS YOU WOULD BET ON.

18) Which of the following horses that drift in the market would you bet on?

	Opening Price	Starting Price
1)	15/10	2/1
2)	15/10	3/1
3)	15/10	4/1
4)	2/1	3/1
5)	3/1	4/1
6)	2/1	4/1
7)	1/1	5/1
8)	15/10	16/10

CIRCLE THE NUMBERS YOU WOULD BET ON. CHOOSE AS MANY AS YOU WOULD BET ON.

19) Which of the following are most important in helping you decide whether to bet or not; please rank the top 5 in order.

A) possible return
B) possible loss
C) amount of money on you
D) amount previously won
E) amount previously lost
F) inside information
G) newspaper tips
H) Computaform/Winning form tips
I) support for horse in market
J) been following the horse

Selections
1)
2)
3)
4)
5)

20) What is the percentage chance, in your experience, of horses with the following odds winning;

	%		%
1) 1/3		5) 3/1	
2) 7/10		6) 5/1	
3) 11/10		7) 10/1	
4) 2/1		8) 25/1	

4.6.3. Results and Conclusions

The results of the study will be statistically interpreted using the non-parametric chi-square test of proportions. It is assumed throughout in the null hypothesis that the answer to any of the questions, is equally likely to be any of the alternatives on offer. In all cases, the number of respondents to an individual question is less than the sample size of eighty-six. This is because not every subject answered every question. A summary of the results is shown in Tables 4.10 to 4.12.

Question Number	Number of Respondents	Results
1	68	Favourites = 23 Outsiders = 45
2	73	6/10 = 3 2/1 = 32 4/1 = 38
3	74	7/1 = 45 20/1 = 19 66/1 = 10
4	77	Yes = 72 ; No = 5
5	76	Yes = 20 ; No = 56
6	73	Yes = 32 : No = 41
7	75	First Choice Only Pick-6 = 10 Jackpot = 14 Trifecta = 7 Win = 15 Place = 29

8	79	Yes = 42 ; No = 37
9	78	Yes = 60 ; No = 18
10	78	Yes = 41 ; No = 36
11	75	Yes = 38 ; No = 37
12	73	Win = 52 ; Loss = 19
13	74	Feature = 18 ; Other = 56
14	64	Late = 38 ; Early = 26
15	68	Large = 40 ; Small = 28
16	69	Yes = 43 ; No = 26
17	79	Number of respondents choosing alternative 1) 19 2) 24 3) 31 4) 28 5) 39 6) 25 7) 33 8) 17

18	79	Number of respondents choosing alternative 1) 30 2) 25 3) 17 4) 28 5) 32 6) 21 7) 17 8) 35

Table 4.10 Results of questions one to eighteen of field study

	first choice
a) possible return	21
b) possible loss	1
c) amount of money on you	13
d) amount previously won	6
e) amount previously lost	0
f) inside information	6
g) newspaper tips	1
h) Computaform tips	2
i) betting support for the horse	5
j) been following the horse	14

Table 4.11 Results of question nineteen of field study - number of respondents = 69

	second choice	cumulative
a) possible return	13	34
b) possible loss	1	2
c) amount of money on you	17	30
d) amount previously won	7	13
e) amount previously lost	1	1
f) inside information	9	15
g) newspaper tips	4	5
h) Computaform tips	3	5
i) betting support for the horse	3	8
j) been following the horse	9	23

Table 4.11 Results of question nineteen of field study - number of respondents = 67

Respondents	Odds	Average Observed Probability	True Probability	Ratio
63	1/3	0.7811	0.7500	1.04
61	7/10	0.6926	0.5882	1.18
62	11/10	0.5976	0.4762	1.25
61	2/1	0.5000	0.3333	1.50
62	3/1	0.4189	0.2500	1.68
60	5/1	0.3498	0.1667	2.10
60	10/1	0.1985	0.0909	2.18
59	25/1	0.0989	0.0384	2.57

Table 4.12 Results of question twenty of field study

Question one (along with some others) is helpful to elicit information regarding the well known favourite-longshot bias. We note that twice as many people prefer backing outsiders to backing favourites. The chi-square test statistic of 7.11 is significant at the 1% level of significance. There are probably many behavioral factors at work here, and for different reasons. Firstly, bettors might overestimate the chances that long shots will win, therefore believing they are getting value for money by backing such horses. Secondly, bettors might derive sufficient extra utility from betting on a longshot that they do not worry about the monetary and probability aspects. Thirdly, it is more fun and more status is derived from backing an outsider rather than a favourite. Finally, it is possible in a large market, that bettors choosing horses for essentially irrational reasons, such as the horses name, boost the pool and drive the odds down on unfancied horses to a larger extent than they could do on fancied runners.

The results of questions two, three, five and six are also useful for gaining insight into the favourite-longshot bias. Question two indicates that bettors avoid very strong favourites (horses with probabilities of winning in excess of 0.6 (say)), while they are indifferent between favourites in the range of 2/1 and 4/1. This again indicates a reluctance to bet on high probability events if an alternative is available offering a lower probability of success. The chi-square test statistic of 28.79 ($p < 0.005$) indicates a significant difference between the alternatives, in the direction as explained above.

Since it is widely acknowledged that the press generally suggest horses that end up as favourites, it is no surprise that the respondents indicated that they did not follow the tips of the newspapers. This is in keeping with their attitude towards betting on fancied horses. The results for question five, regarding newspaper tips yielded a test statistic of 17.05, significant at any conventional level. On the other hand, the professional tipping guides are assumed to provide fewer tips on favourites than the press, as well as the occasional outsider. It is likely for this reason that punters take these guides more seriously when making their choices. It is probably not because they provide a superior service (in terms of return to their bets), that the guides are more readily used, but because they suggest horses with characteristics that the public find attractive, i.e. lower probabilities of winning than the tips suggested elsewhere.

The results of question three are anomalous in the sense that they go against what is observed in aggregate at the track. We have observed that the returns to horses at odds of around 7/1 are far greater than the returns to horses at around 20/1 or 66/1. The reason for this is that too much money is placed on horses at the longer odds, i.e. the longshots are relatively (to their "true" chances of winning) more popular than the 7/1 shots. It appears therefore that when faced with a 20/1 or 66/1 shot against a full field, a bet would readily be placed on such horses. However, when these longshots are compared against a single horse at 7/1, it is the 7/1 shot that is chosen significantly more often, even when the data for the two longshots is combined. Further work is required in this area in order to understand this problem fully.

The results of question four demonstrate the emotional involvement of the bettor, which is likely to allow him to make "irrational" decisions according to Expected Utility Theory. Bettors are often heard to say that they are backing a particular horse because they are following it. This means that they have bet on it in one or more of it's last races, have most likely lost, and are expecting it to win this time. Clearly this approach does not pay any regard to the rest of the field! The extent to which this behaviour is practiced is evidenced by a test statistic of over 58, indicating a significant preference for following horses. The reason for such behaviour is probably an attachment of some kind to the horse, having bet on it recently. Consideration must also be taken of the irrational attitude of bettors that believe that the horse will win as soon as their money is not riding on its back. This close emotional involvement with the situation itself, is far removed from the assumptions underlying Expected Utility Theory.

Question seven investigates risk taking attitudes on a broader scale than looking at individually priced horses in a single race. We regard the Pick-6, Jackpot and Trifecta to be high risk, high return bets, while Win, Place, Quinpot, Place Accumulator, and Swinger are considered to be lower risk and to provide lower returns than the first three. By combining the original data into two categories we have the following results. We consider only the first choice of subjects, i.e. that bet type which they would spend most money on.

High Risk = 31 ; Low Risk = 44

The test statistic for these data is 2.25, indicating there is not a significant difference between the number of bet types chosen.

Questions eight, nine, sixteen, seventeen and eighteen have implications for the Efficient Markets Hypothesis. Questions eight and nine examine attitudes towards inside information that bettors may acquire directly, (from an owner or trainer, (say)) question sixteen asks whether bettors follow inside information not directly available to themselves, while questions seventeen and eighteen examine what level of movement in the odds is necessary for bettors to act on such perceived inside information.

The test statistic for question eight is 0.31 which is evidently not significant. Bettors are therefore as likely, as not, to pursue inside information directly. The test statistic for question nine however is 22.61 which is highly significant. This indicates the belief among the general betting public that inside information does exist, and that they would use it if it came to hand directly. The results of these two questions, taken together, imply that the majority of bettors, (of our sample anyway) believe that inside information is available, but would not be able to obtain such information. This is therefore indicative of a perceived strongly inefficient market.

A further indicator that bettors perceive the market to be strongly inefficient, is provided by the results of question sixteen. By following market movements, bettors are implicitly suggesting that information not available to the bookmakers at the start of the betting period, is being made available during this period, thereby influencing the odds. We wanted to know the level of movement required before bettors themselves would place a bet on a horse they believed was being backed on the basis of inside information. Tables 4.13 and 4.14 give the sixteen market movements our subjects could chose to bet on, arranged in order of the number of times chosen. The percentage change in the odds/probability is also shown.

Firming of Odds in Betting

Option	Number of Times Chosen	Percentage Change in Probability
5) 4/1 to 3/1	39	25
7) 5/1 to 1/1	33	200
3) 4/1 to 15/10	31	100
4) 3/1 to 2/1	28	33
6) 4/1 to 2/1	25	67
2) 3/1 to 15/10	24	60
1) 2/1 to 15/10	19	20
8) 16/10 to 15/10	17	4

Table 4.13 Analysis of results of question eighteen of field study

Easing of odds in betting

Option	Number of Times Chosen	Percentage Change in Probability
8) 15/10 to 16/10	35	25
5) 3/1 to 4/1	32	200
1) 15/10 to 2/1	30	100
4) 2/1 to 3/1	28	33
2) 15/10 to 3/1	25	67
6) 2/1 to 4/1	21	60
3) 15/10 to 4/1	17	20
8) 1/1 to 5/1	17	4

Table 4.14 Analysis of results of question eighteen of field study

If we assume that the greater the change in probability, the greater the value of the inside information causing such changes, the subjects have exhibited a high degree of understanding in this regard, especially with respect to horses easing in the betting market. The number of horses easing in the market that are chosen, decreases almost monotonically with an increase in the percentage change in probability. For horses firming in the market the pattern is not quite as clear, although the two smallest changes in probability are chosen least often, while the two greatest changes in probability are chosen 2nd and 3rd most often.

Questions ten and eleven investigate risk attitudes to consecutive gambling. The method of investigation is probably too simple to gain any insights into gambler's behaviour. The questions themselves are very broad, and coming one after another, probably confused some of the subjects, although no queries were reported. Of the 70 people that answered both questions, only seven had different answers to the two questions. In addition the questions would have made less sense to bettors that may have been winning on the day they were questioned. Other studies into this area have shown mixed results as described above in Leopard (1978). The results here (chi-square values of 0.32 and 0.013 for the two questions respectively) indicate that bettors are as likely as not to be affected by their betting history, (for the day) when deciding whether to bet, and if so, how much to bet. In order to gain clearer insight into this topic it would be probably be necessary to observe gamblers losing, and then ask them specific questions relating to their next bets.

Question twelve examines bettors attitudes to positive and negative in connection with the outcome. Clearly a win is viewed as positive, while a loss is viewed as negative. We are thus investigating the direct viewpoint of the subjects as regards the framing of the problem. Consider the example from Tversky and Kahneman (1986), which studied the preferences for different medical treatments. Two treatments are presented in both a survival frame, wherein numbers of people surviving each treatment are quoted, and in a mortality frame, wherein numbers of people dying as a result of each of the two treatments are quoted. The net result (numbers dead) of each treatment, in both frames is identical, but the choices of the respondents differed markedly depending on the way the scenarios were described to them.

In our case, which is far simpler than that described above, subjects essentially indicated that they might bet differently if the gambling game as it exists (everything presented in terms of returns (wins), without attached probabilities) was presented rather in terms of expectations, (which inevitably would be negative (losses)). Under such a situation bettors would most likely consider the possible loss before any possible win, which might lead to different choices than we currently observe at the track. In any event, the fact that one alternative was chosen significantly more often, (chi-square test statistic = 15.34, $p < 0.005$) than the other, suggests that the framing of the scenarios is important in determining choices.

The results of question thirteen are in sharp contrast to those expected. It is possible that the question was misinterpreted by the majority of subjects, in that they ignored the word "single" and assumed the question was asking them if they bet more on feature races as opposed to all other races. If this is the case the results become meaningless. We do not pursue the problem further.

Question fourteen essentially asks bettors whether they have some preconceived plan of betting, on arrival at the track. If this were the case, we could assume that their behaviour was quite well thought out, and determined well before their actual actions. The results show that bettors are as likely to bet on early races as late races, which means that it is possible that they have little or no specific plan regarding their actions for the racing day.

If we assume that the perceived risk (variance of returns) associated with betting on horses, with the same expected return, in races with large fields is larger than for small fields, the results of question fifteen can be interpreted as supplying evidence that bettors prefer greater risk. The test statistic of 11.32 ($p<0.005$) indicates that bettors significantly prefer betting on races where the risk is perceived to be greater.

Question nineteen is a broad question which combines some of the other questions in an attempt to confirm the earlier results. In addition we can now compare the relative importance of factors which we have already deemed to have an influence on bettor behaviour. We have treated the first two choices as interchangeable and have therefore supplied cumulative data for these choices above. Using these data we note the following; Firstly it is evident that the possible return from a bet is far more important a consideration than the possible loss. Secondly, current financial status at the track is more important in determining choices than the days betting history. Thirdly, an important factor is the emotional attachment to some horses, (described above) that bettors get by having bet on them recently, and/or often.

These three factors are clearly the most important, of all the alternatives considered, in determining behaviour. Combined, they are chosen nearly twice as often as all the other factors combined, implying that one of them gains the upper hand in bettors minds at the time of their decisions. The tipping guides and the press are shown to have little influence over bettor's behaviour, which confirms the results above. Directly obtained inside information, as well as that indirectly obtained via the betting market, are of secondary importance as far as bettor's behaviour is concerned. It is likely however, that were such information more freely available, it would be utilised to a greater extent, and would probably replace the "following of specific horses" as a betting determinant.

Question twenty reveals the perceptions and biases of bettors. The range of answers obtained, indicated that subjects, in general, do not understand percentages and therefore, probabilities. Although the question specifically states, "in your experience" we took the answers to be compatible with the question: "What is the percentage chance of horses with the following odds winning?"

The ratio of the observed probability to the theoretical probability, as shown in the results above, indicates that bettors overestimated the probabilities of horses with specific odds winning, in all odds categories. The overestimation is far greater in categories of low probability. In order to test for differences between the theoretical and observed probabilities, we calculated the standard deviation for each odds category. These are shown in table 4.15 along with the range of answers for each category, and the test statistic against the t-distribution.

Category	Range (%)	Std. Dev. (%)	observed t
1) 1/3	33 - 100	22.38	1.10
2) 7/10	20 - 100	19.37	4.21
3) 11/10	20 - 99	20.25	4.72
4) 2/1	10 - 90	22.59	5.76
5) 3/1	5 - 90	22.26	5.97
6) 5/1	4 - 90	21.23	6.68
7) 10/1	0 - 80	18.99	4.39
8) 25/1	0 - 50	11.24	4.13

Table 4.15 Analysis of results of question twenty of field study

All the test statistics are highly significant except that for the category with the highest probability, which is not significant. The reason for this category being estimated close to the theoretical probability, is probably owing to the fact that it is the category most difficult to overestimate since the theoretical probability itself is so high.

CHAPTER FIVE

FUNDAMENTAL ANALYSIS OF HORSERACES

"... in Wiesbaden I invented a system, used it in actual play, and immediately won 10,000 francs. The next morning I got excited, abandoned the system and immediately lost. In the evening I returned to the system, observed it strictly, and quickly and without difficulty won back 3,000 francs."

Fyodor Dostoyevsky in a letter to his brother Michael

5.1 Literature Review

Simple Systems

The volume of literature on this topic is extremely small (we found 3 papers) and also of a somewhat rudimentary nature. The first paper to broach the field of horseracing, proposing a systematic approach to the evaluation of fundamental information, was Vergin (1977). Instead of using sophisticated statistical techniques to evaluate the information, he derives a rudimentary form of expert system. A database is available, rules are set up, and in this way decisions regarding betting are made in a systematic manner.

The starting point for the derivation of the expert system is the testing for profitability of 6 betting systems, using fundamental information, proposed by professional authors of handicapping guides. Examples of such systems are reproduced in Figure 5.1. All the systems use straight-forward rules to determine whether or not a horse should be bet on. The aim was now to combine the "best" elements of each system into a superior expert system.

Each system was tested on 102 races run in the U.S.A. in 1972. Only one of the systems, McQuaid Elimination, made a profit on win betting. It was therefore decided that the basis of the expert system should be this system with some adjustments. An

A brief description of six betting systems

1. System 73 by Ainslie [1] rates each horse on its winning percentage, percentage starts in the money, average winnings, speed rating, previous class rating, time of last race and last workout, and change in weight carried. A bet is placed on the horse with the highest rating in each race.

2. Singularly Best Race and Speed by Cohen and Stephens [2] suggests betting on a horse which had a last race within the past fifteen days at a distance within one furlong of today's race and has a best pace rating two points greater and a best speed rating one and a half points greater than any other entry, with the last three races of each horse used as the basis of comparison.

3. Singularly Easy Win by Cohen and Stephens [2] suggests betting on a horse which had a race within the last fifteen days at a distance within one furlong of today's distance and was first at the stretch call and won the race by at least one and a half lengths.

4. An Elimination Rule advocated by McQuaid [6] eliminates any horse which does not meet all of a set of nine criteria. Eliminate any horse which:

(a) has not had one race at today's track;
(b) has not run today's distance at todays' track (+1 furlong);
(c) has not raced within one month of today's race;
(d) has not won a race;
(e) in its last race did not finish in the money;
(f) did not finish within eight lengths of the winner in its last race;
(g) in its last race lost more than ¾ lengths in the stretch;
(h) has a speed rating at today's distance which is not within five points of the highest speed rating for any of the competing horses for the past four races;
(i) has a consistency rating which is not within five points of the highest consistency rating for any of the competing horses unless the horse's speed rating is as high or within one point of the highest speed rating.

5. The Consistent Horse System was also suggested by McQuaid [6]. To qualify for a bet the horse must have:

(a) had a race at today's distance at today's track (±1 furlong);
(b) had at least ten races in his past performance;
(c) finished no worse than second in at least five of its last ten races;
(d) won at least three of its last ten races;
(e) either raced and finished second or better in the last ten days or shown an exceptional workout in the last four days;
(f) not moved up more than 25 percent in its claiming price. In addition, if the horse is a three-year-old against older horses early in the year or if the horse is a filly against males—pass the race.

6. A Breaks and Trials System was suggested by Reynold [8]. To qualify for a bet, a horse must have attained specified positions at the first call in its past three races and had a successful workout as described in a table in [8].

Figure 5.1 reproduced from Vergin (1977) examination of the rules was made to determine which could be modified to allow more winners. Modifications were made and new rules were introduced and this resulted in the return rising from 17 per cent to 78 per cent. Clearly the model has been derived to fit the data so the new system was applied to new data. One hundred races run in the U.S.A. in 1972 yielded a return of 42 per cent, but 160 races run in Canada in 1972 yielded a loss of 4 per cent. It is interesting to note that none of the systems uses odds data as an input.

The paper was published in the journal "Interfaces", the editor of which suggested to the author, (Vergin), that he was only interested in real-world applications. The author therefore went to the track and watched 80 races which produced 31 system bets. The results are shown in Table 5.1.

The Extreme Value Distribution

Henery (1984) examined race results in England in the years 1979 and 1980. This paper could be viewed as using technical rather than fundamental data as its base. A comment on this point is made in section 5.2. Horses are first categorised by their odds (SP's) and an average time rating is derived for each of 11 odds categories. The time rating is inversely proportional to the time taken to run a race. The rating is derived as follows:

$$R = \frac{(L - \bar{L})}{d}$$

where $\bar{L}$ is the average distance of all horses behind the winner
L is the distance of a particular horse behind the winner
and d is the distance of the race in furlongs.

It is hypothesised that the times to run races have an extreme value distribution (Gumbel distribution). A location parameter β is calculated for each odds class. The model

Results of Professor Vergin's System Application April 15–27

Date	Race	Horse Bet	Finish Position	Payoff* Win	Place	Show
15	6	Oh Really	2		4.10	2.50
	6	Full Moon Charlie	3			2.30
	7	Rippling Snow	4			
16	3	Kim's Shadow	2		3.50	3.10
	8	Alberta Green	1	3.40	2.60	2.40
	8	Run Joy	2		2.90	2.50
18	7	Money Hush	3			2.40
	8	Chery's Capri	1	4.10	3.20	2.50
	9	All American Kid	9			
20	8	Tudor Tay	1	53.50	14.40	4.50
	8	Duoro Valley	4			
	9	Kim's Shadow	10			
22	6	Summer Shot	1	7.30	4.60	3.90
	7	Poonaward	7			
	8	Ticket Count	4			
	9	Title Victory	2		3.40	3.00
23	1	Better Peace	2		3.00	3.00
	5	El Escorial	2		2.90	2.70
	6	Lord Hubert	4			
	7	Alberta Green	1	3.40	2.80	2.50
	7	Run Joy	2		3.20	2.80
	10	Apache Boy	8			
25	6	James Jessie	2		2.80	2.50
	8	Glan Sal	1	6.50	3.70	2.70
	9	First Purchase	2		2.60	2.10
	10	Poo Koo	6			
27	6	Winner's Deal	5			
	6	Double Dew	3			2.60
	8	Dandy Homer	4			
	8	Lucky Gary	5			
	10	Oh Really	3			2.70
	Total Payoffs			78.20	59.70	52.70
	Total Bets			62.00	62.00	62.00
	Dollars Won (Loss)			16.20	(2.30)	(9.30)
	% Won (Loss)			26.1	(3.7)	(15.0)

*Payoff on $2.00 wager; author placed bets of 10 times this amount, i.e., $20.00.

Table 5.1 reproduced from Vergin (1977)

predicts that the true probabilities of winning, p, for the odds class is

$$p = \frac{\exp(\beta_0 - \beta)}{\theta}$$

for some constant β_0, where θ is a scale parameter common to all odds classes. Thus, given the odds of a particular runner, we will be able to predict his probability of winning using the extreme value distribution which predicts the time the horse will take to run the race. The reason for using this approach to calculating the probability of winning as opposed to simply using the odds directly is discussed in section 5.2.

Six hundred and thirty-three races confined to 3-year-old horses were examined. The data consisted of SP's for all horses as well as the distances between the horses at the finish. From this data, a relative time rating for each horse is derived by comparing the distance of a particular horse behind the winner to the average distance behind the winner of horses in that particular race. For a given horse and race we thus have the SP of the horse and a time rating for the horse. The joint distribution of the time ratings and SP's is specified in a contingency table. Extreme value distribution parameters are now derived for each odds class.

The empirical distribution functions for each odds class are plotted against the times. These functions are shown to conform to the theoretical extreme value functions at the lower tails. Thus the lower (faster) times are well approximated by the model and therefore the probabilities of winning (fast time) as opposed to not winning (slow time) of a horse in a particular odds class can be accurately predicted via the model.

A Stochastic Utility Model

Bolton and Chapman (1986) presented the first paper attempting to process a large amount of fundamental data using a systematic, statistical basis. The paper consists of two distinct sections. The first postulates a model of the horserace process and derives parameters for the model in order to predict, accurately, the probability of winning the race for a given horse. The second section uses the probabilities calculated in section one as input to various algorithms for determining the optimal betting strategy. The topic of section two falls into another area of this research and therefore is not discussed here.

Bolton notes that previous attempts to model the horse race process have either used ad hoc filter techniques, (Vergin (1977)) or regression analysis. It is noted that these models fail to account for the within-race competitive nature of a horserace. This means that the predicted probability of winning for a horse with certain characteristics is the same regardless of the other horses in the race. This is intuitively unsound.

A stochastic utility model is proposed and is parameterized in the form of the multinomial logit model. It is assumed that a stochastic utility function exists which measures the overall worth of each horse for a particular race, as follows,

$$U_h = U(X_h, Y_h)$$

where X_h is a vector of attributes of the horse
and Y_h is a vector of attributes of the jockey.

The stochastic function consists of a deterministic component V_h, and a random component ϵ_h which reflects the measurement errors in the modelling process and, supposedly, the existence of variables which are not included in the model but which may influence the results. Included here would obviously be any variables whose values would only be known by people with inside information.

The probability of a horse winning a race is now given by the probability that its stochastic utility function is greater than that for all the other horses in the race. That is, the probability of horse h^* winning a race of H horses is

$$P_{h^*} = \text{Prob}(U_{h^*} \geq U_h,\ h = 1, 2, \ldots, H).$$

The stochastic error terms are assumed to be i.i.d. according to the double exponential distribution which leads to the winning probabilities being calculated as follows,

$$P_{h^*} = \frac{\exp(V_{h^*})}{\sum_{h=1}^{H} \exp(V_h)}$$

Note that the probability for horse h^* depends not only on its own characteristics but also on the characteristics of all the other horses in the race.

It is now clearly necessary to specify the form of V_h. A linear-in-parameters specification leads to:

$$V_h = \sum_{n=1}^{N} \theta_n Z_{hn}$$

where Z_{hn} is the measured value of attribute n for horse h. θ_n is then the relative importance of attribute n in the determination of the winning horse. Maximum likelihood estimation is used to derive the parameters.

The collection of data for model estimation is time consuming and costly. For these reasons use is made of the Chapman and Staelin (1982) explosion process. Each race is split into independent subsets which are themselves races which can be used in the data set. For example, the winner is removed from the original race leaving the 2nd placed horse the "winner" over the rest of the field, which then constitutes another race. The data set is only exploded to a depth of 3, since horses finishing lower than 3rd may not to have run to their true worth.

The data base consists of 200 races run at 5 racetracks in the U.S.A. Restrictions were placed on the data with regard to the track condition, distance of race and age of the competing horses.

The specification of the model was as follows:

$$Uh = \theta_1 LIFE\%WINh_h + \theta_2 AVESPRAT_h + \theta_3 W/RACE_h$$
$$+\theta_4 LSPEDRAT_h + \theta_5 JOCK\%WIN_h + \theta_6 JOCK\#WIN_h$$
$$+\theta_7 JMISDATA_h + \theta_8 WEIGHT_h + \theta_9 POSTPOS_h$$
$$+\theta_{10} NEWDIST_h + \epsilon_h.$$

where

LIFE%WIN = % of races won in the past two years

AVESPRAT = average speed rating over last four races

W/RACE = average earnings per race in past year

LSPEDRAT = speed rating in last race

JOCK%WIN = % of races won by jockey in last year

JOCK#WIN = number of winning rides by jockey in last year

JMISDATA = indicator variable relating to jockey data

WEIGHT = weight carried by the horse

POSTPOS = barrier draw of the horse

NEWDIST = indicator variable relating to distance of race.

Comments on the likely relationships between the variables and the probability of winning are given and explained. A very important assumption is that the quality of the competing horses is the primary determinant of the outcome of the race. Quality is split into long-term quality and current quality. Each of the above variables is assumed to measure either current or long-term quality. Jockey variables are also included.

The parameters of the model are now estimated. The test of the null hypothesis that the parameter vector is zero is conducted at the 0.005 level of significance, and the null hypothesis is rejected. A parameter vector of zero means that all horses have the same probability of winning the race. It is noted that the signs of the coefficients are consistent with a priori theoretical expectations. The relative importance of each variable is calculated as the product of the coefficient of the variable and the standard deviation of the variable. Collinearities among the variables would lead to interpretation difficulties of the relative importance values.

The relative importance of the variables is shown here.

Variable	Std. Dev. * Coefficient
AVESPRAT	0.562
W/RACE	0.228
JOCK%WIN	0.195
NEWDIST	-0.172
POSTPOS	-0.109
LSPEDRAT	0.099
JMISDATA	0.086
LIFE%WIN	0.077
JOCK%WIN	0.076
WEIGHT	0.012

For the logit model, a measure of goodness of fit is given by

$$R^2 = \frac{L(\theta = \hat{\theta})}{L(\theta = 0)}$$

where $\hat{\theta}$ = the parameters as determined from the data

0 = the vector of zeros indicating equal probabilities for all horses.

Now to the extent that the MLE parameters, $\hat{\theta}$, explain the horse race process completely, R^2 will approach unity. If the vector of parameters is essentially equal to 0, R^2 will approach zero. Hence R^2 varies between zero and one depending on the explanatory power of $\hat{\theta}$. Different parameter estimates for the model of the horse race process are derived using the original 200 races, as well as 400 "races" and 600 "races" through use of the aforementioned explosion process.

It is observed that using 600 "races" leads to an R^2 of 0.055 while using the original 200 races leads to an R^2 of 0.091. Thus the explanatory power of the model is decreased when the number of races is increased, probably as a result of some "noisy" observations being included. This means that the additional "races" are not as reliable an indicator of winning probabilities, as the original races are. However, using more data does lead to more accurate estimates of the model parameters, and this is cited as the main reason for the use of the explosion process. The apparent trade off between estimation accuracy and explanatory power is not mentioned, nor is it stated which model is to be preferred. Comments are given regarding the relative importance of the variables of the model.

A final caveat is inserted, stating that it remains to be seen whether the model yields sufficiently accurate estimates of the winning probabilities to implement a profitable betting system. The rest of the paper examines various betting systems proposed by other authors.

5.2 Comments And Further Ideas

Vergin's paper is the only one of the three examined, that suggests the concept of an expert system. His system is too elementary to be of any use, since the average bettor could quite easily assimilate the few rules into his own decision making system. What is required from a money making expert system is a complexity of nature that requires the speed, accuracy and consistency of a computer to make the decisions. This type of system will involve rules, meta rules, meta-meta rules etc.

Besides the simple nature of the derived system, the paper has one other problem. This is the sparseness of the data used in testing the systems. The results are thus statistically meaningless. This can be clearly seen in the results as obtained from the "real-world" in Table 5.1. The payoff for a win on Tudor Tay has distorted the results. This payoff is clearly an outlier which would probably not occur in repeated samples. Without this payoff the 26.1 per cent profit turns into a 59.5 per cent loss!

Henery's paper could be viewed as technical in nature since one of the two variables relating to the horses is the odds. The odds, however, are only used to group the horses and not to predict their performance. The extreme value model of times to run the races is used to predict racing performance. The likely time taken by the horse to run a race is specific to that horse and therefore is considered to be a piece of fundamental information related to the horse. Note, however, that the predicted time is essentially determined by the odds class the horse falls into.

A problem arises with the data used, in that the distances between successive horses finishing in 6th position or lower were taken as 1 length regardless of the actual distance between them. This approximation could lead to large inaccuracies. It is important to consider the reason for the apparent success of the model in predicting relative race times. This is because of the high correlation between odds class and predicted time, as well as the high correlation between predicted time and estimated win probability. The question now arises as to why we do not derive estimates of winning probabilities directly from the odds rather than first calculating a model for relative times from which estimates of winning probabilities are derived.

The reason for this is not explained in the paper but must be based on the assumption that the estimated probabilities are more accurately estimated using the extreme value model. The reason for this assumption is probably that in deriving probabilities from the odds alone, account is not taken of the other horses in the race. Consider the following example. Suppose we are concerned with a horse whose SP is 1/1. The theoretical winning probability of the horse based on the odds is 0.5. Assume that we have observed a large number of horses going off at 1/1 in the past and that their win ratio is 0.46 (i.e. win probability = 0.46). This ratio has been derived without reference to the odds of other horses running in the races considered. Assume now that the same large number of 1/1 horses are given time ratings relative to all the other horses in each of their particular races. From these a model would be derived to predict the winning probabilities of horses in the 1/1 odds class. Suppose this results in 1/1 horses being given a predicted winning probability of 0.47 by the model.

The observed ratio of wins to runners, of these horses is still 0.46, but they have been relatively more impressive in victory and closer up in defeat than the average horse.

Impressiveness here is measured by relative time rating. If the winning probability predicted by the model was 0.45 we would know that these horses were relatively unimpressive in victory and were further behind the winner in defeat, than the average horse. By taking account of the other runners in the race we are refining our estimate of winning probability for a given odds class by examining the performance of such horses in the class relative to the average performance of all the horses.

Bolton and Chapman (1986) have published the most complex by far of the three papers regarding fundamental research. The paper follows nicely from Henery's in that winning probabilities are also calculated taking account of the other horses in the race. The logit model as specified by Bolton is intuitively appealing, but the variables utilised are too elementary (and too few) to provide an accurate indication of winning probabilities. The most important variables have been considered but many less obvious ones have been excluded.

A further shortcoming of the model is that only linear-in-parameters specifications are considered. This is obviously for practical convenience and is not necessarily the optimal approach. Given the results of the regressions with and without the exploded data, no comment is made as to the model which the authors consider to be better. No explanation is given as to the meaning in this specific context of R^2, other than "we should expect low values".

The null hypothesis in the context of the regressions, is that all the horses have equal probabilities of winning. The improvement in probability estimates does not appear substantial, yet it is not explained. It would surely make more sense to compare regression estimates with the null hypothesis that the true winning probabilities are given by the odds of the horses and try and improve on those with some model.

Although the topic of this chapter was most appealing at the outset of this research, we realized quickly that the difficulties involved pushed this topic beyond the sphere of our research. These difficulties are succinctly described by three separate books and we quote directly from them here.

Firstly, from a book on horseracing called " The Winning Horseplayer ", Beyer (1983), we find the opening paragraph. " When I started playing the horses and trying to comprehend the mysteries of the game, I thought I was searching for great, immutable truths. I thought there must be a set of principles that governed the outcome of races and was waiting to be discovered, just as the laws of physics had always existed and were waiting for Newton to discover them. By the middle of the 1970's I had realized that there were no such timeless verities - but I wished there were. "

Secondly, from a book called " The Theory of Gambling and Statistical Logic ", Epstein (1977), we find a paragraph from the horseracing section. " Predicting the outcome of a horserace is an activity that exerts continuing appeal to the extraordinarily opulent. It is intellectually lucrative albeit fiscally ruinous. So many factors can affect the outcome that a strategic decision by weighted statistical logic without the use of a high speed computer for each application is unfeasible. An enumeration of the pertinent factors might include considerations of post position, weather, weight carried, previous performances, appearance or condition of the horse, earnings, jockey, owner, trainer, class of race, equipment changes and numerous others. Many of these factors comprise statistical phenomena of a nonstationary nature. For this reason, data samples gathered over a few seasons of racing at several tracks offer little predictive value, although copious records of past races have been sifted in the search for significant patterns. Any finite data sample, if analyzed sufficiently, can be shown to exhibit patterns of regularity. A simple prediction, however, cannot be sensibly constructed on the shifting sands of nonstationary processes. "

Finally, from a well known book called " Generalized Linear Models ", McCullagh and Nelder (1989), we find a paragraph from the introductory text. " Modelling in science remains, partly at least, an art. Some principles do exist, however, to guide the modeller. A first, though at first sight, not a very helpful principle, is that all models are wrong; some, though, are more useful than others and we should seek those. At the same time we must recognize that eternal truth is not within our grasp. "

CHAPTER SIX

STATISTICAL THEORY

"This remarkable regularity occurs sometimes in streaks - and this is what throws out the inveterate gamblers, always doing sums with a pencil in their hands. And what terrible jests fate sometimes plays!"

Dostoyevsky - The Gambler

Introduction

This chapter considers those papers which concerned themselves mainly with exploring statistical theory and methods, and which used as illustration of these methods, examples from horseracing or gambling. In these papers the methods are more important than the results, which were derived simply to demonstrate the theory more clearly.

Two main topics of theory are covered in the various papers, viz. optimization and permutation probabilities. Optimization has always been a specific goal of statisticians in various situations. The hope of the researchers is probably that the methods that they have developed, can be carried over from horserace betting, to other areas where probabilities are either known or estimated with some accuracy.

The probabilities of permutations involve assigning probabilities to the various possible outcomes of any multi-entry competition. It is assumed that the probabilities of finishing first are known. In addition any other information, relevant to the situation, needs to be to built into the models which are derived to predict specific finishing orders.

Optimal Betting Methods

Willis (1964) investigated the optimal placing of win and place bets, assuming only that the amounts bet on each horse in the separate pools is available. This is in contrast to previous no risk strategies that concentrated simply on win betting and required as input to the algorithm, the true probabilities of winning for each horse. A similar idea, examining the subjectively determined win and place probabilities, that encouragingly showed profitable results, is encountered in the papers by Hausch, (1981) considered in section 2.2.4. Unlike Hausch's model which does not guarantee a return greater than or equal to the original investment, Willis' algorithm ensures that no matter what the result of the race, the return to the investor will be greater than the bet, or no bet will have been made on that race.

As in the scenario which yielded profit proposed by Hausch, the requirements for such a no-risk system are inconsistent estimates of win and place probabilities, (through their betting) by the public. Since the take (tax and charges) is approximately 18% and a profit is guaranteed, the patrons forming the win and place pools need to be highly inconsistent in order for a bet to actually be made. The problem of finding the optimum no-risk strategy for placing simultaneous win and place bets, is formulated as a linear programming problem. Assuming a race with n horses, a set of [n(n-1) +1] linear equalities in [2n +n(n-1)] unknowns is derived from the original conditions. It is shown that any feasible solution, (amounts bet on each horse to win and place) will ensure that the return is greater than the original bet, or alternatively, no bet is made. It is pointed out, (as it was in Hausch's study) that it is impractical to use the final win and place pools as inputs to the problem, since these are only known after the close of betting for that race.

Arvesen and Rosner (1971) proposed a procedure to enable a bettor to optimally place a bet on a parimutuel event. In this case the actual probabilities of winning are required, as well as the odds of each runner and certain other quantitative handicapping factors such as speed and class etc. Note that risk is present in that only one horse is to be bet on, (if a bet is placed at all) and the return is positive or negative depending on the outcome of the race. Parimutuel wagering is treated as a problem in statistical decision theory. The states of nature, (different horses winning) are defined, as well as the possible actions (bet on any horse or not at all). The optimal Bayes procedure is given assuming certain conditions hold. The conditions compare the relationship between the handicapping factors for each pair of horses, with the expected return relationship, between the pair of horses. The problem of estimating the true winning probabilities is addressed to the extent of suggesting that the probabilities used be the same for each horse, and be equal to the reciprocal of the number of horses in the race. It appears quite possible that on introduction of real values for the handicapping factors, (whose estimation is considered beyond the scope of the paper) the procedure will suggest no bet. In any event the calculations are of too complex a nature to be performed quickly at the track once the approximate final odds are available and therefore the model seems of theoretical interest only.

Rosner (1975) suggests an optimal algorithm for betting on a parimutuel event given that the true probabilities of winning are known. Hausch et al, approached the problem after discovering discrepancies between win and place betting. They suggested placing bets so as to maximize the expected log return. This is also the optimality criterion of Rosner. The purpose of the paper then being, how to wager optimally within the system. A desirable property of the rule, maximize the expected log return, is that if the amount we wish to win is fixed, the expected number of trials to achieve the amount is minimized.

The inputs to the problem are the true probabilities of winning, the public's predicted probabilities of winning and the corresponding win odds for each horse. Given certain conditions regarding the amount bet, a theorem gives the optimal allocation between all the runners and the amount not to be bet on that race. The theorem suggests betting on horses where the objective and subjective probabilities are sufficiently different. Essentially the horse being bet on has to be substantially underrated by the public.

The given theorem is reduced to a simplified form when the condition is introduced that only one horse is to be bet on per race. In this case the optimal amount bet on the horse considered is equal to the expected return on that horse divided by the win odds on the horse. The expected return is given by

$$R = (1 - f) \times \frac{P_i}{p_i} - 1$$

where P_i = true probability of winning for horse i

p_i = subjective probability of winning for horse i

f = the track take.

Various consequences of the optimizing procedure were noted, and some examples were given. The optimal bet on a favourite is always higher than an optimal bet on an outsider, when the expected return from the two bets is the same. In addition, one does not necessarily bet the largest part of one's holdings on the horse with the largest expected return. Further, the optimal amount bet on a horse cannot exceed that horse's true probability of winning, (assuming the total holdings to be 1). Finally, it is possible that a bet is made on a horse even though the expected return on the horse is negative.

Two other points are raised in the paper. Firstly, consideration is given to the effect of one's own bet. A formulation of the problem is given, and it is pointed out that the author knows of no solution to the problem. As one's bet increases in size, (which is likely to occur in this situation) so the return approaches the negative track take, since eventually, your individual bet swamps the whole pool. Secondly, optimal place betting is considered. This differs from win betting in that, the payoffs to a horse placing is dependent on the other horses placing along with him. The maximization problem in this instance is far more complex and is simply posed in the paper as an interesting extension of the previous work.

Probabilities and Odds

Henery (1985) examined the returns from betting on horses in certain odds categories. He used several data sets dating from 1973 through to 1980 Although his approach did not consider either the Efficient Market Hypothesis or utility related aspects, his results had implications for both topics. Average returns, measured as a percentage of the amount staked, are calculated for odds classes at SP. The data from the 1973 flat racing season in Britain and the results are shown in table 6.1. As usual the favourite-longshot bias is present. In addition it was possible to make a profit backing all horses at 4/1, and at very short odds, although these results were not subjected to significance tests.

Returns from bets at given SP (1973 flat season)

SP odds	Number of bets winning at these SP odds	Rate of return %
2/1 on	15 out of 22	102.3
6/4 on	34 " 51	111.1
Evens	55 " 116	94.8
6/4 against	68 " 183	92.9
2/1 "	74 " 298	74.6
5/2 "	97 " 365	93.0
3/1 "	128 " 538	95.2
4/1 "	155 " 742	104.4
5/1 "	133 " 867	92.0
6/1 "	131 " 970	94.5
8/1 "	113.5 " 1294	78.9
10/1 "	119 " 1561	83.8
12/1 "	88 " 1830	62.5
14/1 "	81 " 1689	71.9
16/1 "	37 " 1508	41.7
20/1 "	40.5 " 3957	21.5
25/1 "	25 " 2019	32.2
33/1 "	19 " 3567	18.1
50/1 "	4 " 530	38.5

Table 6.1 reproduced from Henery (1985)

A further 883 races were considered from the seasons of 1979 and 1980. The horses were divided into odds classes, with class limits based on a logarithmic scale. The midpoint of the j'th class, X_j, was chosen so that $1+X_j = ((j\text{-}0.5)/3)$. The average returns to all such classes were calculated and the results are shown in table 6.2.

A model of betting is now hypothesised. The model suggests that if the true probability of losing for a given horse is q, implying that the fair odds should be q/(1-q), bettors rate the horse's chance of losing as fq=Q, where f is a fraction between 0 and 1, and are therefore prepared to accept odds of Q/(1-Q). Depending on f, the ratio of fair to accepted odds is determined, with the accepted odds always less than the fair odds. To investigate the validity of the hypothesis, the empirical losing probability is calculated for each odds class. The accepted odds by the bettor is the average of the odds class, leading to Q=X/(1+X), where X = the average odds for a particular class. If the model

Average return from a unit bet on horses with SP odds in the given classes (883 races in the 1979-80 flat seasons).

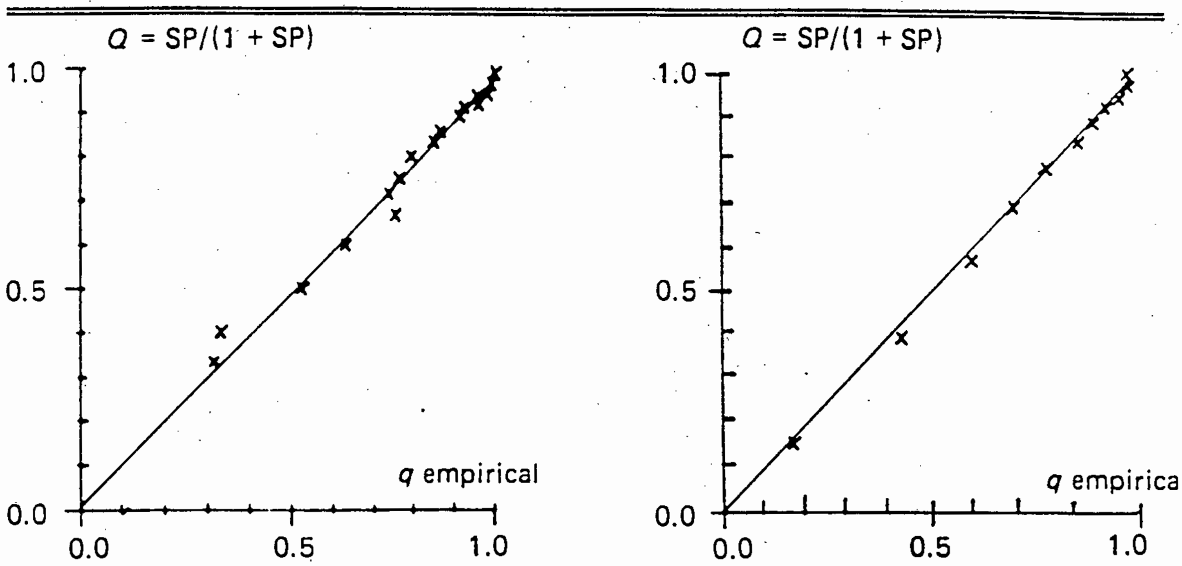
SP odds class limits		Mid-point X_j	Number of bets in class	Total winnings to unit stakes	Rate of return %
0.0	– 0.396	0.181	14	13.7	97.9
	– 0.948	0.649	126	117.3	93.1
	– 1.718	1.30	218	198.8	91.2
	– 2.794	2.21	514	485.1	94.4
	– 4.294	3.48	687	663.0	96.5
	– 6.389	5.25	1095	924.0	84.4
	– 9.312	7.73	1231	1089.0	88.5
	– 13.39	11.2	1116	891.0	79.8
	– 19.09	16.0	1024	567.0	55.4
	– 27.03	22.7	1206	608.0	50.4
	– 38.12	32.1	968	306.0	31.6
38.12	or more	45.2	512	51.0	10.0

Table 6.2 reproduced from Henery (1985)

is correct, the plot of Q against q will be a straight line, with slope f. The results are shown in figure 6.1.

The 1973 data fit well on average but have substantial deviations at certain odds levels. The 1979/80 data fit the straight line better. It is suggested that this is owing to the point in the season that these races were selected from.

The bookmaker's take is the excess over one, of the sum of the probabilities of all the horses in a particular race. The model also predicts that this take should vary linearly with the number of runners in the race, and that the line should have slope 1-f. The average take, R_n, was calculated for races with n=3 through 20 runners. The take was then regressed against the number of horses and the regression line, $R_n = 0.0222(n-1)$, was obtained. The graph of R_n versus number of horses is plotted along with this line,



(a) 1975 Flat season (b) 1979-80 Selected races

A comparison of two estimates for the probability that horses with given SP odds will lose the race: the empirical lose probability q is the relative frequency of losing; the subjective lose probability $Q = SP/(1+SP)$ is implied by the Starting Price SP. The straight lines are weighted least squares fits: $q = 0.974Q$ in (a); $q = 0.978Q$ in (b).

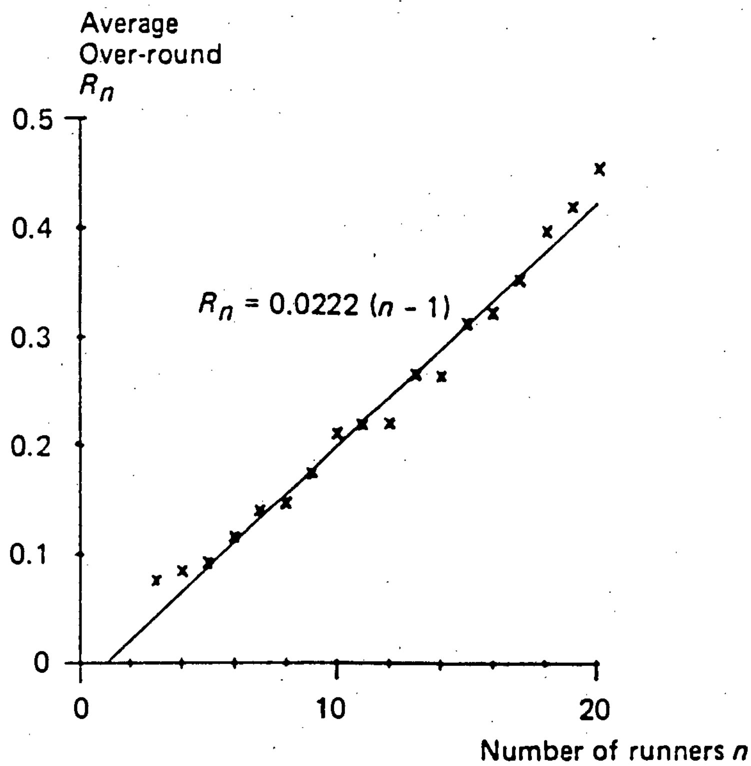
Figure 6.1 reproduced from Henery (1985)

and is shown in figure 6.2. No R^2 value was reported, but the fit looks close to the data.

The conclusion of the examination, is that the average return from a bet at SP odds, without regard to the number of horses in the race or the odds of the other horses, decreases nearly linearly with the SP odds. Two practical rules are now suggested. Firstly, only bet on favourites which are at short odds. Secondly, bet on races on which the take of the bookmaker is lower than that predicted by the regression line derived above, for a race with a particular number of horses.

Probabilities of Permutations

Henery (J. R. Statist. Soc. B (1981)) describes properties of models which yield estimates of placing in a horse race given that the win probabilities for each horse are known. If the win probabilities are p_i, then as suggested by Plackett (1975), the probability that horses i, j and k finish in 1st, 2nd and 3rd places respectively, is



The average over-round R_n plotted against the number n of runners in the race (1979–80 data). The straight line $R_n = 0.0222\ (n-1)$ was found by weighted least squares.

Figure 6.2 reproduced from Henery (1985)

$$p_i \times \frac{p_j}{1-p_i} \times \frac{p_k}{1-p_i-p_j}$$

Now, if $p_i > p_j > p_k$, then the order ijk is more likely than jik which is more likely than jki. Thus the relative orders of ijk are as suggested by their win probabilities. Stochastic ordering over permutations is defined in the paper as follows. "Given two permutations D and E which differ only in the transposition of two numbers, and supposing D to be the permutation in which these two numbers are in the natural order, we maintain that D has a greater probability than E." By natural order is meant that if horse A has a greater win probability than that of B, then it is natural for A to finish ahead of B.

Let {i,j,k} represent the permutation that horse i finishes first, horse j finishes second and horse k finishes third. If we have a sequence of permutations D,E,F,...,T in which we proceed from D to T by changing one pair of numbers that were in natural order each time, we can say D has a greater probability than T, or D > T. For example, if $p_1 > p_2 > p_3$, then

$$\{1,2,3\} > \{2,1,3\} > \{2,3,1\} > \{3,2,1\}$$

and also

$$\{1,3,2\} > \{2,3,1\}$$

by transposing horse numbers 1 and 2. Note however that the two permutations {1,3,2} and {2,1,3} are not stochastically comparable.

Assume $X_1, X_2, \ldots, X_n$ to be independent continuous random variables, and to represent the times taken by the n horses to run a particular race. The probability of the permutation {1,2,3} is the probability that $X_1 < X_2 < X_3$. Since stochastic ordering over the permutations is both natural and desired, distributions for the X's are investigated to see whether they provide such ordering. Examples of families of distributions that lead to stochastic ordering are the Normal with fixed variance, the exponential and the gamma distributions.

In another paper Henery (J. Appl. Prob 1981) applies the Normal model to a horse race scenario. If X is the time for a particular horse to run a race, then F(X) is the distribution function for this horse and the other horses are allocated distribution functions $F(x-\Theta_i)$, $1 <= i <= n$. The probability of an outcome will then depend on the Θ's which may be interpreted to be the means.

It is pointed out that for non-identically distributed variables, e.g. for horses with differing probabilities of winning, the calculations required to determine the probability that the a given horse finishes in k'th place are prohibitively difficult. The rest of the paper is devoted to suggesting theoretical approximations to the exact probability and developing these to the level of available formulae.

Stern (1990) determines the probability of a permutation involving n horses under the assumption that the distribution of times to run races follows the gamma process with common shape parameter but different scale parameters for each horse. If the shape parameter is set to one, the probability of the finish 123 is given by the formula suggested previously by Plackett (1975) and Harville (1973). If the shape parameter is greater than one the model becomes more complex and this is an obvious drawback. In some situations however the increased complexity is worth the addition to explanatory power of the model. Consider the example of a horse i that has a greater probability of winning a race than horse j, but given that some other horse k has won the race, has a smaller probability of finishing ahead of j, than the probability of j finishing ahead of i. Under the gamma model with shape parameter equal to one, this phenomenon, known in racing as the Silky Sullivan phenomenon, cannot be modeled. Gamma models with shape parameter greater than one are useful in modelling such situations.

Some empirical data was investigated to test the appropriateness and accuracy of the models for predicting place probabilities in horse races given that the win probabilities were known. The probabilities of winning for each horse were taken as the subjective probability estimates derived from the starting odds. The data consisted of 47 races in which there were six runners each. The data were restricted owing to the calculation difficulties when the shape parameter used was 2. Two separate models, one with shape parameter one, and the other, two, were used to predict the probability that each horse finished second in a particular race. The actual results of the 47 races were used to determine which model gave better probability estimates Horses were divided into classes based on their probability of running second. The results are shown in table 6.3.

The expected number of second place finishes for a particular group is computed as the sum of the estimated probabilities for the horses in that group. Horses that have a high probability of finishing second, do so less often than predicted. By taking the shape parameter to be two, some of this problem is solved. In this example the more complex model did provide better results, although it is noted that the amount of computation increases exponentially with the number of objects being ranked. It is pointed out that approximations that are easily computed would be particularly useful.

Expected and Observed Second-Place Finishes

$\hat{p}$	r = 1 Number	Observed	Expected	r = 2 Number	Observed	Expected
.00–.10	66	6	4.15	58	4	3.75
.10–.15	61	7	7.69	63	9	7.94
.15–.20	49	13	8.56	57	13	9.97
.20–.25	55	12	12.54	62	13	14.10
>.25	51	9	14.06	42	8	11.23

Table 6.3 reproduced from Stern (1990)

CHAPTER SEVEN

ECONOMIC APPLICATIONS

"In short, he must regard all these roulette or trente-et-quarante tables as an amusement arranged solely for his pleasure. He ought not even to suspect the greed and trickery on which the bank is founded and constructed."

Dostoyevsky - The Gambler

Introduction

It was suggested in section 2.3.3, with regard to the informational efficiency of the betting market, that the most important link in the chain that is the horseracing industry, is the betting public. Without the bettors there would be no money to pay for the stakes that the owners' horse's race for, and clearly everyone involved in the industry is affected.

Attendances at the racetrack and at off-track betting shops and concomitant volumes of wagering, are thus of paramount importance to the racing industry, and of some importance to the local government who collect betting taxes.

At the time of writing (March 1993), the above points are of major concern in Cape Town in particular, as well as at other racing centres around the country. The racing clubs of the Cape reported losses for the 1992 financial year. In an effort to cut costs, the clubs have decided to merge, and other measures include cancelling ten race meetings over the next few months.

The reasons for the problems cannot be laid only at one door. Firstly the poor performance of the South African economy has kept people away from gambling by concentrating their spending on essentials. The introduction of casino gambling reduced those prepared to bet at the racetrack where the take out rates (gambling charges) are far higher. Large capital expenditures undertaken when profits were still being made, and appeared certain in the future, are not being utilised anywhere near their capacities. The prime examples, are the luxurious stands built at Kenilworth and Milnerton which cater to a handful of owners a few times a year.

With declining attendances at the track itself, have come declines in the volume of wagering overall. However, instead of aiming to attract new punters to the sport, authorities have rather attempted to get those currently involved to bet more than before. The methods employed thus far include the introduction of new bet types (such as the quartet), and the altering of the unit of wagering (such as the adjustment in the unit of pick-6 betting from 50c to 10c). Provision has also been made for bettors to place bets by phone, thus making it easier for business people to bet during the week.

One aspect of the equation that has not been used is the price of gambling (the take out). The reason is probably that this is under governmental control and not alterable at the will of the race clubs. Most of the papers reviewed in this section analysed what factors were most influential in affecting the volume of public wagering.

Literature Review

The Demand for Gambling

Suits (1979) investigated the price elasticity of demand for gambling in the U.S.A. using bookmaker and parimutuel data. The reason this is of importance, is that the government's ability to raise taxes via gambling is to a large measure dependent on the size of this elasticity. In discussion with gamblers, Suits determined that the main reasons for gambling were not monetary gain, but instead the participation in a fun and exciting activity. The view is then taken that gambling is a good, in the sense that it can be purchased and has a price. This price is the average expected loss for all bettors and is equal to the track take which includes taxes and contributions to the track and the horseracing industry.

A theoretical relationship between the handle (amount bet by the public) and the track take is put forward. The theoretical price elasticity of demand is -1.6, which suggests that the seller's revenue (handle) would be greater at lower prices (track takes). An empirical study was made of bookmaking turnover following the reduction in federal tax on bookmaking in 1974, from 10% to 2%. The average handle per quarter was calculated for 1974 (10% tax), and 1975 (2% tax). The decrease in price led to an increase in handle which suggested an elasticity of demand of -1.64. It is conjectured that a large portion of the additional amount wagered with legal bookmakers, came from people who had been betting with tax free illegal bookmakers. The estimate of the elasticity of demand would in such a case be overestimated, since the extra wagering is not new, but existing and transferred from another outlet.

The investigation into the effects of the track take on parimutuel wagering, covered 24 states that offered thoroughbred racing from 1949 to 1971. Regressions can be performed to determine the effects of price on handle, since the track take varies from state to state and from time to time. The regression equation estimating demand is of the form

$$Q_{it}=b_0+b_1Y_{it}+b_2d_{it}+b_3P_{it}+u_{it}$$

where Q_{it} = real handle at all tracks in state i in year t divided by the population of the state

Y_{it} = real per capita income in the state

d_{it} = number of days on the racing calendar

P_{it} = parimutuel take out rate in state i in year t.

To compensate for small states where visitor betting presented a problem, a dummy variable was used to indicate whether it was a small state or not. Three regression models are presented, although two of them have R^2 values of 0.12 and 0.49. The third model which includes the small state dummy variable (the other models did not), has an R^2 value of 0.81. In addition the number of racing days variable is adjusted to be the number of racing days divided by the state population.

Elasticities of demand are calculated for various factors. The elasticity of demand with respect to income is 0.86, which means that gambling increases almost proportionally to any increase in income. Elasticity with respect to the number of racing days is 0.027, which means that an increase in the number of racing days will have virtually no effect on the betting volumes. The price elasticity of demand is -1.59, which means that an increase in the take out will lead to a considerably greater, in percentage terms, decrease in betting volumes. The revenue to the government is maximized by adopting a monopoly pricing formula. This leads to an optimal take out rate of 18.9%. During the period of investigation the average take out rate was 14.3%.

Off Track Betting

Coate and Ross (1974) investigated the allegation that the decrease in attendances and turnover at New York City's local race tracks, was owing to the opening, in 1971, of off-track betting shops throughout New York State. Table 7.1 summarizes the relevant data for the period under consideration. Such data is typical of that used in the papers considered in this chapter. Although it is evident that the total handle decreased through 1971 and 1972, the president of the Off-Track Betting Corporation, cited a slow down in the national economy, poor weather and the increase in the track take from 16% to 17% during 1971, as reasons for the declining handle. Through the use of regression analysis the paper attempts to determine the effect of the introduction of off-track betting on the race tracks' handle and attendances.

Two separate regressions are performed against the same independent variables. Firstly, the daily attendance at the track is used as the dependent variable, and secondly the daily parimutuel handle at the track is used as the dependent variable. Dummy variables represented day of the week, off-track betting activity (yes or no), and whether a major sports event occurred on the day in New York or on television involving a major New York based team, and the season of the year. Quantitative variables included the temperature, rainfall, weekly earnings in manufacturing industries, unemployment rate, and average number of hours worked per week in manufacturing industries per employee. The results are shown in table 7.2. Only those variables which had a

SUMMARY STATISTICS, NEW YORK CITY AREA RACE TRACKS, 1969 TO 1972

	1972	1971	1970	1969
		Handle (000)		
Roosevelt	$ 289,201	$ 297,815	$ 310,923	$ 283,846
Yonkers	297,773	312,884	316,666	314,997
	$ 586,974	$ 610,699	$ 627,589	$ 598,843
Aqueduct	$ 396,515	$ 486,394	$ 484,873	$ 450,311
Belmont	207,022	218,874	233,088	209,577
	$ 603,537	$ 705,218	$ 707,961	$ 659,888
Combined Total	$1,190,511	$1,315,917	$1,335,550	$1,258,731
		Attendance (000)		
Roosevelt	2,648	3,013	3,078	2,992
Yonkers	2,502	2,794	2,964	2,955
	5,150	5,807	6,042	5,947
Aqueduct	3,053	4,046	4,169	4,020
Belmont	1,601	1,875	1,983	1,891
	4,654	5,921	6,152	5,911
Combined Total	9,804	11,728	12,194	11,858
		Racing Days		
Roosevelt	154	142	155	143
Yonkers	145	155	142	152
	299	297	297	295
Aqueduct	136	147	138	136
Belmont	96	72	72	72
	232	219	210	208
Combined Total	531	516	507	503
		Handle Per Racing Day (000)		
Roosevelt	$1,878	$2,097	$2,006	$1,985
Yonkers	2,054	2,019	2,230	2,072
Aqueduct	2,915	3,309	3,514	3,311
Belmont	2,156	3,040	3,098	2,911
		Attendance Per Racing Day (000)		
Roosevelt	17.2	21.2	19.9	20.9
Yonkers	17.3	18.0	20.9	19.4
Aqueduct	22.4	27.5	30.2	29.6
Belmont	16.7	26.0	27.5	26.3
		Average Handle Per Person		
Roosevelt	$109	$ 99	$101	$ 95
Yonkers	119	112	107	107
Aqueduct	130	120	116	112
Belmont	129	117	113	111

Table 7.1 reproduced from Coate (1974)

significant effect are shown.

The conclusion drawn is that, ceteris paribus, the introduction of off-track betting caused a decline in daily attendance at the thoroughbred tracks of approximately 4 750 people, and a decline in daily handle of about $440 000. It can be seen that harness racing was also negatively affected. A further regression was performed, the dependent variable being the average handle per attendant at the thoroughbred tracks. The results showed that the introduction of off-track betting caused in increase in the average handle per attendant of $8.51. This implies that the bettors lost to the off-track betting shops were below average bettors when measured by amount staked. The conclusion is that they are casual bettors, who are more sensitive to the reduction in price via the elimination of

DEMAND MODELS

Variables	Thoroughbred		Harness	
	AF1	PHF1	AH1	PHH1
Monday	5700 (9.11)**	520,505 (9.22)**	2138 (5.04)**	335,591 (11.65)**
Thursday	−1155 (−1.84)	−89,263 (−1.57)	1100 (2.92)**	31,556 (1.23)
Friday	813 (1.30)	164,758 (2.92)**	5009 (13.26)**	348,511 (13.58)**
Saturday	19148 (30.66)**	1,955,919 (34.78)**	10399 (26.51)**	514,933 (20.61)**
Temperature	48.8 (3.36)**		90.1 (12.01)**	3,624 (7.26)**
Precipitation	−2361 (−5.00)**	−240,091 (−5.65)**	−2244 (−7.83)**	−232,646 (−11.95)**
OTB Dummy	−4755 (−8.92)**	−439,034 (−11.11)**	−1904 (−5.80)**	−102,557 (−5.78)**
Trend	−1.48 (−2.39)*		−1.19 (−2.81)**	
Fall Season	−2241 (−4.76)**	−160,961 (−4.04)**	−1670.0 (−5.26)**	−136,415 (−6.41)**
Total Unemployment	.214 (2.01)*	20.33 (2.15)*		
Knick TV			−1388 (−2.83)**	−119,839 (−3.61)**
Ranger TV			−1230 (−1.98)*	
NFL's Monday Night Football			−2017 (−2.64)**	−306,732 (−5.94)**
Intercept	23482	3,007,432	14341	1,782,835
R^2	.698	.726	.593	.522
Adjusted R^2	.694	.722	.587	.516
F	143.8	206.7	104.9	94.6
# Observations	632	632	877	877

*t statistics are significant at the 95% confidence level in a two tail test.
**t statistics are significant at the 99% confidence level in a two tail test.

Table 7.2 reproduced from Coate (1974)

transport and admission costs associated with going to the track itself.

The Price of Gambling

Gruen (1976) also poses the questions about gambling, "does it have a price?" and "do consumers act in the same way towards it, as they do towards other goods?" Some theoretical analysis is presented to show how a bettor maximizing his utility at the margin would bet on a particular race. The expected return (bettor's subjective probability of wining multiplied by the available odds) is calculated by the bettor for each horse. Horses with expected returns greater than zero are assumed to attract bets. The amounts bet are not considered. Now assume that for a particular race, the track take is increased from 10% to 18%. The expected return for all horses will decrease, and some will have negative expected returns whereas before these were positive. These horses will now not be bet on by punters, who had fixed subjective probabilities, before the change in take out. The point is that the number of bets will decline following an increase in take out rate.

This hypothesis is tested empirically using data for 1 specific race track in the U.S.A. from 1940 to 1969. 1940 was the year in which the parimutuel system was instituted, while 1969 was before the advent of off-track and exotic betting, both of which are factors which are likely to have affected the results of tests relating handle to price, since they affect the handle as well. The single location is chosen in order to correct for tastes and customs which may vary geographically. In addition, the quality of the track is such that competition from other nearby tracks is small.

The model postulates that the number of bets per race per capita is a function of the price of the bet and the real income per capita of the potential patrons, who are defined as those that live in certain areas near the track. In addition dummy variables are used to represent a depression or pessimism factor, as well as an optimism or prosperity factor. The former is set to 1 for the years 1940 to 1944, while the later is set to one in years when the unemployment rate is less than 4%.

The general form of the model is thus

$$BETS=b_0+b_1P+b_2Y+b_3PES+b_4OP$$

where BETS = number of bets per race per capita

P = track take or price of the bet

Y = income per capita converted to 1967 dollars

PES = pessimism factor

OP = optimism factor

A regression using all the variables gives an R^2 value of 0.814. The income elasticity of demand is 0.98 while the price elasticity of demand is -1.57. Thus the results are very similar to those found in the previous study. The derived curve was used to calculate the price which yielded maximum revenue for the 1969 data. This was 14.88%, while the take out rate in 1969 was actually 17.16%. Thus by decreasing the take out rate by 2.28%, the state and track could have increased their net proceeds by over eleven million dollars in 1969.

Determinants of Betting Behaviour

Degennaro (1989) attempted to model betting turnover (handle) in terms of certain variables, with the aim of providing racetrack managers with strategies to optimize returns to state and track. His explanatory variables were as follows;

i) P_t = total stakes available on day t,

ii) A_t = number of people attending the track on day t,

iii) $Tote_t$ = 0 if the observation is before the installation of the new tote system and 1 otherwise,

iv) $Trackcond_t$ = 0 if all races on day t are run on a goodtrack and 0 otherwise,

v) $Subsidy_t$ = sum of the state's, track's and owner's contributions to the stakes for subsidized races,

vi) $Tues_t$, Wed_t , $Thurs_t$, and Fri_t are 1 if the observation is for the respective day of the week, and 0 otherwise,

vii) Hol_t = 1 if the observation is for a Saturday or a national holiday and 0 otherwise.

The handle on day t, H_t, was modelled in terms of these variables and only Trackcond, Subsidy and Thurs were not significant in explaining the variation in handle. A negative sign was found on the coefficient for the Tote variable, indicating that the new system had reduced the handle. Overall costs were still reduced though because of the reduction in labour required to operate the new system.

Tuesday is a special day in that women are permitted into the track free of charge. This so called "Ladies Night" also produced a negative coefficient for the Tues variable. It is suggested that in addition to the decrease in per capita wagering, owing to the presence of non gambling females, the men whom they may accompany bet less when they are with women. The additional people (women) that may purchase parking, programmes, food and beverages, apparently more than compensates for the loss in handle.

In addition to modelling turnover, this paper also modelled attendance at the racetrack in terms of the same variables. The results suggested that racing from Monday through Saturday should be replaced with Sunday racing with one weekday falling away. The reason for this is that the turnover on non working days (Saturdays and Holidays), was far greater per capita than on other days. Also, days influenced by the work week, especially Tuesday and Wednesday, have lower per capita wagering than Fridays and non working days.

Telephone Betting

Thalheimer and Ali (1992) investigated the effects on handle owing to the introduction of a telephone betting service. In addition to the effects of this service, the effects of the takeout rate, the price of admissions, racing quality, number of racing days, personal income, and competition from other sports, were investigated.

Two demand equations were formulated; the first to explain variation in on-track wagering and the second to explain variation in total wagering (on-track + phone betting). The dependent variable was the handle per capita, for on-track and total betting. All the coefficients in both equations had the anticipated signs and were significant at the 12%, or lower, level of significance.

The introduction of the phone betting system led to a decrease in on-track wagering of 22.3%. It is further estimated that the introduction of the system led to a 13.7% decrease in total wagering as well. Consistent with other literature, the handle demand is found to be elastic, (elasticity = -1.88), with respect to the takeout rate. Handle was found to be inelastic with respect to the price of admissions. The impact of income on handle was found to be significant, and the income elasticity was 1.16.

Competition was deemed to have a negative effect on handle. This was in the form of other racetracks holding simultaneous meetings, as well as the local baseball team playing in home fixtures on the day of a race meeting. Both racing quality (defined by stakes available to owners) and number of days racing were found to positively affect the handle.

Comments and Proposals

Owing to the different structure of gambling law in the United States in comparison with South Africa, it is likely that results of analysis similar to that described in the above section, would be of little practical value. In addition to the Tote, South Africa also has legal bookmaking, which most likely operates alongside some illegal activity. The difficulties in obtaining reliable data on handle in this country, should be evident.

The above is most likely to be a problem in estimating the effects on handle of a change in takeout rates, which in any event are not the same for bookmakers as for the tote, nor do these rates necessarily change simultaneously. The takeout rate is generally viewed as the most important factor affecting handle, but it would be of some considerable use to estimate the effects of other variables such as competition from other sources (in particular, newly legalised casinos), or racing quality which no doubt do have an effect on turnover to the extent that could seriously affect local taxes or profits to the track. Such variables are not beyond the control of the racing authorities (or their lobbyists). We suggest that there is opportunity for interesting and practically useful work in the field of racetrack management and economics, but we do not pursue this topic further.

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