Paying to Play - the Pricing Policies of Casinos *(1)

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1 the Importance of Gambling for the Us and South African Economy

Wherever gambling activity is permitted it becomes a major competitor for the household budget.*(3) The growth in gambling in the US has become an important social and political issue and the subject of a National Commission, the National Gambling Impact Study Commission (NGISC 1999).*(4) The Commission indicates that more than 86 per cent of all Americans have gambled at least once and that over $50 bn. was spent (amount wagered minus prizes received) on gambling activities in the US in 1998. Lotteries accounted for 52 per cent of this in 1998, casinos 29 per cent and horse racing 7 per cent (NGICS Overview (1999): 72-75).

In 1996 the gross revenues of all the organisations providing

2003 SAJE v71(2) p346

gambling or gaming opportunities in the US were estimated at $46.07 bn. or just under about 0.09 per cent of all private consumption expenditures for that year. These revenues had grown by 11.2 per cent *p.a*. (nominally) between 1982 and 1996 (see International Gaming and Waging Business (IGWG 1996)). These gross revenues are the amounts wagered by gamblers, known in the industry as the "handle", less the prizes paid out by the gambling firms. Thus the gambling revenues of the industry, its value added or contribution to GDP, are the accumulated losses of the households.

In South Africa an entirely new dispensation for gambling activity has been established recently. The major change has been the licensing of up to 40 casinos in the established metropolitan areas by the Provincial Gambling Authorities. Previously casinos were prohibited in South Africa and were confined to the so called "homelands" including Bophutatswana which included within its boundaries the renowned Sun City complex. A full description of this new dispensation is provided by the National Gambling Board on its web site (www.ngb.org.za).

An investment analysis undertaken on behalf of Sun International and referred to in an HSRC Report on the social impact of gambling (available on the National Gambling Board's Web site at www.ngb.org.za), by Van Zyl (1999), estimated that 2 per cent of personal disposable income (PDI) in South Africa would be spent on all forms of gambling, including casinos, the national lottery and horse racing, during the years 1999 to 2001 (Statistics SA does not, as yet, release figures for expenditure on any forms of gambling, including the national lottery). The propensity to spend money on gambling was estimated to be highest in KwaZulu-Natal (2.3 per cent of PDI) and Gauteng (2.1 per cent), followed by the Western Cape and North West (both 2 per cent). In the other five provinces, the expectation was that 1.7 per cent of PDI would be spent on gambling. It was estimated that more than one-third of the anticipated R508 million nationally spent on gambling in 2000 would be spent in the province of

2003 SAJE v71(2) p347

Gauteng (38 per cent). In addition, it was estimated that a further 15 per cent would be spent in each of the Western Cape and KwaZulu-Natal and 8 per cent in the Eastern Cape. The other provinces would account for the balance, namely 6 per cent in each of the Free State and Mpumalanga, 5 per cent in North West, 4 per cent in the Northern Province and 2 per cent in the Northern Cape (Van Zyl, 1999).

2 Gambling and Utility Theory

The classic economic analysis of utility maximisation under uncertainty, of which gambling is an example, follows the pioneering work of Von Neumann and Morgenstern (1944) and as Varian (1984, p.156) states, the analysis works from the standpoint that "… the utility of a lottery is just the utility of its prizes". Therefore, given that gamblers on average must expect to lose, this would imply that gambling, on the face of it, is an irrational economic activity.

The sheer scale of gambling activity in SA, the US and elsewhere therefore might be regarded as highly challenging for the classical assumptions of risk aversion by households. But there is an alternative explanation of the demand for gambling which is consistent with the position that gamblers are in fact risk averse. This is that large numbers of gamblers gain enjoyment from playing these games and are willing to pay for such pleasure. In other words, it is not only the gambling outcomes but the gambling *activity* that matters for consumers. The great bulk of gamblers may indeed be rational economic agents who are simply willing to pay for the opportunity to gamble, as they would for other competing forms of entertainment (see Christiansen and Brinkerhoff-Jacobs 1997). The extension of the standard utility models by John Conlisk (1993) represents a helpful attempt to deal with these facts.*(5)

2003 SAJE v71(2) p348

Economists have long distinguished between *transaction utility* and *process utility*, the former being derived from expected monetary payoffs from an activity, and the latter being derived from the intrinsic excitement of the activity itself. Often, however, this excitement is itself explained in terms of pleasure derived from fantasies of wealth. Moreover it has been recognized at least since Pascal that the utility of gamblers is highly complicated. Pascal's account of the motives of gamblers is very subtle.

"This man spends his life without weariness in playing every day for a small stake. Give him each morning the money he can win each day, on condition he does not play; you make him miserable. It will perhaps be said that he seeks the amusement of play and not the winnings. Make him, then, play for nothing; he will not become excited over it and will feel bored. It is, then, not the amusement alone he seeks; a languid and passionless amusement will weary him. He must get excited over it and deceive himself by the fancy that he will be happy to win what he would not have as a gift on condition of not playing; and he must make himself an object of passion, and excite over it his desire, his anger, his fear, to obtain his imagined end .....".[Pascal, 1995:139].

While Pascal was certainly contemptuous of this behaviour, as an instance of what he found contemptuous about humans generally, notice that although his gambler's psychology is complex, it is not irrational. The gambler enjoys the experience of his passions; and so in arousing them he maximizes his utility.*(6) In association with these ideas, the question arises whether there is an empirical link between the propensity to gamble out of disposable income and the level of disposable income*(7). Our research on the Sun International (SA) database indicated that this propensity approximates the shape of an inverted "V"; that is, the propensity is low for low and high income gamblers and at a maximum for middle-income gamblers. This is consistent with the notion that

"process utility gambling" applies to people with enough discretionary income to have access to a range of entertainment activities and, hence, the option of substituting gambling for other such activities; but, by contrast, genuinely poor people who are not in a position to afford any entertainment engage in "transaction utility gambling".

This paper is not at all intended to advance utility theory and expand our knowledge of why people gamble. For a deeper understanding of current thinking on these issues see Becker and Murphy (1996) and Moene (1999). The purpose of the paper is rather to demonstrate how the typical large casino caters largely for entertainment by providing playing time on low denomination slot machines. It will demonstrate that low denomination slot machines provide the ordinary customer of the casino with a given (small) stake or playing budget, with significantly more playing time than higher denomination machines. It is suggested that the more time spent playing the machines the more entertainment value derived by the players and willingly paid for. The paper reveals how the operators of casinos and slot machines respond to the demands of their customers by providing machines with different denominations to cater for these different tastes.

3 Some Empirical Facts about Casinos

In Table 1 below we present the slot machine configuration of a large South African casino managed and owned by Sun International SA (SISA) in January 1996.*(8) It may be seen that the low denomination machines predominate in both number and in their share of the revenues or winnings (see note below Table 1) collected by machines in the casino. It should also be noticed that the odds for the gambler improve as the cost of a turn rises.

Table 1. SISA - Total Win and Win Ratios across different machine configurations as at January 1999

Token Value	Number of Units (machines)	%all units (machines)	Win Amount R'000	% Total Win	(%)Win Ratio
25c	301	3.60	3 119	2.49	13.00
50c	2 790	33.35	34 686	27.74	9.50
R1	3 699	44.21	52 238	41.78	6.46
R2	833	9.96	13 475	10.78	4.62
R5	504	6.02	10 344	8.27	3.56
R10	165	1.97	6 601	5.28	3.68
R25	74	0.89	4 563	3.65	2.82

Notes: In the jargon of the casino operators, applied to slot machines, the win refers to the amount taken by the machine and the win ratio is the ratio of the win to the amount of money that has passed through the machine (usually expressed as a percentage). A similar configuration may be observed of the Las Vegas Strip, almost certainly the most competitive gambling location.*(9) Slot machines in the Strip area accounted for $1 728bn., or 47.63 per cent of all casino revenues on the Strip, in 1995. The configuration of slot machines, their contribution to the total revenues or wins of the casinos as well as the win percentages are indicated in Table 2.

It should be noticed that the 25c and 1$ machines account for about 80 per cent of the number of machines on the Strip and about 81 per cent of the revenues from all slot machines. Clearly high denomination slots are a minority taste despite the much better odds offered. Also a minority taste is “Megabucks” where the prizes are large but the odds relatively poor. It would appear that the Las Vegas high roller must play other table games where incidentally the odds against the punter are much worse. Of the more important games the win per cent for the Strip casinos in 1995 averaged 13.31 per cent for ‘twenty one’, 13.59 per cent for craps, 20.5 per cent for roulette and 14.97 per cent for baccarat. The low rollers not only (probably) spend more time playing, they do so at significantly better odds.

Table 2. Total Win and Win Ratios across different machine configurations. Las Vegas Strip – 1995

Token value	**#Units (machines)**	**% All units (machines)**	**Win Amount $‘000**	**%Total Win**
5c	7 668	15.15	128 777	7.49
10c	150	0.30	3 108	0.18
25c	29 182	57.64	783 135	45.56
50c	569	1.12	21 028	1.22
$1	11 369	22.46	617 615	35.93
Megabucks	306	0.60	28 756	1.67
$5	1 135	2.24	103 899	6.04
$25	173	0.034	19 640	1.14
$100	76	0.15	13 131	0.076

The low denomination slot machines offer the player poorer odds than the higher denomination machines. The casinos are able to do this, as we will show, because they deliver more entertainment or playing time per dollar spent. We establish that the high denomination slot machines offer better odds but much less playing time per dollar lost. The high denomination machines offer the excitement of large prizes to compensate for very limited playing time. They cater for the serious or risk loving gambler and are part therefore of a highly segmented slot machine market. Thus the configuration of slot machines in a typical casino is consistent with a market segmented between the vast bulk of low rollers who clearly prefer more playing time for their buck and the few high rollers who play high denomination machines sporadically in the hope of large wins.*(10)

4 Modelling Gambling Behaviour

The win-ratio (w_r) determines the percentage amount of money passing through a machine that is kept by the house. Thus a win-ratio of 10 per cent says that of each 100 coins passing through the

machine, 10 are expected to be kept by the machine. In the simplest case where the machine only had one particular win payout,

where *w* is the payout, and *p* the probability of a payout.

Thus, for example, if a machine paid out 9 whenever there was a win with a probability of 10 per cent, w_r would equal 10 per cent.

In reality, of course, machines have complex payout configurations with different amounts paid out with different probabilities. On average, though, we are able to compute the average w_r’s by simply determining the per cent that the machine keeps as a percentage of the total coin through-put. In SA, as in the US, the w_r is related to the quantum of the machine token. In SA, for example, the 50c machines have an average w_r of close to 12 per cent whereas the R50 token machines have a w_r of just more than

2 per cent. In a stylised form the relationship between w_r and the token amount can be seen in Table 3 and in Fig. 1 for the SISA casinos. Note that the magnitudes follow a fairly smooth curve.

In addition, the w_r's infer a probability of winning for the player. In the table, for the sake of comparison, we give the probability a player has of winning (something) under the assumption that the average win (w) is 4.5 tokens (very close to the average win on the R1 and R2 machines used at the Wild Coast Sun). In fact, this value of p does not change substantially (on average) across the different machines (50c - R50). It is thus interesting to see that although the w_r is quite different for different token machines this does not translate into very different*(11) probabilities of winning (something) for the gambler.

2003 SAJE v71(2) p353

Table 3. Token amount, Win-Ratio and Probability of Punter Winning (something)

COIN Amount (Rands)	**Win Ratio**	**p**
0.5	11.70 per cent	19.62 per cent
1	8.20 per cent	20.40 per cent
2	6.10 per cent	20.87 per cent
5	4.20 per cent	21.29 per cent
10	2.93 per cent	21.57 per cent
25	2.45 per cent	21.68 per cent
50	2.10 per cent	21.76 per cent

Figure 1. Graphical Characterisation of Win Ratio and Token Amount

5 Pricing Slot Gambling

The average player of slots at a casino plays slots for entertainment. He usually goes with an initial amount or stake which he is prepared to lose. There is some hope of winning but the underlying expectation is to play for some length of time until the money runs out. Thus, for a large proportion of players, an important motivation for slot playing is entertainment measured in time. It is priced in Rands per minute.

The more serious "hard-core" gambler goes primarily to win. This type of gambler plays the high token machine and is looking for the big hit, the jackpot. Most machines have some sort of jackpot; the serious slot player normally plays the high token

2003 SAJE v71(2) p354

machines looking for a financially meaningful jackpot, say R25 000 on the R25 machine. This is not the entertainment gambler, he is there for the rush of the big win only.

Between these poles clearly lies a continuum of player tastes for entertainment on the one hand and/or the search for a big win on the other. In the first instance, however, we will focus on how one prices the entertainment sector of the market. A first approximation of this price (for this low-end of the market) would just be the inverse of the expected time at a machine (of some given token value).

In this section, we will establish, for a stylised machine with only one win configuration and probability associated with that win, the first two moments of the distribution of this time "at the machine". We shall see that the expected time at a machine is only dependent upon the win ratio, but that the variance is dependent, as one could imagine, on the relationship between w and p.

Defining T to be the first time (or turn) that the gambler's fortune is zero, it may be shown that the gambler's fortune at times 1,2,3 ... is a supermartingale (see, for example, Jacod and Protter (2002)). Applying the martingale stopping theorem we may conclude that,

where a is the original stake*(12). In addition, we may establish that,

The frequency distribution for a typical T with p=0.1 and w=9, (that is with wr = 10 per cent) is shown in Fig. 2 below for 5 000 simulations. Over a range of simulations, with different wr, w and p the distribution demonstrated consistent characteristics; namely it is positively skewed, having a thin but long right tail but a kurtosis close to that of the normal distribution. The distribution shows many similarities to that of the family of Paretian distributions often used to describe stock returns.

Figure 2. Frequency Plot of Time to Ruin – 5 000 simulations

As mentioned above, the higher token machines have lower w_r's. In Table 4 below we consider how the probability of a win changes under the assumption that w remains constant at 4.5. (On machines observed at the Wild Coast Casino, w was between 4.5 and 5 tokens across machines of different token value). That is, we will work under the assumption that the distribution of punter payout is fairly constant in machine-played-token terms. This means that if the R50 machine pays out a R50 000 jackpot the 50c machine will pay a R500 jackpot albeit with a somewhat higher probability. As we will conjecture later, the higher end machines are specifically played by punters with risk-seeking utility functions that "thrive" on high payouts - the so-called rush of the big payout.

In addition, Table 4 considers the expected number of turns at the machine and the standard deviation of the number of turns at the machine, thus measuring the risk or uncertainty of the

amount of entertainment time delivered by the machine. Note that the higher token machines with the lower win ratios and thus the higher probability of punter win, have a resulting higher expected time at the machine per 100 tokens. Note, of course, that this does not mean the cost per turn is lower because we see that the higher expected number of turns *do not compensate* for the higher cost of each token.

Table 4.Expected Turns and Variability according to Machine played*(Initial Stake = 100)*

Token value (R)	**Win Ratio (%)**	***P (%)***	**E(T)**	**Risk(T)**	**E(T)/Risk(T)**
0.5	11.70	19.62	855	447	1.91
1	8.20	20.40	1 220	772	1.58
2	6.10	20.87	1 639	1 214	1.35
5	4.20	21.29	2 381	2 140	1.11
10	2.93	21.57	3 413	3 691	0.92
25	2.45	21.68	4 082	4 835	0.84
50	2.10	21.76	4 762	6 101	0.78

Also note that the standard deviation of time increases at a faster rate than the actual time for the range of typical p's considered. This is intuitive and reflects the fact that as the w_r approaches zero, the game approaches a fair game and thus the swings in the number of turns become much greater.

If we now factor in the price per play or value of the token we can compute an estimate of the expected cost of play at a certain type of machine per time unit. Thus, for example, we could compute the expected Rand cost per minute at a certain machine. For this calculation we make the assumption that each "turn" takes 3 seconds – see Table 5.

It certainly appears that, within an entertainment framework, the low-end machines are expected to be far superior providers of entertainment. We will consider below whether factoring in the uncertainty of the provision of this entertainment changes any of these conclusions.

Table 5. Expected Cost of Slot Entertainment

Token (R)	**Expected Cost (R/min)**
0.5	1.17
1	1.64
2	2.44

5	4.20
10	5.86
25	12.25
50	21.00

6 Taking Uncertainty Into Account

These costs are in terms of the expected time of entertainment and take no account of the uncertainty surrounding the time of play. If we abstract from the actual token cost for a moment, we can plot the expected number of turns (proportional to the time of play) *per Rand spent* against the uncertainty or risk associated with the this number of turns. By considering the expected number of turns *per Rand*, we allow a comparison to be made across the different token value machines, in terms of their expected provision of entertainment (and the uncertainty with which they do this), *per Rand spent*. This measure is clearly inversely proportional to the expected price of slot machine entertainment. The risk-return plot is given in Fig. 3. This approach has parallel features to the classic mean-variance risk-return framework of portfolio analysis. Portfolio analysis considers shares with different expected return and risk characteristics, and combines them into portfolios that trace out an "efficient frontier". Note that, in contrast, in this application the low-end machines (specifically the 50c machines) dominate the higher end machines from *both* a *E(T)* and *s(T)* perspective. The standard approach would be to maximise expected utility from entertainment by computing the (risk-averse) expected quadratic utility function:

where is the expected time at the machine, is the penalty for risk, and where measures the degree of aversion to uncertainty in time spent. In this case, our conclusion would be to unambiguously play the 50c machines. The only unknown factor is where on the line joining the origin and the 50c point (in Fig. 3) to position ourselves, that is how much expected entertainment do we want to purchase. *From a strictly entertainment perspective* the high-end machines (and in fact all but the lowest-end machine) become effectively irrelevant to the decision process.

Figure 3. The Risk-Return Profile of T (number of turns) per unit cost

Using the utility function discussed above we can compute *risk-adjusted costs* of slot entertainment. The value of is, of course, unknown. If, for example, we took the penalty for risk to be 20 per cent of time spent on average, we would get the results shown in Table 6, reflecting expected and risk-adjusted costs of slot entertainment per minute.

It is clearly seen that the price of entertainment (especially when you take risk into account) is significantly higher for the higher token machines. As discussed above, anyone who is simply interested in *playing* the machines, will play the low end machines. The entertainment seeking player is thus faced with no uncertainty

regarding which machine to play, only how much to play. He treats entertainment as a normal good, operates in a risk-averse way and simply purchases that quantum of risk-adjusted entertainment which is consistent with his expected utility preference for entertainment, *vis-a-vis* other goods.

Table 6. Cost of Slot Entertainment (Expected and Risk adjusted)

Token	Expected Rand Cost/min	Risk Adjusted Rand Cost/min
0.5	1.17	1.19
1	1.64	1.69
2	2.44	2.58
5	4.20	4.75
10	5.86	7.70
25	12.25	18.66

50	21.00	39.55

7 the High - End Slot Machines

Why do the high-end machines exist? They exist because they are serving an entirely different market segment: the segment of the market that is much less interested in the entertainment aspect of slots and much more interested in the gambling aspect. The player of the high end slot is only interested in the thrill of a big win. In stark contrast to the person playing for entertainment, this form of activity is clearly risk-seeking. Consider then Table 7 below, where we compare the cost per turn across the various token values with the jackpot values.

One can interpret Table 7 as follows. A turn at the 50c machine costs 50c gross. Taking into account the expected winnings, the effective (net) expected cost is only 6c for the turn. Thus the expected winnings are 44c. These comprise an expected jackpot win of 9c and winnings on the other options of 35c. As discussed above, this machine has a very low playing cost and is the choice of someone seeking entertainment. But, if the jackpot is won it’s only worth R500. The hard-core gambler doesn’t rate this win and plays say the R50 machines. For the R50 machines, the expected (net) cost of a turn is about 15 times as much at R1.05 and

thus the price of this machine from an entertainment perspective is very high. If we take risk into account the cost is R1.98 per turn, and the entertainment value even more highly priced. However, it gives the player the opportunity to win a *significant* jackpot (R50 000), with a slightly higher chance per unit cost of play than for the low-end player. This is the crucial point. The high end player is primarily interested in the quantum of the jackpot. He may have very little entertainment motive and is prepared to incur the higher playing costs just so that he can get a chance at winning what is to him something financially significant. His behaviour is dominated by a strong *gambling, risk seeking motive*. The actual cost of time at the machine is often irrelevant; in fact, the gambler may well wish to *minimise* the time at the machine. The gambler is, in most cases, simply prepared to pay for the opportunity to make a large stake bid offering a high possible jackpot win.

Table 7. Cost of Playing the Machines

Coin	Probability (Jackpot win) (%)	Jackpot Value	E (Jackpot win) per turn	Expected cost per turn(R)
0.5	0.0183	500	0.09	0.06
1	0.0192	1 000	0.19	0.08
2	0.0196	2 000	0.39	0.12
5	0.0199	5 000	0.99	0.21
10	0.0201	10 000	2.01	0.29
25	0.0204	25 000	5.10	0.61
50	0.0206	50 000	10.31	1.05

The relationship between cost of play (expected and risk-adjusted) and the expected value of a jackpot win, as well as the magnitude of the jackpot win, is represented in Fig. 4 below. It makes the point that the opportunity to make a high jackpot strike comes with a near proportional expected cost.

Figure 4. Expected Playing Costs and the Value of the Jackpot

8 Concluding Remarks

In summary, the following salient points emerge. The percentage returns for playing low-end or high-end machines are different with the higher end machines offering better returns. However, this has a negligible impact on the cost of playing, the low-end machines offering by far the cheapest route to “slot entertainment”. High end punters are prepared to play the high token machines simply because it gives them a chance of a large jackpot. For these punters, there is very little entertainment motive in the sense of a desire to "play the machines" - the cost of time at the machine is a minor consideration. Their primary motivation is a risk loving gambler's desire to hit a jackpot. The low-end player, in contrast, generally plays for the entertainment value. The average low-end player goes with a fixed stake and typically plays until bust. This player will thus play the machines that are cheap in terms of delivering time at the machine per rand.

Casinos have recognised this fact and have catered for the tastes that range from an entertainment to a gambling motive by offering an appropriate mix of low-end and high-end machines. In South Africa and in Las Vegas, the entertainment segment of the slot market is by far the largest. In Nevada for the twelve months ending June 1998, $25 slot machines accounted for 0.76 per cent of

the revenues of all the State's casinos while $100 dollar machines brought in 0.58 per cent of all slot machine revenues.*(13) Clearly the legendary high rollers are also playing other games.

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Endnotes

1 (Popup - Popup)

This Paper Emerged Out O a Comprehensive and Inter - Disciplinary Research Programme Into the Economics and Politics of Gambling in South Africa. the Study Examined Ways to Regulate Casino Gambling in South Africa in the Broad Public Interest. the Research was Made Possible by the Sponsorship and Assistance with Data of Sun International (South Africa). the Responsibility for the Conclusions of the Research Remain the Authors' Entirely.

2 (Popup - Popup)

Professors in Statistical Sciences and Economics, respectively, at the University of Cape Town. The authors would like to thank two anonymous referees for their helpful comments.

3 (Popup - Popup)

For an overview of the US gambling industry and its recent development, see Eadington (1997).

4 (Popup - Popup)

The Final Report is available at www.ngisc.gov Details of spending on gambling of different kinds are to be found in Chapter 2 of the Report.

5 (Popup - Popup)

For a comprehensive survey of the economics of gambling see Sauer (1998). The discussion of the alternatives to Utility of Wealth Models of gambling in Section 3.3 is particularly relevant.

6 (Popup - Popup)

We are indebted to Professor Don Ross, School of Economics, University of Cape Town for pointing us to Pascal and also for his helping us understand the recent literature. Naturally we are responsible for the conclusions reached.

7 (Popup - Popup)

We would like to thank an anonymous referee for this insight.

8 (Popup - Popup)

These statistics were supplied on request by Sun International South Africa Ltd.

9 (Popup - Popup)

Source: Nevada State Gambling Control Board, Gaming Revenue Report 1996.

10 (Popup - Popup)

The notion of consumption as playing and also that there might be different motives for playing, is being explored in the marketing literature. We are indebted to John Deighton for this insight. See Deighton and Grayson (1995).

11 (Popup - Popup)

The limit for the gambler would be that probability that made the machine a fair game(equal chance of winning or losing).

12 (Popup - Popup)

These were derived by Prof IL McDonald of the Dept. of Actuarial Science, UCT.

13 (Popup - Popup)

Source; Nevada State Gaming Control Board, Gaming Revenue Report 1998.