U How gaming machines work

This appendix sets out how gaming machines work. This is important because the technology and how it works is at the heart of some gamblers' cognitive errors about their gambling. Moreover, the technology can play a role in harm minimisation, but appropriate measures require an understanding about how the machines function. As Global Gaming Services noted:

> Most forms of venue gambling are technology based. I observe with interest that no-one involved in the problem gambling industry reference groups (eg NSW) would appear to have any appreciation of the design theory and technology behind the gambling devices. Probably most know that the devices make money, but do they know why? (sub. D189, pp. 1-2).

The appendix also describes some of the consequences of differing playing styles, and how the playing styles adopted by problem gamblers are likely to affect the outcomes.

It also considers the persistent myth that the history of outcomes affects future game results — the so-called 'gambler's fallacy'.

Finally, as some industry representatives have questioned whether the Commission's calculations in respect of *Black Rhino* (in chapter 16) are correct, it sets out the calculations for assessing the likelihood of the highest jackpot on this game.

U.1 How do poker machines work?

Modern poker machines are electronic 'chance' machines. Their central component is a program embedded in a chip. This program uses random numbers to generate random outcomes, which in turn determines the outcomes visible to the player. Most Australian machines have five 'reels' and three visible rows. These are displayed on a video unit. Each 'slot' on each reel depicts some icon, such as a tree, a card, or some other readily identifiable symbol. Certain combinations of symbols generate payoffs for the player.

Machines in widespread use in Australia employ virtual reels, rather than electro-mechanical reels as used in older machines, and still often used in some countries, such as France and the US (Casino International 1999, p. 35). The use of virtual reels has a range of attractions. Mechanical reels have major limitations. In particular, on a spinning reel there are only so many symbols that can be fitted (and still be readily visible to the player). In the US, the Telnaus system used reel mapping to overcome some of these physical limitations.[1] But video reels, as used in Australian machines, presents a more transparent and simple way of overcoming the limitations of physical reels. Any number of symbols can be fitted to a video reel, allowing a great deal of flexibility.[2]

Most Australian gaming machines allow for multiple lines. A 'line' in such a display is a series of five outcomes from each of the five reels. The first line is the second row, the second is the top row, while the third is the bottom row. Other lines can be formed by moving from row to row across the reels (table U.1). For example, line 4 is like a shallow 'V'. Multiple lines allow the player to play a set of games simultaneously. *Black Rhino*, for example, allows up to nine lines per button push. Other games, such as *Black Panther* allow only three lines while *Cash Crop* and *Cash Chameleon* allow 20 lines.

Table U.1 **Lines in poker machines**[a]

Reel1	*Reel2*	*Reel3*	*Reel4*	*Reel5*
Line numbers	Line numbers	Line numbers	Line numbers	Line numbers
2,4,6	2,6,9	2,5,9	2,6,9	2,4,6
1,8,9	1,4,5	1,6,7	1,4,5	1,8,9
3,5,7	3,7,8	3,4,8	3,7,8	3,5,7

a Based on the Aristocrat *Black Rhino* game.

Source: Venue observations by the Commission.

An example may be useful in explaining how the machines work. Suppose someone is playing just one line and one credit per line on a *Black Rhino* machine. People

1 This mapping system worked as follows. A random number would be sought between 1 and a large number (say 128), which identifies a position on a virtual reel (in this case, one with 128 stops). Then each of the stops on the large virtual reel are mapped onto a smaller reel. It is this smaller reel that is used to display the symbols on the gaming machine and which is visible to the player. Because the large virtual reel has many more stops than the smaller visible reel, many different stops on the big virtual reel can be mapped to one stop on the small reel. Thus non or low paying symbols on the visible reel will be represented by many stops on the virtual reel, while high paying symbols may be represented by single stops. In this way, the probability of selection of any given stop on the reel visible to consumers will no longer be the same, but will depend on the number of associated stops on the virtual reel.

2 Aristocrat Leisure Industries provided advice on the workings of modern Australian machines.

usually play more than one line, but it is easier to explain how the machines work by looking at the most simple style of play.[3]

When the player pushes the machine button, the random number generator in the machine randomly determines the stopping point of each of the five reels. The reels are like lists of symbols. The symbols on any given reel are always in the same relative position in every game. Thus on reel one of *Black Rhino*, a king always follows the rhino symbol, then a queen, a ten and so on. Once the stopping point on line one for any given reel is determined, then that determines what symbols appear on that reel for the other lines. The stopping point for each reel is determined *entirely* randomly and no single position on any reel has a higher probability of selection than any other position. The outcome on each reel is also *entirely* independent. A physical analogy to the gaming machine is a set of five wheels on which symbols are etched. Each of the wheels is separately rotated and allowed to come to rest.

The payoffs associated with each winning combination are displayed on the machine. For example, five rhinos pays 5 000 times the credits bet (plus a scatter). However, much more frequently, the winning combinations return lower amounts, such as 3 scatter trees or two nines (which pay 2 times the credits staked) or three tens (5 times the credits staked). But mostly no winning combination occurs.

For example, one possible outcome from the *Black Rhino* game is shown in table U.2. This scenario would pay out 3 kings on line 1 (since rhinos also substitute for other symbols) which, on a 10 cent machine would be a payout of 10 x 10 cents or $1. Because scatters[4] are paid regardless of the number of lines being played, and rhinos are substitute symbols for the scatter symbol (a tree), a scatter payout would also be paid. This provides an additional payout of 50 x total credits staked = $5. So in this case, the total payout would be $6. This is just one of many possible outcomes on the machine.

[3] The player selects the lines and credit options at the start of play and can then repeat that style of play with a single button push (or a touch of the screen on some of the newer machines). They can, of course, change their lines/credits options at any time during play.

[4] Scatter wins occur when the 'scatter' symbol appears enough times anywhere in the 15 available spots on the video screen, regardless of the number of lines actually being played.

Table U.2 **An example of an outcome on *Black Rhino***

	Reel 1	*Reel 2*	*Reel 3*	*Reel 4*	*Reel 5*
	Symbols	Symbols	Symbols	Symbols	Symbols
Line 2	Rhino	Queen	Ten	Rhino	Ten
Line 1	King	Rhino	Rhino	Queen	King
Line 3	Queen	Ten	Nine	King	Rhino

If the gambler had been playing five lines and ten credits per line (with line 4 being the pathway shown by the bold line and line 5 being the pathway shown by the other line) then the win would have been $265, comprising:

- $10 on line 1 (10 x 10 credits per line x credit value);
- $250 in the scatter win; and
- $5 on line 4 (based on 2 rhinos[5]).

U.2 Game returns and the 'price' of gambling

As noted in chapter 16, gaming machines have statutory minimum player return rates. These minimum player return rates are usually exceeded by gambling venues. Returns of around 90 per cent are common. Player returns on gaming machines have tended to increase over time in Australia.

The player return rate is defined as the average amount won by players as a share of the cumulative amount staked. The 'price' of gaming machines is therefore one minus this rate. For example, if a machine offers an average player return of 90 per cent this means that the average loss is 10 per cent of the accumulated amount staked (which is the turnover of the machine).

The amount of expected losses vary with the playing style of the gambler. It should not be assumed that low denomination machines, such as the now common one and two cent machines (chapter 16), necessarily involve low player losses. They instead allow a large amount of player choice about the intensity of playing. For example, the expected player losses per hour of continuous play on a two cent *Cash Chameleon* machine (with an 85.15 per cent return) is between a very modest $2.14 for one line, one credit per line to $1 069 per hour at maximum intensity — a difference in spending rates of 500 times (table U.3).

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5 While the rhinos substitute for nines, three nines provides the same prize as two rhinos, and other than when a scatter rhino occurs with a payline rhino win, the highest win only is paid.

Table U.3 **Expected hourly losses on *Cash Chameleon*[a]**

Results for different playing styles

Credits\ lines	*1 credit per line*	*5 credits per line*	*10 credits per line*	*20 credits per line*	*25 credits per line*
Player return=92.13%	$	$	$	$	$
1 line	1.13	5.67	11.33	22.67	28.33
5 lines	5.67	28.33	56.66	113.33	141.66
10 lines	11.33	56.66	113.33	226.66	283.32
15 lines	17.00	85.00	169.99	339.98	424.98
20 lines	22.67	113.33	226.66	453.31	566.64
Player return = 87.78%					
1 line	1.76	8.80	17.60	35.19	43.99
5 lines	8.80	43.99	87.98	175.97	219.96
10 lines	17.60	87.98	175.97	351.94	439.92
15 lines	26.40	131.98	263.95	527.90	659.88
20 lines	35.19	175.97	351.94	703.87	879.84
Player return = 85.15%					
1 line	2.14	10.69	21.38	42.77	53.46
5 lines	10.69	53.46	106.92	213.84	267.30
10 lines	21.38	106.92	213.84	427.68	534.60
15 lines	32.08	160.38	320.76	641.52	801.90
20 lines	42.77	213.84	427.68	855.36	1069.20

a The formula for the expected (or average) dollar value of losses from playing one hour continuously is:

$$Expected\ loss = D \times C \times L \times (1 - r) \times \frac{3600}{BPT} \text{ where}$$

C is the number of credits staked per line, L is the number of lines played per button push, r is the player return (for example, 0.9213), D is the denomination of the machine (such as 1 or 2 cents, and in the above examples a 2 cent machine), BPT is the time elapsed between button pushes (here set at 5 seconds). *Cash Chameleon* comes with four return options for the venue/jurisdiction (87.78%, 85.15%, 90.42% and 92.13%). The table above shows the player loss outcomes associated with three of these return rates.

Source: Commission calculations.

The expected losses also vary by the machine denomination and the player return rate. Clearly, the one cent *Cash Chameleon* with the same return rate as above, has half the expected player loss per hour for the same playing style. Far less obvious is the influence of the player return on the expected player losses. The *Cash Chameleon* machine has a number of variants, offering returns as low as 85.15 per cent and as high as 92.13 per cent. As noted in chapter 16, both the maximum and minimum return rates on these variants appear to be high returns, and many people would think the difference slight. However, different player return rates — which are produced by usually making a few simple changes to the symbols on one or two reels — can have a large impact on expected player losses. Thus playing at top intensity on the 85.15 per cent *Cash Chameleon* will set back the gambler an expected $1 069 per hour but nearly halves this to $567 per hour on the 92.13 per cent version.

Gaming machines are entertaining precisely because of interesting game features and the unpredictability of the outcomes. The complex payoff distributions in gaming machines mean that the returns that gamblers make from games vary significantly in the short run. The corollary to this is that the return rates realised by players will vary considerably from playing session to session. As noted by the AGMMA (sub. D257) and in chapter 16, this implies that players will not be able to readily determine the 'price' of single machine, except after many trials.

Figure U.1, which shows the player returns from 100 000 simulations of a gaming machine, confirms gaming manufacturers' statements about the extreme volatility of actual outcomes on poker machines.[6]

For example, while the expected net losses from playing on a 10 cent *Black Rhino* at maximum intensity (nine lines and ten credits per line) are around $780, there is around a 30 per cent chance that the losses will be $1 300 or more per hour. Similarly, there is around a 2.3 per cent chance that the gambler will make a net $1 300 win in an hour long session at this maximum intensity. The odds of breaking even or better are around 17 per cent.

U.3 Game volatility

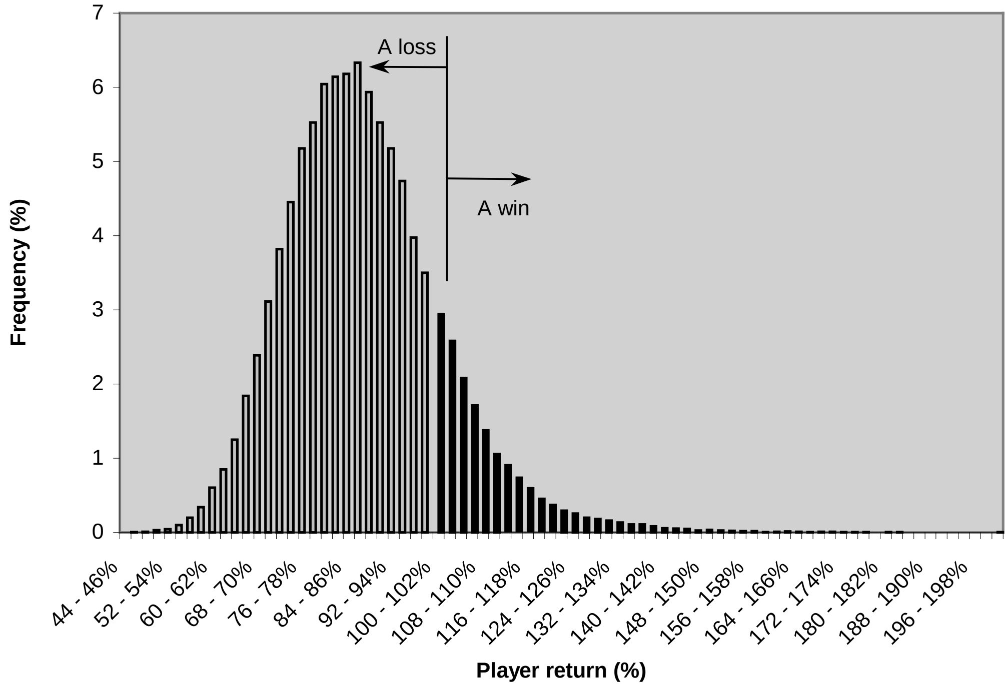
Even while all styles of play involve highly unpredictable returns over a reasonable session time, the player can decide whether they wish to increase this unpredictability further by choosing certain playing styles. For example, a *Black Rhino* player could:

- choose a 10 cent machine and play one line with 10 credits per line (staking $1 per button push) — playing style 1; or
- also stake $1 a button push by choosing a 2 cent machine and playing 5 lines and 10 credits per line — playing style 2.

6 These data and other simulations of a gaming machine in this appendix are based on software developed by the Commission. The program, which runs on MS Windows 95+ platforms, is available on request from the Commission.

Figure U.1 **Player returns from a gaming machine**[a]

Black Rhino return distribution from one hour of play



a This is based on a particular poker machine game, *Black Rhino*, whose details were provided by Aristocrat. The player price results are based on 100 000 simulations of a gambler making 720 button pushes (playing nine lines). 720 button pushes amounts to around 1 hour of continuous play. The consumer return rate of the version of *Black Rhino* simulated is 87.84 per cent (with the simulation average being 87.82 per cent, within 0.02 per cent of the actual price).

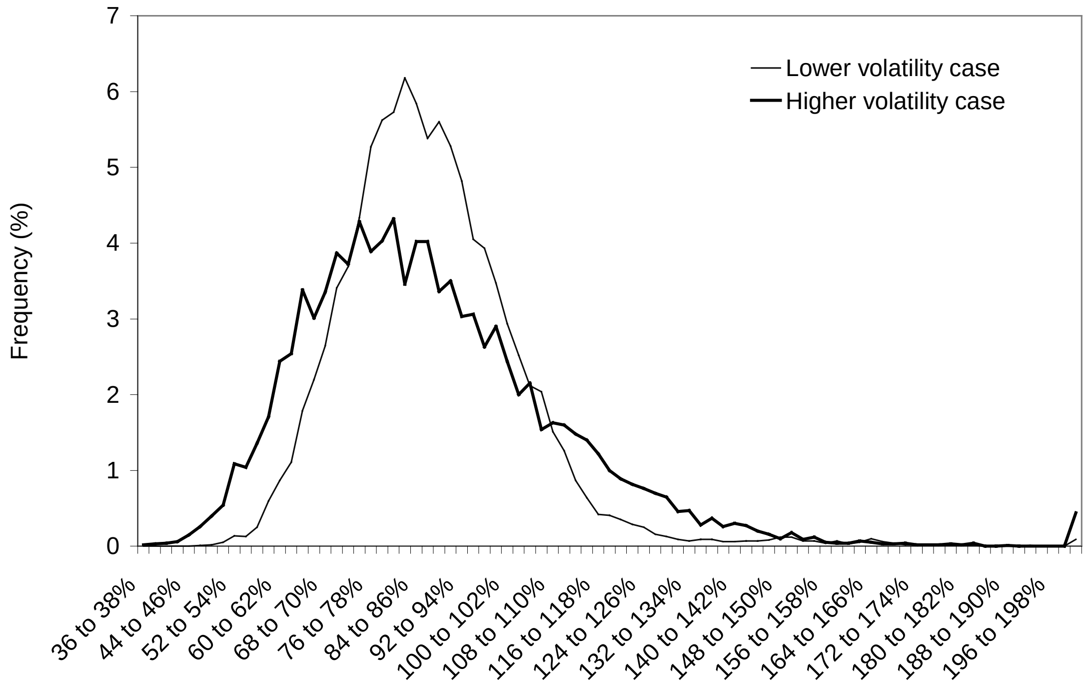
Data source: Commission estimates.

The rate of return is equal for each playing strategy, but the variance — the spread of results — is much greater for the first strategy than the second. The person who plays gaming machines the first way has a higher probability of a bigger win (because payouts for a line win are a multiple of the credits bet on that line), but also a higher probability of losing more. The distribution of returns from playing for one hour for each playing style is illustrated in figure U.2, based on the results of 10 000 gaming machine simulations in each case. For example, for around 21 per cent of occasions the hourly returns are below 70 per cent using player style 1 compared to less than 10 per cent of occasions for player style 2. On the other hand, for around 15 per cent of occasions the hourly returns are *above* 110 per cent using player style 1 compared to 6 per cent of occasions for player style 2.

The example also illustrates the point that the likelihood of having a net win can vary significantly over the shorter run, depending on play style, even though the expected return is the same. However, as noted in chapter 16, the Commission still considers that the machine price — one minus the player return — is a useful summary measure of the expected cost of playing the game. It is an especially good guide over the longer run, as demonstrated next.

The volatility in returns is a function of the number of games played. Over a year the numbers of games played, even by a regular recreational gambler, tends to run into the hundreds of thousands.

Figure U.2 **Differences in the distribution of returns from differing playing styles**[a]



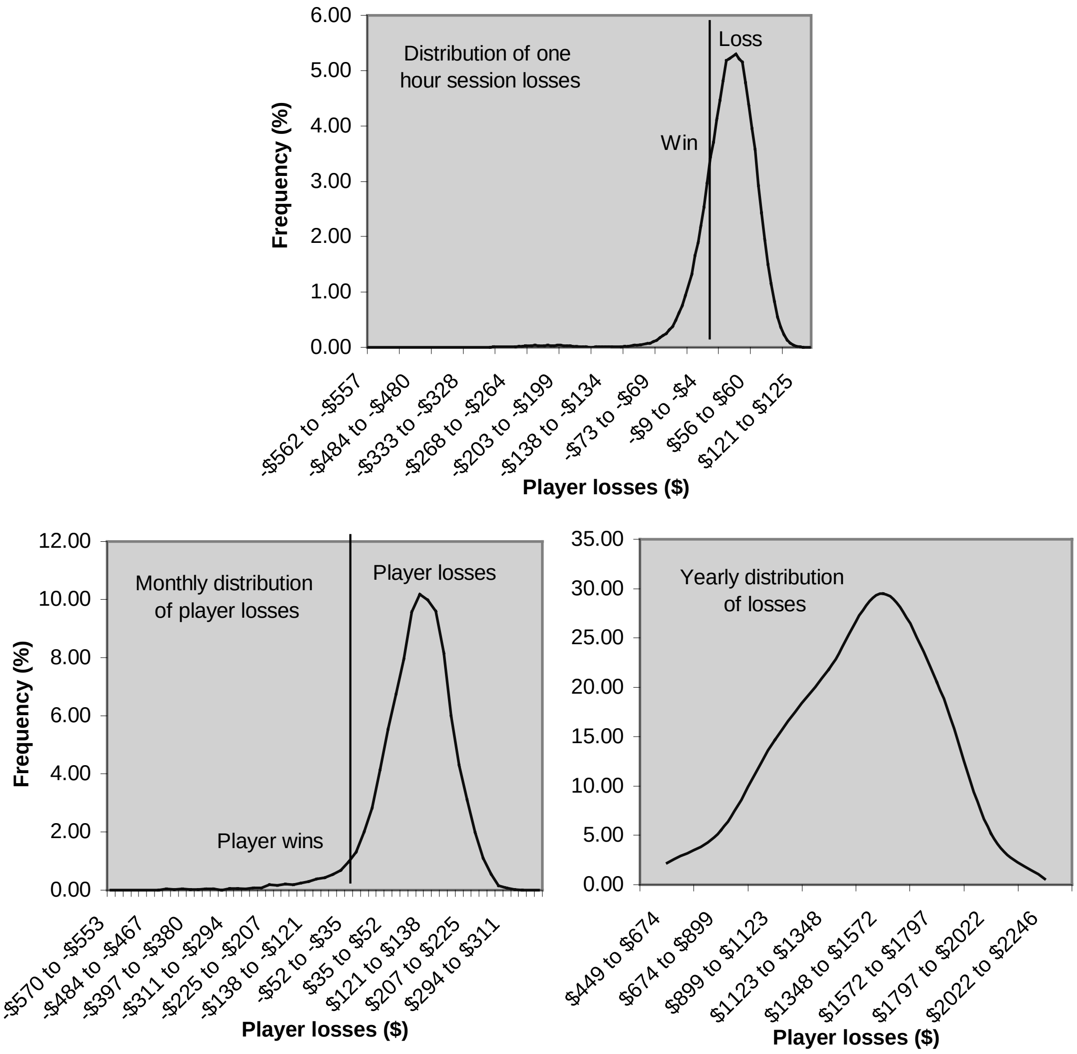
a The higher volatility case is associated with player style 1 (10 credits per line, 1 line only on a 10 cent machine), while the lower volatility case is associated with player style 2 (10 credits per line, 5 lines on a 2 cent machine). The results are based on 10 000 simulations in each case. The coefficient of variation was 0.326 for player style 1 and 0.183 for player style 2 — indicating the substantial difference in the volatility of returns.

Data source: Commission calculations using a poker machine simulation program.

For example, if a player bet on 3 lines a button push (each line best seen as a separate game) then they would be playing around 2 160 games an hour. If they played once a week for the year, they will have played 112 320 games. Over a thirty year period, they would have played around 3.4 million games. The volatility is much reduced over a large number of games and will tend to be concentrated around the expected player return. This has some interesting implications.

A once a week hourly session of gambling will produce significant differences in returns from week to week. It would not be unusual to win $100 in one week and lose $100 in the next. In the game simulated by the Commission, around one in five are net winners in any given hourly session (figure U.3).

Figure U.3 **Distribution of player losses associated with different periods of play**[a]



a Based on varying simulations of a gaming machine as noted in the accompanying table. A minus value indicates a win (ie a negative cost).

Data source: Commission simulations.

Over a month, however, returns are much less volatile, with significantly reduced probabilities of being a winner overall. Now only 7 per cent are net winners in any given month. And over the year none won in 1000 simulations undertaken. The average recorded a loss of $1365 and the least loss was $484. Over a lifetime of regular playing (30 years) the probability of winning overall on the type of machine simulated is so remote that it may as well be regarded as impossible.[7] The average loss in our simulation of this was $41 000 and the least lifetime cost was $35 500 (table U.4). The degree of variation is very low relative to the mean for the 30 year period, but high for an hour long session. The measure of relative variance — the coefficient of variation — shrinks by around a factor of 40 as the time span increases.

Table U.4 **The impact of regular play on the distribution of gaming machine losses**[a]

	Hourly sessions	*Monthly*	*Yearly*	*30 years*
Average cost ($)	26.26	105.04	1 365.52	40 965.60
SD ($)	39.88	81.1	302	1574
Coefficient of variation	1.52	0.77	0.22	0.04
Least cost ($)	-559.60	-559.60	483.80	35 574.30
Share making a profit (%)	19.2	6.7	0	0
Simulations	1.56 million sessions	13 000 months	1 000 years	1 000 30 year periods

a Based on a person playing a 2 cent machine with 3 lines and 5 credits per line (ie a stake per button push of 30 cents). The machine 'price' is 12.16 per cent (ie expected losses from a stake) and they play for a one hour session, once per week. A minus number indicates a win. Someone playing at higher levels of intensity could expect to make proportionately higher overall losses. Thus someone who plays at around 90 cents a button push, would expect to lose around $123 000 over the 30 year period.

Source: Commission calculations.

Of course, for many people such 'losses' are merely the form of payment for a well-enjoyed entertainment. The cost of attending other forms of entertainment, such as movies, is not termed a loss. A survey of 262 gaming machine players at 5 Victorian venues (Tabcorp, sub. D286, p. 21) suggests that 52 per cent of people who *lost* in a session of play at gaming machines still considered the outcome had met or even exceeded expectations. However, for many it also appears that they expect to win from playing gaming machines. This is a goal that can be frequently achieved in separate gaming sessions, but is *inevitably* elusive for any prolonged period of regular play.

U.4 Game duration

It is relatively easy, as in the case of player losses, to calculate the expected duration of a game associated with any given style of play. Modern Australian machines give

[7] The distribution of losses after 30 years can be approximated as a normal distribution. To make a win would require a shift 26 standard deviations away from the mean — a probability of effectively zero.

players a large amount of choice about how much time is purchased on the machine. Someone willing to spend $50 on the 2 cent *Diamond Touch* gaming machine (a typical machine) can expect to sit there for an average of over 28 hours if they stake only one credit per line and hit only one line (table U.5). Most people would never play this long of course, but it demonstrates that the machines do not necessarily involve large losses even over enduring periods of play. On the other hand, someone who elects to bet at the maximum intensity can expect this 2 cent game to last under 4 minutes for a $50 initial stake.

Table U.5 **How much time is $50 expected to buy on the *Diamond Touch* gaming machine?**[a]

Results for different playing styles

Credits\ lines	*1 credit per line*	*5 credits per line*	*10 credits per line*	*20 credits per line*	*25 credits per line*
Player return=87.79%	Hours of play	Hours of play	Hours of play	Hours of play	Hours of play
1 line	28.438	5.688	2.844	1.422	1.138
5 lines	5.688	1.138	0.569	0.284	0.228
10 lines	2.844	0.569	0.284	0.142	0.114
15 lines	1.896	0.379	0.190	0.095	0.076
20 lines	1.422	0.284	0.142	0.071	0.057

a The formula for calculating the expected duration in hours is:

$$Duration = \frac{T}{(D \times C \times L)} \times \frac{1}{(1-r)} \times \frac{BPT}{3600}$$

where T is the initial amount of money the player outlays on the machine (in this case a $50 note), C is the credits per line, D is the machine denomination (in this case 2 cents), L is the lines per button push, r is the player return rate and BPT is the time elapsed between button pushes (here set at 5 seconds). The expression above is derived by dividing the initial amount of money the player puts into the machine by the expected hourly loss (as in the previous table).

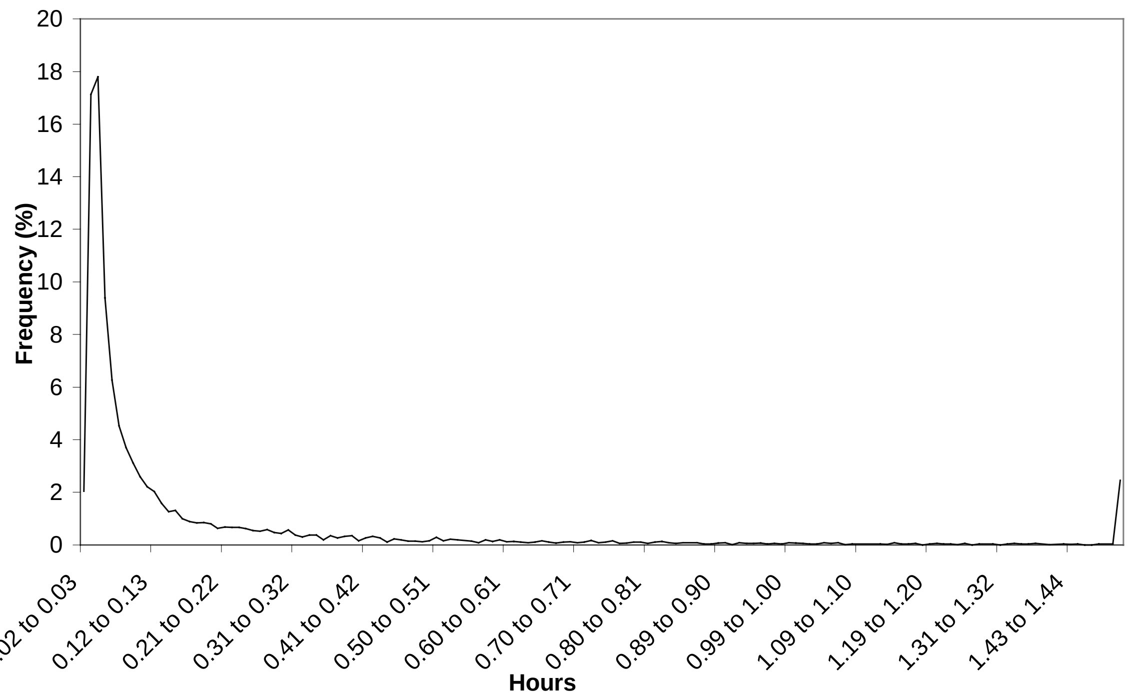
Source: Commission calculations.

The distribution of time purchased, is, however, highly skewed towards shorter duration sessions for a given amount of money (figure U.4). For example, in 10 000 simulations of someone who puts $30 into a ten cent *Back Rhino* machine and plays 3 lines and 5 credits per line, the average duration is 13 minutes and 4 seconds. But on fifty percent of occasions the money runs out and the session is over in less than 4 minutes. On other occasions, the game could, in theory, last several hours.

The notable feature of the distribution is its skewness — this reflects the situation in which someone makes periodic wins and keeps playing. It is this characteristic that makes the Commission wary about using expected player duration as a proxy for the cost of playing the machine. After all, 50 per cent of the time a player will play for an amount of time that is less than one third of the expected duration — and this may fuel excessive player suspicion and disputes.

Figure U.4 **The distribution of duration**[a]

A *Black Rhino* example



a This is based on someone who puts $30 into a 10 cent machine and plays 3 lines and 5 credits. The simulation assumes that If they have a win of $100 or more on a single button push they stop playing. Otherwise they play until their money has gone. The simulation suggests that the mean is 13 minutes and 4 seconds (with a standard deviation of 35 minutes). On fifty per cent of occasions, the game is finished within 48 button pushes (about 4 minutes).

Data source: Commission simulations of a poker machine.

U.5 The impact of recycling wins

Gaming machines tend to produce most of their prizes as small wins, and many players will recycle or re-‘invest’ these winnings. However, problem gamblers are much more likely to recycle big wins (table U.6). For example, problem gamblers are 4 times more likely to re-invest a prize of $100 than non-problem infrequent gamblers.

Since every game (bar some temporary features) has a house advantage, the impact of re-investment has a significant impact on overall player losses, and also tends to prolong gambling sessions.

Table U.6 **Percentage of people who reinvest $20, $50 and $100 wins into gaming machine play**

Nova Scotia VLT players

	Problem players	*Frequent non-problem players*	*Infrequent players*
$20 win	74	34	26
$50 win	58	29	17
$100 win	48	21	13

Source: Focal Research (1999, pp. 3-57).

The Commission examined the impact on duration and player losses of two different styles of gambling behaviour. In both cases, the gambler bet on 3 lines with 5 credits per line using a five cent machine (ie a button push cost of 75 cents). Each started with a stake of $30. In one case, the gambler stopped playing if they won a prize of over $50 or an hour had elapsed. In the other, the gambler stopped playing if they won a prize of over $250 (recycling all other smaller wins) or after three hours had elapsed. The average share of the initial outlay lost in the former case was about 70 per cent, while it was 86 per cent for the latter (table U.7).

Table U.7 **The impact of differing playing styles on expected returns from a given outlay**[a]

	Plays up to one hour and stops on a prize of $50	Plays up to 3 hours and stops on a prize of $250
Initial outlay ($)	30.00	30.00
Average number of button pushes (number)	224.7	287.9
Average session time (minutes)	18.7	23.98
Standard deviation of session time (minutes)	17.4	34.2
Average loss (gain) ($)	20.74	25.79
Share of initial outlay lost (%)	69.1	86.0

a The results are based on 10 000 simulations in each case. The gambler plays 3 lines and 5 credits per line on a 5 cent machine (*Black Rhino*). In one case, the gambler will stop playing if they get a prize of $50 or if they exceed one hour, whichever comes first. In the other, the gambler will stop playing if they get a prize of $250 or if they exceed three hours, whichever comes first. The latter is behaviour typical of someone who recycles their wins.

Source: Commission calculations.

The Commission observed in its *National Gambling Survey* that the ratio of overall player losses to outlays tended to be higher in problem gamblers than recreational players — and it is this behaviour that most readily explains this pattern.

U.6 The gambler's fallacy

Gamblers and others have many misconceptions about gaming machines (and indeed other gambling forms). The 'gambler's fallacy' (also called the 'Monte Carlo effect') refers to the spurious belief that pure games of chance have memories and that the probability of future events is affected by the history of the game (Wildman, 1998, pp. 40ff). Thus people think that a machine that has not paid off for a while has a much higher chance of paying off in the future, and that similarly, a machine that has suddenly paid off is 'exhausted' and is not likely to pay off quickly in the future. This has the unfortunate consequence for problem gamblers that they believe they can make up past losses on a machine by playing a bit longer, since the machine must be ready to pay up. Or, by not believing that each button push is an independent event they believe that they can exert some control over the outcome:

> Players have spent years trying to beat slot machines for big money by devising schemes to influence the reel outcome. They alternate between pushing the button and pulling the handle to confuse the random number generator. They think the 'rhythm' of handle-pulling will lead to winnings. They heat up coins with a lighter. They freeze coins in a cooler. They think the RNG will pick a different result because they bet three instead of two coins. They pull the handle harder or slower. Save your strength. Put the lighter away. Leave the cooler at home. None of it maters. The RNG is going to pick a random reel result no matter how hard you heave the handle, and whether you play two coins, play three coins, push, pull or stand on your head (Legato, 1999).

In fact, the outcome on each new game is independent of past games. People then wonder how it is possible that a gaming machine can guarantee a given rate of return, as required by regulators, if they do not 'tighten' up after jackpots or 'loosen' up after a sequence of low or no payouts. The regulated return rate is naturally achieved, even with independence, by the sheer number of games that are played. The concept is similar to throwing a coin. A fair coin has a 50 per cent chance of a head. But there is a 3 per cent chance that a coin will show 5 heads in a row, and an even higher chance that it will be significantly biased towards heads or tails. But after a million tosses, the observed odds will converge to 50 per cent heads and tails. No memory in the coin throws is required to achieve this, just an abundance of trials.

U.7 The case of *Black Rhino*

A number of industry groups suggested that the Commission's calculations of the probability of winning the top jackpot on the *Black Rhino* gaming machine revealed a misunderstanding of random number generators or the laws of probability (box U.1). Aristocrat Leisure Industries, the maker of the machine, have confirmed that the Commission's calculations are correct, but did point out that many people play *Black Rhino* and similar modern games in expectation of their frequent 'scatter' wins, rather than for the jackpot prize (a point also made subsequently by the Australian Casino Association in sub. D289).

Box U.1 **Random number generators and *Black Rhino***

A number of industry representatives argued that the Commission's representation of *Black Rhino* showed a poor understanding of how gaming machines actually worked:

> It **could** take 6.7 million button presses … but it **could** be any quantum short of this (or longer than this), including one button press. The Commission appears not to understand the working of random number generators (Star City Casino, sub. D217, p. 18);
>
> The description of the *Black Rhino* is misleading. If fails to adequately reflect the laws of probability and an understanding of random number generation. In talking about the alleged number of times a player would need to press the button to win, the PC contradicts its earlier claim that the odds of winning are the same for every push of the button (ACIL, sub. D233, p. 9).
>
> Our impression is that you are labouring under a number of misunderstandings about … how poker machines work (Australian Casino Association, sub. D289, p. 1).
>
> … the PC suggests that consumers could be told that in order to get a 50 per cent chance of getting 5 rhinos it will take 6.7 millions button presses … This conveniently overlooks the fact that random numbers are involved and the jackpot could be achieved with just one press of the button … Later … the PC has a description of the chances of winning on an EGM which seems to contradicts its discussion … it is acknowledged that any press of the button is independent of previous wins … This is an acknowledgment of the random numbers. What does the PC really believe? (Australian Casino Association, sub. D234, p. 7).

Below, the Commission sets out the calculations that were used to illustrate the odds of winning the top jackpot and its likely cost.

Black Rhino is a game in which there are five (virtual) reels. On each reel there are 25 symbols. There is only one black rhino on each reel. The internal computer in the gaming machine generates a random number to determine the stopping point of each reel. Each reel is 'spun' independently. The probability of getting 5 rhinos on a single button push, playing one line at a time, on the *Black Rhino* gaming machine is, therefore, $(1/25)^5$, which is one in 9,765,625.

This does not mean that a person cannot win on any given button push. Indeed, that is precisely what we took account of when making our calculations. They *could* win on the next button push as Star City Casino noted (sub. D217, p. 18) and the likelihood of doing so is exactly one in 9 765 625 as above.

However, many people find one in 9 765 625 a daunting number. So how can one provide a picture of what one in 9 765 625 means? One — quite common way of explaining low probability outcomes in statistics — is to calculate how many *cumulative* trials (or button pushes in this case, given the example is based on a person playing one line per button push[8]) would be needed to increase the probability to 50 per cent of winning the jackpot (instead of the roughly one in ten million represented by a single trial).

This is a straightforward statistical problem. The probability of winning the jackpot is p. Therefore the probability of not winning is $(1- p)$. The odds, therefore, of **never** winning the jackpot in n trials is $(1-p)^n$. Therefore, the odds of winning the jackpot (at least once) in n trials is $1-(1-p)^n$. We can then ask how big is **n** in order that the expression $1-(1-p)^n = 0.5$. Some simple mathematical manipulation shows that:

$$n = \ln 0.5 / \ln (1-p)$$

Now substituting $p = (1/25)^5$, then the number of button pushes (n) required is 6 769 015.[9] This has the implications that:

- assuming each button push takes 5 seconds, this suggests that, at 17 280 button pushes per day, it will take 392 days to have a 50 per cent probability of winning the top jackpot;
- data from the VCGA (1999) suggests that the average player spends less than 50 hours playing per year. At that rate of normal play, the gambler can expect to play for 188 years to have the 50 per cent probability;

8 As noted in section U1, this assumption is adopted for ease. The Australian Casino Association (sub. D289, p. 3) says that a different time spent would be obtained had the calculations been based on multiple lines. Of course, since playing multiple lines increases the number of games being played per minute, a fewer number of *button pushes* and therefore a reduced time would be required to achieve the fifty per cent chance. But that in no way affects the correctness of the calculations using the assumptions used by the Commission. The point of the calculation is to illustrate the remoteness of the probability of winning the top prize. Nothing put to the Commission suggests that our calculation under or over-estimates this remote probability.

9 The binomial formula suggests that this 50 per cent probability of winning at least one jackpot consists of the following: there is a 34.7 per cent chance of winning just one jackpot over the 6.7 million trials, a 12 per cent chance of exactly two jackpots, a 2.8 per cent chance of winning exactly three jackpots over the trials, and a 0.5 per cent chance of winning exactly four jackpots. The probability of winning other multiples of jackpots are so negligible that they are not worth noting.

- assuming that the gambler is on a 10 cent machine running one line and 4 credits per line on average[10] (which roughly equates with the industry average loss rate) then they will outlay 40 cents per button push. With a machine 'price' of 0.1216 (one of the settings on *Black Rhino*), the consumer will lose an expected 4.864 cents per button push. This implies *net* player losses of $329 245 to have this 50 per cent probability. This expected cost fully *factors in* any wins made by achieving any jackpots (and all other wins — including scatters— which are, of course, quite frequent[11]).

The above calculations rely on independent randomly generated numbers, and the possibility that on any button push a win is possible. Of course, this does not mean that the gambler will be *guaranteed* a jackpot win in 6 769 015 trials (as was implied in some popular stories, as noted by sub. D289, p. 3) — to the contrary, this many trials simply provides a fifty-fifty probability of making at least one jackpot win.

[10] *Black Rhino* has a number of options for playing multiple credits, but 4 is not one of them. However, this appears to be the average amount wagered, as suggested by the VCGA. Our calculations rely on playing an average of 4 credits per line (which could be achieved by a player who plays 3 credits half the time and 5 credits half the time).

[11] The Australian Casino Association (Sub. D289, p. 3) says that the Commission's dollar figure does not 'cover returns from the higher-probability minor prizes that a player could be expected to win on the way'. This is simply not correct. The Commission has applied the full game return of 87.84 per cent when calculating player wins.