Responsible Investing

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PLATYPUS ASSET MANAGEMENT

Electronic gaming machines: a schematic

Creating successful games requires multiple design decisions. These decisions cover statistics to graphics to the physical design of the machine, and have to result in an electronic gaming machine (EGM) that is compliant with regulations. In this note, we focus on the statistics of EGM design using a simple example to discuss the key concepts. The concepts are important to understanding the interaction between the player and the EGM and are helpful for context around responsible gameplay.

The physical structure and user interface of a typical EGM is shown in Exhibit 1.

The highest panel displays the largest jackpot available to the player (we have used example amounts), which we call the Mega Jackpot. The player has the lowest probability of winning the Mega Jackpot with the amount being many multiples of a single bet. On the next panel, often there are three amounts displayed. The largest jackpot is repeated, followed by two smaller ones. In addition, there might be bonus wins. Bonus wins do not increase during play, while jackpot amounts increase as the EGM is played. The next panel displays the denomination that the player chooses to bet on a single spin. This can be multiplied up to a maximum bet size of $10 in NSW, the ACT and the Northern Territory, and $5 in Victoria, Tasmania, South Australia, and Queensland.

Exhibit 1: Schematic of EGM display.

Source: Platypus

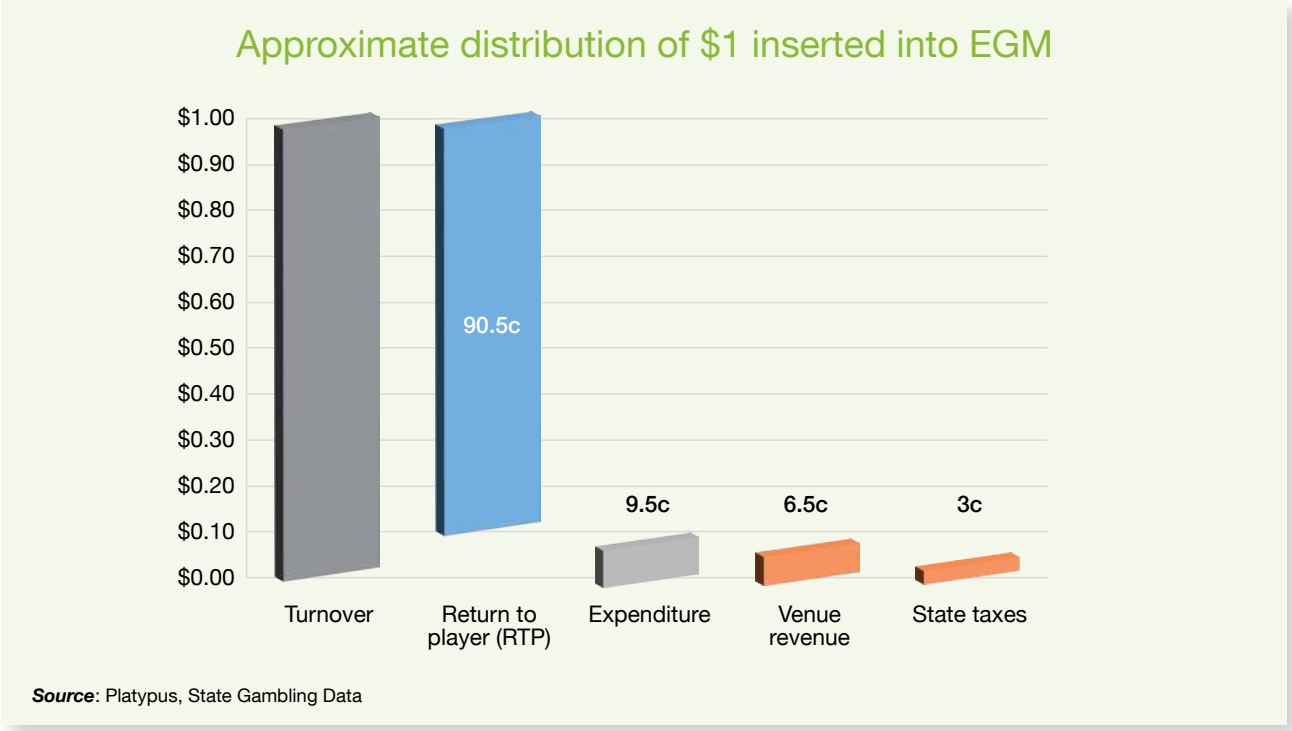
The player experience varies between EGMs.

Some EGMs perform better than the floor average (sometimes up to as much as ~8-9x), engaging the player in a way that other EGMs are unable to. This is influenced by a number of factors: the graphical display, the frequency with which players win, the frequency with which they experience game features, the size of the jackpots, and the psychological effect of the machine sounds and features. For a more comprehensive discussion, see the Platypus EGM report.

For each $1 inserted, approximately between 90.5c and 93c are returned to the player.

Exhibit 2 shows how this is split. From the venue revenue, we estimate about 0.075c is spent on the product with an EGM manufacturer.

Exhibit 2: Revenue split from $1.



Source: Platypus, State Gambling Data

The return to player (RTP) is legislated.

In NSW, Victoria, Tasmania, Queensland and the Northern Territory, for every $1 a player spends, by law 85c on average has to be returned to the player. In the ACT it is 87c and in South Australia it is 87.5c. However, the RTP is measured differently, depending on the state. Outside Victoria, it is calculated over the life of the machine, with the QLD government[1] estimating that EGMs usually function for 3 to 4 years and have approximately 1 million spins. In Victoria, the RTP is calculated on a venue basis over a calender year.[2] This can lead to variable gaming experiences for individual players.

The return to player (RTP) is generally higher than legislated values.

EGM designers aim to balance time on machine with RTP. Too little RTP and players will lose interest, too much and the economics are less attractive to the venue operator.

[1] Gaming machines and gambling odds refresher course | Business Queensland

[2] Glossary (responsiblegambling.vic.gov.au)

The player denomination choice can correspond to different returns to the player.

In Exhibit 1, the RTP is often altered depending on the amount bet. For lower denomination bets, example EGMs provide RTPs of 90.5% while for $2 denomination example EGMs can provide RTPs of 93%. The higher value bets are more profitable for the venue because the time spent on the machine to spend a fixed amount is lower when compared to smaller denomination bets.

Within the EGM, the return to player is calculated via a pay table.

This lays out the probability of winning a certain multiple of bet size. The RTP is calculated by multiplying the win probability with the win multiple, and summing the results. We construct an example pay table that produces an RTP of 90.5c for each $1 (which we call 90.5%). While individual EGM odds are the intellectual property of the manufacturers, the QLD government[3] state that with gaming machines there is often a 1 in 7,000,000 chance of winning the top prize. We have used that in our example.

Exhibit 3: Example pay table for RTP of 90.5%.

Symbol	Win (multiple of bet)	Win probability	Win amount (2c bet)
Mega Jackpot	750,000	0.000014%	$15,000
Major Jackpot	50,000	0.0002%	$1,000
Minor Jackpot	10,000	0.001%	$200
Wild (W)	1,000	0.006%	$20
Diamond	500	0.02%	$10
Gold Bar	250	0.1%	$5
Treasure Chest	50	0.2%	$1
Ace (A)	10	0.5%	$0.20
King (K)	1.5	1%	$0.03
Queen (Q)	1	2%	$0.02
Jack (J)	0.5	10%	$0.01
No Win	0	86.2%	None

Source: Platypus

The first thing to notice is that the player wins 13.8% of the time for a RTP of 90.5%. Our guess is that small wins occurring often keep players engaged, so we have designed our pay table accordingly. The second thing to notice is that the probability of winning more than $5 (250x the original bet) is 1 in 3,704 spins.

Players might be happy to take those odds. We see similar behaviours with stock market investors.[4] From Bali et al (2011):

> *'Given a preference for upside potential, investors may be willing to pay more for, and accept lower expected returns on, assets with … extremely high positive returns. In other words, it is conceivable that investors view these stocks as valuable lottery-like assets, with a small chance of a large gain.'*

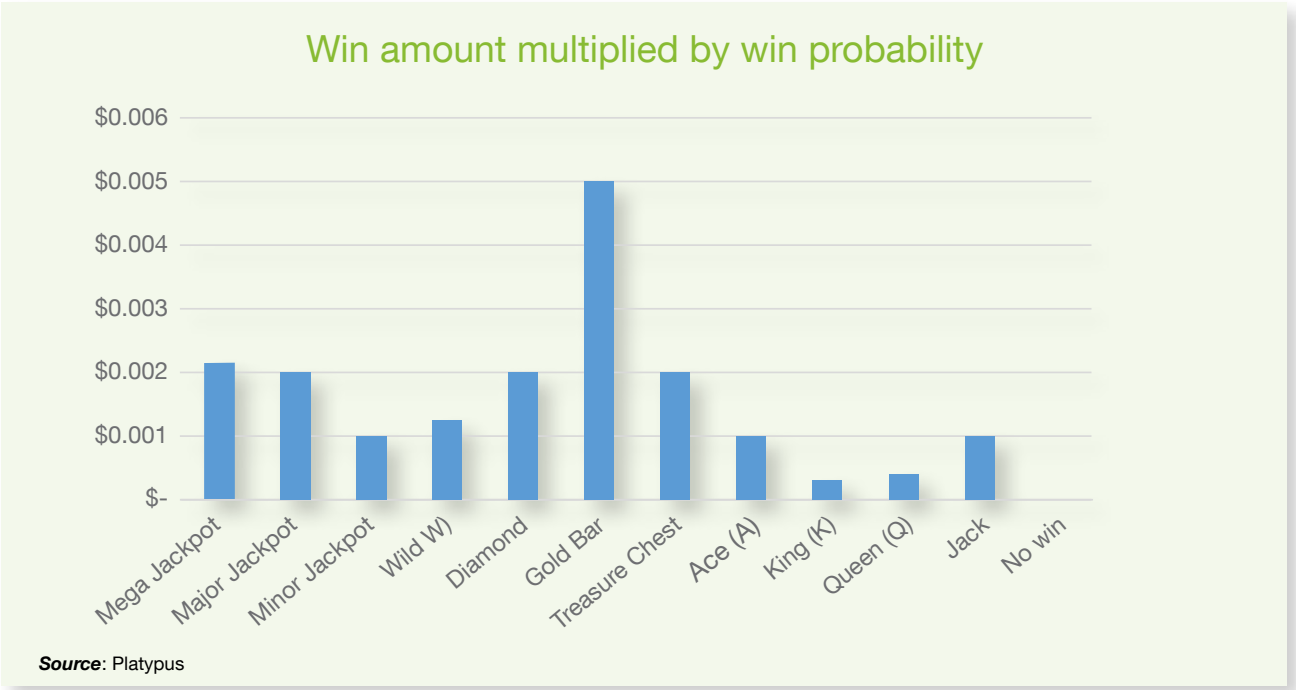
The lottery effect can be operationalised in systematic investment strategies, implying that the investor behaviour is persistent. For our paytable example, the win probabilities and amounts can be modelled using exponential curves, showing the lottery-like payoff structure of our example EGM.

[3] Gaming machines and gambling odds refresher course | Business Queensland

[4] Bail, T.G., Cakici, N. & Whitelaw, R.F. (2011). Maxing out: Stocks as lotteries and the cross-section of expected returns. Journal of Financial Economics, 99, 427-446.

Multiplying the win probability by the win amount is another way to demonstrate the payoff. From a future return perspective, a 10% chance of winning $10 is the same as a 50% chance of winning $2. Exhibit 4 shows how this expectation does not change dramatically across the win amounts. This way of thinking can be used in game design to achieve the desired RTP. In our example, we have chosen to increase the payoff for the Gold Bar win to make the pay table work as desired.

Exhibit 4: Payoff for each win amount, defined as the win amount multiplied by the win probability.



Source: Platypus

The RTP in the pay table is a theoretical RTP achieved over many spins.

Individual players will not experience the theoretical RTP. The variation around the RTP is called volatility. In Australia, Gamble Aware[5] argue that moderate volatility games are preferred. Discussions with industry participants imply that this is split between venue type: low volatility games are preferred in Clubs while higher volatility games are preferred in Hotels. We note that the expenditure per machine is generally higher in Hotels.

Theoretical volatility is calculated from the pay table.

The volatility is calculated as follows:

- Calculate the (Win - RTP) for each result,
- Then, square the answer and multiply this by the Win probability,
- Do this for each Symbol and sum the result,
- The volatility is the square root of this sum.

For our pay table, the volatility is 293. We can then use this to calculate a theoretical RTP range, dependent on the number of spins. We use a 99% confidence interval that assumes the game follows a normal distribution (the number 2.57 in Eq. 1) and use the following formula:[6]

$$\text{RTP range} = \text{RTP} \pm \frac{2.57 * \text{volatility}}{\sqrt{\text{Number of spins}}} \qquad (1)$$

As the number of spins increases, the RTP range decreases, and the practical RTP converges to the theoretical RTP.

[5] RGF NEW LITERATURE REVIEW-28-10-19-MASTER (nsw.gov.au)

[6] https://slotdesigner.com/wp/wp-content/uploads/Elements-of-Slot-Design-2nd-Edition.pdf

Exhibit 5: RTP range for 99% confidence interval.

Spins	100,000	500,000	1,000,000	2,000,000
RTP - upper	91.3%	90.7%	90.6%	90.5%
RTP - lower	89.7%	90.3%	90.4%	90.5%
Size of range	1.5%	0.3%	0.2%	0.1%

We simulate 1,000,000 spins using the pay table in Exhibit 3.

We use a third party random number generator to choose the outcomes. It cost $20,000 to play 1,000,000 spins. The total winnings came to $16,487.7 and the total number of times a spin won was 138,152, or 13.8% of the time. The pay table designed to have an RTP of 90.5% has resulted in an RTP of 82.4%: there are small wins every ten or so presses, but the largest win remained elusive. Winnings of $1 or more occurred 3245 times, which is approximately ~0.32% of the time. The Queensland government estimate that machines function for 3-4 years and have approximately 1,000,000 spins.

Exhibit 6: Simulated play using example pay table.

	Win amount (2c bet)	Frequency	Total $ won
Mega Jackpot	$15,000.0	0	$ -
Major Jackpot	$1,000.0	3	$3,000.0
Minor Jackpot	$200.0	2	$400.0
Wild (W)	$20.0	62	$1,240.0
Diamond	$10.0	216	$2,160.0
Gold Bar	$5.0	1,007	$5,035.0
Treasure Chest	$1.0	1,955	$1,955.0
Ace (A)	$0.2	4,982	$996.4
King (K)	$0.03	9,941	$298.2
Queen (Q)	$0.02	20,023	$400.5
Jack (J)	$0.01	99,961	$999.6
No Win	None	861,848	$ -
Total		**1,000,000**	**$16,484.7**

This RTP is outside of regulatory requirements. However, in Victoria, if this machine was part of a larger floor, it may be permissible for a machine with this volatility if the floor average is above legislated requirements.

We simulate 100 EGMs each with 1,000,000 spins using the pay table in Exhibit 3.

This is analogous to a gaming floor with 100 machines, each using our example pay table. In practice, venue operators would choose different combinations of machines with different volatilities and RTPs. If the distribution was normal, and our assumption within Eq. (1) was correct, we would expect to observe an RTP inside the bounds shown in Exhibit 5. This is not the case and further testing confirmed the distribution of winning outcomes is statistically unlikely to be normal.

The players bet $2,000,000 across the 100 machines and won $1,847,091.66.

The RTP in this instance is 92.35%. The revenue to the venue operator was $152,908.34, which is $37,091.66 less than the theoretical value expected. The operator revenue was down ~19.5% from the theoretical amount, which highlights the importance of managing game volatility across the venue depending on the risk tolerance of the venue operator.

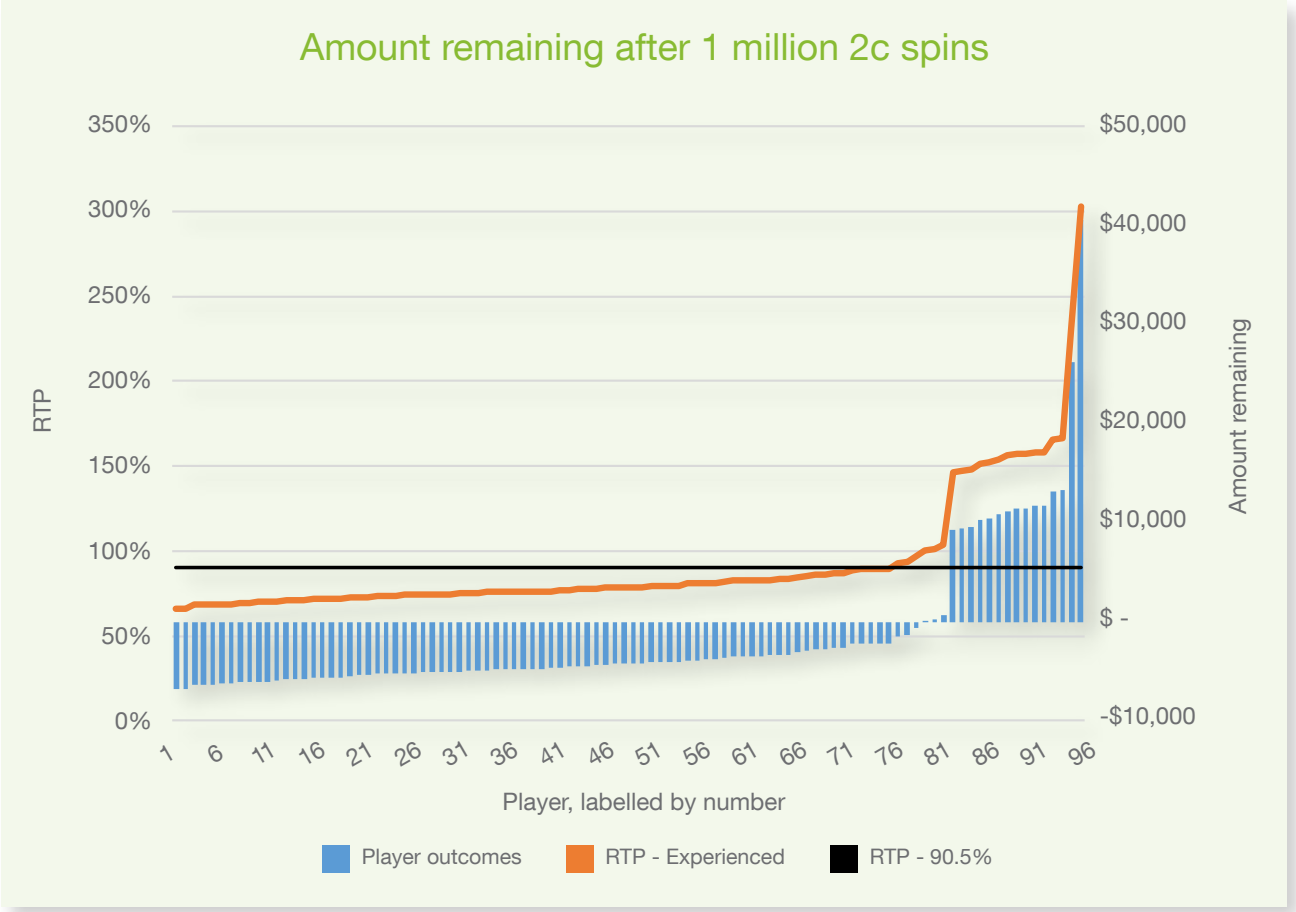
Exhibit 7: Comparison between simulated and theoretical RTP using 100 million spins and a 2c bet. The theoretical frequency and $win are derived analytically from the pay table in Exhibit 3. The simulations are derived from the same pay table, but use a random number generator to derive player outcomes for an individual spin.

	$ Win	Frequency	Total $ won	Theoretical frequency	Theoretical $ win
Mega Jackpot	$15,000	18	$ 270,000	14.29	$ 214,285.71
Major Jackpot	$1,000	179	$ 179,000	200	$ 200,000
Minor Jackpot	$200	513	$ 102,600	500	$ 100,000
Wild (W)	$20	6,186	$ 123,720	6,285.71	$ 125,714.29
Diamond	$10	19,990	$ 199,900	20,000	$ 200,000
Gold Bar	$5	100,321	$ 501,605	100,000	$ 500,000
Treasure Chest	$1	200,045	$ 200,045	200,000	$ 200,000
Ace (A)	$0.20	501,011	$ 100,202.20	500,000	$ 100,000
King (K)	$0.03	1,000,026	$ 30,000.78	1,000,000	$ 30,000
Queen (Q)	$0.02	2,002,025	$ 40,040.50	2,000,000	$ 40,000
Jack (J)	$0.01	9,997,818	$ 99,978.18	10,000,000	$ 100,000
No Win	$ -	86,171,868	$ -	86,173,000	$ -
Total		**100,000,000**	**$ 1,847,091.66**	**100,000,000**	**$ 1,810,000**
Expenditure (player loss)			**$ 152,908.34**		**$ 190,000**
RTP			**92.35%**		**90.50%**

Each player had a different trajectory.

After 1,000,000 spins, out of 100 players, 18 had more money than they had inserted into the machine. The average loss was $4,447, which means after inserting $20,000 into the EGM, on average the player left the venue with $15,553. In our example, if a player bets 10c per second (five lots of 2c), that equates to 55.6 hours of play at a cost of $80 an hour. The minimum RTP experienced was 65.89% and the maximum was 303.13%. The average RTP was 92.35% (as shown in Exhibit 7), but only 21 players experienced this or better.

Exhibit 8: The individual player experience varies. By number 79 players experienced a lower RTP than 90.5%.

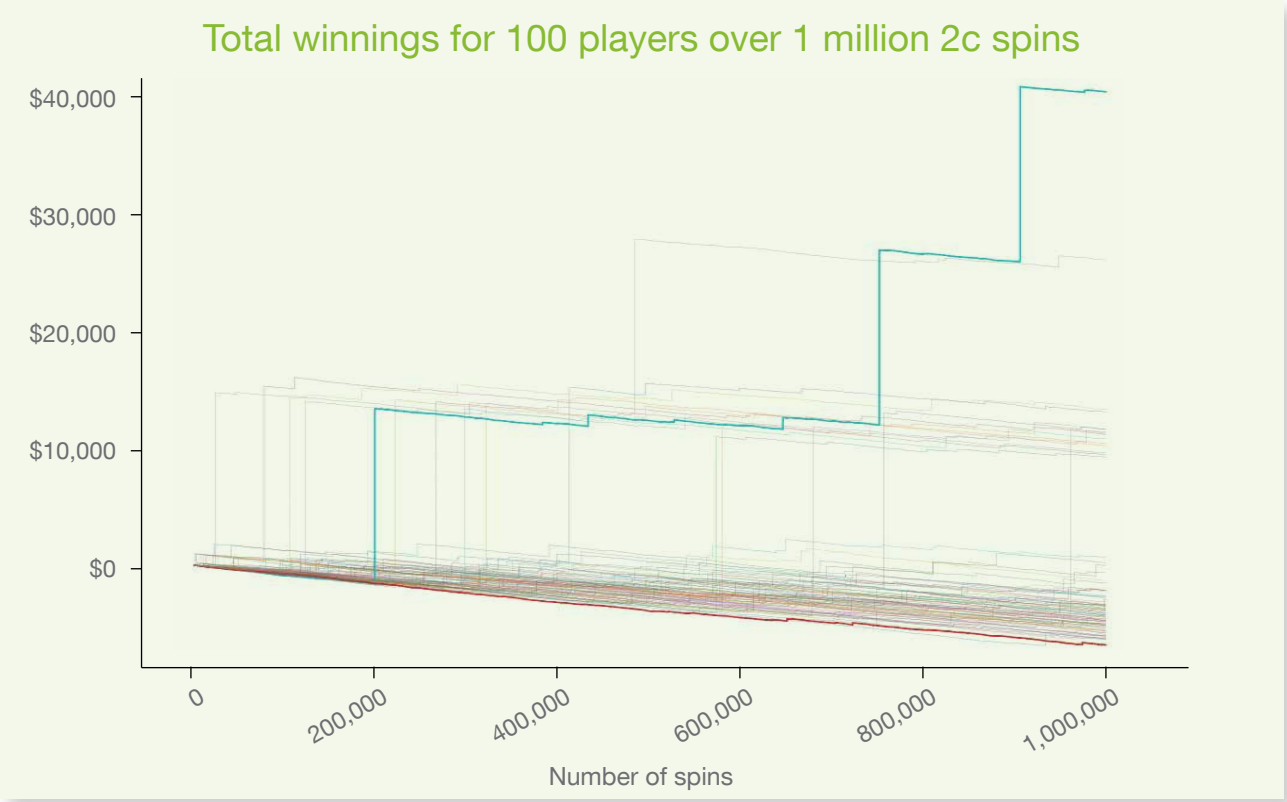


Player trajectories are made of small losses interspersed by big wins.

Exhibit 9 details this player experience. The total winnings do not accrue slowly: players generally lose until they win a large amount that compensates them for the string of previous small losses. This is typical of a higher volatility game[7] and can provide the illusion about "other's wins" and bias players memory, potentially giving rise to unrealistic expectations.

[7] Palomäki, J., Turner, N., Macey, J., & Castrén, S. (2023). Increased volatility in video poker results in more winning players but shorter winning streaks - Evidence from simulations. J. Behav. Addict, 12(3), 711–720.

Exhibit 9: Individual player trajectories.



The relationship between volatility and problem gambling is an emerging area of research.

Palomäki et al (2023) argue that volatility is more likely to be indirectly connected to gambling harm than a direct predictor.[8] Percy et al (2021) support this idea using data from online slot players from operators in the UK. Their findings suggest that while volatility might be influence behaviour, unlike established behavioural biases, this influence is hard to categorise in general terms.[9]

Understanding the statistics of EGMs is useful to investors for the following reasons:

- It allows us to have in-depth conversations with EGM manufacturers,
- It assists us in understanding player psychology, and the interaction between EGMs and players, and
- It provides us with more detail around how players can develop gambling harm.

[8] Palomäki, J., Turner, N., Macey, J., & Castrén, S. (2023). Increased volatility in video poker results in more winning players but shorter winning streaks - Evidence from simulations. J. Behav. Addict, 12(3), 711–720.

[9] Percy, C., Tsarvenkov, K., Dragicevic, S., Delfabbro, P. H., & Parke, J. (2021). Volatility under the spotlight: panel regression analysis of online slots player in the UK. International Gambling Studies, 21(3), 395–410.