

How do loot boxes make money? An analysis of a very large dataset of real Chinese CSGO loot box openings

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Abstract

Loot boxes are a form of video game monetisation that shares formal similarities with gambling. There are concerns that loot box revenues are disproportionately drawn from a small percentage of heavily-involved individuals, as is the case with gambling, leading to the potential for financial harm. In this paper we analyse a dataset of 1,469,913 loot box purchases from 386,269 separate Chinese users of the game *Counter-Strike: Global Offensive*. The Gini coefficient was used to measure the distribution of spending, and how much spending was concentrated within top percentiles. It estimated the concentration of spending amongst loot box openers as lower than observed elsewhere amongst gamblers (95CI: 63.76% - 64.26%). However, the majority of loot box revenue is drawn from the top 10% of players, with 1% alone responsible for 26.33% of all revenue. Overall, this research provides a crucial first step in understanding the financial consequences of loot box monetisation.

Introduction

Loot boxes are items in video games that may be purchased for real-world money, but which contains randomised contents of uncertain value. Loot boxes are extraordinarily widespread in video games: The majority of top-grossing mobile games contain loot boxes, and the majority of play sessions on desktop take place in a game that features loot boxes^{1,2}.

Loot boxes share several formal similarities with gambling: Both when gambling and when paying to open a loot box, individuals stake something of value on the chance outcome of a random process, in the hopes of receiving something of greater value^{3,4}. For example, in the online video game *Counter-Strike: Global Offensive* (CSGO), players may pay real money to open sealed virtual 'weapon cases'. After payment, the case is unsealed and its contents are revealed: a randomly-selected cosmetic 'skin' for a player's in-game weapon. However, when players hand over their money to open a weapon case, they have no way to know if they are paying to obtain a cheap and common skin, or a rare and valuable one.

Indeed, loot boxes share so many formal similarities with gambling that they have been regulated as a form of gambling in several territories. For example, in Belgium some loot boxes have been banned as an illegal form of unregulated gambling⁵. Similarly, in China loot boxes are regulated under national lottery laws that require video game companies to disclose both (a) the odds of receiving specific loot box rewards and (b) the details of an anonymised subset of all loot box openings⁶.

These structural similarities have led to concerns that engagement with loot boxes may cause gambling-related harm. Problem gambling refers to a pattern of excessive and uncontrolled gambling that is so severe it causes important negative psychosocial and financial consequences for an individual and those around them. Significant attention has focused on the idea that loot box spending may act as a gateway to engagement in other forms of gambling, and hence the development of problem gambling⁷⁻¹¹.

Beyond the idea that loot boxes may lead to problem gambling, concerns have been raised regarding the possibility that loot box spending may have negative consequences for an individual in and of itself. More specifically, there is concern that loot box revenues are dependent in part on potentially problematic spending amongst a small proportion of gamers⁷. There is good reason to believe that this may be the case: A widely-publicised monetisation strategy in the video game industry involves

generating revenue by targeting so-called 'whales': high-spending players¹². Under a whale-centric monetisation scheme, large volumes of profit are drawn from the spending of a small number of individuals, and the game ecosystem itself is structured in such a way as to extract the maximum amount of money from these players. Indeed, widely-used tools in the game industry exist to encourage just this kind of spending distribution, such as the revenue optimisation tool *Game of Whales*¹³. However, it is unclear whether loot boxes are associated with this kind of spending distribution.

There is therefore concern that loot box revenues may lead to risk-laden spending amongst a small proportion of gamers. As noted above, these concerns are theoretically justified by reference to monetisation practices in games. However, they are also theoretically justified by reference to formal similarities between loot boxes and gambling. Gambling appears to be a domain in which a small proportion of individuals are known to spend heavily, and hence expose themselves to financial risk. Documents obtained from the UK Gambling Commission reveal that some gambling operators are able to obtain more than 80% of their revenue from just 2% of their customers; more than 90% of rakes paid in online poker are drawn from the top 10% of players^{14,15}. Indeed, cross-sectional research large and representative samples of French (n=15,635), German (n=15,023) and Quebecois (n=12,008) individuals has found that the vast majority of loot box spending may be attributed to a small percentage of gamblers¹⁶.

Does loot box spending behaviourally, as well as formally, mirror gambling? Multiple studies in the literature have observed a correlation between loot box spending and problem gambling: the more money that a gamer spends on loot boxes, the more likely they are to be a problem gambler^{17,18}. This relationship has led to suggestions that either loot boxes act as a 'gateway' to gambling amongst gamers, or that loot boxes are so similar to gambling that individuals with gambling problems may be driven to spend heavily on loot boxes.

However, this literature contains little information about the concentration of actual spending on loot boxes amongst gamers. Similarly, little is known about the amounts that are spent by the most-involved individuals, and whether these amounts are potentially problematic. Direct behavioural data that may address this question is held by representatives of the video game industry. There have been multiple calls for the release of this data to independent researchers. However, no such co-operation has thus far occurred. As a recent report by a UK Select Committee phrased it: "When we put the proposal to games makers of sharing aggregated data on player behaviour with researchers, they expressed willingness in principle; however, none have been able to point to examples of doing so in practice"¹⁹.

Indeed, industry statements on this topic often imply that loot box revenue is trivial in terms of the amount spent by individual gamers. Comparisons are made by industry figureheads between loot boxes and relatively innocuous products such as *Kinder Surprise* chocolates²⁰.

By contrast, cross-sectional research in the literature frequently contains participants who self-report annual spending on loot boxes that is in the order of hundreds, or thousands of dollars. This suggests that spending in video games may be financially important to individual gamers. However, the samples that these reports are drawn from are convenience samples, and it is impossible to determine from them either (a) the range or (b) the distribution of spending on loot boxes; and hence how commonly this spending could be associated with meaningful financial consequences¹⁸.

The Present Research

The evidence base on loot box spending is therefore very limited. However, Chinese lottery regulations require the disclosure of an anonymised subset of loot box openings by companies who sell loot boxes to Chinese audiences. The first-person shooter *CSGO* therefore publicly publishes 200 recent loot box openings from Chinese servers approximately every 10 minutes. Using this information, our aims were to conduct exploratory data analysis that addresses the following research questions:

RQ1. How much money is spent on loot boxes in Chinese *CSGO*? There is no reliable evidence in the research literature for the overall revenue that is generated on a daily basis by loot boxes. In this paper we aim to provide an initial exploration of the overall revenue generated by one popular game in one national context.

RQ2. How is loot box spending in Chinese *CSGO* concentrated amongst gamers? Loot boxes have been compared to gambling products, and it is well-known that many gambling products produce a concentration in the distribution of individual spending, in which a small percentage of highly involved individuals are responsible for a substantial proportion of overall revenue. This mirrors video game industry narratives regarding high-spending ‘whales’. In this paper we investigate whether similar issues exist here with reference to spending concentration. More formally, we will investigate (a) whether the top percentiles of spenders are responsible for a disproportionate amount of overall revenue, and (b) whether this spending concentration is as extreme as is seen in gambling.

RQ3. What is the range of loot box spending within gamers in Chinese *CSGO*? One of the key risks associated with gambling is a pattern of overspending leading to financial harm. However, the range of loot box spending is currently unclear. In this paper, we therefore investigate how much money in real-world terms is spent by the top percentiles of loot box spenders.

Method

Ethics

Ethical approval for this study was provided by the University of York Physical Sciences Ethics Committee. All methods were carried out in accordance with relevant guidelines and regulations.

This is not an experimental study, and makes use of a very large public dataset of anonymized behavior (see ‘Design’). As this data was both public and anonymized prior to collection by the research team, no informed consent was either required or possible in this case.

Design

The data that was gathered for this study consists of all loot box opening information published by the Chinese *CSGO* partner PerfectWorld (<https://www.csgo.com.cn/hd/1707/lotteryrecords/> / <https://www.csgo.com.cn/api/lotteryHistory>) for the 66 days ranging between 2020-07-29 and 2020-10-03.

In order to comply with Chinese lottery legislation, CSGO's Chinese website displays rolling windows of 200 anonymised loot box openings. As detailed below, whilst these openings are anonymised, they are tracked to individuals via distinct player IDs. This data is updated approximately every 10-15 minutes. Over the course of the 66 days during which this study was run, a raw dataset was gathered consisting of the record of the opening of 1,469,913 individual loot boxes by 386,269 separate users.

During the time under study the dataset was updated, on average, once every 12.84 minutes. Each update yielded a fresh sample of the 200 most recent openings. Our monitoring of this data, therefore, yielded a total of 7,420 separate windows, with 200 loot box openings per window. After cleaning the data for partially-overlapping windows, the total number of loot box openings collected was 1,469,913. The observed windows covered 1,290,633 seconds of time, or 22.59% of all time under study.

Each of these 1,469,913 openings contains the following information:

1. An anonymised user identifier in the form of two alphabetical characters followed by three asterisks, an alphanumeric character, and three further alphabetical characters (e.g. FF***9FFF). This identifier contains a total of 604,661,760 possible combinations. During the period under study, 386,269 distinct identifiers were observed purchasing loot boxes. 216,162 of these identifiers purchased only one loot box, suggesting that this alphanumeric code is an effective unique identifier for individual gamers for all practical purposes.
2. A UNIX timestamp representing the second that the loot box was opened (e.g. 1596018463). The distribution of timestamps within each window of 200 openings suggests that each window represents the 200 most recent loot box openings. For example, despite an average gap of 770.10 seconds between windows, the mean length of time from a window's start to the record of a loot box's opening is only 83.47 seconds.
3. An identifier of the specific loot box that was opened
4. An identifier of the specific contents that were received

Measures

Revenue per second

First, the number of openings per second for each observed window of 200 openings was calculated: For example, if one window spanned a period of 50 seconds, it would represent a rate of 4 openings per second ($200/50=4$); if it spanned 400 seconds it would represent a rate of 0.5 openings per second ($200/400=0.5$).

Purchasing a key to open a loot box in Chinese CSGO currently costs ¥18, equivalent to \$2.646 at the time of writing this. In order to estimate the total amount of revenue, instead of simply the number of openings, the numbers of openings per second were therefore multiplied by both 18 and 1.47 to yield overall estimates in both Chinese Yuan and US dollars respectively.

Spend per user

The total number of observed openings by a user are transformed into spending by multiplying the number of openings associated with a specific account by the US Dollar and Chinese Yuan conversion rates outlined above.

Concentration of Spending

The Gini coefficient is a measure of the dispersion of a distribution that may be used to understand the extent to which spending is concentrated within specific members of a group. Gini coefficients are standardised, and vary from 0 to 100%: A coefficient of 0% represents perfect equality of spending amongst a group; a coefficient of 100% represents a situation in which all spending within a group is attributable to one individual. In previous work on gamblers, Gini coefficients of spending have been estimated as ranging from 80.16% to 87.9%, indicating a situation in which the vast majority of gambling spend is attributable to a small proportion of gamblers. In order to estimate spending concentration, Gini coefficients will be calculated for the spending observed here.

Statistical Analysis

RQ1: How much money is spent on loot boxes in Chinese CSGO?

In order to address RQ1, a Generalized Additive Model was fitted to the observed data. The predictors within this model were (1) a smooth term describing the time of day in seconds (0-86400) that an observation was made as a cubic cyclic spline, and (b) a parametric (linear) term describing the number of days since data collection began on which an observation was made.

In order to account for potential autocorrelation in the residuals of any model, an uncorrected model was first produced. The order of any (p,q) ARMA structure within the residuals of this model were automatically estimated using the Hyndman-Khandakar algorithm, and a final model produced using the derived autocorrelation-moving average correlation structure.

The raw outcome variable for this model was the number of purchases per second. Following estimation, model outputs were multiplied linearly by 0.147 to yield estimates of revenue in dollars; and multiplied linearly by 18 to yield estimates of revenue in Chinese Yuan. This model was then used to estimate the total amount of revenue during the period under analysis.

RQ2: How is loot box spending in Chinese CSGO concentrated amongst gamers?

In order to address RQ2, we extracted the observed spend by each of the 386,269 users under study. We then calculated bootstrap confidence intervals of the Gini coefficient for this dataset. These confidence intervals were then inspected to determine if they overlapped with previous Gini coefficients that have been calculated for the concentration of gambling revenues amongst gamblers (80.16% - 87.9%).

RQ3: What is the range of loot box spending within gamers in Chinese CSGO?

Finally, in order to address RQ3, raw observed spending for each user in the dataset was described. In order to make as few assumptions as possible, no interpolation or imputation of missing values was conducted.

Results

Over the course of 66 days, 1,469,913 loot box openings were observed. These openings were attributable to 386,269 separate individuals. Of the 386,269 gamers observed during this study, 216,162 purchased only one loot box, representing 14.70% of all revenue. The top 1% of players were responsible for 26.33% of all revenue, and were observed to spend (on average) \$265.64 (95CI: \$256.55 - \$274.74) during the 66 days under test. Observed spending in this top percentile group ranged as high as \$5,146.47.

How much money is spent on loot boxes in Chinese CSGO?

A GAM was produced that modelled the relationship between purchases per second and time, with an ARMA correlation structure of order (1,1). This GAM provided a good fit to the data, with an R^2 of 0.852. A Ljung-Box test provided no evidence of residual autocorrelation ($\chi^2 = 12.233$, $p=0.141$).

Overall, this model estimated the existence of 13,192,985.71 loot box openings during the 66 days during which data was collected (95CI: 12,571,605.05 - 13,814,366.37).

This equates to a total revenue of \$34,908,640.19 (95CI: \$33,264,466.97 - \$36,552,813.40), or \$528,918.79 per day. A visualisation of variance in purchases per second over the first seven days of data is given as Figure 1.

Formally, the smooth term indicating time of day within this model was significant, $F=279.013$, $p<0.001$, indicating cyclic changes in spending over the course of each day. Inspection of Figure 1 (below) indicates diurnal fluctuations in spending over the course of each day. Maximum spending occurred at approximately 22:10 CST, and minimum occurred at approximately 07:00 CST.

The linear term associated with this model was not significant ($t=0.983$, $p=0.33$), indicating a lack of evidence for either linear growth or decline in loot box spending during the period under analysis.

The full dataset and all code used to generate these models is available at https://osf.io/97ves/?view_only=8ac012cedc9c46f582a1b7e3e77d1a6d.

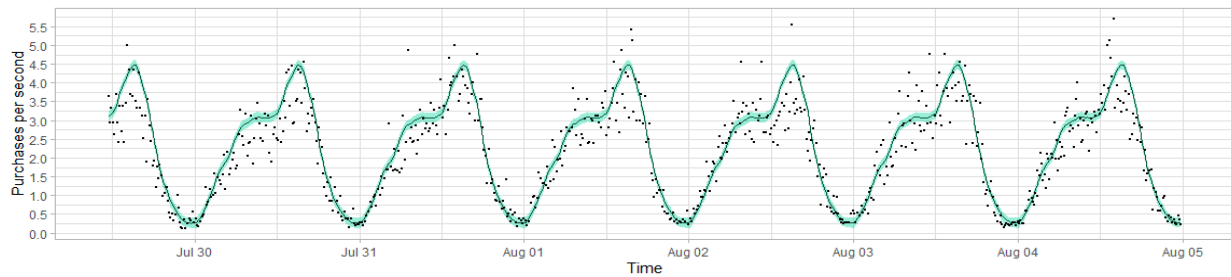


Figure 1: GAM modelling of the relationship between time and purchases per second. Due to the size of the dataset, only the first 7 days are visualised here

How is loot box spending in Chinese CSGO concentrated amongst gamers?

First, users were ordered by the number of openings that they were observed to engage in, and decile splits for number of opens were calculated. All users in the bottom 5 deciles (i.e. 50% of users) of the dataset opened only a single loot box during the 66 days under study, providing a long tail of casual engagement.

The distribution of spending was top-heavy, with the top 10% of users accountable for 59.37% of all revenue.

These decile splits are reported in full below as Table 1, alongside linear transformations of numbers of openings into amounts spent, and statistics representing the proportion of overall revenue attributable to users within a specific decile.

In order to formally address whether this concentration of spending resembled the concentration of spending amongst gamblers, basic bootstrap confidence intervals were then calculated for the Gini coefficient of spending for the 386,269 users observed here. A 95% confidence interval for this statistic was calculated as 63.76% to 64.26%. This is significantly lower than estimates in the literature of the concentration of spending amongst gamblers (Gini coefficient: 80.16% - 87.9%)

Grouping	% of all observed spending	Mean observed openings per user	Mean observed spend per user (CNY)	Mean observed spend per user (USD)
0-10%	2.63%	1.00	¥18.00	\$2.65
		(95CI: 1.00 - 1.00)	(95CI: ¥18.00 - ¥18.00)	(95CI: \$2.65 - \$2.65)
10-20%	2.63%	1.00	¥18.00	\$2.65
		(95CI: 1.00 - 1.00)	(95CI: ¥18.00 - ¥18.00)	(95CI: \$2.65 - \$2.65)
20-30%	2.63%	1.00	¥18.00	\$2.65
		(95CI: 1.00 - 1.00)	(95CI: ¥18.00 - ¥18.00)	(95CI: \$2.65 - \$2.65)
30-40%	2.63%	1.00	¥18.00	\$2.65

		(95CI: 1.00 - 1.00)	(95CI: ¥18.00 - ¥18.00)	(95CI: \$2.65 - \$2.65)
40-50%	2.63%	1.00	¥18.00	\$2.65
		(95CI: 1.00 - 1.00)	(95CI: ¥18.00 - ¥18.00)	(95CI: \$2.65 - \$2.65)
50-60%	3.69%	1.40	¥25.27	\$3.71
		(95CI: 1.40 - 1.41)	(95CI: ¥25.18 - ¥25.36)	(95CI: \$3.70 - \$3.73)
60-70%	5.26%	2.00	¥36.00	\$5.29
		(95CI: 2.00 - 2.00)	(95CI: ¥36.00 - ¥36.00)	(95CI: \$5.29 - \$5.29)
70-80%	6.89%	2.62	¥47.18	\$6.94
		(95CI: 2.62 - 2.63)	(95CI: ¥47.10 - ¥47.27)	(95CI: \$6.92 - \$6.95)
80-90%	11.66%	4.44	¥79.88	\$11.74
		(95CI: 4.43 - 4.45)	(95CI: ¥79.72 - ¥80.05)	(95CI: \$11.72 - \$11.77)
90-100%	59.37%	22.59	¥406.65	\$59.78
		(95CI: 22.16 - 23.03)	(95CI: ¥398.83 - ¥414.46)	(95CI: \$58.63 - \$60.93)

Table 1: Proportion of spending attributable to each decile of users. Mean observed openings per user are given, as are linear transformations of this statistic to yield spending estimated in both US Dollars and Chinese Yuan

What is the range of loot box spending within gamers in Chinese CSGO?

The observed loot box openings of the top 5% of our data is described below as Table 2. Spending amongst the top percentile of users was, on average, \$265.64 during the period in question. This ranged as high as \$5,146.47.

Grouping	% of all observed spending	Mean number of observed openings per user	Mean observed spend per user (USD)	Range of spending per user (USD)
95-96%	3.44%	13.13	\$34.73	\$31.75 - \$39.69
		(95CI: 13.10 - 13.15)	(95CI: \$34.67 - \$34.80)	
96-97%	4.29%	16.36	\$43.29	\$39.69 - \$50.27

		(95CI: 16.32 - 16.39)	(95CI: \$43.19 - \$43.38)	
97-98%	5.66%	21.58	\$57.09	\$50.27 - \$66.15
		(95CI: 21.52 - 21.64)	(95CI: \$56.93 - \$57.25)	
98-99%	8.48%	32.35	\$85.59	\$66.15 - \$113.78
		(95CI: 32.19 - 32.50)	(95CI: \$85.19 - \$86.00)	
99-100%	26.33%	100.39	\$265.64	\$113.78 - \$5,146.47
		(95CI: 96.96 - 103.83)	(95CI: \$256.55 - \$274.74)	

Table 2: Observed spending of the top five percent of users

Discussion

In the 66 days under analysis here, loot boxes in Chinese CSGO were estimated to generate \$34,908,640.19, equivalent to \$528,918.79 per day.

How costly has this revenue been to individual players? Our analysis suggests that the majority of loot box revenues are drawn from the top 10% of players. This is in line with video game industry narratives regarding the profitability of high-spending 'whales'. Indeed, 26.33% of all loot box revenues in this case were drawn from the top 1% of spenders alone.

However, it is also important to note that this spending concentration seems significantly less extreme than that observed amongst gamblers. Indeed, a 95% confidence interval on the Gini coefficient was estimated at 63.761% to 64.261%. This is markedly lower than Gini coefficients that have been calculated on gambling spending (80.16% - 87.9%).

In a similar vein, whilst 59.37% of spending was attributable to the top 10% of loot box openers here, documents obtained from the UK Gambling Commission reveal that some gambling operators are able to obtain more than 80% of their revenue from just 2% of their customers. It therefore appears to be the case that the concentration of loot box spending observed here in Chinese CSGO diverges in an important way from spending concentration amongst gamblers.

The reason for this divergence is unclear. It may be the case that loot box opening is a more prevalent activity than many forms of gambling, and hence it may be reasonable to expect a lower concentration of spending attributable to the small group of top-spending users. This idea is certainly borne out by the presence of 216,162 users in our dataset who purchased only one loot box.

Alternatively, the comparative dilution of revenue from heavily-engaged individuals that is observed here may be a consequence of the fixed nature of stakes in loot box spending. In many forms of gambling, individuals can vary both the amount of currency that they are staking, and the frequency with which these stakes are paid. In these cases, both increases

in frequency (gambling more often) and stake (gambling more with each transaction) may contribute towards concentration within an overall spending distribution. By contrast, an individual loot box costs a fixed amount to open. This means that players may only vary the frequency of purchases, potentially making distributions as severe as those seen in gambling less likely. Significant further work is necessary to determine the generalisability of this distribution across different contexts and games.

However, it is key to make clear that this divergence in spending concentration does not mean that opening loot boxes is always financially trivial. Indeed, there was a clear cadre of high-spending individuals within our data whose expenses may be financially important. For example, the top 1% of players here were observed to spend (on average) \$265.64 during the 66 days under test, with this amount ranging as high as \$5,146.47. Further work must focus on understanding whether or not this spending represents money that players cannot afford.

Revenue drawn from the top percentile appears important to the monetisation of Chinese CSGO. Indeed, it was estimated to generate 26.33% of all revenue from loot boxes (See Table 2). Furthermore, given that the windows of observation here allowed only 22.59% of all time during this period to be observed, the true number of openings engaged in by these specific high-spending players may be far greater: A player who is observed to spend \$1000 on loot boxes may, in fact, have spent a further \$2000 during unobserved gaps in our time series.

Indeed, any specific player may have spent thousands of dollars on loot boxes either before measurement began, or after it finished. Due to the random nature of the sampling employed here, the dataset supporting this paper is capable of accurately estimating the distribution of spending between players. However, for amounts spent by individual players, our data can only provide a lower bound.

Limitations

The data examined here is drawn solely from Chinese servers of the game CSGO. Its ability to generalise beyond this context to international markets is unclear. For example, whilst the raw cost of a loot box key in Chinese CSGO (\$2.65) is approximately equal to the cost of a key in US/UK markets, it is unclear how the cost of a loot box varies as a proportion of a gamer's disposable income between international markets.

Similarly, cultural differences may determine important distinctions in loot box spending between markets. Chinese gamers often use public internet cafes to play online games such as CSGO; this phenomenon is relatively uncommon in Western markets. This difference may lead to important changes in how loot box spending occurs: For instance, players in an internet café may either be socially inhibited or encouraged to open large numbers of loot boxes. Significant further work is necessary to determine the extent to which these results generalise beyond a Chinese context.

Additionally, it is unclear whether the patterns observed here generalise across the wider video game market. Loot boxes in CSGO are cosmetic in nature – their contents cannot affect gameplay. This stands in contrast to so-called 'pay to win' games such as *Fire Emblem Heroes* in which loot box contents may give players an in-game advantage. It may be the

case that, in pay to win games, spending concentration amongst highly-involved players is far higher.

Finally, it is important to note that the data collected here has gaps, and does not represent a complete record of all spending during the period under scrutiny. This does not affect estimates of the total revenue generated during the period under test, or estimates of spending concentration amongst users. However, as described above, it does make the true maximum amount spent by specific individuals difficult to estimate from our data. Further work using complete, industry-provided, datasets is necessary to determine this.

Conclusions

Loot box openings on Chinese CSGO servers alone generated an estimated \$528,918.79 in revenue per day. Contrary to the idea that loot box spending is inherently financially trivial, thousands of individual gamers were observed to spend hundreds of dollars on loot boxes during the period under test.

The distribution of spending observed here suggests that loot box revenues are skewed, with the majority of loot box revenue coming from the top 10% of players. However, it is important to also note that, within the data observed here, spending concentration is not as extreme as that observed amongst gamblers.

Overall, these results represent an important first step in quantifying the nature and consequences of the trade in loot boxes.

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