Deciding When to Quit: Reference-Dependence over Slot Machine Outcomes

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A growing collection of evidence indicates that decision-makers value outcomes in relative terms rather than absolute terms. That is, rather than simply valuing outcomes (ex. wealth, earnings, etc.), utility may also critically depend on comparison to a benchmark, where decision-makers' marginal valuation of possible outcomes is asymmetric around this reference point (Kahneman and Tversky, 1979; Koszegi and Rabin, 2006). In spite of recent advances detecting reference-dependent preferences in the field, there is relatively little consensus on how decision-makers determine the reference point to compare their outcomes to. While Koszegi and Rabin (2006) have proposed endogenously determined rational expectations as a potential reference point, lagged status quo has long been proposed as a likely candidate.

In this paper, we conduct a simple test for reference dependent loss aversion in the context of slot machine gambling. Our analysis focuses on gamblers' decisions regarding when to quit gambling for the day, as a function of the amount of money won or lost. We find simultaneous evidence for lagged status quo and for endogenously determined reference points. Specifically, when gamblers' quitting decisions are considered in the aggregate, independently of their intensity of gambling, gamblers clearly prefer to stop at the break-even point, implying a reference point of lagged status quo - the wealth level at the start of the gambling session. However, conditional on betting intensity, gamblers tend to bunch their stopping near a stakes-specific loss level, indicative of an endogenously determined reference point, above which they are more likely to quit compared to when they are below.

II. Data

The data for the analysis are from a casino loyalty program which tracks customer activity and offers participants reward points which can be redeemed for meals, merchandise and other benefits, similar to an airline mileage rewards program. Customers keep track of how much money they have wagered by inserting their membership card into the slot machine while they play. The card does not hold a cash balance, but does hold the customer's reward point balance, similar to other loyalty programs. Membership is free to anyone of legal age who provides a photo ID and address.

The dataset consists of one month of new loyalty program members (N = 2393), for a single visit's worth of activity, on the visit that they sign up for the card. The data are aggregated at the individual slot machine level, logged each time a customer exits a machine, and consist of the number of bets taken, the average wager size, and the net wins or losses. More detailed data is unavailable since recording the result of each bet for each customer is quite costly in data storage for the casino.

For each individual in the sample, the data covers slot machine activity for the entire length of their visit, including occurrences of continuous gambling into the next calendar day. We focus on gamblers' decisions about whether to quit or continue playing for that visit.

III. Predictions

Reference-dependent loss aversion carries specific predictions regarding when gamblers will quit their gambling session, based on what the shape of the utility function implies about their current risk appetite.

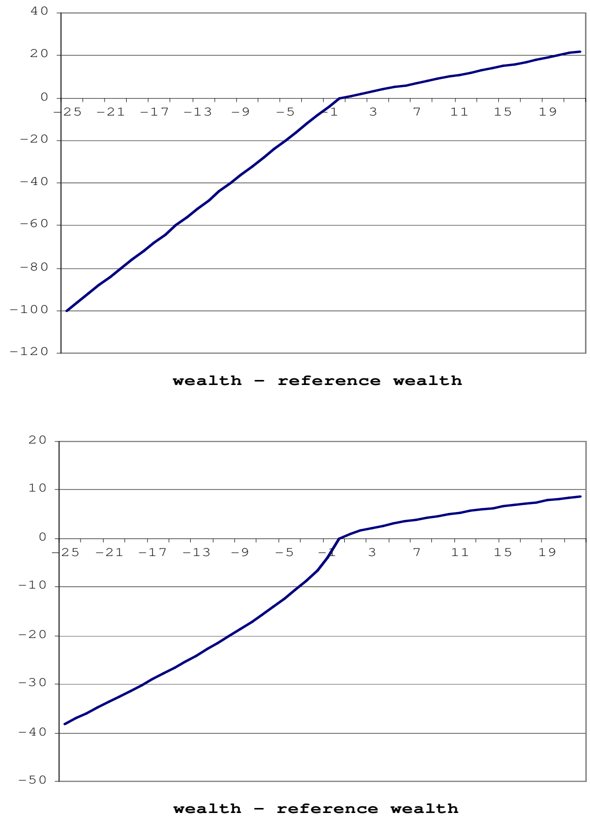

FIGURE 1. EXAMPLES OF REFERENCE DEPENDENT LOSS AVERSE UTILITY WITHOUT (TOP PANEL) AND WITH (BOTTOM PANEL) DIMINISHING SENSITIVITY

Figure 2 shows examples of reference-dependent loss averse utility functions, without and with diminishing sensitivity of the gains or loss segments. It is apparent from either panel that the decision-maker's lowest appetite for risk is located at the concave kink induced by loss aversion. Holding a particular gamble fixed, gamblers become relatively less risk averse, moving away from the kink in either direction. In the case of the utility function with diminishing sensitivity in the gains and loss segments, gamblers are relatively more risk averse on the gains (+) side than on the loss (-) side.

The implications for gamblers' decisions on when to quit playing can be inferred directly from the utility functions in Figure 1. For any given lottery, gamblers are most apt to quit in close vicinity to their reference point, where the kink induced by loss aversion is located. Moving away from the reference point in either direction, they are relatively less likely to quit.

In the case of loss aversion with diminishing sensitivity, gamblers are furthermore relatively more likely to quit playing when they are experiencing gains, compared to when they are experiencing losses, with the highest propensity to quit still located in the vicinity of the reference point.

A neoclassical expected utility function on the other hand, does not predict any substantial changes in risk aversion as a function of small changes in monetary outcomes, such as those in the slot machine data.

IV. Results

A. Evidence for a Lagged Status Quo Reference Point

A simple cross-sectional histogram of final net winnings levels at the time of quitting for all gamblers in the sample, reveals the overall preference regarding when to quit gambling for the visit, shown in Figure 2. The modal quitting level is close to the nominal break-even point of zero winnings. That is, gamblers were most likely to quit at lagged status quo, the amount of money they had when first entering the casino, regardless of their chosen betting intensity. This indicates a global reference point of lagged status quo across gamblers in the aggregate.

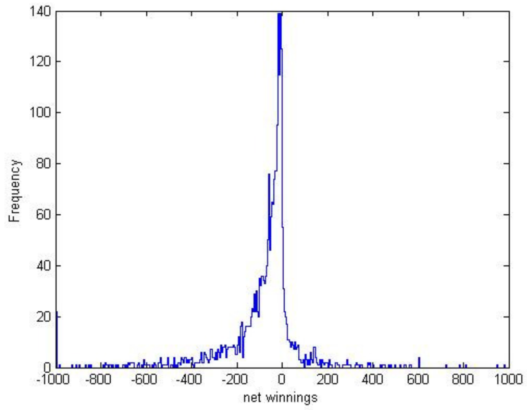

FIGURE 2. NET WINNING LEVELS AT QUITTING

In the aggregate data, gamblers were relatively more likely to quit in the net loss range than in the net gains range, as shown by the pile up of quitting gamblers below the break-even point. However, since slot machines are negative expected value gambles, customers may have preferred to stop at a different monetary gain or loss level, but may have been unable to do so due to the negative expected value of slot machine bets. Thus, cross-sectional comparison of winning levels at quitting should also take into account individual heterogeneity in gambling intensity. Here, we proxy for intensity using two additional observable variables, average wager and number of bets taken, which affect the distribution of winnings even under the case of random quitting.

B. Evidence on Local Reference Points

Figure 3 shows the distributions of number of bets taken and average wager sizes, by individual gambler. The number of gamblers is generally decreasing in the number of bets taken. The modal average wager size was between 30 to 40 cents, and frequency generally decreases from there as the average wager size increases. We proxy for gambler heterogeneity by grouping gamblers based on gambling intensity, measured by the number of bets they took and their average wager size for the visit.

In the case of fully homogeneous gamblers, if gamblers stop randomly as predicted by expected utility theory, the cross-sectional distribution of net winnings should converge to a normal distribution as the number of bets taken gets large. To see this, note that the outcome of any single slot machine bet is a random variable which is independently and identically distributed as enforced by US gambling law.[1] Cumulative net winnings, which is merely the sum of such random variables, converges to a normal distribution via the central limit theorem. We model the distribution of net winnings as $N(w\mu b,(w\sigma)^2 b)$, where b is the number of bets taken and w is the average wager size of those bets, where μ is the expected value of a single bet, and σ^2 is the variance of a single bet.

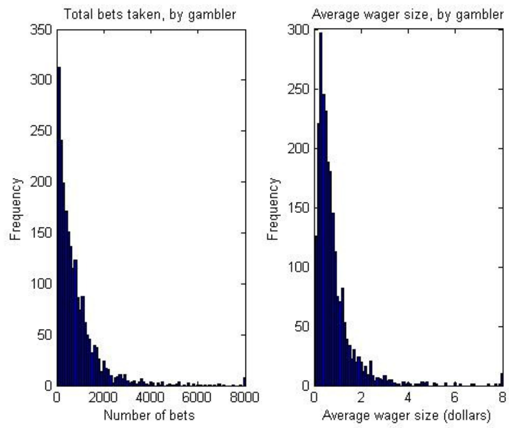

FIGURE 3. DISTRIBUTION OF BETS TAKEN AND AVERAGE WAGER

In the case of slightly heterogeneous gamblers, the theoretical distribution of net winnings will not be strictly normal. Rather it will depend on the exact heterogeneity in number of bets taken and average wager of bets. We use a simulation approach to test whether the empirical distribution of winning levels at quitting is different than what is implied by random stopping *conditional* on

[1] See Walker, Schellink and Anjoul (2008). The casino which provided the data also verified the serial independence of the slot machine outcomes.

actual numbers of bets taken and average wager amounts.

Table 1 shows the comparison between these simulations and the actual data from the casino. For most of the gambler bins, the data easily rejects normality. We use the adjusted Jarque-Bera normality test, which detects deviations from normality using the third (skewness) and fourth (kurtosis) moments. The right-most four columns in the table show that the skewness and kurtosis in the data tend to exceed the levels simulated by random quitting when taking betting intensity into consideration.

In other words, similarly to the aggregate distribution in Figure 2, gamblers stopped much more densely clustered around particular winnings levels than predicted by neoclassical theory and heterogeneity in betting intensity alone. The location of the cluster of stopping can be interpreted as a reference point, which is endogenously determined by individual betting intensity. However, in contrast to Figure 2, the positive excess skewness in most rows of Table 1 indicates that in the cross-section, the long tail of the distribution is on the right – that is, conditional on betting intensity, gamblers were more likely to stop ahead of the betting-specific reference point, than they were to stop while behind it. This provides support for diminishing sensitivity of the gains and loss segments, conditional on individual gambler betting intensities.

V. Conclusion

In this paper, we examine the quitting behavior of slot machine gamblers to gain insights on whether their risk preferences are reference-dependent. The loss aversion framework implies that individuals will be most risk averse, and hence most willing to quit near the reference point, and relatively less likely to quit moving away from the reference point in either direction.

Examining the distribution of winning levels at the time of quitting can thus inform us about the location of the reference point, if we assume that there is some uniformity in the reference point across gamblers.

In the aggregate, gamblers tended to most prefer quitting near the nominal break-even point, suggestive of lagged status-quo as a common reference point. Conditioning on betting intensity in terms of wager size and number of bets taken, which is endogenously chosen by the gamblers, they had an intensity-specific reference point, around which they were more likely to quit above than below. We leave the formal modeling of the simultaneous existence of global and endogenously determined reference points to future work.

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TABLE 1— DISTRIBUTION OF WINNINGS AT QUITTING, CONDITIONAL ON GAMBLING INTENSITY, DEVIATIONS FROM NORMALITY

Number of bets	Average wager (dollars)	N	Simulated reject rate at 95% level	Adjusted Jarque-Bera statistic (data)	Simulated 95th percentile of excess skewness	Excess skewness (data)	Simulated 95th percentile of excess kurtosis	Excess kurtosis (data)
1 to 60	0.21 to 0.40	43	0.20	9.40**	0.83	0.17	2.89	2.15
1 to 60	0.41 to 0.60	30	0.15	38.28**	0.95	1.89‡	2.82	3.59‡
1 to 60	0.61 to 0.80	36	0.17	1586.31**	0.90	5.16‡	3.03	28.88‡
61 to 130	0.21 to 0.40	50	0.12	41.81**	0.62	1.41‡	2.18	3.27‡
61 to 130	0.41 to 0.60	49	0.09	1.32	0.64	0.00	1.71	0.77
61 to 130	0.61 to 0.80	33	0.08	66.98**	0.78	2.16‡	2.10	4.99‡
131 to 210	0.21 to 0.40	37	0.12	3.81	0.78	0.74	2.21	0.27
131 to 210	0.41 to 0.60	41	0.07	4.77	0.67	0.37	1.65	1.41
131 to 210	0.61 to 0.80	26	0.05	15.34**	0.78	1.06‡	1.86	2.79‡
211 to 300	0.21 to 0.40	43	0.09	29.85**	0.67	1.45‡	1.87	2.63‡
211 to 300	0.41 to 0.60	34	0.08	200.04**	0.74	2.89‡	1.88	9.61‡
211 to 300	0.61 to 0.80	26	0.07	1.95	0.80	-0.57	2.18	0.53
301 to 410	0.21 to 0.40	49	0.12	1.06	0.68	0.18	2.03	0.59
301 to 410	0.41 to 0.60	39	0.08	47.13**	0.64	1.69‡	1.76	3.86‡
301 to 410	0.61 to 0.80	31	0.06	85.94**	0.66	2.33‡	1.64	6.11‡
411 to 540	0.21 to 0.40	45	0.087	58.84**	0.60	1.20‡	1.83	4.77‡
411 to 540	0.41 to 0.60	36	0.061	840.02**	0.65	4.08‡	1.81	20.78‡
411 to 540	0.61 to 0.80	31	0.06	200.30**	0.73	2.76‡	1.87	10.29‡
541 to 700	0.21 to 0.40	48	0.11	42.52**	0.66	1.30‡	1.91	3.58‡
541 to 700	0.41 to 0.60	47	0.067	86.99**	0.59	1.85‡	1.56	5.21‡
541 to 700	0.61 to 0.80	22	0.054	126.18**	0.82	2.60‡	1.94	9.44‡
701 to 870	0.21 to 0.40	53	0.105	63.03**	0.62	1.54‡	2.00	4.12‡
701 to 870	0.41 to 0.60	37	0.06	1.22	0.60	0.11	1.59	0.81
701 to 870	0.61 to 0.80	34	0.052	63.94**	0.65	1.89‡	1.65	5.10‡
871 to 1120	0.21 to 0.40	47	0.116	0.99	0.66	0.06	2.11	-0.67
871 to 1120	0.41 to 0.60	37	0.075	178.22**	0.69	2.35‡	1.84	9.02‡
871 to 1120	0.61 to 0.80	37	0.079	154.53**	0.70	2.33‡	1.84	8.26‡
1121 to 1520	0.21 to 0.40	44	0.099	3.58	0.65	0.29	1.98	1.20
1121 to 1520	0.41 to 0.60	35	0.074	27.25**	0.69	1.20‡	1.88	3.31‡
1121 to 1520	0.61 to 0.80	32	0.062	5.34	0.69	0.62	1.75	1.43
1521 to 2490	0.21 to 0.40	46	0.093	11.53**	0.63	0.47	1.77	2.15
1521 to 2490	0.41 to 0.60	44	0.092	20.87**	0.68	1.35‡	1.79	1.79
1521 to 2490	0.61 to 0.80	28	0.055	12.52**	0.75	1.15‡	1.78	2.05

*‡ indicates deviation from simulated data at the 95th percentile in direction predicted by reference-dependent loss aversion (kurtosis) and diminishing sensitivity (skewness). ** indicates rejection of normal distribution at 95% level. Simulations repeated 1000 times for each bin, drawing from $N(w\mu b, (w\sigma)^2 b)$ using empirical b and w frequencies, and μ = -0.05, σ = 10.6 (Eadington 1999).*