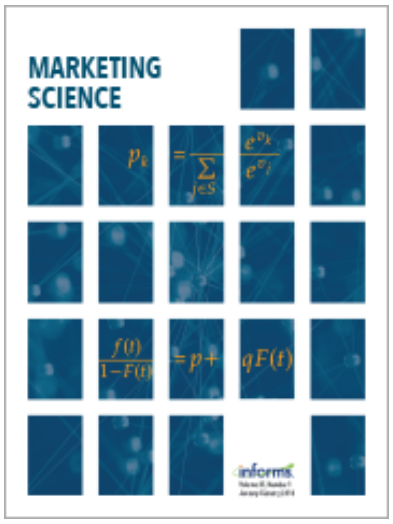

Marketing Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

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To cite this article:
Hee Mok Park, Joseph Pancras (2022) Social and Spatiotemporal Impacts of Casino Jackpot Events. Marketing Science

Published online in Articles in Advance 24 Jan 2022

. https://doi.org/10.1287/mksc.2021.1342

http://pubsonline.informs.org/journal/mksc

MARKETING SCIENCE
Articles in Advance, pp. 1–18
ISSN 0732-2399 (print), ISSN 1526-548X (online)

Social and Spatiotemporal Impacts of Casino Jackpot Events

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Received: August 27, 2018
Revised: February 11, 2020; May 19, 2021; August 3, 2021
Accepted: August 9, 2021
Published Online in Articles in Advance: January 24, 2022

https://doi.org/10.1287/mksc.2021.1342

Abstract. Jackpots are an important advertising and promotional tool in the casino gambling industry. In this paper, we use a unique data set to measure the impact of a slot machine jackpot event on subsequent gambling behavior. We use a difference in differences method to partition jackpot value into its impact on the post-jackpot behavior of three categories of players: (1) jackpot winners, (2) their peers or partners, and (3) bystanders who are in the proximity of the jackpot event. We find that jackpot events increase gambling expenditures (average slot machine bet amount) and frequency of plays by jackpot winners. The average impact on the jackpot winner is a $39 increase in bet amount per play and a 33% increase in the number of plays for the two-hour period after the jackpot event, whereas the impact on peers is a 21% increase in number of plays in the same period. For bystanders, effects are weaker and dissipate about an hour after the jackpot. Our study of jackpot return on investment shows that 49% of jackpots are profitable for the casino. Our study of the underlying mechanism of winners' response favors the hot hand effect rather than the house money or gambler's fallacy effects.

History: Yuxin Chen served as the senior editor and Hema Yoganarasimhan served as associate editor for this article.

Funding: J. Pancras thanks the University of Connecticut School of Business Dean's Office for research funding support for this project in summer 2016.

Supplemental Material: The data files and online appendix are available at https://doi.org/10.1287/mksc.2021.1342.

Keywords: causality • jackpots • ad response • gambling • promotions • social influence

1. Introduction

> "The steady, partial 'winning' that gamblers experience on video slots does not disrupt or inhibit play as large jackpots have been shown to do … "
>
> (Schüll 2014, p. 123)

U.S. casino gambling revenues were $43.6 billion in 2019, with slot machines (referred to in the industry as electronic gaming devices (EGD)) accounting for a major share of these revenues and exhibiting strong growth in many states in 2019 (Miller 2020). The payout ratios of slot machines is typically about 91%, with a major proportion of these payouts in the form of "jackpots" (Grochowski 2005). Jackpots are substantial payouts to a slot machine player that are accompanied by loud, exciting sounds and flashing lights designed to impress the recipient and attract the attention of neighboring players. Jackpots play an important function in casino gambling, breaking up monotony, creating "events," and increasing excitement and involvement in gambling.

In this respect, jackpots are an important advertising and promotional tool in casino gambling. According to the Nevada Gaming Control Board "'Jackpot payout' means money, tokens, payout receipts, wagering vouchers, electronic money transfers made from a slot machine through the use of a cashless wagering system and the actual cost to the licensee of personal property, other than travel expenses, food, refreshments, lodging or services distributed to a slot machine player as a result of a legitimate wager."[1] The strong audiovisual stimuli that advertise jackpot events suggest that casino managers expect jackpots to increase casino profits by increasing the amounts bet by nearby players, as well as possibly their frequency of plays after the jackpot event. However, although casinos invest large dollar amounts on jackpots, there is little empirical evidence on whether they are effective and profitable for casinos.

Although one would expect jackpots to affect the subsequent behavior of the jackpot winner, other gamblers in the vicinity of the jackpot are also likely to be affected. In particular, because gamblers often travel to casinos with friends or partners, they may also be affected by a jackpot event. In addition, there could be an advertising aspect of jackpot events, where nearby bystanders who witness a jackpot

change their gambling behavior in response. However, the direction and strength of response of jackpot winners, peers, and bystanders to a jackpot event is not obvious a priori. In fact, alternative behavioral theories make different predictions for how these three categories of slot players should respond to a jackpot event. For example, the gambler's fallacy (Narayanan and Manchanda 2012) would predict that all three categories of players should reduce their bet amounts as a response to the jackpot event. On the other hand, theories of windfall gains, such as the house money effect (Thaler and Johnson 1990), would predict increases in bet amounts for winner and peers. Research on overconfidence, such as the "hot hand" effect (Croson and Sundali 2005), social interaction effects, and advertising effects also predict an increase in bet amounts by jackpot winners, peers, and bystanders.

We study the empirical question of how different player categories respond to jackpots with a rich individual panel data set of slot machine plays that allows us to make causal inferences and account for spatial effects. Jackpots are designed to be random[2] to minimize chances of fraud and therefore constitute "the purest form of an exogenous shock" (Flepp and Rüdisser 2019, p. 146). Because they are random, jackpots constitute a natural experiment, leading to clearer measurement of their causal effect. We measure jackpot value using a causal model that draws on the random nature of jackpots for slot machines located throughout the casino. This model is based on a difference-in-differences (DID) regression analysis (Angrist and Pischke 2008) that measures the differential impact of jackpot events on jackpot winners, peers, and bystanders with respect to a control group of "strangers," who were playing slot machines far away from the jackpot slot machine at the time the focal jackpot occurred.

The rich proprietary data we use is from a gaming and gambling company in the northwestern United States and consists of play details of a panel of individual players on slot machines over a two-year period and details of the casino floor layout. The unit of analysis in our data is the play session, which is defined as the aggregate amount bet within a slot machine session for an individual player. As we discuss in the data section, the play session data enables measurement of the causal impact of jackpot on bet amounts and on frequency of plays through a DID regression analysis of play sessions that occur entirely (i.e., sessions that begin as well as end) in an "event window" that has equally spaced durations before and after the jackpot event.

We find that jackpots have a causal impact of an increase of about $39 betting amount per play for jackpot winners in the two-hour period after the event on average; bystanders who see the jackpot also increase average bet amounts by $2 per play in the half-hour after the jackpot event, although this dissipates after a half-hour period elapses from the jackpot event. In the two-hour period after the jackpot, jackpots increase the number of plays for winners by 33% and for peers by 21%. For bystanders, in number of plays increases by only about 3% for the hour after the jackpot event. The median causal impact of a jackpot is a positive return of $1,539, and our analysis indicates that 49% of jackpots are profitable for the casino. We find evidence that jackpot winners are influenced by the hot hand rather than the house money effect. For bystanders we find evidence of a weak and transient advertising effect.

To summarize, the research question that we study is: What is the causal impact of casino jackpot events on jackpot winners, their peers, and nearby bystanders? We study this research question utilizing a proprietary data set of individual casino slot machine plays. Exploiting the random nature of jackpot events, we apply a DID methodology to study this causal effect. Our analysis contributes to the literature on windfall gains by providing the first empirical test of the prediction of greater risk taking after a windfall gain of Thaler and Johnson (1990). We investigate two competing theoretical predictions in Thaler and Johnson (1990); namely, whether greater windfall-assisted risk-taking behavior of winners is because of the house money or the hot hand effect. For jackpot winners we find evidence in favor of the hot hand effect rather than the house money effect, and do not find evidence in favor of the gambler's fallacy. A substantive contribution is that our method enables measurement of the overall profitability of the jackpot and partitions this impact in terms of jackpot winners, their peers, and bystanders. Our findings provide valuable information for managers to understand response patterns to jackpots as influenced by temporal decay patterns, locational influence, and social effects, enabling them to manage jackpot events.

The rest of the paper is organized as follows. In the next section, we describe related literature and how this research contributes to these studies. This is followed by a description of the data, after which we describe the models we use. Then we describe the results of the study, discuss theoretical and managerial implications of these results, and finally conclude.

2. Literature Review

Our research question is relevant to literature in marketing, economics, and psychology. There are several psychological accounts of risky decision making that lead to different predictions for response to jackpots, and these predictions could vary by slot machine player category. We first identify accounts that predict

a positive gambling response to the jackpot event for different player types, followed by research that predicts a negative response, and then describe how our study differs from these papers and contributes to a better understanding of the above effects.

Several psychological accounts of risky decision making predict a positive response to the jackpot event by different player types. *Winners* of jackpots might bet more because of a belief that luck and/or skill is on their side and that they therefore possess a hot hand, as shown by Croson and Sundali (2005) in casino roulette plays. Similarly the "house money" effect, in which a jackpot winner thinks of the jackpot amount as a windfall from the house or casino, would predict an increase in the jackpot winner's subsequent bet amount (Thaler and Johnson 1990). *Peers* (friends or companions) of jackpot winners may also increase their bet amounts as a response to the jackpot win by their partner because of imitation and/or social comparison (Cooper and Rege 2011, Lahno and Serra-Garcia 2015). As noted by Fafchamps et al. (2015), social comparison affects risk taking such that when "others win big, they take more risk, presumably to keep up with them … in a way similar to 'keeping up with the Joneses' in the consumption domain" (p. 60). Although bystanders are less likely to be influenced by these social effects because they do not personally know the jackpot winner, they may be influenced by the advertising effect of lottery wins (Guryan and Kearney 2008; Kuhn et al. 2008, 2011; Mitton et al. 2018).

There could also be psychological reasons that lead to an inhibitory effect on play amounts after a jackpot for different player types. For *winners*, the "gambler's fallacy" (Tversky and Kahnemann 1974) predicts a negative dependence between past wins and current plays such that players believe that the probability of a jackpot is lower if one has recently occurred, despite knowing that outcomes are actually random. The gambler's fallacy also predicts sales patterns in winning numbers and amounts in U.S. state lotteries (Clotfelter and Cook 1993, Terrell 1994) and slot machine bets by individual players, where there is an inverse relationship between amount earned (won or lost) in the previous bet and the current bet amount (Narayanan and Manchanda 2012). *Peers* and *bystanders* may also be affected by the gambler's fallacy, negatively influencing their response to jackpot events; something that has not been tested in prior literature. In addition, the envy or jealousy that bystanders may experience on seeing a jackpot event where somebody else is the winner may negatively affect risk taking (Moreno et al. 2002).

An important aspect of this paper that differentiates it from past literature is that we measure the impact of casino jackpots on different types of players, each of whose behavior is affected by a different jackpot-related process. Jackpot winners receive a direct cash payout; hence measuring the response of this winner (*direct winner effect*) becomes relevant. In contrast, peers of jackpot winners are affected through a social process. Given that previous research has shown strong peer effects in slot machine casino gambling (Park and Manchanda 2015), it is important to account for this peer response (*peer social effect*). Finally, the effect on bystanders who are playing close to the jackpot machine is closest to a pure advertising effect (*bystander advertising effect*). Using rich individual panel data on slot machine play sessions and on the layout of slot machines on the casino floor, we identify these different player types and causal effects to more comprehensively measure the impact of jackpot windfall gains.

We incorporate these three effects to causally infer the return on investment (ROI) of jackpot events, another main contribution of our research. Although there have been some attempts to apply time disaggregated analyses to the measurement of ad effects (Tellis et al. 2005) and measure ROI on casino marketing investments using casual inference methods (Nair et al. 2017), to our knowledge, our study is the first to measure ROI of casino slot machine jackpot events using causal inference-based methods.

Our approach differs from earlier literature in several ways that enable us to perform this ROI analysis. Previous work on measuring social interaction effects that operationalize peers using laboratory experiments (Lahno and Serra-Garcia 2015) lacks external validity and hence cannot provide the generalizable results required to measure ROI and does not differentiate between social peers and bystanders, for whom the mechanisms and jackpot impacts are likely to be different. Similarly, studies in economics on the effect of windfall lottery wins on neighborhoods and focal stores (Guryan and Kearney 2008) typically use sales data for lottery purchases at the store level and responses at the street or postal code level and time periods of days, weeks, or months. Such approaches cannot be used to measure the ROI of slot machine jackpots on a fast moving, dynamic, casino floor where the response to a jackpot event is likely to be of the order of minutes or hours and where impacted players are moving around the casino floor. In contrast to these approaches, we use a rich data set that enables us to identify winners, social peers, and bystanders, thus measuring ROI impact at the individual level. A major benefit of our individual player level approach is that impacted players can be tracked in terms of their play behavior beyond the slot machine at which they were exposed to the jackpot event stimulus, thus enabling a more accurate and comprehensive measurement of the jackpot ROI effect. We note that the measurement of the immediate impact of the

jackpot is consistent with the findings of Tellis and Franses (2006) that time-disaggregated response data need to be used to accurately measure response to advertisements.

Finally, our analysis enables us to operationalize and test for whether the house money effect hypothesized by Thaler and Johnson (1990) exists in field gambling data. Our analysis shows greater risk-taking behavior by jackpot winners as a result of the jackpot win. In this respect our findings differ from those of Flepp and Rüdisser (2019), who use a more limited data set and methodology using data from a Swiss casino and who find lesser risk-taking behavior by jackpot winners.[3] Our detailed analysis based on winners' cumulative earnings and on interaction (moderator) analyses using jackpot amounts indicates that the house money effect is unlikely to account for this increased risk taking behavior. Instead, it seems that the more conventional "positive" hot hand effect (rather than the "negative" one hypothesized in Thaler and Johnson 1990) is a plausible explanation for this effect.

3. Data

The data used for this study comes from a gaming and gambling company in the northwestern United States and is a rich data set consisting of a panel of individual players and their play details on slot machines over a two-year period. We first provide population descriptive statistics, identification of player types, sample selection, and sample descriptive statistics and then present model-free evidence of the impact of the jackpot event.

3.1. Population-Level Descriptive Statistics

Our data set consists of disaggregate data of the play sessions of individual players. Play "sessions" are defined as "the time spent gambling in a single sitting" (Blackwood 2006, p. 337), which consist of multiple plays (or pulls) of the slot machine in that sitting. Casinos collect play session bet amount data using the time stamps of when the player's loyalty card is inserted into and removed from a specific slot machine (see Appendix B for a detailed description of play sessions). The original data set has 7,110,376 play sessions by 44,732 players across 751 slot machines. After cleaning the data set to retain jackpot events that have complete winners' play information, there were a total of 5,868 jackpot events by 2,045 unique players. Population level descriptive statistics are presented in Table 1. Average bet amount is \$73.32 with negative average earnings of \$14.09. Average duration of a play session is 11.6 minutes, whereas the average frequency of playing is about 13 play sessions for each gaming visit. All variables are highly skewed, with medians that are much lower than the average values. The fifth row of Table 1 shows the distribution of jackpot amounts, with the average jackpot amount of around \$1,400 and a highest jackpot payout of \$25,000. The last row of the table shows the distribution of number of jackpots won per winner, with a median of one jackpot won for every winner.

3.2. Identifying Player Types

Play sessions that resulted in jackpots are identified in the data set, and we identify jackpot winners using this information. Peers of jackpot winners are players who accompany them to the casino and who were playing in the casino at the time of the jackpot event. Bystanders are players who were playing at a slot machine that was physically proximate (less than five units of distance[4]) to the jackpot machine at the time of the jackpot. As described in Appendix A, we coded the coordinates of each slot machine's location on the casino floor layout and combined data on the distance of the slot machine from the jackpot winning machine and data on play session timing to identify bystanders. This information was also used to identify strangers as players who were playing far away (50 units or more) from the jackpot machine at the time of the jackpot.

Because the data does not have explicit information about the social network, we infer peer relationships based on shared behavior. We assume that the (inferred) peer relationship is stable and does not evolve during the period of our data. This assumption seems reasonable as we do not have indications of any changes in the environment (new gamblers, new games, changes to the casino) over this time period. We identify peers for a base of 2,045 unique jackpot winners. For these winners, we identified how many times each of them visited the casino with another customer in the data. We defined visiting together as starting the first game on a visit within five minutes of each other within the same geographic area (defined as a bank of slot machines in the casino). From this analysis, we obtained information representing the number of visits that customer i made with customer j during the entire two-year period. We then defined a peer group as those pairs that had at least four such visits during the data period. This resulted in a total of 2,017 individuals, of whom 544 players were present at the time of jackpot occurrence: these are defined as peers for the jackpot winners in our data set. This player categorization resulted in a total of 2,045 jackpot winners, 544 peers, 4,186 bystanders, and 16,466 strangers for the 5,868 jackpots. Table 2 shows the distribution of the number of each player type per jackpot.

3.3. Event Windows and Sample Selection

We selected a sample of players and play sessions based on the following criteria. (a) An event window

Table 1. Population Level Descriptive Statistics and Distribution of Jackpot Amounts

Variable	Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum
Bet Amount ($)	73.32	185.96	0	9.75	24.22	65.1	50025
Amount earned ($)	−14.09	429.09	−50,025	−20	−5.5	−1.98	1,111,110
Time Played (minutes)	11.62	20.52	0.017	2.43	5.45	12.75	1,660
Frequency (number of play sessions per visit)	13.41	14.99	1.00	4.00	9.00	18.00	430.00
Distribution of Jackpot Amounts ($) (5,868 jackpots)	1,405.71	1,332.31	136	626	1,010	1600	25,000
Distribution of Number of Jackpots per Winner (2,045 unique jackpot winners)	2.87	6.62	1.00	1.00	1.00	2.00	115.00

Note. A total of 7,110,376 play sessions; 44,732 players; and 5,868 jackpots.

was constructed around each jackpot event which is equally divided into "before" and "after" periods with respect to the time of the jackpot event. We constructed event windows to cleanly measure the impact of jackpots by temporally isolating the effect of the jackpot, because there could be other factors unobserved to the researcher such as promotional events run by the casino that could contaminate results if we analyzed at the level of the gaming visit rather than these shorter event windows. Play sessions that are completed (started and ended) within either the before period or the after period of the event window are retained. We focus on a four-hour event window (two hours before/after the jackpot event) to perform most of the analyses for the following two reasons. One is that the descriptive statistics of the sample in this event window seem to be very close to that of the overall data set (details in next subsection). The second is that this event window will enable inclusion of the 99th percentile of play session durations. (b) Players were chosen such that they should have started playing before the beginning of the event window and should have been active (made at least one play) in the first half of the before period. This is required to ensure a fair before/after comparison of the number of plays over the event window. Consider, for example, a player who took a break for lunch at 12 p.m., and came back at 1 p.m., and was involved in a jackpot that occurred at 1.10 p.m. as one of the three concerned player types (winner or peer or bystander). The event window for this jackpot event would stretch from 11.10 a.m. to 3.10 p.m., and so using the "before" observations for this player would not be a fair comparison for the number of plays DID regression. (c) Play sessions that temporally overlap (those that start before the jackpot event and end after the jackpot event) were segregated for separate analysis, since such play sessions cannot be cleanly categorized into either the "before" or into the "after" period. (d) players with any play sessions that are double counted were identified, and all play sessions for those players with any double counted play sessions were removed from the data set. Consider, for example a jackpot (*Jackpot 1*) that occurs at 1 p.m. and another (*Jackpot 2*) that occurs at 1.30 p.m. within five units of a slot machine where the winner of the 1 p.m. jackpot was playing at 1.30 p.m. Then the play sessions of the winner of jackpot 1 would be double counted as a bystander play session for jackpot 2, and we removed all the play sessions of the winner of jackpot 1 from the data set to not bias our estimated effects. These sample selection criteria resulted in a final sample of 626,944 play sessions for 14,154 players with a total of 3,084 jackpot events for the four-hour event window analysis (details of samples for the other event windows are in Online Appendix 3).

3.4. Sample-Level Descriptive Statistics

The descriptive statistics of the final sample shown in Table 3 shows that the final sample are largely representative of the population statistics. The comparatively higher average bet amount in the final sample ($93.63) is because of the player type categorization, which tends to undersample lighter players in terms

Table 2. Population Distribution of Number of Players (of Each Type) per Jackpot

Player type	Number of jackpots	Mean	Standard deviation	Minimum	Lowe r quartile	Median	Upper quartile	Maximum
Winner	5,868	1.00	0.00	1	1	1	1	1
Peer	5,868	0.23	0.51	0	0	0	0	7
Bystander	5,868	1.39	1.96	0	0	0.5	2	14
Strangers	5,868	16.95	18.80	0	0	12	27	137

Table 3. Sample Descriptive Statistics and Distribution of Jackpot Amounts

Variable	Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum
Bet Amount ($)	93.63	264.27	0.00	10.35	28.00	79.30	17,350.00
Amount earned ($)	−12.23	146.42	−7,400.00	−20.00	−7.00	−0.97	7,418.00
Time Played (minutes)	11.53	14.66	0.02	2.68	6.00	13.77	1,470.00
Frequency (number of play sessions per visit)	10.58	9.03	1.00	4.00	8.00	14.00	157.00
Distribution of Jackpot Amounts ($) (3,084 jackpots)	1,409.02	1,392.49	136.00	625.00	1,012.00	1,600.00	25,000.00

Note. A total of 626,944 play sessions; 14,154 players; and 3,084 jackpots.

of bet amounts. The distribution of jackpot amounts in the last row of Table 3 shows that the median jackpot is around $1,012.

Descriptive statistics of play details at the play session level are given for the four-hour event window in Table 4 for each player type for the bet amount and number of plays, whereas additional descriptive statistics of the play duration and amount won/lost are presented in Table A3.1. The average bet amount per play is about $355 for winners, $149 for peers, $91 for bystanders, and $72 for strangers. Jackpot winners lose about $99 per play on average, whereas peers lose about $21, bystanders $13, and strangers about $5 per play. On average the number of plays per visit is about 13 for winners, about 10 for their peers, 11 for bystanders, and about 10 for strangers, with each play lasting for about 11–15 minutes. It should be noted that the higher bet amounts of winners and peers is because players who play for longer durations and higher bet amounts are probabilistically more likely to hit a jackpot.

3.5. Model-Free Evidence

For each of these categories of players, we examine how much money an individual increased/decreased their bet compared with their average bet amount before the jackpot. It is useful to interpret some of these descriptive statistics for the four-hour event window across both bet amount statistics in Table 5 and the number of plays statistics in Table 6. For example, the control group in our field experiment setting are strangers, and we see that, although the average bet amounts are comparable in magnitude in the after period (mean of $69.4) compared with the before period (mean of $74.5), the number of plays shows a clear reduction (average of 4.48 in the after period as compared with 7.10 in the before period). For jackpot winners, there is a clear increase in the average bet amount after the jackpot event ($367.8) compared with the before period ($344.3). The number of plays in the four-hour event window shows a decline in the after period (average of 6.6) compared with the before period (average of 8.2). These trends seem to be largely reflected for winners in the other time windows as shown in Online Appendix 3 for the one-hour (Tables A3.3 and A3.4), two-hour (Tables A3.5 and A3.6), and six-hour (Tables A3.7 and A3.8) event windows. Although both winners and peers decrease their number of plays, the magnitude of the decrease is lesser than the decrease for strangers so that the number of plays behavior seems to be positively influenced by jackpots. This model-free analysis does not account for other factors that might bias the impact of the jackpot impact, which we try to control for in our model with fine-grained fixed effects and other control variables.

Table 4. Sample Descriptive Statistics for Each Player Type: Four-Hour Event Window

Player type	Variable	Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum
Jackpot winners	*Bet Amount* ($)	355.54	755.01	0	34	113	340	15,790
	Number of Play Sessions	13.42	13.63	1	5	10	17	149
Peers	*Bet Amount* ($)	148.67	288.13	0	18	48.5	148.8	3,706.25
	Number of Play Sessions	10.01	9.03	1	4	7	13	60
Bystanders	*Bet Amount* ($)	91.27	214.23	0	10.8	29.2	82.25	8,465
	Number of Play Sessions	10.98	9.35	1	5	9	14	139
Strangers	*Bet Amount* ($)	72.31	160.8	0	9.8	25.57	68.75	17,350
	Number of Play Sessions	10.38	8.61	1	4	8	14	157

Notes. A total of 626,944 play sessions in total across player types. Number of players: winners, 1,194; peers, 299; bystanders, 2,379; strangers, 10,282. Number of play sessions: winners, 42,529; peers, 6,061; bystanders, 45,205; strangers, 533,149.

Table 5. Bet Amount ($) per Play Session Before and After Jackpot: Four-Hour Event Window

Period	Player group	Number of players	Number of play sessions	Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum
Before jackpot event	Jackpot winners	1,194	22,257	344.34	732.85	0.05	36	110	320	11,660
	Peers	299	3,156	150.52	287.16	0.05	20	51.47	152.475	3,622
	Bystanders	2,379	25,499	92.88	216.67	0.01	12.5	30.85	83.68	8,465
	Strangers	10,282	300,975	74.54	163.68	0.01	11.3	27.3	70.85	17,350
After jackpot event	Jackpot winners	1,194	20,272	367.85	778.45	0	32	117	360	15,790
	Peers	299	2,905	146.66	289.21	0	15	45.6	144	3,706
	Bystanders	2,379	19,706	89.18	211.02	0	8.5	26.4	80.75	6,470
	Strangers	10,282	232,174	69.42	156.95	0	7.5	23.2	65.98	11,325

4. Model

4.1. Model Setup: Empirical Strategy

We adopt a DID estimation strategy of analyzing data in an "event window" of four hours (from two hours before the jackpot event to two hours after the jackpot event). We conduct two DID regressions: the first of which models the amount bet on a slot machine play in the event window, whereas the second regression models the number of plays in the same event window. The data we use for these DID regressions consist of observations that do not time-overlap the jackpot event. Such time-overlap observations that start before the jackpot event and end after the jackpot event are removed from the DID analysis and separately analyzed to determine whether the post jackpot duration of the overlapping observations is affected by the jackpot, after controlling for prejackpot duration, as described in Online Appendix 4. The DID regressions focus on measuring the causal impact of the jackpot event on three groups of players: winners, their peers, and bystanders. The baseline or control group with respect to whom the causal impact is measured for these three groups are strangers who were playing at slot machines[5] far away (i.e., more than 50 units of distance away) from the jackpot slot machine at the time of the jackpot event. The DID analyses are described later.

4.2. Bet Amount

The amount bet by a player is given by the following equation:

$$\begin{aligned}\ln(Bet\_amount_{ijt}) = {} & \alpha_{ij} + \alpha_s + \alpha_h + \beta_1 After_{ijt} + \beta_2 After_{ijt} \\ & * Winner_{ij} + \beta_3 After_{ijt} * Peer_{ij} \\ & + \beta_4 After_{ijt} * Bystander_{ij} \\ & + \beta_5\ Bet\_amount_{it-1} \\ & + \beta_6 Earned\_amount_{it-1} + \varepsilon_{ijt}, \end{aligned} \quad (1)$$

where i indexes players, j indexes the focal jackpot event, and t indexes slot machine play sessions within an event window split into two periods of equal duration before and after the focal jackpot event j; Bet_amount_{ijt} refers to total bet money by individual i on his/her tth slot machine play session for the focal jackpot j. We log transform Bet_amount_{ijt} to correct for skewness to be consistent with the assumption of normally distributed error term.

There is a possibility that intensity of bet amount per play session could be positively correlated with jackpot incidents, which could lead to spurious estimates of the impact of jackpots. We include fine-grained fixed effects to avoid such spurious effects. Specifically, α_{ij} represents *individual* × *jackpot* level fixed effects, which controls for correlated unobservables specific to an individual around the time of jackpot (e.g., budget constraint based on previous win or loss); α_s are slot machine specific fixed effects; and α_h are fixed effects that control for the intensity of play at the *year* × *month* × *day* × *hour* level. Because of idiosyncratic characteristics of each slot machine such as its unique theme, denomination of play (unit of bet amount such as 1 cent, 25 cent, 1 dollar, etc.) and location in the floor, the intensity of play could vary across different slot machines. There could also be higher intensity of play at different times of the day (e.g., evening hours) or during particular periods in a year (e.g., the holiday season) or because of the casino's promotional events. The fixed effects, α_s and α_h, attempt to control for such varying intensity of play across space and time.

We use a dummy variable $After_{ijt}$ to capture the immediate impact of jackpot j on the tth slot machine play session of slot player i in the period after the occurrence of the jackpot event j. $Winner_{ij}$ refers to the slot player i who won the jackpot j, $Peer_{ij}$ refers to the peer or partner of the jackpot winner for jackpot j, and $Bystander_{ij}$ refers to nearby slot machine players who are likely aware of jackpot j; Bet_amount_{it-1} indicates the bet amount in the previous play by player i, which is used to control for player i's state dependence in bet amounts. Previous studies including Park and Manchanda (2015) and Narayanan and Manchanda (2012) have used this variable to test for a player's addiction to gambling. It should be noted that a positive coefficient for this variable would indicate addiction, where there is a tendency toward increasing bet

Table 6. Number of Plays Before and After Jackpot: Four-Hour Event Window

Period	Player group	Number of players	Number of *player* × *jackpot* observations	Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum
Before jackpot event	Jackpot winners	1,194	3,084	8.25	8.77	2	3	6	10	136
	Peers	299	584	6.40	5.43	1	3	5	8	46
	Bystanders	2,379	3,973	7.44	5.83	2	3	6	10	74
	Strangers	10,282	49,461	7.10	5.40	1	3	6	9	78
After jackpot event	Jackpot winners	1,194	3,084	6.63	6.57	0	2	5	9	75
	Peers	299	584	4.84	4.73	0	2	3	6	33
	Bystanders	2,379	3,973	4.74	5.00	0	1	3	7	67
	Strangers	10,282	49,461	4.48	4.67	0	1	3	6	84

amounts on successive play sessions. The term $Earned\_amount_{it-1}$ indicates the amount won or lost by player i in the previous play session. Following Park and Manchanda (2015) and Narayanan and Manchanda (2012), we use this variable to test for carryover effects (i.e., a positive coefficient could indicate belief in the hot hand, whereas a negative coefficient could be evidence of the gambler's fallacy) on betting behavior based on the outcome of previous plays.

The causal effect of jackpot on slot player bets are given by β_2, β_3, and β_4, which are the interaction coefficients of the $After_{ijt}$ and the three player-type dummy variables $Winner_{ij}$, $Peer_{ij}$, and $Bystander_{ij}$. If these coefficients are positive and significant, the jackpot should result in an increase in bet amounts, whereas if they are negative, jackpots should result in a decrease in bet amounts. The coefficient of the $After_{ijt}$ variable (β_1) captures the impact of jackpot on strangers who serve as the baseline or control group for our DID analyses.

4.3. Number of Play Sessions

The total impact of jackpots depends not only on the amount bet per play but also on the number of plays impacted by the jackpot. Therefore, we develop a model to measure whether people increase or decrease the number of plays within the event window through a DID regression that is similar to Equation (1) except that it is written at the level of the individual player i and the focal jackpot j, rather than at the play session level t:

$$\begin{aligned}\ln(Num\_plays_{ija}) = {} & \gamma_{ij} + \gamma_d + \theta_1 After_{ija} + \theta_2 After_{ija} \\ & * Winner_{ij} + \theta_3 After_{ija} * Peer_{ij} \\ & + \theta_4 After_{ija} * Bystander_{ij} + \xi^b_{ija}, \end{aligned} \quad (2)$$

where the dependent variable $\ln(Num\_plays_{ija})$ is the number of play sessions of player i during jackpot j, aggregated to either the period before jackpot j ($a = \{Before\}$) or to the period after jackpot j ($a = \{After\}$); γ_{ij} represents *individual* × *jackpot* specific fixed effects to control for player i's intrinsic frequency of play for jackpot j, whereas γ_d are fixed effects that control for the intensity of play at the *year* × *month* × *day* (e.g., 2021 April 6) level. $Winner_{ij}$, $Peer_{ij}$, and $Bystander_{ij}$ are dummy variables indicating player type that are identical to those used in Equation (1). The control group (baseline) in Equation (2) are also (as in Equation (1)) strangers who were playing on slot machines far away from the jackpot machine when the jackpot occurred. The terms θ_2, θ_3, and θ_4 measure the causal impact of jackpots on the number of plays for the focal jackpot for winners, peers, and bystanders, respectively.

5. Results

5.1. Main Results: Four-Hour Event Window

DID results are shown in Table 7, with the bet amount regression results in the left panel and the number of plays regression results in the right panel. Because the dependent variable is log-transformed, the exponent of the coefficient represents the proportionate increase or decrease in the dependent variable for a unit change in the independent variable. For winners there is an increase in average bet amount by \$39 (increase of 10.9%) after the jackpot event, whereas there is no effect on peers or bystanders in the same four-hour event window. Witnessing a jackpot event increases the number of plays by 1.33 times (exp(0.287)) for jackpot winners and 1.21 times (exp(0.189)) for peers compared with strangers for the four-hour event window.

The strong positive impact on winners provides evidence that winners are less affected by the gambler's fallacy and are more strongly impacted by the hot hand effect, an irrational belief that luck and/or skill is on their side. Another interesting possibility is raised by Thaler and Johnson (1990), who predict the possibility that winners may become even more risk taking because of the perception that they are no longer playing with their own money but rather with the house's money. We study this possibility in Section 6.2. The null effect on bet amount for the peers seems to indicate that the hot hand effect that seems so prominent for winners is less effective for peers, although it still seems to manifest in the form of an increase in the frequency of plays.

Table 7. Jackpot DID Fixed Effect Regression Results for Four-Hour Jackpot Event Windows

	Bet amount regression			Number of plays regression		
Parameter	Estimate	Standard error[a]	$p > \|Z\|$	Estimate	Standard error[b]	$p > \|Z\|$
After	−0.250	0.003	<0.0001	−0.522	0.004	<0.0001
After × Winner	0.103	0.013	<0.0001	0.287	0.013	<0.0001
After × Peer	0.012	0.029	0.688	0.189	0.028	<0.0001
After × Bystander	−0.005	0.011	0.664	0.003	0.013	0.831
Bet_amount_{it-1}	0.011	0.001	<0.0001	—	—	—
$Earned\_amount_{it-1}$	0.016	0.002	<0.0001	—	—	—
Fixed effects (FEs)	Individual × jackpot FEs; slot machine FEs; Year × Month × Day × Hour FEs			Individual × Jackpot FEs; slot machine FEs; Year × Month × Day FEs		
Estimation and sample details	R^2: 0.496; number of observations (play sessions): 626,944 (winners 42,529, peers 6,061, bystanders 45,205, strangers 533,149); number of players: 14,154 (winners 1,194, peers 299, bystanders 2,379, strangers 10,282); number of jackpots: 3,084			R^2: 0.601; number of observations (before/after no of plays): 114,204 (winners 6,168, peers 1,168, bystanders 7,946, strangers 98,922); number of players: 14,154 (winners 1,194, peers 299, bystanders 2,379, strangers 10,282); number of jackpots: 3,084		

[a]Standard errors clustered at the Individual × Jackpot level.
[b]Standard errors clustered at the Individual × Jackpot level.

An important null effect in Table 7 is that there is no causal impact on bystanders in this four-hour event window. This seems to indicate that the casinos' efforts to advertise the jackpot events with loud audio-visual stimuli do not have the desired advertising effect in this four-hour event window. This raises the question of whether there is a more short-lived impact of jackpots in shorter event windows, and we examine this question in the next section with shorter event windows of two hours and one hour, where we do find some evidence of a very short-term advertising impact on bystanders.

5.2. Impact of Jackpot in Shorter Event Windows

We conducted the DID regression analyses for shorter event windows of one hour (30 minutes before the jackpot event to 30 minutes after) and two hours (one hour before the jackpot to one hour after the jackpot event). These enable us to measure whether there are changes in the effect of the jackpot over time. Relevant descriptive statistics for these shorter event windows are reported in Online Appendix 3, and the summary results of the DID regressions for bet amount and number of plays are reported in the two panels of Table 8 (full regression results are in Online Appendix 3, Tables A3.9 and A3.10). The trend in average bet amount for winners is an increase of $27 (increase of 7.5%, significant at 99% confidence) in the 30 minutes immediately after the jackpot. However, when we consider the total one-hour period after the jackpot event, there is an increase in average bet amount to $50 (increase of 13.9%), and the increase is $39 (increase of 10.9%) when we consider the two-hour period after the jackpot event, as shown in Table 7. The average bet money of peers also increases by 9.9% and 9.1% in the one-hour and two-hour windows around the jackpot event, although there is no significant effect when we extend this period to the four-hour period around the jackpot event as shown in Table 7. The effect on bystanders appears to be fairly weak in magnitude and short-lived in duration, with an average bet amount coefficient of 0.027, significant at 90% confidence in the one-hour event window.

The results for number of plays (frequency) show that for winners, there is a consistent increase in the number of plays in the period half-hour (coefficient, 0.262) and one hour (coefficient, 0.271) after the jackpot (Table 8), which continues in the two-hour period (coefficient, 0.287) after the jackpot event (Table 7). For peers, the increase in the number of plays we observed in the two-hour period after the jackpot from Table 7 (coefficient, 0.189) starts in the one-hour period after the jackpot (coefficient, 0.094). For bystanders, frequency response also shows the trend of shorter and comparatively weaker effects than the winners and peers, with the number of plays coefficients being significant at 99% confidence in the half-hour (coefficient, 0.031) and one-hour (0.029) periods after the jackpot event.

5.3. Player Heterogeneity Effects

In this section, we explore potential sources of jackpot impact by examining whether these effects vary based on player heterogeneity for the four-hour event window scenario. We use a vector of four heterogeneity variables $Demog_i$ and interact this vector with the respective player types in Equations (1) and (2) to test for heterogeneity effects. Two of the four variables in $Demog_i$ are typical demographics variables: gender (dummy variable) and age. A third variable is play frequency of player i, which will test for whether players with higher frequency (who visit the casino more

Table 8. Impact of Jackpots for Different Time Windows: Summary Results of DIDRegressions

Parameter	One-hour window	Two-hour window	Four-hour window
		Bet amount regression	
Jackpot winners	0.073***	0.131***	0.103***
Peers	0.094**	0.087***	Not significant
Bystanders	0.027*	Not significant	Not significant
		Number of plays regression	
Jackpot winners	0.262***	0.271***	0.287***
Peers	Not significant	0.094***	0.189***
Bystanders	0.031***	0.029***	Not significant

Note. Full DID regression results for four-hour window in Table 7 and for one-hour and two-hour windows in Online Appendix 3, Tables A3.9 and A3.10.

***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

frequently during the data period) react differently to the jackpot event. The fourth variable in $Demog_i$ is the average bet amount of player i, which tests whether those players with higher bet amounts react differently to jackpot events. Descriptive statistics for these variables are presented in Table 9, for the sample of 10,922 players, of whom 41% are male. Average number of gaming visits is 34, whereas average bet amount is $95 across all visits of the players. We also tested for whether the effect of the jackpot varied with the large jackpot amount ($JackAmt_j$), which is operationalized as a dummy variable for a jackpot amount that is greater than $1,600, which is the third quartile for the jackpot amount distribution. The relevant equations to test these heterogeneity effects for the bet amount regression (Equation (1)) are as follows:

$$\begin{aligned}\ln(Bet\_amount_{ijt}) = {} & \alpha'_{ij} + \alpha'_s + \alpha'_h + \beta'_1 After_{ijt} + \beta'_2 After_{ijt} \\ & * Winner_{ij} + \beta'_3 After_{ijt} * Peer_{ij} + \beta'_4 After_{ijt} \\ & * Demog_i + \beta'_5 After_{ijt} * JackAmt_j + \beta'_6 After_{ijt} \\ & * Winner_{ij} * Demog_i + \beta'_7 After_{ijt} * Peer_{ij} \\ & * Demog_i + \beta'_8 After_{ijt} * Bystander_{ij} * Demog_i \\ & + \beta'_9 After_{ijt} * Winner_{ij} * JackAmt_j \\ & + \beta'_{10} After_{ijt} * Peer_{ij} * JackAmt_j \\ & + \beta'_{11} After_{ijt} * Bystander_{ij} * JackAmt_j + \\ & + \beta'_{12} Bet\_amount_{it-1} \\ & + \beta'_{13} Earned\_amount_{it-1} + \varepsilon''_{ijt}. \end{aligned} \quad (3)$$

Similar equations were estimated for the number of plays regression equation (Equation (2)) by including heterogeneity and jackpot amount variables analogously. The results are presented in the two panels of Table 10. For winners, the positive impact of the jackpot on bet amount is higher for older players (coefficient, 0.051) for those who play higher average bet amount (coefficient, 0.132), to some extent, for women (negative coefficient, −0.073), and to some extent, for higher jackpot amounts (coefficient, 0.0510). As shown in the right panel, the positive impact of the jackpot on the number of plays of winners is attenuated for those who play high bet amounts (coefficient, −0.049). There is no impact of the jackpot amount on bet amount for peers or bystanders, whereas there is a negative impact of the jackpot on winner's number of plays for higher jackpot amounts (coefficient, −0.1102). Interestingly, although there is no average bet amount effect for peers, there is a significant positive effect of the jackpot on bet amounts for peers who play large bet amounts (coefficient, 0.095), for peers who are older (coefficient, 0.065) and for peers who have lower play frequency (coefficient, −0.060). The impact of the jackpot on the number of plays of peers is attenuated (coefficient, −0.0437) for peers who play high bet amounts. Thus, peers who play high bet amounts tend to play even more intensively (higher bet amount, lower frequency of plays) as a response to a jackpot event. Bystanders who play larger bet amounts place large bet amounts in response to a jackpot event (coefficient, 0.032), whereas the number of plays is slightly negatively affected by the jackpot event for bystanders who play large bet amounts (coefficient, −0.028).

Table 9. Descriptive Statistics of Heterogeneity Variables

Variable	Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum
Age	56.83	13.03	20.00	49.00	58.00	66.00	94.00
Frequency of Play	34.08	56.13	1.00	5.00	13.00	38.00	643.00
Average Bet Amount	95.47	131.30	1.06	29.16	54.77	107.72	2,824.20

Table 10. Bet Amount and Number of Plays Regressions: Heterogeneity Results (Four-Hour Event Window)

	Bet amount regression			Number of plays regression		
Parameter	Estimate	Standard error[a]	$p > \|Z\|$	Estimate	Standard error[b]	$p > \|Z\|$
After	−0.267	0.005	<0.0001	−0.522	0.005	<0.0001
After × Gender	0.011	0.006	0.060	−0.025	0.007	0.001
After × Age	−0.010	0.002	<0.0001	0.001	0.003	0.833
After × Play Frequency	−0.023	0.003	<0.0001	0.002	0.004	0.569
After × Average Bet Amount	−0.155	0.006	<0.0001	0.065	0.003	<0.0001
After × Jackpot Amount	0.006	0.007	0.411	0.007	0.008	0.403
After × Winner	0.192	0.022	<0.0001	0.277	0.024	<0.0001
After × Winner × Gender	−0.073	0.026	0.005	−0.011	0.027	0.672
After × Winner × Age	0.051	0.012	<0.0001	−0.003	0.013	0.809
After × Winner × Play Frequency	0.007	0.016	0.671	−0.002	0.016	0.918
After × Winner × Average Bet Amount	0.132	0.007	<0.0001	−0.049	0.004	<0.0001
After × Winner × Jackpot Amount	0.051	0.027	0.056	−0.110	0.030	0.000
After × Peer	0.074	0.047	0.112	0.136	0.056	0.015
After × Peer × Gender	0.068	0.057	0.238	0.089	0.057	0.116
After × Peer × Age	0.065	0.025	0.010	0.008	0.028	0.767
After × Peer × Play Frequency	−0.060	0.030	0.043	−0.015	0.026	0.567
After × Peer × Average Bet amount	0.095	0.019	<0.0001	−0.044	0.013	0.001
After × Peer × Jackpot Amount	0.029	0.066	0.663	0.073	0.072	0.313
After × Bystander	0.019	0.016	0.232	0.033	0.021	0.118
After × Bystander × Gender	0.021	0.022	0.331	−0.019	0.027	0.478
After × Bystander × Age	0.016	0.009	0.084	−0.005	0.011	0.676
After × Bystander × Play Frequency	−0.012	0.011	0.250	−0.037	0.014	0.007
After × Bystander × Average Bet Amount	0.032	0.015	0.030	−0.028	0.009	0.001
After × Bystander × Jackpot Amount	−0.014	0.025	0.591	−0.021	0.030	0.479
Bet_amount_{it-1}	0.010	0.001	<0.0001	—	—	—
$\text{Earned\_amount}_{it-1}$	0.016	0.002	<0.0001	—	—	—
Fixed effects (FEs)	Individual × Jackpot FEs; Slot machine FEs; Year × Month × Day × Hour FEs			Individual × Jackpot FEs; Slot machine FEs; Year × Month × Day FEs		
Estimation and sample details	R^2: 0.499; number of observations (play sessions): 626,944 (winners 42,529, peers 6,061, bystanders 45,205, strangers 533,149); number of players: 14,154 (winners 1,194, peers 299, bystanders 2,379, strangers 10,282); number of jackpots: 3,084			R^2: 0.613; number of observations (before/after no of plays): 114,204 (winners 6,168, peers 1,168, bystanders 7,946, strangers 98,922); number of players: 14,154 (winners 1,194, peers 299, bystanders 2,379, strangers 10,282); number of jackpots: 3,084		

[a]Standard errors clustered at the Individual × Jackpot level.
[b]Standard errors clustered at the Individual × Jackpot level.

6. Discussion

6.1. Implications for the Casino

How does the effect of jackpots on betting behavior compare with the jackpot prize money (cost to the casino)? To study this question, we quantify the overall benefit of the jackpot as the combined effects of change in bet amount per play and change in number of plays per visit, aggregating across the plays for a jackpot j and slot player i, and include any impact of the jackpot on overlapping observations (as described in Online Appendix 4). Here, we focus on the four-hour event window to study the implications for the casino.

For each *individual* × *jackpot* observation, we first calculated the average bet money for plays that occurred in the two-hour period before the jackpot. We then obtained the net increase in the bet amount for plays that occurred after the jackpot by applying the causal coefficients estimated in Table 7. It should be noted that this causal impact only applies to winners because only their coefficient was significant. Table 7 shows that jackpots also increase the number of plays for winners and peers. Therefore, we obtained the number of plays that occurred in the two-hour period before the jackpot for each *individual* × *jackpot*. We then applied the causal coefficients from Equation (2) for winners and peers to obtain the increase in the number of plays in the two-hour period after the jackpot. Finally, for play sessions that time-overlap with the jackpot event, we estimate the decrease in expected postjackpot duration for the winners (because this effect is significant only for winners; see Online Appendix 4). Assuming that play rate is constant during the time of play of the overlapping play session, we estimate the reduction in bet money for the winners' overlapping play session because of the jackpot.

We then combine the jackpot effect on bet money, number of plays, and plays with overlap to obtain the overall jackpot impact for each *individual* × *jackpot*. By aggregating the jackpot impact of *individual* × *jackpot* for each jackpot, we determine the overall impact at the jackpot level. Jackpots have an average dollar impact of an increase of $1,539, as shown in Figure 1.

Based on the jackpot amounts shown in Table 3 and overall impact of jackpots shown in Figure 1, we can calculate the net profit for each jackpot. We find that 49% of the jackpots were profitable for the casino. By dividing the net profits by the jackpot amount paid, we obtain the return on investment, the distribution of which is given in the second row of Figure 1 and the second panel of Figure 1. Although maximum ROI is almost 27 times the payout amount, the median jackpot ROI is negative, and the top quartile is only 0.94, which is less than the jackpot payout amount. We decomposed the dollar impact of jackpots by winners and peers because these were the two player types that had significant causal coefficients for the four-hour window. The results are presented in Table 11, which show that on average, jackpot winners contributed an average of $1,478 per jackpot, whereas peers of jackpot winners contributed $61 dollars, the comparatively lower contribution of peers being because of both their lower average increase in bet amount and the fact that there were on average fewer than 1 (0.18) peers per jackpot.

6.2. House Money Effect and Alternative Explanations

We examined whether a jackpot's impact on the winner exceeded the money gained from that jackpot. Our rationale is that if the house money effect is applicable, then the jackpot winner should limit subsequent bets to the money gained from that jackpot. We ran a DID regression similar to our original analysis except that we focused on jackpot winners only and included a dummy variable $I(spent > jackpot\ money)_{ijt}$ to indicate whether the focal play occurred before or after the winner spent the jackpot money from jackpot j. This variable will take the value of one in the play session (t) immediately after the play session $(t-1)$ that the jackpot money has been depleted. Other slot players who were far away from the jackpot were included as the baseline for the DID regression in the following equation, whereas peers and bystanders were excluded:

$$\begin{aligned}\ln(Bet\_amount_{ijt}) = {} & a''_{ij} + a''_{s} + a''_{h} + \beta''_1 After_{ijt} + \beta''_2 After_{ijt} \\ & * Winner_{ij} + \beta''_3 After_{ijt} * Winner_{ij} \\ & * I(spent > jackpot\ money)_{ijt} \\ & + \beta''_7 Bet\_amount_{it-1} \\ & + \beta''_8 Earned\_amount_{it-1} + \xi''_{it}, \end{aligned} \tag{4}$$

where β''_3 measures the amount bet after the jackpot by winners after the jackpot amount is spent. Results in Table 12 show that β''_3 is positive and significant (0.147), implying that winners play even more intensively after they spent all money gained from the jackpot. This result thus appears to provide more support for a hot hand belief than a house money effect. This may indicate that winners' bet behavior may be driven by a desire to make up for what they have lost, a type of irrational gambling behavior where gamblers ignore the sunk cost effect that has been predicted by cumulative prospect theory (CPT; Tversky and Kahnemann 1992). Barberis (2012) argues that probability weighting introduces a time inconsistency into the gambling behavior of naïve, inexperienced players and sophisticated, experienced gamblers and that the positively skewed subjective probabilities of winning that result from this time inconsistency can

Figure 1. (Color online) Distribution of Overall Dollar Impact and ROI of Jackpot

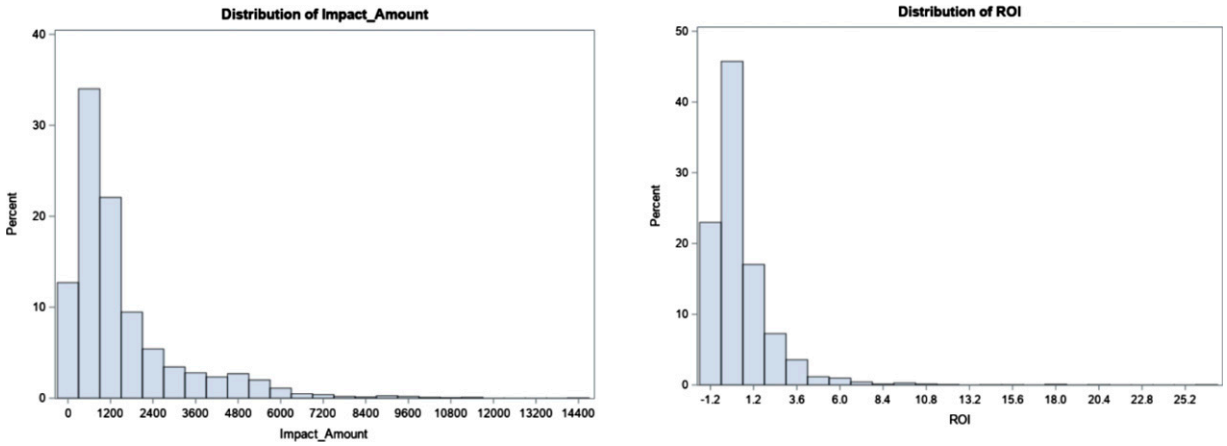


Table 11. Decomposition of Dollar Impact by Player Type

Type	Number of jackpots	Mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum
Winners	3,084	1,477.76	1,659.72	7.33	453.33	879.80	1,700.96	14,691.62
Peers	3,084	61.04	186.59	0	0	0	0	1,936.67

explain risk seeking behavior despite recurring losses in blackjack gambling and slot machine gambling.

6.3. Slot Machine–Level Analysis

An alternate method to analyze the effects of jackpot events is to make the unit of analysis the slot machine rather than the individual player. One advantage of this slot machine–level analysis is that it fixes the physical location of the jackpot event and measures all effects relative to the slot machine at which the jackpot event occurred and at the nearby slot machines,[6] which may enable managers to identify patterns of response to jackpots around the fixed layout of the casino. This analysis is similar to the analysis of Guryan and Kearney (2008) of the "lucky store hypothesis," except that our unit of analysis is the slot machine at which the jackpot event occurs, whereas their focus was the store at which the winning lottery ticket was sold.

If the slot machine at which the jackpot event j occurred is given by $Winner_{sj}$ and slot machines within five units of $Winner_{sj}$ is given by $Nearby_{sj}$, the slot machine level causal analysis requires estimation of the following equations:

$$\ln(Bet\_amount_{sjt}) = \alpha_{sj} + \alpha_h + \beta_1 After_{sjt} + \beta_2 After_{sjt} * Winner_{sj} + \beta_3 After_{sjt} * Nearby_{sj} + \varepsilon_{sjt}, \quad (5)$$

$$\ln(Num\_plays_{sja}) = \gamma_{sj} + \gamma_d + \theta_1 After_{sja} + \theta_2 After_{sja} * Winner_{sj} + \theta_3 After_{sja} * Nearby_{sj} + \xi^b_{sja}, \quad (6)$$

where Bet_amount_{sjt} is the amount bet at slot machine s in play session t in the relevant event window for jackpot event j, $After_{sjt}$ is a dummy variable that captures the impact of jackpot event j on play session t at slot machine s in the period after the jackpot event, Num_plays_{sj} is the number of plays at slot machine s in the event window for jackpot event j, α_{sj} are fixed effects at the *slot machine* × *jackpot* level, γ_{sj} are fixed effects at the *slot machine* × *jackpot* level, α_h are fixed effects at the *Year* × *Month* × *Day* × *Hour* level, and γ_d are fixed effects at the *Year* × *Month* × *Day* level. The terms β_2 and β_3 are the causal impact coefficients of the jackpot on the average bet amounts at the winning slot machine and the nearby slot machines, whereas θ_2 and θ_3 are the analogous coefficients for number of plays. All causal coefficients are measured relative to slot machines that are located 50 units or more away from the winning jackpot machine $Winner_{sj}$ for the focal jackpot j. The "a" subscript in Equation (6) is similar to the use in Equation (2), picking up the play sessions in the period before the jackpot j (a = {*Before*}) or to the period after the jackpot j (a = {After}).

The results of the slot machine level DID regressions are shown in Table 13 for the four-hour event window. These regressions show jackpots increase the average bet amount at the winning slot machine by about 12%, whereas they decrease the number of plays at the winning slot machine by about 2% compared with slot machines far away. For nearby slot machines, there is no impact on the average bet amount, whereas there is a small increase in number of plays. The model-free evidence in Tables A6.1, A6.2, and A6.3 in Online Appendix 6 show that these

Table 12. DID Regression: House Money Effect for Jackpot Winners (Four-Hour Event Window)

Parameter (variable)	Estimate	Standard error[a]	$p > \|Z\|$
After	−0.251	0.003	<0.0001
After × Winner	0.075	0.015	<0.0001
After × Winner*I(spent > jackpot money)$_{ij}$	0.147	0.028	<0.0001
Bet_amount$_{it-1}$	0.010	0.001	<0.0001
Earned_amount$_{it-1}$	0.015	0.002	<0.0001
Fixed effects (FEs)	Individual × Jackpot FEs; Slot machine FEs; Year × Month × Day × Hour FEs		
Estimation and sample details	R^2: 0.483; number of observations (play sessions): 575,678 (winners 42,529, strangers 533,149); number of players: 11,476 (winners 1,194, strangers 10,282); number of jackpots: 3,084		

[a]Standard errors clustered at the Individual × Jackpot level.

Table 13. Jackpot DID Fixed Effect Regression Results for Four-Hour Jackpot Event Windows: Slot Machine–Level Analysis

	Bet amount regression			Number of plays regression		
Parameter	Estimate	Standard error[a]	$p > \|Z\|$	Estimate	Standard error[b]	$p > \|Z\|$
After	0.091	0.003	<0.0001	−0.059	0.001	<0.0001
Nearby machines	0.005	0.009	0.530	0.007	0.004	0.060
Winning machine	0.114	0.027	<0.0001	−0.021	0.011	0.048
Fixed effects (FEs)	Individual FEs; Slot machine × Jackpot FEs; Year × Month × Day × Hour FEs			Individual FEs; Slot machine FEs; Year × Month × Day FEs		
Estimation and sample details	R^2: 0.601; number of observations (play sessions): 1,223,675 (jackpot slot mcs 18,070, nearby mcs 110,195, far mcs 1,095,410); number of jackpots: 3,084			R^2: 0.748; number of observations (before/after no of plays): 555,146 (jackpot slot mcs 6,168, nearby mcs 46,856, far mcs 502,122); number of jackpots: 3,084		

[a]Standard errors clustered at the Slot Machine × Jackpot level.
[b]Standard errors clustered at the Slot Machine level.

are because of the increase in bet amount in the jackpot slot machine ($443 in the after period compared with $382 in the before period). There is a decrease in the number of plays from 3.68 in the before period to 3.16 in the after period. The decrease in the number of plays seems due to the winners playing lesser number of plays in the winning slot machine in the after period, as shown in Table A6.3.

7. Conclusion

In this paper, we study the impact of jackpots on casino slot machine players. We partition the causal impact of the jackpot into its effect on jackpot winners (*direct winner effect*), on peers of jackpot winners (*peer social effect*), and on bystanders who are players on nearby slot machines who witness the jackpot event (*bystander advertising effect*). We find that the overall effect of jackpots is largely attributable to the positive impact of the jackpots on jackpot winners and to a lesser extent, on their peers. The causal impact on bystanders who are playing in nearby slot machines at the time of the jackpot is considerably smaller and dissipates within a short period of 30 minutes to an hour after the jackpot. This seems to reflect similar short-term ad response effects uncovered with finer ad response time intervals (Tellis and Franses 2006). We find a causal effect of an increase in play amount for jackpot winners of about $39, which constitutes about 10.9% increase in the average play amount. For bystanders there is an increase of $2 in bet amount within 30 minutes of the jackpot, although this dissipates thereafter. The number of plays on a visit when a player encounters a jackpot also increases for winners by 33%, for peers by 21% in the two-hour period after the jackpot, whereas for bystanders, there is a weak increase in number of plays of only about 3% for an hour after the jackpot event.

Our results have important implications for casino managers in terms of managing casino loyalty programs and targeted marketing. Because many slot machine players use loyalty program cards at the casino, their position can be tracked and they could be dynamically targeted with customized offers based on their proximity to jackpot events. Using such information in targeted offers may be particularly important because our analysis suggests that a large proportion of jackpots are not profitable to the casino. Our method also can enable managers to evaluate the profitability of jackpots over the casino layout at different points in time during the day. Because casinos already have programs that encourage slot players to sign up for loyalty programs, both for themselves and for their peers, our measurement of the jackpot ROI at the level of different player types will enable customization of different reward levels and offers for different player types, potentially with dynamically varying rewards with restricted durations.

Future research can address some limitations of our research. We limit our study to relatively short-term implications of jackpots because we do not observe other gambling activity of the players in between visits. If a more comprehensive database of gambling activities of players across different casinos were available, interesting long-term and complementary effects of jackpots could be explored. Our unit of analysis is the play session (an industry norm of data collection), not individual plays at the slot machine. Although we identify play sessions as belonging to the before and after periods, it is possible that a data set of individual slot machine plays might show some more dynamic causal changes because of the jackpot event that may wash out in the play session level analysis. Future research could also examine how jackpots could interact with loyalty program progress of slot machine players.

More generally, this article contributes to an understanding of risky decision making in several ways. One, it investigates whether there are changes in risky

decision-making behavior when there is an endowment through jackpot winnings. By exploiting individual panel data, we show that in our field context there is greater evidence in favor of the hot hand effect rather than the house money effect or even the gambler's fallacy effect. Two, we find evidence in favor of a social interaction effect in risky decision making. Finally, we find evidence of a transient and weak advertising effect. Future research could investigate the boundary conditions under which these effects hold for different types of risky decision-making behaviors. In particular, our research raises the question of the conditions under which either the house money effect (positive response to winning; Thaler and Johnson 1990) or the gambler's fallacy (negative response to winning) can be identified in a field context.

Acknowledgments

The authors thank Puneet Manchanda, Nicholas Lurie, and seminar participants at Korea Advanced Institute of Science and Technology, University of Manitoba, and Penn State University for valuable feedback and Logan Bement for capable research assistance with coding the casino layout.

Appendix A. Spatial Data Augmentation

The data set used in this study consists of two years of panel data on individual player level casino betting information from July 2005 to June 2007 at a single casino in the northwestern United States. The augmented spatial data were prepared as described below. To conduct a spatial analysis of the impact of possible complementarities in spatial location, the casino floor layout (Figure A.1) needs to be mapped to fix the spatial locations. Because the layout we were provided with by the company did not have the spatial locations, our strategy was to superimpose a grid with evenly spaced vertical and horizontal lines[7] to fix the coordinates of each slot machine. This strategy of data preparation enables us to determine the distance between two slot machines (or, at a higher level of spatial aggregation, between zones), to cluster slot machines based on distance between them, and so on. The grid coordinates of each of the 776 slot machines was entered with the help of a research assistant.[8] A zoomed snapshot of one quadrant of the layout of the casino floor with grids superimposed on it is shown in Figure A.2. Individual slot machines are organized into tables. For example, slot machine number 10,312 in table 46 has coordinates (50,9), whereas slot machine number 11 in table 35 has coordinates (57,27). Using these coordinates, the distance between these two slot machines can be computed using the standard geometric formula.

Appendix B. Play Sessions

The fundamental unit of observation in our data set is the play session. A player will engage in several play sessions within a gaming visit. "Bet amount" is the amount bet in a play session, which may consist of several individual plays at a specific slot machine. In line with the industry norm of sessions as "the time spent gambling in a single sitting" (Blackwood 2006, p. 337), casinos collect play session data rather than data on individual pulls of the slot machine. The play session consists of the duration of time between the player starting to gamble at a slot machine

Figure A.1. (Color online) Overall Casino Layout

Figure A.2. Casino Floor Layout with Mapped Locations of Slot Machines: Expanded View

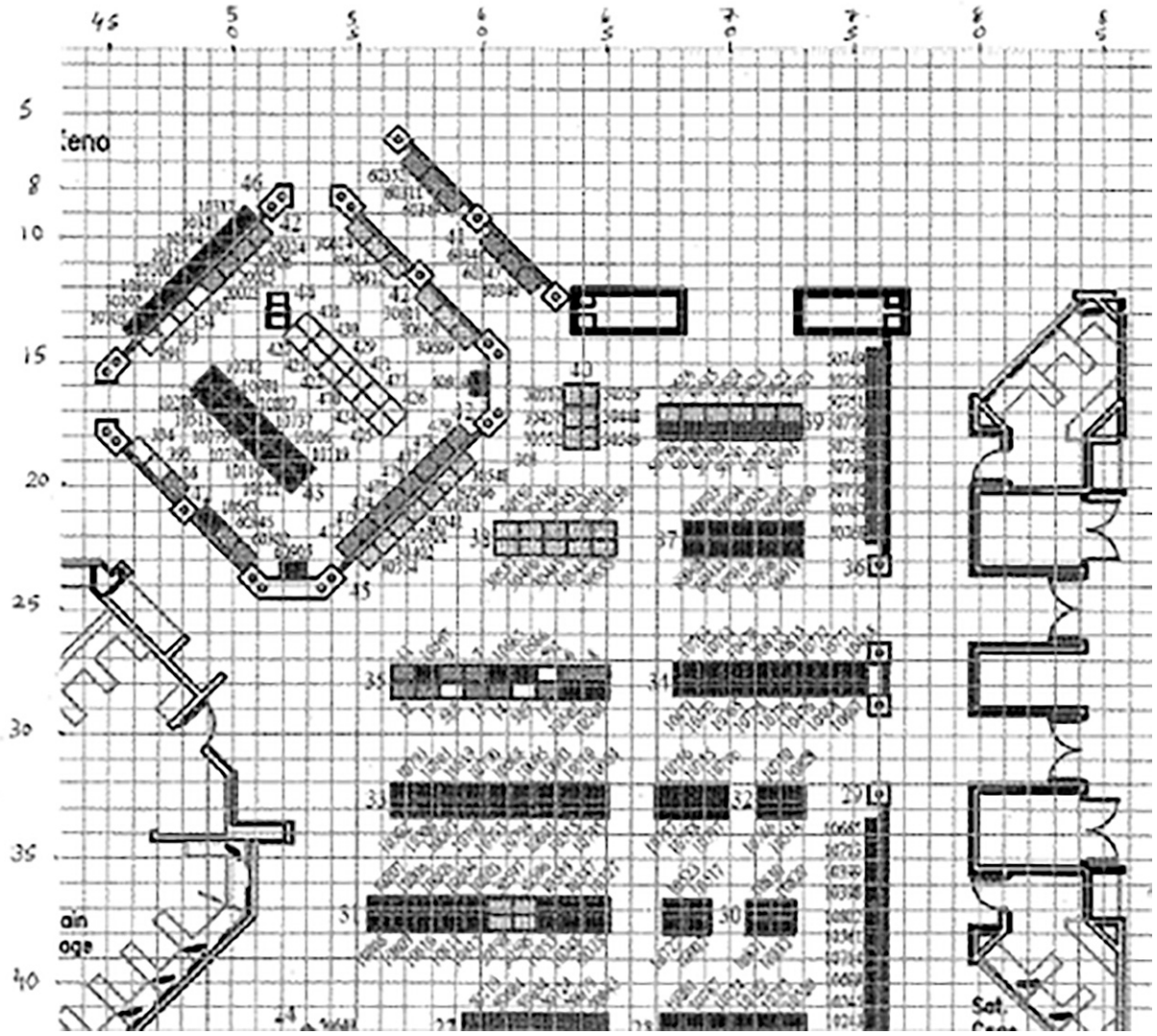
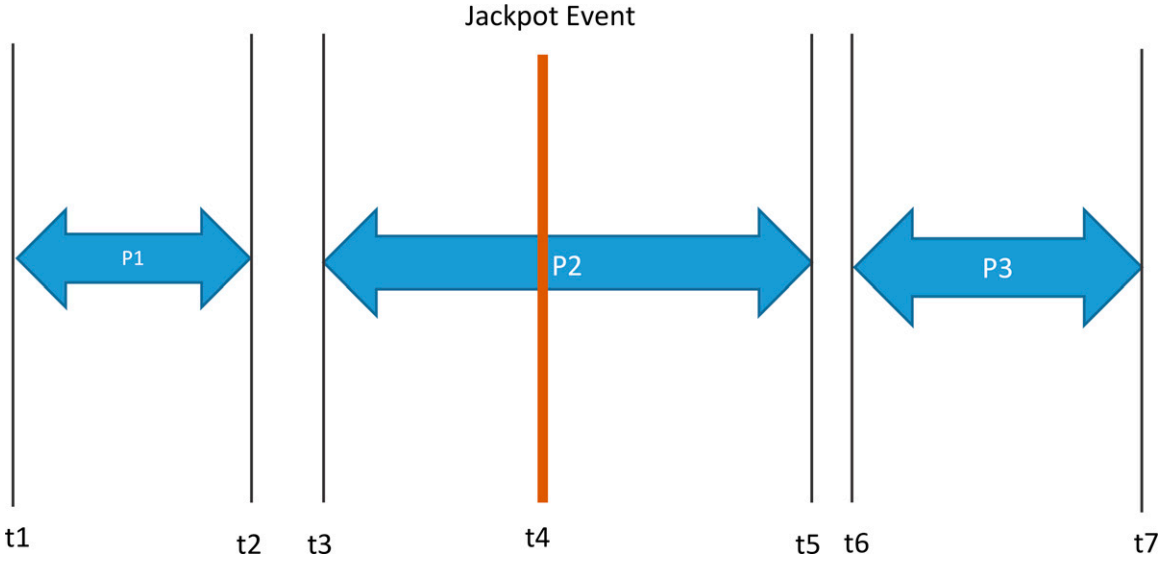


Figure B.1. (Color online) Illustrative Example of Play Session Durations Relative to the Jackpot Event



by inserting their loyalty card and ending the play session on that slot machine by removing the loyalty card, at which point the cumulative bet amount of the session is recorded in the casino's data set for that individual player and that particular slot machine. Thus, the amount bet in a play session is the aggregate amount bet within a slot machine session for an individual player.

Consider three play sessions P1, P2, and P3 as shown in Figure B.1, where the focal jackpot occurs at time $t4$. Play session P1 starts at time $t1$ and ends at $t2$, so that it occurs entirely before the jackpot ($t1 < t4$ and $t2 < t4$). Play session P3 starts at time $t6$ and ends at time $t7$, so that it occurs entirely after the jackpot ($t6 > t4$ and $t7 > t4$). Play sessions such as P1 and P3 are suitable for analysis of the causal impact of jackpots using DID regression methods because they occur entirely either before or after the jackpot. We analyze the impact of the jackpot using a time window of two hours before the jackpot and two hours after the jackpot and use observations such as P1 and P3 that fall entirely within this time window to conduct the DID regression analysis. However, consider the play session P2, which begins at time $t3$ ($t3 < t4$) and ends at time $t5$ ($t5 > t4$). Play sessions such as P2 are not suitable for direct analysis of causal impact using DID regression methods because they overlap the jackpot event, and we cannot conclusively say which proportion of plays fall before and after the jackpot. However, the data provides valuable information from the time stamps of the prejackpot overlap duration ($t4–t3$) and the postjackpot overlap duration ($t5–t4$), and we use this information to draw inferences about the relative impact of jackpot on the duration of postjackpot overlap duration, results for which are presented in Appendix D. In the implications section, we also incorporate these insights for the overlap play's duration into the profit implications for the casino under the assumption of a constant rate of play during the play session.

Endnotes

[1] Regulation 1.140, https://www.gaming.nv.gov/modules/showdocument.aspx?documentid=13741, accessed on September 25, 2019.

[2] Winnings by a player (payouts by the casino) occur on a slot machine through a random number generator (RNG). The RNG is the computer program that determines what is displayed on the slot machine and hence determines whether there is a jackpot or not. The RNG is delinked from the game graphics, coin counters, and slot club tracking system. Because a winning number must be generated in the same microsecond as a player pulls the handle of the slot machine (Grochowski 2005, p. 10), jackpots constitute "the purest form of an exogenous shock" (Flepp and Rüdisser 2019, p. 146).

[3] A detailed discussion of the differences between our approach and those of Flepp and Rüdisser (2019) are available from the authors on request.

[4] Robustness checks of the underlying assumptions for identifying each of the player types are available in Online Appendix 5.

[5] By defining strangers as those who were playing far away from the jackpot slot machine at the moment of the jackpot, we exclude those who were not playing at that moment but who played in the casino subsequent to the jackpot, as it is difficult to ascertain whether they were in the vicinity of the jackpot when it occurred; including such players could contaminate our estimates of the impact of jackpots.

[6] The authors thank an anonymous reviewer for suggesting this analysis.

[7] Although the dimensions of the casino are not available to us, each of our grids corresponds roughly to the footprint of a slot machine, which would correspond to a grid unit corresponding to about 4 to 5 feet.

[8] We thank the research assistant for help in preparing the data file with the coordinates for each of the 776 slot machines on the casino floor.

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