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A Deeper Look Into the Relationship Between House Advantage and Reel Slot Performance

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Abstract

Results from an international field study conducted on three different casino floors indicated significantly elevated win levels on reel slots with increased house advantages. This work extended that of Lucas and Spilde, which found the same. Our study expanded their work by dramatically increasing the difference in the pars of paired slot titles, which were otherwise identical games. Still, the high par games outperformed their low par counterparts in the all-important metric of T-win. In addition, like Lucas and Spilde, the results of time series regression analyses failed to indicate signs that players were detecting a difference in the pars of the paired games. Specifically, there was no evidence of play migration from the high par game to the low par game. This result provided a valuable addition to the literature, replicating an outcome that refuted a popular operating theory. Moreover, the result was reproduced with considerably expanded differences in pars. Overall, the results supported the ideas that (a) players could not detect the egregious differences in the pars of otherwise identical games and (b) operators may be able recognize material gains in revenues from increasing pars. Both of these outcomes challenged the inveterate wisdom of the industry.

Keywords

casino management; operations; casino marketing; pricing; marketing and sales; operations analysis; slot machines

Introduction

The annual contribution of the gaming industry to the overall U.S. economy is estimated at US$240 billion, providing US$38 billion in tax revenues, and supporting 17 million jobs (American Gaming Association [AGA], 2017). Tribal casinos operating in the U.S. reported a record-level US$31.2 billion in annual gaming revenues in 2016 (National Indian Gaming Commission [NIGC], 2017). Nevada properties added another US$11.6 billion in 2017 gaming revenues (Nevada Gaming Control Board [NGCB], 2017). The majority of these U.S. gaming revenues came from slot machine play. Even in table-heavy markets such as Nevada, 64% of the gaming revenue was generated by slot machines (NGCB, 2017). In other U.S. jurisdictions, the reliance on slot revenues was more profound, exceeding 88% of total gaming win (Iowa Racing and Gaming Commission [IRGC], 2017; South Dakota Commission on Gaming [SDCG], 2017).

Outside the United States, most operators within jurisdictions such as the Australian club market rely entirely on electronic gaming devices (EGDs) for gaming revenues, as live table games are not permitted. With a heavy reliance on a clientele of frequent visitors and their lower spend-per trip, slot win is also critical to the success of the many smaller Mexican casinos (Alvarado & Steller, 2010).

This reliance on slot win exaggerates the value of insight related to optimizing game performance. The primary aim of this study is to extend the quasi-experimental work of Lucas and Spilde (2018), which sought to understand how changes in the house advantage (i.e., par) affected individual slot machine performance. While many in the industry fear or caution against increases in pars (Frank, 2017; Gallaway, 2014, 2016; Meczka, 2017), Lucas and Spilde found statistically significant increases in game performance associated with increased pars.

Literature Review

Player Sensitivity

Several studies have concluded or inferred that players are able to detect differences in pars, within various contexts

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(Applied Analysis, 2015; Dixon, Fugelsang, MacLaren, & Harrigan, 2013; Harrigan & Dixon, 2010). Applied Analysis concluded that U.S. slot revenues posted sluggish gains in the period following the global financial crisis, due to increased pars. Harrigan and Dixon conducted a simulation featuring two reel slots with a 13 percentage-point difference in pars (2% vs. 15%). These games were played by 2,000 virtual players via identical wagering protocol. The authors found individual wagering measures to be greater on the low par game, noting that the differences in the outcomes substantially dissipated when the means were replaced by the medians. In a lab study, using what appeared to be the same two games from Harrigan and Dixon, researchers found significant differences in session-level payback percentages for six of the seven players who completed their 30-week study (Dixon et al., 2013). In addition, all seven players were able to identify the high par game after completing the 30 play sessions.

Player Insensitivity

From the problem gambling literature, several studies have supported an inability of slot players to detect differences in pars (Haw, 2008; Weatherly & Brandt, 2004; Weatherly, Thompson, Hodny, & Meier, 2009). In an Atlantic City field study that featured a year-over-year design, Lucas and Brandmeir (2005) found increases in T-win when the pars of 38 reel slots were increased from 5.0% to 7.5%. Lucas and Singh (2011) found that very few players would produce actual results that would allow them to detect a difference in the pars of reel slot games. This conclusion was based on 90 different simulations of reel slot games featuring six par comparisons, five play durations, and three levels of pay table variance. Their maximum difference between pars was nine percentage points (i.e., 3% vs. 12%).

Lucas and Spilde (2018) conducted a field study to analyze the performance of paired games with par differences ranging from 2.46 to 4.90 percentage points. They found mixed results related to the difference in daily coin-in levels. While the mean daily coin-in was generally greater for the low par games, only two of five pairings produced a mean difference significantly different from zero (i.e., with outliers omitted). The results of the *t* tests were more consistent for the T-win data, with the high par games producing significantly greater means in each of the five pairings. These increases were economically significant, ranging from approximately US$50 to US$150 per unit, per day. In addition, the results of their time series regression analyses found no evidence of a significant shift in play from the high par game to the low par game, over the course of the sample periods. These results held for both the coin-in and T-win differences, across all five, two-game pairings.

Extension of Literature

Using a similar design, this study extends the work of Lucas and Spilde (2018) by examining performance data from paired titles with differences in pars ranging from 6.95 to 8.90 percentage points. These differences represent considerable increases from those examined in Lucas and Spilde. Our study replicates both the time series regression analyses and dependent-measures *t* tests performed by Lucas and Spilde. The results will tell us whether the new pairings generally behave in the same manner as those analyzed in Lucas and Spilde. If so, these findings may indicate an opportunity for performance gains. If not, a start position will be established for understanding the limits of player sensitivity to pars. Given the early stages of this work, results from new casino venues, new game titles, six new pairings, and increased differences in pars all represent important additions to this research stream. At this juncture, replication and meaningful extension are critical to the foundation of a working theory.

Play Migration

Because the variance in the outcome distribution obscures the true mean (i.e., par), at the level of the individual play session (Singh, Lucas, Dalpatadu, & Murphy, 2013), we are not sure that players would be able to detect differences in the pars of otherwise identical games. Some contend that over time, players are able to mentally cobble together these short-run outcomes to detect programmed differences in pars (Frank, 2017; Gallaway, 2014). If this is the case, then we would expect to see the difference between the coin-in on the low par game and the coin-in on the high par game to change over time. This would indicate learning or detection on the part of the clientele. We refer to this phenomenon as play migration.

By way of time series regression analysis, Lucas and Spilde (2018) failed to find evidence of play migration in the coin-in and T-win data for any of the paired games. The current study expands the differences in the pars of the paired games to see whether play migration is triggered by the wider gaps.

Method

Data Sources

The slot machine performance data were gathered from three different casinos located in two different countries. One property was located in Australia (AUS) and the other two in Mexico (MEX1 and MEX2). All three properties were heavily reliant on a local repeat clientele, with each estimating an average number of visits per player at 3 to 5 days per week. Frequent visitation was an important characteristic, as highly

Table 1.
Par Comparisons Within Two-Game Pairings.

Two-Game Pairing	Game Theme/Title	Par 1 (%)	Par 2 (%)	Par Difference (% Pts.)	Par Increase. (%)
AUS-A	Tokyo Rose	7.98	14.93	6.95	87.09
AUS-B	Dragon's Fortune X	7.98	14.93	6.95	87.09
MEX1-A	Wild Americoins	5.50	14.40	8.90	161.82
MEX1-B	5 Dragons Gold	6.95	14.93	7.98	114.82
MEX2-A	Wild Americoins	5.50	14.40	8.90	161.82
MEX2-B	5 Dragons Gold	6.95	14.93	7.98	114.82

involved players were more likely to detect differences in the pars of otherwise identical games.

Neither AUS nor MEX2 featured a hotel, relying entirely on frequent visitation from nearby residents of the suburbs. Located in suburban Sydney, AUS offered a variety of quality restaurants, with options ranging from quick service to gourmet dining. This property also offered limited entertainment and meeting/convention space. The casino was comprised of less than 400 EGDs, as live table games are not permitted in the Australian club market. Approximately 230 of these EGDs offered a base credit value of A$0.01. MEX1 and MEX2 were both located in Northern Mexico, near the U.S. border. While both catered to a local clientele, MEX1 also featured 120 hotel rooms. Neither property offered noteworthy nongaming amenities, a condition common to many smaller Mexican casinos. Both casinos operated approximately 10 table games and 300 reel slot machines. Nearly all of the reels at MEX1 and MEX2 featured a base credit value of Mex$0.05.

Experimental Design

The difference in game-level performance was measured in terms of daily coin-in and daily T-win. Two-game pairings were formed holding the following variables constant: game title, payout schedule, bank membership, and cabinet design. Each of the six pairings consisted of a low par game and a high par game. The pars differed via differences in the frequencies of the payouts, which were concealed from the players. To the players, both games within each pairing would appear identical, with both listing the same pay table. Table 1 describes each of the six, two-game pairings, including the par for each game and the magnitude of the par difference for each pairing. None of the listed games were altered from the manufactured and licensed pay table specifications.

Both Tokyo Rose and Dragon's Fortune X were 25-line games with a base credit value of A$0.01 and a minimum bet per spin of A$0.01. The maximum bet per spin was A$10.00 on Tokyo Rose and A$5.00 on Dragon's Fortune X. Wild Americoins was a 20-line game, whereas 5 Dragons Gold featured 243 lines/ways. The base credit value for both of these games was Mex$0.05. The minimum and maximum bets per spin on Wild Americoins were Mex$2.00 and Mex$20.00, respectively. For 5 Dragons Gold, the bet per spin constraints ranged from a minimum of $Mex2.50 to a maximum of $Mex25.00.

The average par across all of the games on the floor at AUS was approximately 9%, while MEX1 and MEX2 posted average floor pars of approximately 6%. Of course, these averages did change over the sample periods as games were added and removed from the floors, but the averages listed here provide close approximations of the overall floor pars. For AUS, the legal maximum par was 15%. In Mexico, there was no legal maximum par, but 12% served as the de facto maximum across the casinos operating in the MEX1 and MEX2 markets.

In Lucas and Spilde (2018), the increases in par ranged from 24.97% to 86.55%, across their five, two-game pairings. As shown in Table 1, the same increases ranged from 87.09% to 161.82%. To further clarify the design, Figure 1 illustrates the experimental bank configuration for MEX1 and MEX2.

While each property offered many reel games with the same base credit value as the experimental units, there were no other games with the same titles. For example, other than the experimental games, there were no other Wild Americoins offered in MEX1. If a player wanted to play Wild Americoins, she would have to play one or both of the experimental games. This was noteworthy, as Lucas and Spilde (2018) mentioned the tendency of reel players to select games from a limited set of titles (i.e., their evoked set). By making the experimental game titles exclusive, it potentially increased the number of times a player would interact with those units over the course of the sample period.

For AUS, daily performance data for each game were collected from May 4, 2017, through October 30, 2017, for a total of 180 consecutive daily observations. The MEX1 and MEX2 sample dates ranged from May 23, 2017, through November 18, 2017, also resulting in 180 sequential daily observations. Although the specific date ranges held no particular relevance, the management teams deemed the duration of the 180-day sample periods sufficient for (a)

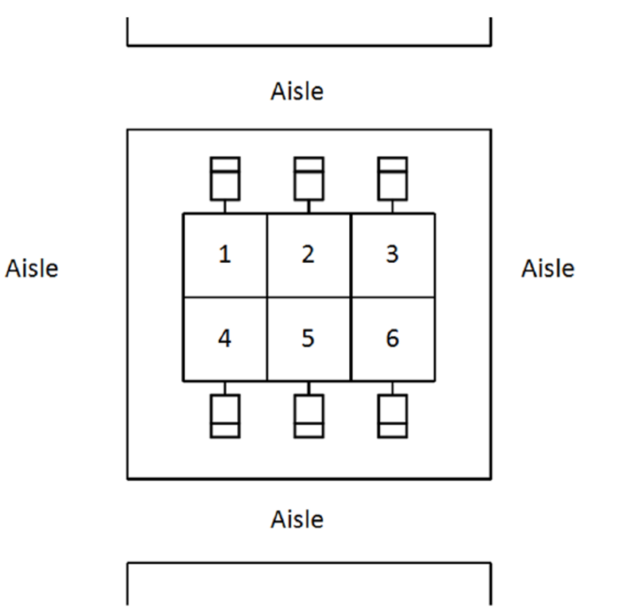

Figure 1.
Bank Configuration of Experimental Games at MEX1 and MEX2.
Note. All units featured the same credit value. Unit 1: Wild Americoins, 14.40% par; Unit 3: Wild Americoins, 5.50% par; Unit 4: 5 Dragons Gold, 5.50% par; Unit 6: 5 Dragons Gold, 14.93% par; Units 2 and 4: Rhino Charge, 10.50% par.

differences in game-level performance to become apparent and (b) gathering evidence of play migration from one game to another. The latter would serve to evaluate the extent to which the clientele of each casino could detect a difference in the pars, within each two-game pairing. The 6-month time frame was consistent with the samples collected by Lucas and Spilde (2018).

Paired-samples *t* tests were employed to test the following hypothesis for each two-game pairing.

$$H_0 1: \mu_{CI,\ LOW} = \mu_{CI,\ HIGH}.$$

In $H_0 1$, $\mu_{CI,\ LOW}$ represented the mean, daily coin-in for the low par game and $\mu_{CI,\ HIGH}$ represented the same for the high par game. Consistent with Lucas and Spilde (2018), daily coin-in represented the total dollar value of all wagers placed in each machine over the course of each 24-hr gaming day. This measure was analogous to a gross wagering volume, which included promotional credits such as redeemed free-play offers.

Next, per $H_0 2$, paired-samples *t* tests were conducted to test for differences in daily T-win within each of the six, two-game pairings.

$$H_0 2: \mu_{TW,\ LOW} = \mu_{TW,\ HIGH}.$$

In $H_0 2$, $\mu_{TW,\ LOW}$ represented the mean, daily T-win for the low par game and $\mu_{TW,\ HIGH}$ represented the same for the high par game. Daily T-win was the casino's expected value, in terms of win, given the dollar value of wagers placed within each 24-hr gaming day. Because each game within this study featured a house advantage, T-win could not take on a negative value. That is, the casino would always have a positive expected value (i.e., positive T-win).

In step with the approach adopted by Lucas and Spilde (2018), time series plots were first reviewed to assess the stationarity and structure of each difference series. Next, time series regression models were created to examine the stability of each difference series over time. Specifically, these models measured the extent to which a constant mean difference was present. All daily differences were computed by subtracting the low par performance measure from the high par performance measure. If the mean difference in the performance of the paired games was declining over time, then it would suggest that play was migrating from the high par game to the low par game. This would signal the ability of players to recognize a difference in the pars. To the contrary, if the mean difference were to remain statistically constant over time, then it would suggest an inability of players to detect differences in the pars of the paired games.

As each difference series must be examined for each two-game pairing, a total of 12 separate time series regression analyses were conducted, six for the coin-in differences and six for the T-win differences. Consistent with Lucas and Spilde (2018), these models employed binary variables to adjust for outlier dates, autoregressive terms to account for serial correlation among lagged values of the daily differences, and moving average terms to address serial correlation among the errors. All of these variables were included on an as-needed basis. The primary variable of interest was the trend variable, which was set to 1 on the first day of the sample and increased by a value of 1 on each successive day. If the regression coefficient for this variable were to post a statistically significant effect, then it would signal the presence of a nonconstant mean in the difference series. The following hypotheses were advanced regarding the trend variables:

$$H_0 3: B_{TREND(CI)} = 0.$$

$$H_0 4: B_{TREND\ (TW)} = 0.$$

In $H_0 3$, B represented the regression coefficient for the trend variable employed in the model designed to explain the daily variation in the difference series of coin-in observations. This hypothesis was tested for each of the six, two-game pairings. $H_0 4$ represented the same for the trend variables in each of the six models designed to explain the variation in the daily T-win differences produced by each of the six, two-game pairings.

Given the exploratory nature of this research, two-tailed tests with an alpha level of .10 were deemed appropriate, and consistent with that employed by Lucas and Spilde

Table 2.
Descriptive Statistics: Daily Differences by Two-Game Pairing.

Two-Game Pairing	*M*	Median	*SD*	Minimum	Maximum
AUS-A: Tokyo Rose (*n* = 180)					
Coin-in: 14.93% – 7.89%	−282.66	−190.65	1,086.83	−4,044.96	2,936.21
T-win: 14.93% – 7.89%	105.63	93.27	116.34	−190.57	534.40
Outliers omitted (*n* = 175; 178)					
Coin-in: 14.93% – 7.89%	−182.84	−168.74	923.71	−2,991.49	2,936.21
T-win: 14.93% – 7.89%	100.90	91.64	107.97	−190.57	410.83
AUS-B: Dragon's Fortune X (*n* = 180)					
Coin-in: 14.93% – 7.89%	−144.16	−109.58	1,088.74	−9,129.29	2,833.25
T-win: 14.93% – 7.89%	94.28	84.87	123.31	−652.16	499.13
Outliers omitted (*n* = 178; 179)					
Coin-in: 14.93% – 7.89%	−72.84	−104.70	812.27	−2,459.85	2,833.25
T-win: 14.93% – 7.89%	98.45	84.96	110.19	−231.38	499.13
MEX1-A: Wild Americoins (*n* = 180)					
Coin-in: 14.40% – 5.50%	2,698.31	3,123.00	18,123.81	−109,932.00	72,714.00
T-win: 14.40% – 5.50%	2,785.41	2,571.32	1,800.01	−2,033.06	11,808.66
Outliers omitted (*n* = 179; 179)					
Coin-in: 14.40% – 5.50%	3,327.53	3,200.00	16,082.67	−73,636.00	72,714.00
T-win: 14.40% – 5.50%	2,735.00	2,570.67	1,672.80	−2,033.06	9,466.25
MEX1-B: 5 Dragons (*n* = 180)					
Coin-in: 14.93% – 6.95%	−16,597.28	−10,213.75	47,731.84	−243,350.00	292,422.50
T-win: 14.93% – 6.95%	1,235.14	646.53	5,338.11	−14,919.43	46,835.32
Outliers omitted (*n* = 170; 178)					
Coin-in: 14.93% – 6.95%	−13,385.28	−9,637.50	24,563.27	−95,140.00	89,927.50
T-win: 14.93% – 6.95%	789.33	642.49	3,229.91	−14,919.43	17,379.11
MEX2-A: Wild Americoins (*n* = 180)					
Coin-in: 14.40% – 5.50%	−767.56	−242.00	13,525.57	−86,370.00	75,586.00
T-win: 14.40% – 5.50%	2,012.10	1,803.07	1,308.25	−1,396.30	12,892.05
Outliers omitted (*n* = 177; 179)					
Coin-in: 14.40% – 5.50%	−301.49	−168.00	8,977.75	−32,980.00	33,390.00
T-win: 14.40% – 5.50%	1,951.32	1,801.76	1,025.87	−1,396.30	6,314.22
MEX2-B: 5 Dragons (*n* = 180)					
Coin-in: 14.93% – 6.95%	−3,703.99	−2,671.25	9,310.55	−42,605.00	22,877.50
T-win: 14.93% – 6.95%	1,156.88	1,050.38	1,087.70	−2,742.47	4,322.74
Outliers omitted (*n* = 178; 180)					
Coin-in: 14.93% – 6.95%	−3,284.57	−2,533.75	8,468.54	−34,655.00	22,877.50
T-win: 14.93% – 6.95%	1,156.88	1,050.38	1,087.70	−2,742.47	4,322.74

Note. All descriptive statistics associated with the performance of the AUS-A and AUS-B games are in terms of Australian dollars. The descriptive statistics associated with the performance of the MEX1-A, MEX1-B, MEX2-A, and MEX2-B games are in terms of Mexican pesos. All statistics are expressed in terms of daily values. MEX2-B T-win contained no outliers (*n* = 180).

(2018). For the purposes of evaluating the results of all hypothesis tests, a Bonferroni adjustment was employed to accommodate the repeated performance of *t* tests. This reduced the effective alpha level to .0167 (i.e., 0.10 / 6), that is, the initial alpha divided by the number of *t* tests conducted on each of the four hypotheses.

Results

Prior to conducting the paired-samples *t* tests, descriptive statistics were reviewed for the daily difference in coin-in and T-win, for each two-game pairing (see Table 2). While extreme cases were identified, investigations of the data points that produced them verified that the observations were valid. Given the potential influence of outliers on the mean differences, these extreme observations were omitted from a restated battery of descriptive statistics for each pairing.

From Table 2, the mean daily difference in coin-in was negative for each two-game pairing, save MEX1-A. This demonstrated that the low par game produced a greater mean daily coin-in, in five of six pairings. As for T-win, the

Table 3.
Correlation Coefficients: Daily Coin-In by Two-Game Pairing (n = 180).

	AUS-A	AUS-B	MEX1-A	MEX1-B	MEX2-A	MEX2-B
	14.93%	14.93%	14.40%	14.93%	14.40%	14.93%
AUS-A: 7.98%	.516	—	—	—	—	—
AUS-B: 7.98%	—	.426	—	—	—	—
MEX1-A: 5.50%	—	—	.259	—	—	—
MEX1-B: 6.95%	—	—	—	.531	—	—
MEX2-A: 5.50%	—	—	—	—	.323	—
MEX2-B: 6.95%	—	—	—	—	—	.419

Note. All bivariate correlation coefficients were significant at .01 alpha (two-tailed tests).

Table 4.
Results of Paired-Samples *t* Tests on Daily Coin-In for Each Two-Game Pairing.

Two-Game Pairing (Pars)	*M* Difference	*SE* Difference	*t*	*p*	*df*
All cases					
AUS-A (14.93% – 7.98%)	A$-282.66	A$81.01	−3.489	.001	179
AUS-B (14.93% – 7.98%)	A$-144.16	A$81.15	−1.776	.077	179
MEX1-A (14.40% – 5.50%)	Mex$2,698.31	Mex$1,350.87	1.997	.047	179
MEX1-B (14.93% – 6.95%)	Mex$-16,597.28	Mex$3,557.72	−4.665	<.0005	179
MEX2-A (14.40% – 5.50%)	Mex$-767.56	Mex$1,008.14	−0.761	.447	179
MEX2-B (14.93% – 6.95%)	Mex$-3,703.99	Mex$693.97	−5.337	<.0005	179
Outliers omitted					
AUS-A (14.93% – 7.98%)	A$-182.79	A$69.83	−2.618	.010	174
AUS-B (14.93% – 7.98%)	A$-72.84	A$60.88	−1.196	.233	177
MEX1-A (14.40% – 5.50%)	Mex$3,327.53	Mex$1,202.08	2.768	.006	178
MEX1-B (14.93% – 6.95%)	Mex$-13,385.28	Mex$1,883.92	−7.105	<.0005	169
MEX2-A (14.40% – 5.50%)	Mex$-301.49	Mex$674.81	−0.447	.656	176
MEX2-B (14.93% – 6.95%)	Mex$-3,284.57	Mex$634.74	−5.175	<.0005	177

Note. A negative mean difference indicates a greater mean for the game with the *lesser* casino advantage.

daily mean difference was positive for each of the six pairings, indicating greater T-win levels for the high par games.

Regarding daily coin-in observations, statistically significant bivariate correlation ($p < .01$) between the high and low par games was present in each of the six pairings (see Table 3). This was likely due to the chronological observations and served as the basis for the paired-samples *t* test. Because each of the respective daily coin-in values was multiplied by a constant (i.e., par), the correlation coefficients were identical for the T-win observations within each pairing.

Table 4 lists the results of the paired-samples *t* tests for the daily coin-in differences. The results are shown both with and without the effects of the outliers. Our focus was on the latter condition. For AUS-A, MEX1-B, and MEX2-B, the mean was significantly greater for the low par game (A$182.79, $p = .010$, $df = 174$; Mex$13,385.28, $p < .0005$, $df = 169$; and Mex$3,284.57, $p < .0005$, $df = 177$, respectively). The mean coin-in for the high par game was significantly greater for MEX1-A (Mex$3,327.53, $p = .006$, $df = 178$). Given the Bonferroni-adjusted alpha of .0167, the remaining two pairings failed to indicate a statistically significant difference in the mean values of the high and low par games.

While the Table 4 results were mixed, the mean daily coin-in was generally greater for the low par games. Next, we looked for evidence of changes in the magnitude of these differences over time. A review of time series plots indicated a stationary series (i.e., a constant mean and variance) for the coin-in difference produced by each of the six, two-game pairings. Still, the time series models were created to test for a statistically significant change in the means over time, with the results shown in Table 5.

From the Table 5 results, there was no evidence of a significant linear trend in the mean value of the daily difference in coin-in levels. This result held across all six pairings, suggesting that play was not migrating from one game to another.

Table 5.
Summary of Results for Linear Trend Variables (*n* = 180).

Difference Series	Trend Coefficient	*SE B*	*t*	*p*
AUS-A	A$3.81	A$2.04	1.8726	.063
AUS-B	A$0.72	A$1.18	0.6120	.541
MEX1-A	Mex$8.89	Mex$20.48	0.4340	.665
MEX1-B	Mex$-24.22	Mex$37.16	−0.6517	.516
MEX2-A	Mex$0.09	Mex$16.03	0.0057	.996
MEX2-B	Mex$-9.68	Mex$11.94	−0.8109	.419

Note. "Difference Series" refers to daily coin-in differences for each two-game pairing (i.e., high par coin-in – low par coin-in). DV = daily coin-in difference.

Table 6.
Results of Paired-Samples *t* Tests on Daily T-Win for Each Game Pairing.

Two-Game Pairing (Pars)	*M* Difference	*SE* Difference	*t*	*p*	*df*
All cases					
AUS-A (14.93% – 7.98%)	A$105.63	A$8.67	12.182	<.0005	179
AUS-B (14.93% – 7.98%)	A$94.28	A$9.19	10.258	<.0005	179
MEX1-A (14.40% – 5.50%)	Mex$2,806.15	Mex$133.30	21.052	<.0005	179
MEX1-B (14.93% – 6.95%)	Mex$1,234.11	Mex$400.11	3.084	.002	179
MEX2-A (14.40% – 5.50%)	Mex$2,004.45	Mex$97.75	20.505	<.0005	179
MEX2-B (14.93% – 6.95%)	Mex$1,163.25	Mex$81.27	14.313	<.0005	179
Outliers omitted					
AUS-A (14.93% – 7.98%)	A$100.90	A$8.09	12.468	<.0005	177
AUS-B (14.93% – 7.98%)	A$98.45	A$8.24	11.953	<.0005	178
MEX1-A (14.40% – 5.50%)	Mex$2,735.00	Mex$125.03	21.875	<.0005	178
MEX1-B (14.93% – 6.95%)	Mex$789.33	Mex$242.09	3.260	.001	177
MEX2-A (14.40% – 5.50%)	Mex$1,951.32	Mex$76.68	25.449	<.0005	178
MEX2-B (14.93% – 6.95%)	Mex$1,163.25	Mex$81.27	14.313	<.0005	179

Note. All positive mean differences indicate a greater mean for the game with the *greater* casino advantage. MEX2-B contained no outliers.

Next, Table 6 includes the results from the paired-samples *t* tests on the T-win data. Like Table 4, these results were listed with and without the effect of outliers, with our emphasis on the latter. Given the Bonferroni-adjusted alpha of .0167, the mean T-win was significantly greater for the high par game in all six pairings.

To provide perspective, the Australian dollar was nearly equivalent to the U.S. dollar (USD) for most of the sample period, but the average value of the Mexican peso was US$0.055, over the course of the sample periods. When converted to USD, the economic significance of the differences in daily T-win was clarified. The following list restates the gains in daily T-win realized by the high par games, in terms of USD: MEX1-A = $155.44; MEX1-B = $43.42; MEX2-A = $107.33; MEX2-B = $63.99. Again, AUS-A and AUS-B were already stated in comparable terms. All six of the gains listed in Table 6 represented meaningful increases in daily T-win, with four of the six near or beyond US$100 per game, per day.

Time series plots were evaluated for each T-win difference series for signs of play migration. Specifically, we were looking for significant declines in the mean difference over time. As each daily T-win difference was computed by subtracting the low par observation from the high par observation, a decline in the trend line would suggest that play was migrating from the high par game to the low par game. Upon review, the plots failed to reveal such evidence, with all six indicating a stationary series. To verify, the time series regression analyses were performed for each pairing to formally evaluate the effects of the linear trend variables. Table 7 contains the results of these analyses.

From Table 7, none of the trend variables posted a statistically significant result, given the Bonferroni-adjusted alpha of .0167. Notwithstanding the failure to reject the null hypothesis, four of six trend variables did produce a negative slope, but the magnitude of the coefficients was also not economically significant. For example, Mex$-3.18 equates to a daily decline in T-win of approximately US$0.17.

Table 7.
Summary of Results for Linear Trend Variables (n = 180).

Difference Series	Trend Coefficient	*SE* B	*t*	*p*
AUS-A	A$0.01	A$0.16	0.0464	.963
AUS-B	A$0.12	A$0.15	0.7854	.433
MEX1-A	Mex$-5.10	Mex$2.38	−2.1398	.034
MEX1-B	Mex$-3.18	Mex$3.30	−0.9639	.337
MEX2-A	Mex$-2.89	Mex$1.64	−1.7660	.079
MEX2-B	Mex$-3.02	Mex$1.87	−1.6161	.108

Note. "Difference Series" refers to daily T-win differences for each two-game pairing (i.e., high par T-win – low par T-win). DV = daily T-win difference.

Discussion

In terms of the mean difference in daily coin-in, our results were consistent with those from Lucas and Spilde (2018). With outliers removed, the low par game produced a statistically greater mean coin-in in only three of six pairings. Regarding T-win, the results of the paired-samples *t* tests supported Lucas and Spilde, in that the high par game produced a greater mean in each of the six pairings. These results were produced by increases in pars well beyond those examined in Lucas and Spilde, suggesting that economically significant gains in T-win may be possible for operators, with even greater disparity in pars.

In the long term, the low par games would likely produce greater coin-in, as coin-in is a function of par. For example, if played until lost, the same $100 would be expected to generate twice as much coin-in on a 4% game as it would on an 8% game. In the short term, such dramatic differences are often muted by the combination of (a) high pay table variance and (b) insufficient numbers of trials/spins. Of course, if the two games received the same amount of coin-in, the high par game would be expected to win a greater percentage of the wagers. For T-win to increase on the high par game, the gain from the greater house edge must trump the loss from a decline in coin-in, should one occur. When this happens, it suggests that the T-win gained from the increased par is greater than the T-win lost from detection and abandonment.

Regarding the time series analyses, our results were consistent with Lucas and Spilde (2018), providing no evidence of a statistically significant shift in play to the low par game. This result held for the coin-in and T-win data. This was an important finding, in that the increased differences in pars would seem to have provided a greater opportunity for detection by the players.

Our results were not generally consistent with those produced by the single game title tested in Harrigan and Dixon (2010) and Dixon et al. (2013). This could be due to the greater disparity in the pars of their paired title (i.e., 13 percentage points), as well as differences in experimental designs and criterion variables. The results of the current study also challenged the conclusions from Applied Analysis (2015), regarding the role of player sensitivity to increases in pars and the resulting effects on slot revenues.

Although Lucas and Singh (2011) analyzed actual outcomes from slot play, our results generally supported their conclusion that outcomes from session-level play would not allow players to detect differences in pars. The findings from our time series analyses also aligned with the results from Lucas and Singh, regarding the failure to detect a difference in pars after 10,000 simulated play sessions on each of two paired games. While their simulations employed virtual players operating in the de novo condition, our study corroborated their findings by way of a field study, with results produced by actual players in a live casino setting.

The findings from Lucas and Brandmeir (2005) were supported to the extent that the high par games produced the greater T-win. While the mean difference they observed was not statistically significant, the high par version of their games outperformed the low par version.

Managerial Implications

Casino managers are responsible for optimizing the overall yield of the slot floor, which is no simple task. Within this context, the T-win results are particularly meaningful in that they suggest an opportunity to increase win by increasing pars. There are natural trepidations associated with this strategy, as there are widespread fears of being labeled a tight slot floor (Frank, 2017; Lucas & Singh, 2011). However, the results of time series analyses performed by Lucas and Spilde (2018) and those produced by the current study do not provide evidence of play migration from the high par games. This should somewhat allay concerns that a clientele comprised of frequent players is hypersensitive to increases in pars; however, the effects of broader increases in pars remain unknown. Within the broader perspective of the overall slot floor, we do know from performance-potential research that changes in pars did not produce statistically significant effects on game-level coin-in within type and denomination, that is, across all $0.25 reels and all $1.00 reels (Lucas, Dunn, Roehl, & Wolcott, 2004; Lucas & Dunn, 2005).

In terms of the risk-reward relationship, the increases in the unit-level T-win were substantial. For example, with the mean, low par T-win serving as the base, the following percentage gains in mean T-win were produced by the high par game within each pairing: AUS-A, 63%; AUS-B, 170%; MEX1-A, 188%; MEX1-B, 37%; MEX2-A, 154%; and MEX2-B, 77%. These considerable gains were produced by customer bases characterized by frequent visitation, with only one of the three venues featuring a small hotel. This type of clientele would seem to be the most likely to recognize a difference in the pars of otherwise identical games. Still, the high par games produced significantly greater mean T-win levels, in spite of the fact that these savvy players had a clear disincentive to play the high par games.

Our results along with those produced by Lucas and Spilde (2018) question the efficacy of positioning strategies based on low-par messages. If players cannot perceive differences in pars as great as the ones examined in this study, it is not likely they would be able to perceive gaming value via par settings. This could create negative disconfirmation by producing an indistinguishable gaming experience in conjunction with a strong gaming-value message. At the very least, operators may want to revisit this positioning strategy, with consideration for other ways to communicate gaming value. That is, ways that produce gaming experiences that better match the marketing message. For example, decrease the volatility of the games to increase play time. This has been shown to produce a more recognizable effect, at the single-session level (Lucas & Singh, 2008; Lucas, Singh, & Gewali, 2007).

Limitations and Future Research

Although the games were on the floor for 6 months, we do not know how many times an individual played one or both of the paired games. Although no other games with the same titles were offered, there were many other reel games with the same base credit value. For players whose evoked set of games included the experimental titles, there were no other options. For this reason, we contend that at least some players would have had more than an ample opportunity to discover the considerable differences in pars. As noted in Lucas and Spilde (2018), the cross-talk effect allows word to travel quickly throughout player networks. Therefore, the effects of any discovery would be expected to expand considerably.

By making game titles exclusive to the experimental pairings, it is possible that play migration could have been stunted in the single-trip condition. For example, if the low par unit was occupied, a dissatisfied player on the high par game would not be able to immediately migrate to the paired counterpart. While possible, the low occupancy percentage on the slot floors decreased the likelihood of this scenario. In addition, players could still migrate from or avoid the high par units, assuming they were able to discover the greater pars. For example, they could elect to play other games within their evoked set of preferred titles—ones that featured lower pars. They could also wait for the low par unit within a given pairing to become available during their visit. Similarly, players could wait for future opportunities to play the low par games, choosing to boycott the high par units on subsequent visits. In such cases, evidence of migration would appear in the play recorded on future trips. It was not necessary for the gamblers to play both games on the same visit.

At 180 days, the operators all felt that the clientele would have ample time to discover any difference in the pars. Still, it would be interesting to expand the duration of the study. Of course, replication of any stripe would be helpful. To date, 11 two-game pairings have been analyzed across five different casino floors. Results from additional gaming venues and game titles would certainly be helpful in the construction of a working theory. That said, we do not have reason to suspect that changes in game title or venue would necessarily produce different results.

While the findings from Lucas and Spilde (2018) and those produced by this study are consistent, in spite of the increased differences in pars, they represent outcomes from 11 paired titles (i.e., 22 games). The extent to which these results generalize to a wider sample remains unknown. For this reason, the authors suggest a careful and stepped replication of this experiment. Alternatively stated, we do not suggest a simultaneous increase in the pars of all reel games, as such across-the-board changes may produce different results.

Harrigan and Dixon (2010) and Dixon et al. (2013) both found evidence supporting the potential for and ability of players to detect differences in pars, at the level of 13 percentage points. The current study tested paired games with a maximum difference in pars of 8.9 percentage points. Therefore, no one has examined differences in pars between 9 and 13 percentage points. Given the results of this study, addressing this gap in the literature may provide critical insight related to performance and/or detection limits.

Lab studies exploring the psychology of switching behavior would provide additional insight into the gaming activity of slot players. There are a myriad of beliefs and superstitions that could affect play migration within the parameters of our study. For example, the gambler's fallacy could dampen switching behavior in either direction. Similarly, a big payout could spur migration in either direction, that is, away from the game on which it occurred.

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