ANALYTICAL CASE STUDY OF CASINO AND RESORT

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Overview

This article considers the application of big data and data science to real-time player marketing and casino floor management in the casino gaming industry. The article illustrates how using real-time analytics to manage each player's trip can increase estimated casino profitability and improve the player relationship; the article highlights how real-time analysis can improve casino profitability by delivering player real-time insights to front-line employees and management. Other findings indicate that proactively managing player floor navigation could increase player gaming rates for prime players and upgrade middle-tier players to higher-volume betting tiers.

Casino and Resort, a fast-growing industry that combines the gaming and hospitality industries, requires customer-centric thinking to drive revenue. Understanding the needs/wants of individual players and delivering that knowledge to front-line employees and the marketing/floor management groups can provide floor teams (hosts, hostesses. ambassadors, pit bosses, floor operations managers) with real-time player-specific insights that can improve the players' gaming experience and drive new monetization opportunities.

Real-time marketing/sales monetization opportunities make it financially worthwhile for the casino to invest in forming deep, personalized relationships with its players. For real-time marketing/sales to be profitable the casino must understand all the players' gaming and entertainment behaviors in order to improve player acquisition, activation, cross-sell and retention efforts through a better player experience that can drive long-term profits for the casino.

In this paper, we apply Big Data analytics to improve the calculation of the players' Lifetime Value (LTV) [1]. The resulting 'loyalty effect' can reduce the costs of servicing established players and increase long-term player revenues. The underlying premise is that player LTV is built from each customer trip to Casino and Resort. Player LTV is the estimated profitability (CasinoWin as the casino's dollar amount win over player, Timeplay as player's minutes played) of a player over the course of his or her entire tiered (tier rank) relationships with a casino.

This article explores the challenges faced by key casino decision makers and front-line employees to understand and act upon all aspects of player and game playing information including:

1. Tier longevity analysis showing opportunities to encourage play and tier escalation.
2. Statistical analysis indicating when a player's odds of winning shift and when the casino can potentially encourage alternate behavior.
3. Analyzing individual player data to predict which games will be played, and when, as well as predicting casino winnings from that play in order to optimize game inventory and floor layout.

All data in this analysis has been synthesized from real data and altered to prevent privacy conflicts.

Introduction

A Casino and Resort entity comprises departments or lines of business that provide short-term lodging in hotel facilities to support an on-premise casino. The on-premise casino includes table games, slot machines and may include other gambling activities such as Bingo and sports betting. The gaming machines category further includes products from companies that specialize in the design, manufacture, and marketing of electronic entertainment equipment and sophisticated network systems. There are a range of services and amenities, such as food and beverage services, entertainment, valet parking, golf courses, swimming pools and conference and convention facilities provided in the establishments. The industry has growing emphasis on a wide range of entertainment and recreational packages that enrich the casino experience.

As a result, the Casino and Resort industry can offer diversified gaming and entertaining options to maintain profitable hotel occupancy rates regardless of seasonally slow leisure travel periods [5].

Conventionally, for the resort side, there are volume measures for the strength of the business. There are occupancy percentages, average daily rates, and revenue per available room to monitor operating performance. Management needs to optimize room rates and charges for amenities according to booking levels. For the gaming side, relevant gaming indicators include table "win", "drop", and "slot handle":

1. Win, also known as "hold percentage", represents the amount of money wagered that is recorded as casino revenue.

2. Drop is the cash and net markers issued that are deposited into a gaming table's security box.

3. Lastly, slot handle is the coinage placed into machines. Efforts to boost volume and careful review of these measures are crucial to a hotel or gaming company's success.

In this study, we focused the analysis on understanding and monetizing the players' behaviors. The data we used is synthesized from real Casino and Resort data. All personal data has been purged and cleansed. The data population distributions and correlations, however, are maintained to reflect actual players' gaming behaviors.

This paper is organized into the following sections: Casino Data Profiling, Player Tier Duration Analysis, Tier 4 Clustering, Tier 4 Sample Player Analysis and Simulation, Player K Concentration Game Play Analysis, Player K Exploration Game Play Simulation, Casino Front line Floor Management approach for Player K and Conclusion.

Casino Data Profiling

Casino Data contains 88,483 players in the Guest Master file with detailed players' dimension and 1 month of players' gaming transactions from July-August 2014. There are 4 tiered player ranks (Tiers 1-4 with Tier 4 as the highest tier and Tier 1 as the lowest tier) in the data set to indicate the value of the players to the casino. The slot and table games identification data are included in the transactions and are detailed in the appropriate dimensions.

Players' enrollment year tends to concentrate toward 2014 and the 2014 enrollment data is approximately 200% more than the average of prior years as shown in Figure 1. This is reflecting the casino's business focus to drive "my player" acquisition, loyalty enrollment and corresponding casino expansion completeness. The player management becomes more important than prior years.

Overall in this sample, 20% are newly enrolled members in 2014 and 14% are newly enrolled as of July 1, 2014 or later. Guest enrollment day tends to concentrate toward weekends with Saturday (25%) and Sunday (20%) contributing the highest number of enrollments to the loyalty program

The lowest weekday is Tuesday (9%). Monday, Wednesday and Thursday ranges from 10% - 11% as shown in Figure 2.

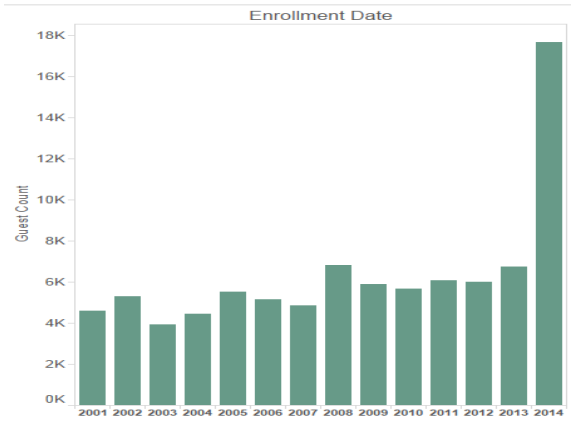


Figure 2. Players' enrollment year distribution (2001 – 2014).

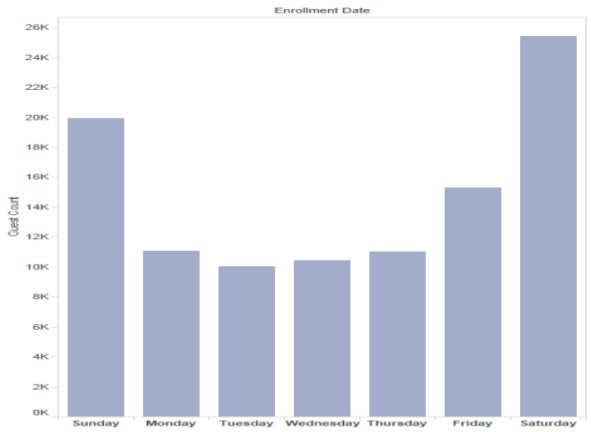


Figure 1. Players' enrollment weekday distribution

Player Tiers (Tiers 1-4 with Tier 4 as the highest tier and Tier 1 as the lowest tier) are broken out as Tier 4 (3.1%), Tier 3 (6.2%), Tier 2 (29.4%), and Tier 1 (61.2%) as shown in Figure 3. The players' gaming activity peaks on weekends and holidays including July 4-5, July 12-13, July 20, and July 26 as shown in Figure 4.

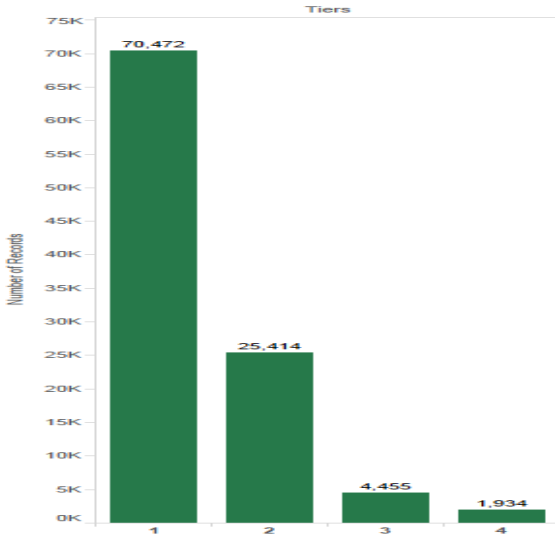


Figure 3. Casino Tier player counter

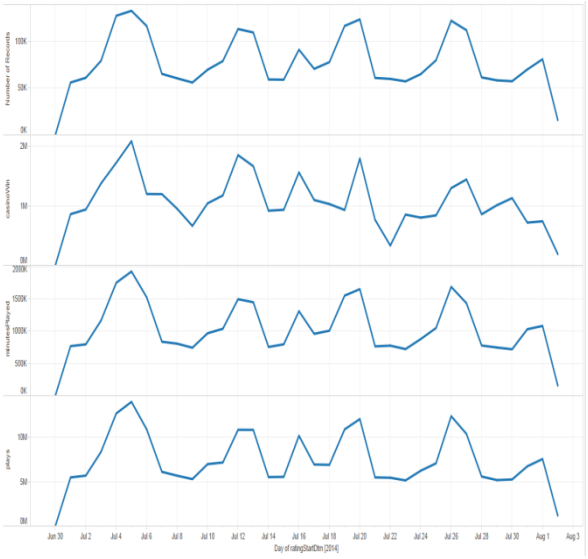


Figure 4. CasinoWin distribution over 1 month

Tier 2 players contribute the highest total CasinoWin every day of the week (Figure 5, Tier 2) except Monday (Tier 4). Mondays, Wednesdays and Saturdays are the most popular days for Tier 4 players. Cumulatively, Wednesday is the second highest grossing day of the week. Tuesdays and Thursdays net the lowest CasinoWin as shown in Figure 6.

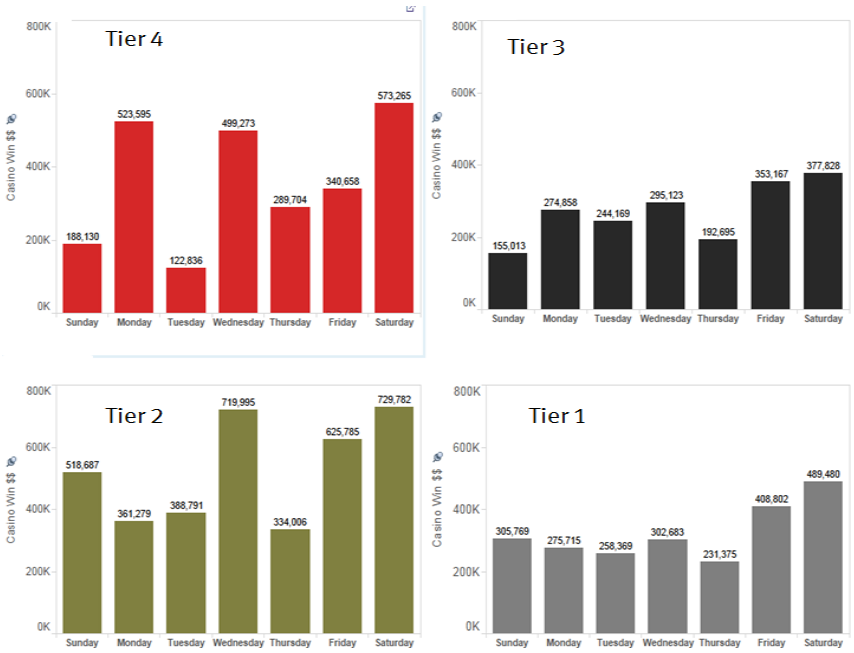


Figure 5. Weekday 4 Tier player CasinoWin ($) distribution

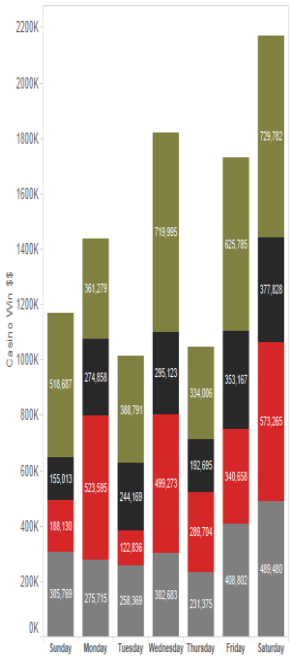


Figure 6. Combined Tiered CasinoWin Per weekday

The casino hourly activities magnitude is dependent on guest volume. However, all tiers' activities counts exhibit Off-peak hours pattern from 4 am to 9 am and with Peak hours pattern from 3 pm to 7 pm within the July 1 –August 1 summer transactions data sample. Timeplay and CasinoWin magnitude is dependent on the casino activities magnitude. All tiers exhibit similar Off-peak hours pattern from 4 am to 9 am and Peak hours pattern from 3 pm to 7 pm within the July 1 –August 1 summer transactions data sample with variability. The variability of Tier 4 hourly CasinoWin is greatest due to large bets/payouts at the end of the casino day (i.e. 4 am jackpot resulted in net negative CasinoWin for that aggregated hour). Tier 3 had steep decline at 7pm. Tier 2 and Tier 1 have very similar temporal distributions. Figure 7a, 7b and 7c demonstrate the patterns.

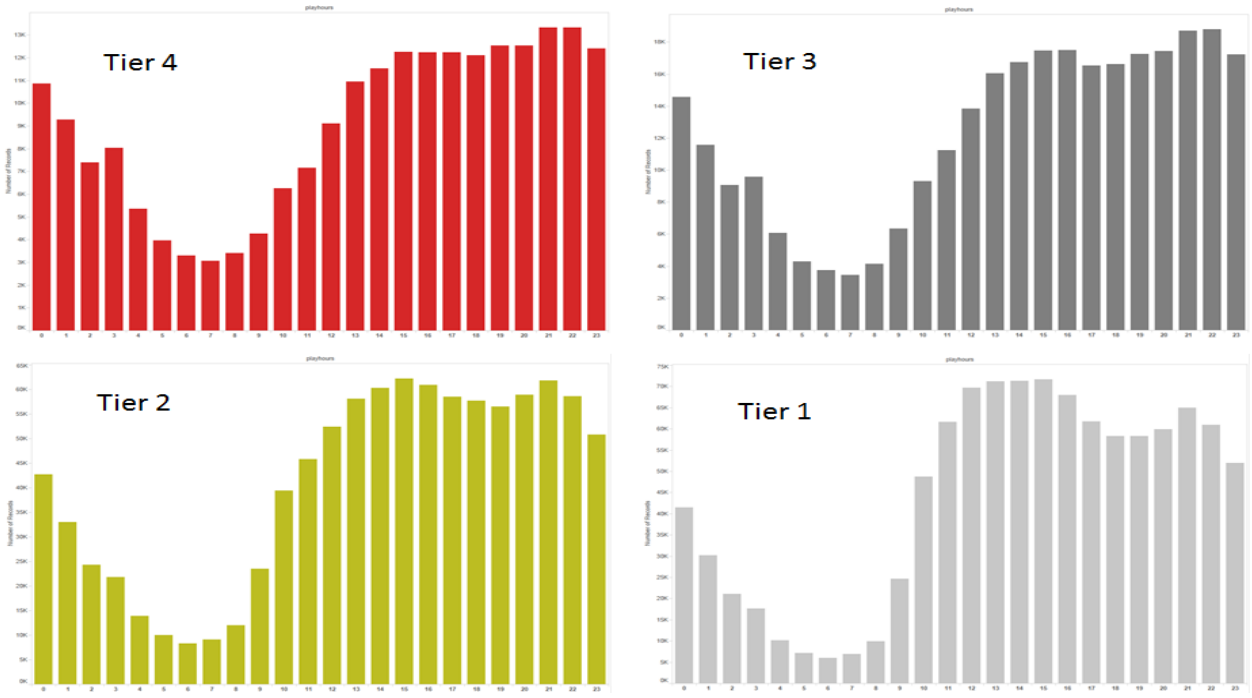


Figure 7a. Four Tiers of the casino players' hourly activities counts.

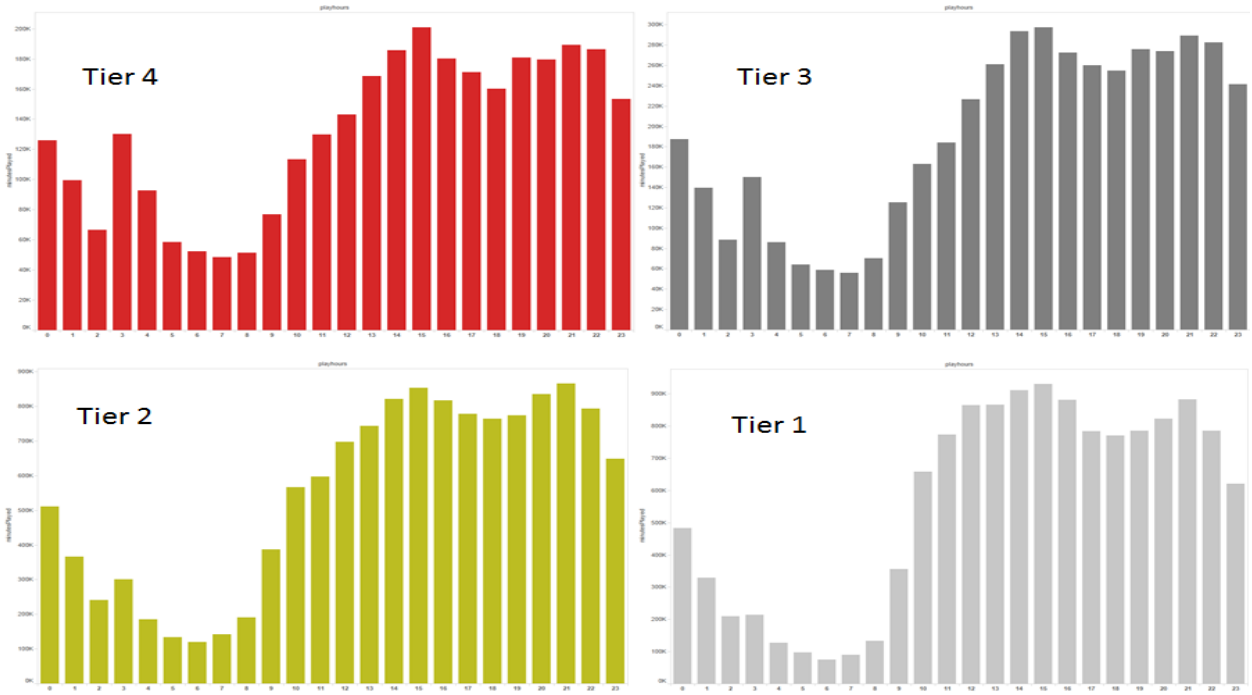


Figure 7c. Four Tiers of casino players' hourly Timeplay.

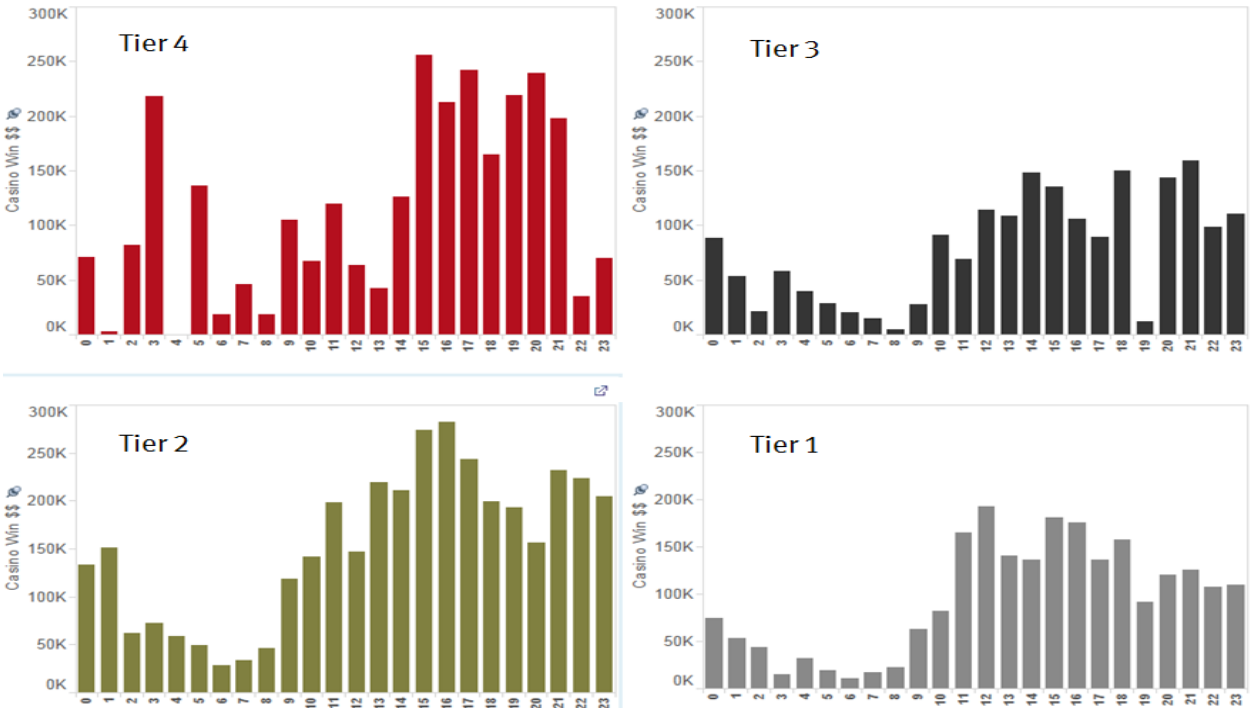


Figure 7c. Four Tiers of casino players' hourly CasinoWin.

For slot and table game categories, the peak-hour CasinoWin pattern is biased toward slot games where the table games are less pronounced as shown in Figure 8. The table games are significantly limited by the number of tables and floor capacity for the tables. The slot games peak hours are from 3 pm to 7 pm and the table games peak from 9 pm to 11 pm.

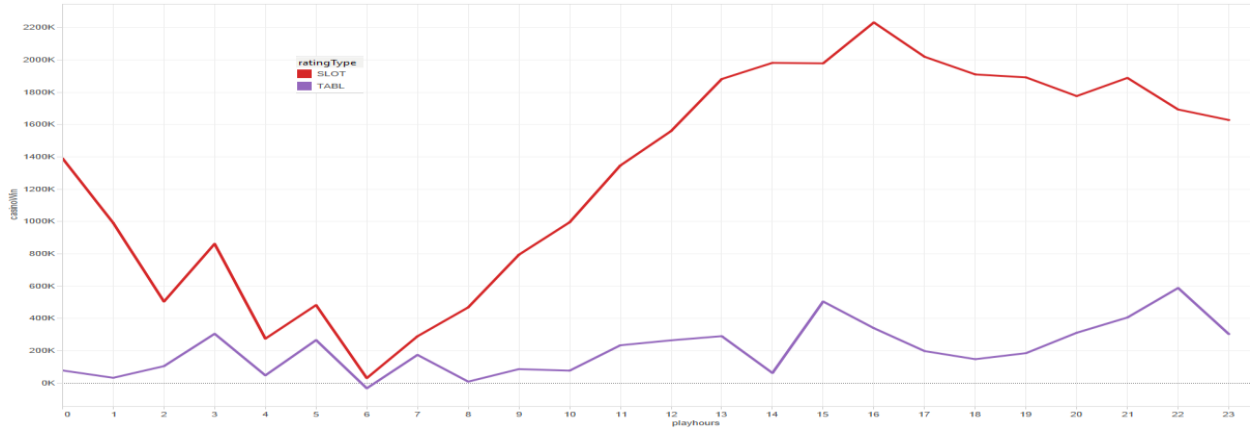


Figure 8. Hourly CasinoWin per Rating type (Slot and Table).

For top 12 ethnicities in the data (shown in Figure 9 and 10), Caucasian players represent the largest CasinoWin of $10,182,818 with average $17 which ranks 8th of 12 ethnicities. Hispanic

players contribute second CasinoWin $7,967,473 with average $13 ranking 10th of 12. The least average CasinoWin is Japanese with average of $11. The midrange ethnicities are Korean, Vietnamese, and Middle Eastern.

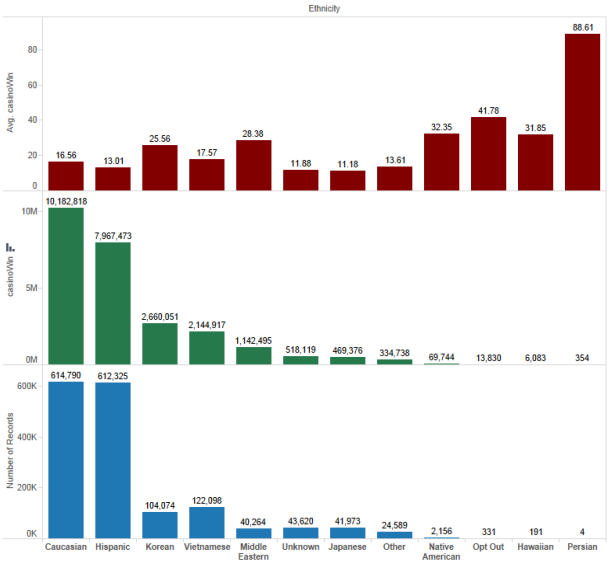


Figure 9. Ethnicity player counts, CasinoWin and average CasinoWin. Korean and Middle Eastern ethnicities have higher average CasinoWin among top 5 total CasinoWin ethnicities.

Ethnicity	Avg. casinoWin	Number of Records	casinoWin
Caucasian	17	614,790	10,182,818
Hispanic	13	612,325	7,967,473
Korean	26	104,074	2,660,051
Vietnamese	18	122,098	2,144,917
Middle Eastern	28	40,264	1,142,495
Unknown	12	43,620	518,119
Japanese	11	41,973	469,376
Other	14	24,589	334,738
Native American	32	2,156	69,744
Opt Out	42	331	13,830
Hawaiian	32	191	6,083
Persian	89	4	354

Figure 10. Details of Ethnicity player counts, CasinoWin and average CasinoWin. Top 5 CasinoWin ethnicities are Caucasian, Hispanic, Korean, Vietnamese and Middle Eastern.

The distribution of players' ages appears to be centralized with a mean of 56.0 and median of 55.5. The curve between ages32-80 presents strongly normalized distribution. 58 is the most common age (aka "mode" age). Figure 11 and 12 show the distributions.

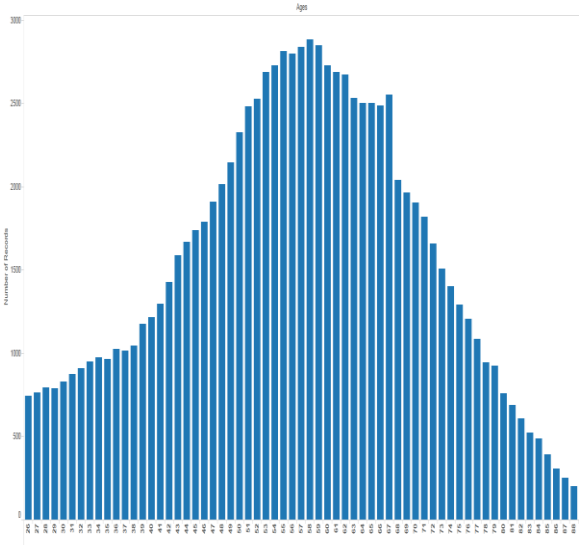


Figure 11. The core player age is centralized at baby boomer. The mode age is 58 years old.

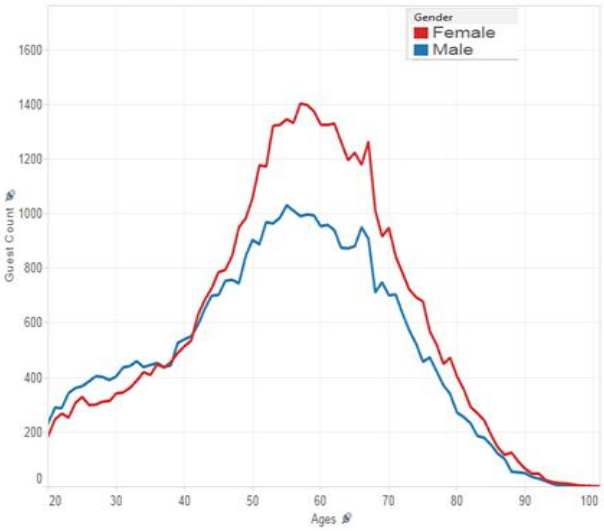


Figure 12. Female player population is 11% more than the male player population.

Domestic players' geographical distributions are concentrated mainly in (southern) California where the casino is located. The next highest geographical distributions are Arizona, and Washington and Nevada. Figure 13 and 14 display the density of geo distributions.

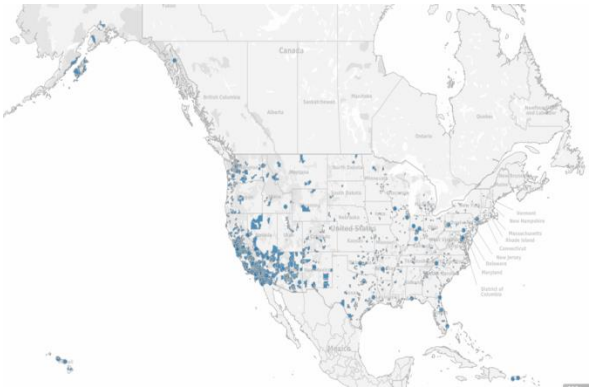


Figure 13. Casino player Geo distribution across domestic US is concentrated at west coast, in particular, southern California.

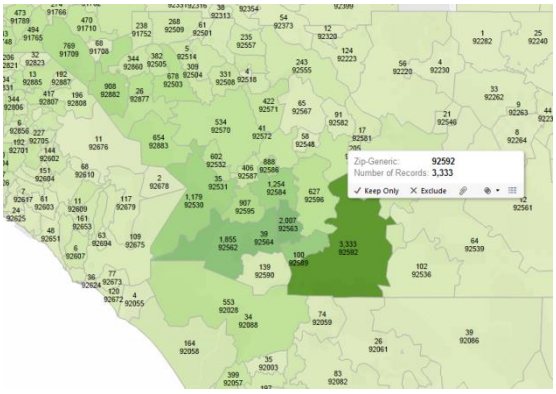


Figure 14. Across southern California, zip code of 92529 has highest concentration of +3K players resided.

Based on current players' zip codes, the distance between players and the casino peaks at 50-100 miles of radius. 86% of players in sample live within a 100 mile radius of the casino (Los Angeles and San Diego represent the vast majority of the core players). Figure 15 and 16 show the behaviors.

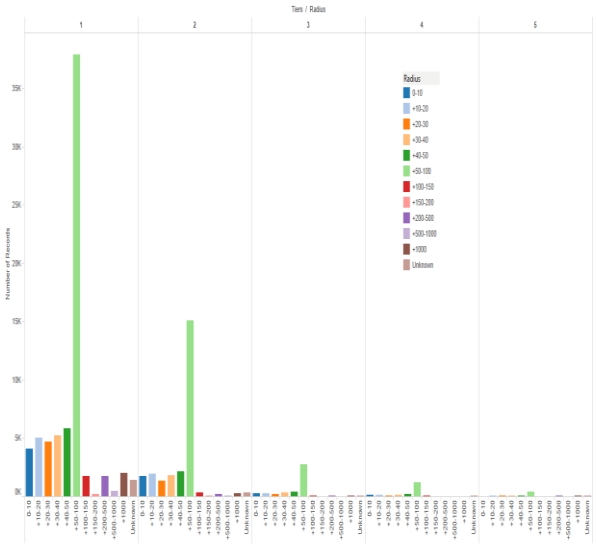


Figure 15. For each Tier, the player counts of 50-100 miles residential radious are 6 times higher than the other distance range.

Figure 16. There are two major matropoltains within the 50-100 miles. One is Los Angeles and the other is San Diego.

There are limited transportation options to reach the casino. The only transportation options are bus and car. Using Google API, expected drive duration/travel time between each zip code and the casino address can be computed. 50% of customers drive time to the casino is 67 minutes or less.

The morning and evening bus schedules be taking consideration round trip time (67 x2 minutes) spend to maxmize the player experience in the casino instead of in transportation when players departing from Los Angles or San Diego. Figure 17 shows the mean travel time and customer counts.

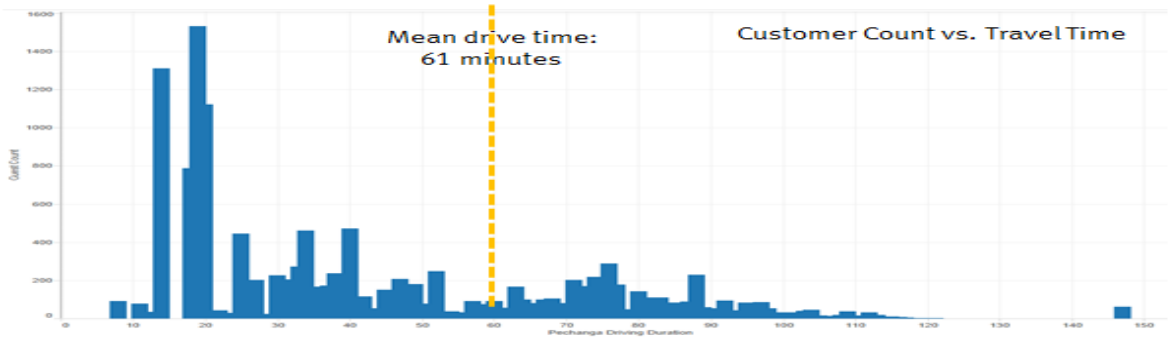


Figure 17. From Google API, the mean travel time for player to the casino is 61 minutes. 50% of customers driving time to the casino are 67 minutes or less. The highest count occurs at 20 minutes driving.

Player Tier Duration Analysis

Players' tier patterns are shaped by the players' transaction interactions with the casino gaming. A tiered players club helps the casino to separate the more valuable players from the average players while at the same time offering incentives for players to move up to the higher tiers. The casino's tier system starts with an entry-level tier for all players, interim levels for those who play above the norm, and finally a top tier that gets the attention and the rewards deserving of the casino's most valuable players. While the criteria for each level may vary from casino to casino, the strategy remains similar. It is to understand player "tier longevity" pattern and incent players across tiers. To measure the tier longevity, survival analysis is adapted for this analysis.

Survival analysis is a statistical analysis technique that analyzes time duration until one or more events happen. This topic is also called duration analysis or duration modeling in event history analysis in sociology. Survival analysis attempts to answer questions such as: what is the proportion of a population that will survive past a certain time? Of those that survive, at what

rate will they die or fail? How do particular circumstances or characteristics increase or decrease the probability of survival?

The sample data is souring from a data warehouse modeling with star schema. It consists of dimensions (type II slowly change dimensions – tracking the changes, including tier, of each player's attributes) and fact tables. The data process approach is to unfold type II slowly changing guest dimension table in the data store and merge with guest dimension to identify the entry and exit of Tiers status historically. The guest dimension contains full history of all the players.

The steps are;

1. Identify the duration (start and ending time IDs).
2. Identify the model time step.
3. Identify the unique ID for the guest and add demographic data, and player gaming patterns.
4. Process the Survival Model and identify the life span of each tier.

To study the tier behavior, the simplified stochastic model is shown in Figure 18. Xi represents tier advancing, Yi represents tier downgrading, and Zi represents tier player move to "Not Playing". To explain X, Y, and Z behaviors, the following analyses, player survival analysis, game effectiveness, and linear trending are used to emulate the behaviors.

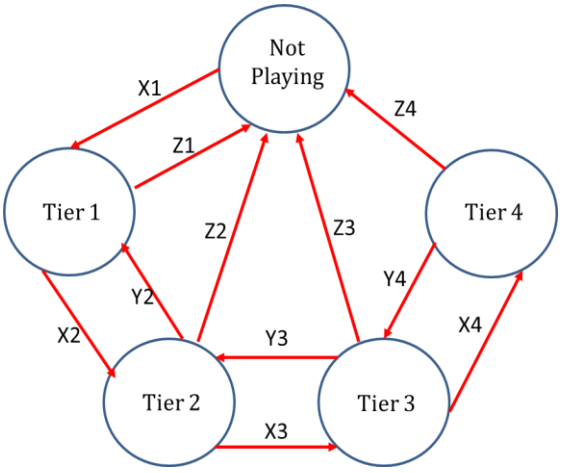


Figure 18: The simplified tier stochastic model.

The analysis is representing the full history guest dimension samples data we received. For each tier, the approach is using survival analysis. The first sets of survival analysis yield the following preliminary observations.

- Tier 1 players have high turnover rate (2%) at the beginning period of enrollments. When a player is in Tier 1 state, he/she is relatively stable. Only 5% will move up to the next stage (Tier 2) within the period of 16 years as shown in Figure 19.
- Tier 2 players have the most stable state. The projected change will only occur after 15 years within 5% range as shown in Figure 20.
- Tier 3 players have highest change rate. The projected change rate will be 25% within 15 years as shown in Figure 21.
- Tier 4 players are very stable for the period of 15 years and a steep drop 5% at the end of 15 years as shown in Figure 22.

The casino has relatively stable low-end customers (Tier 1 and 2), very fluid midrange players (Tier 3), and relatively stable high-end players (Tier 4).

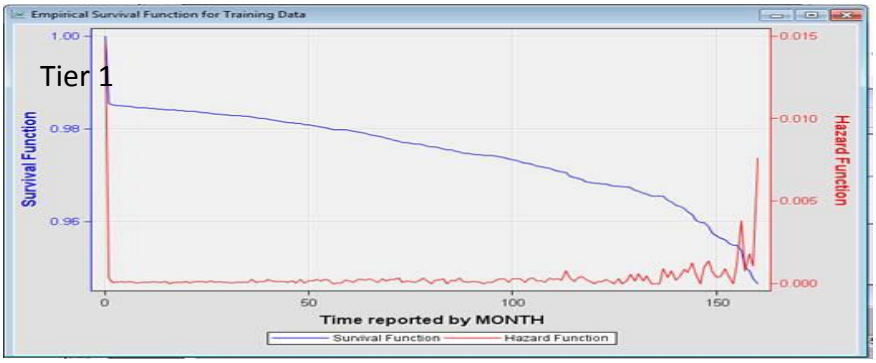


Figure 19: Player staying Tier 1 duration after entering Tier 1

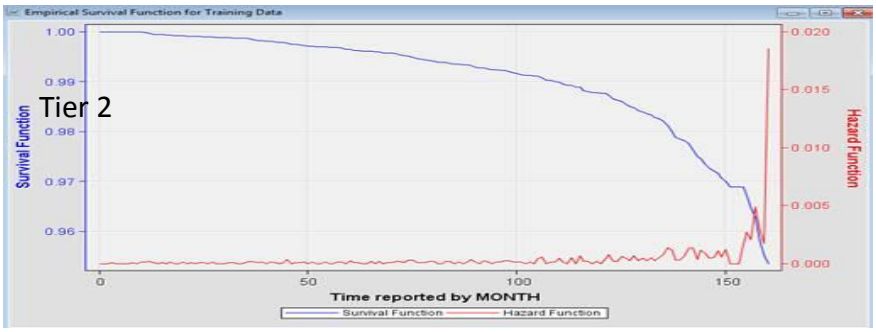


Figure 20: Player staying Tier 2 duration after entering Tier 2

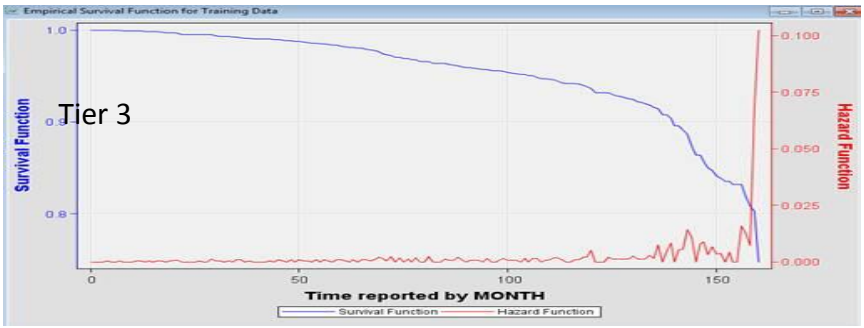


Figure 21: Player staying Tier 3 duration after entering Tier 3

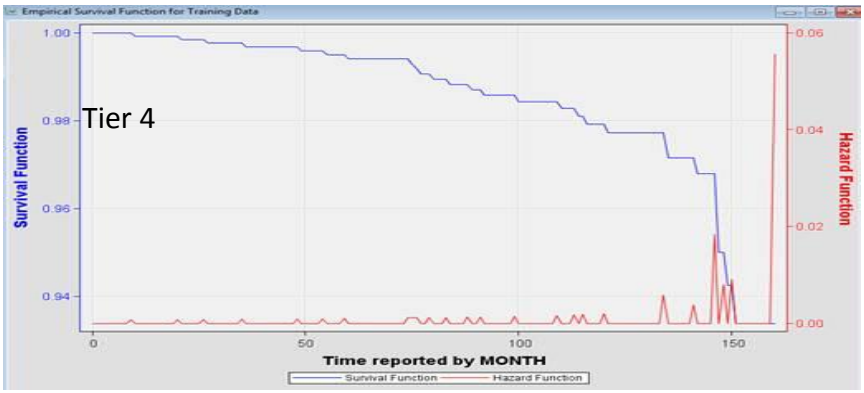
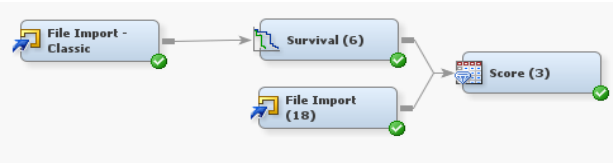


Figure 22: Player staying Tier 4 duration after entering Tier 4

Figure 23 is an example. With the trained model, the casino could score each customer's tenure duration. In the following example, the trained model results could be leveraged for individual customer's scoring within the Tier. The sets of scores related to current survival rate, future survival rate (with event occurrence probability) could provide the risk and lead-time to actions. In the example below, Player 2558681 has 96% probability of staying with the casino and 92% 3 month outlooks. The event of downgrading or leaving the casino is 3.8%.



Variable Name	Creator	Variable Label	Function
EM_HAZARD	SURV6	Hazard Function at Censoring Time	TRANSFORM
EM_HZRDFCST	SURV6	Hazard Function at Future Time	TRANSFORM
EM_SUBHZRD0	SURV6		TRANSFORM
EM_SUBHZRD0_SURV	SURV6		TRANSFORM
EM_SUBHZRD1	SURV6		TRANSFORM
EM_SUBHZRD1_SURV	SURV6		TRANSFORM
EM_SURVEVENT	SURV6	Event Probability before or at the Future Time	TRANSFORM
EM_SURVFCST	SURV6	Survival Probability at Future Time	TRANSFORM
EM_SURVIVAL	SURV6	Survival Probability at Censoring Time	TRANSFORM
T_FCST	SURV6	Number of Time Units in Future	TRANSFORM
_T_	SURV6		TRANSFORM
warn	SURV6	Warnings	TRANSFORM

	guestname	SourceAccountID	..	..	..	..	tiers	..	Survival Probability at Censoring Time	Survival Probability at Future Time	Event Probability before or at the Future Time	Hazard Function at Censoring Time	Hazard Function at Future Time
1	2558681:	2558681.0	...	...	...	...	Classic	...	0.961424265857087	0.9256905008360597	0.03716752976811065	0.0385757341429130	0.0044291882190251
2	2558679:	2558679.0	...	...	...	...	Classic	...	0.9614256371370442	0.9256931063969146	0.03716619295334663	0.0385743628629557	0.0044290251796161
3	2558673:	2558673.0	...	...	...	...	Classic	...	0.9614281053230571	0.9256977961889519	0.03716378680452577	0.0385718946769428	0.0044287317237363625
4	2558572:	2558572.0	...	...	...	...	Classic	...	0.9614694933984151	0.9257764387858624	0.03712343954501555	0.0385305066015849	0.0044238110720495
5	2558561:	2558561.0	...	...	...	...	Classic	...	0.9614725067573475	0.925782164642669	0.03712050200483357	0.0385274932426525	0.0044234582826747023
6	2558540:	2558540.0	...	...	...	...	Classic	...	0.9614788066859324	0.9257941355401884	0.03711436060535076	0.0385211933140675	0.0044227038617145
7	2558539:	2558539.0	...	...	...	...	Classic	...	0.9614796283428403	0.9257956968271054	0.03711355962605053	0.0385203716571596	0.0044226061799314
8	2558531:	2558531.0	...	...	...	...	Classic	...	0.9614812716061851	0.9257988193078307	0.03711195771785108	0.0385187283938149	0.0044224108228086

Figure 23: Steps to score player using survival analysis results.

Slot and Table Game Profit Effectiveness and Duration for Ranking could be evaluated using CasinoWin as a criterion. Figure 24 and 25 show the survival curves of slot and table games.

- The Players expected to win is rapidly decreased for both Slot and Table games.
- For slot machines games, the casino expects to win over player at average 30 minutes duration of continual betting. Player survival rate is at 2% after 30 minutes of playing.
- The hazard value increase from 20% to 50% after 30 minutes of betting (with 2 gaps occurred as shown in Figure 24).
- For table games, the risk is decreased at the same level of a player playing life span.
- Post-15 minutes play, the average table game player risk increase doubles and moves into risk increasing damping area.
- The lows of hazard functions are introduced by the events of jackpots (Figure 24).

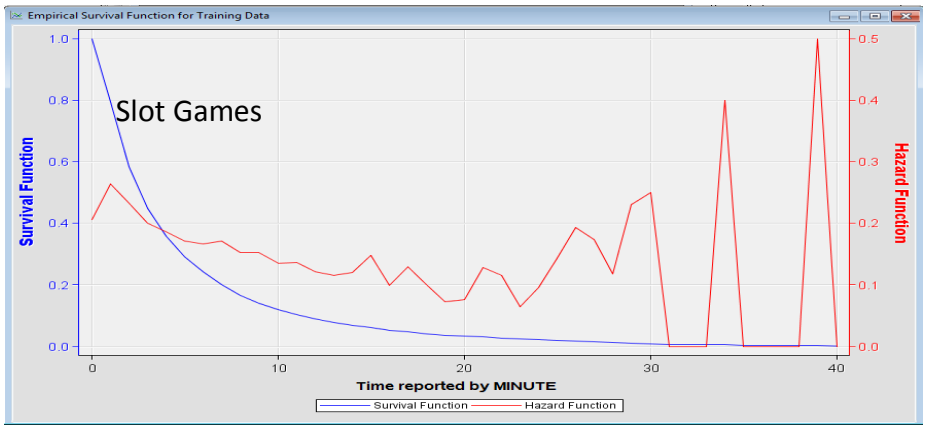


Figure 24: Analyze Slot machine player wining distribution vs. time play in using survival analysis.

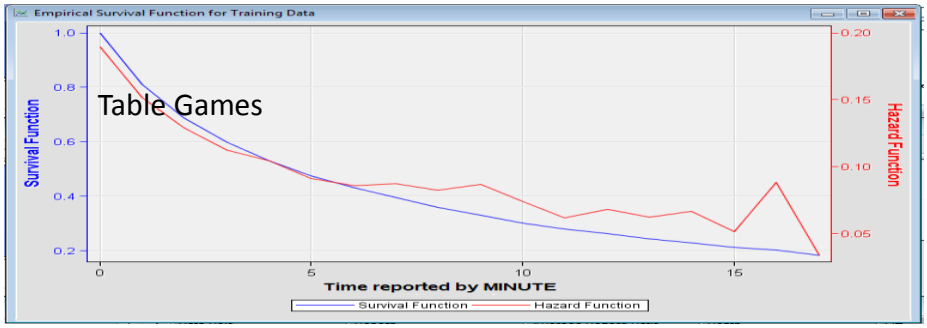


Figure 25: Analyze Table Game player wining distribution vs. time play in using survival analysis.

To utilize the study above, the following is an example (Table 1). In this example, the projected Survival rate for a player playing a Table Game is rapidly decreased at 40 minutes of continuous play. This knowledge could be leveraged to evaluate the casino income vs. comps rationalization.

Table MasterKey	Time Interval (to Stop Play)	Table Survival Probability at Future time
87	3 minutes	81%
87	10 minutes	28%
87	20 minutes	14.50%
87	40 minutes	3.40%

Table 1: Example of using particular Table Game to study the effectiveness of the casino winning.

Leveraging the approach above, gaming effectiveness could be calculated for each slot and table games across all casino floors.

Casino Win Probability of Slot Machine				
Slot Game Name	Game installation Counts	Playing 5 minutes	Playing 10 minutes	Playing 15 minutes
GAMEKING6.0M	219	0.803	0.964	0.986
BONUSTIMES1L	110	0.94	0.979	0.989
BUFFALO	61	0.958	0.988	0.995
BONUSTIMES	47	0.942	0.974	0.989
SUN&MOON	37	0.935	0.981	0.989
TIKITORCH	36	0.932	0.982	0.988
WICKEDWINNINGS2	34	0.951	0.981	0.995
WOLFRUN	31	0.942	0.982	0.994
ROULETTESM	30	0.833	0.955	0.984
5DRAGONS	26	0.936	0.985	0.999
POMPEII	26	0.959	0.989	0.999
DMNDS&DEVILS	26	0.907	0.962	0.981
BLZNG7S1L	25	0.903	0.969	0.983
CLEOPATRA2	22	0.911	0.971	0.988

Table 2: Top 14 slot machine installations' probability of the casino to Win over Player by play time.

Casino Win Probability of Table Game				
Table Game Name	Game installation Counts	Playing 5 minutes	Playing 10 minutes	Playing 15 minutes
Continuous Shuffler Blackjack	29	0.54	0.71	0.79
Double Deck Blackjack	29	0.57	0.73	0.79
Manual Shoe Blackjack	24	0.51	0.68	0.76
Midi Baccarat-EZ	16	0.51	0.69	0.75
Roulette	12	0.52	0.65	0.75
Emperor's Pai Gow	9	0.49	0.72	0.83
Ultimate Texas Holdem	7	0.53	0.71	0.8
Three Card Poker	6	0.55	0.71	0.82
Fortune Pai Gow	4	0.44	0.63	0.75
Craps	2	0.5	0.71	0.8
Let it Ride	2	0.52	0.73	0.79

Table 3: Top 11 table game installations' probability of the casino to Win over Player by play time.

With the projected Survival rate for each player, it is feasible to calculate the casino win ratio per types of games with the time duration that is rapidly increased at 15 minutes continuing play. *Note:* the gaming type entertainment characteristics (e.g. game theme, game age, game size, and other game physical characteristics) have not been evaluated.

To study dynamic within the tier, the linear trend analysis is used. CasinoWin and TimePlay linear trend rate (Eq. 14) could be calculated to evaluate the flows within the tiers.

$$y = \alpha x + \beta \qquad \text{Eq. 14}$$

The Coefficients are

$$\alpha = \frac{n\sum(xy) - \sum x \sum y}{n\sum x^2 - (\sum x)^2} \qquad \text{Offset } \beta = \frac{\sum y - \alpha \sum x}{n}$$

The coefficient (α) represents the acceleration rate in terms of CasinoWin (cw) and TimePlay (tp) calculated for each player. Four types of conditions with combinations of cw(+/-) and tp(+/-) with 0 is inactive. Each individual has a different acceleration rate to be treated (examples shown in Table 4). The Positive Coefficients represent the tendency to move to a higher tier and Negative Coefficients represent the tendency to move to a lower tier. Coefficient = 0 represents inactive or no playing.

guestMasterKey	minutesplayed_RegressCoeff	minutesplayed_Intercept	casinowin_RegressCoeff	casinowin_Intercept	Tier
1	0	1	0	100	Tier 1
16	0	56	0	45	Tier 1
21	0	154	0	565.77	Tier 1
23	1.401853412	-192.9595619	2.049570345	-335.694147	Tier 1
27	0	0	0	0	Tier 1
35	7.047830923	-1026.470523	0.980107675	-245.0956197	Tier 1
40	0	125	0	134.1	Tier 1
49	3.686075949	-716.843038	-1.522531646	483.1987658	Tier 2
52	2.63372093	-459.4767442	7.589249128	-1388.828027	Tier 1
58	7.829808661	-1462.98288	4.026988922	-689.857851	Tier 1
61	0	121	0	224	Tier 1
67	-0.177588842	62.34017959	-0.387983187	67.07795418	Tier 1
70	2.023431761	-257.5457617	-6.504767049	1791.078607	Tier 3
74	-8.253554502	1693.42891	-23.70533246	4895.798501	Tier 2
78	-10.72030238	2448.382289	-11.87454071	2720.101987	Tier 2
81	0	204	0	0	Tier 1
89	0	3	0	7.9	Tier 1
96	5.965690054	-1029.206631	9.761777178	-1753.471881	Tier 2
106	1.081632653	-171	-8.042142857	1520.625	Tier 1
107	0	46	0	0	Tier 1
122	0.328125	-57.96875	2.07125	-411.8575	Tier 1
134	152	-30138	90.5	-17984.3	Tier 1
135	0	366	0	357.81	Tier 2
136	-3.325	848.025	-1.8131375	402.5880875	Tier 2
141	-3.510373444	772.0124481	6.191951452	-1227.408582	Tier 1
144	6.816568047	-1190.313609	-80.48816568	15796.38314	Tier 1
145	0.689533239	24.23055163	4.338755304	-778.318529	Tier 1
149	-5.825242718	1395.048544	2.763851133	-458.7752265	Tier 1
153	0	45	0	133.01	Tier 1
187	-1.972477064	466.412844	36.89697248	-7377.129413	Tier 2

Table 4: Linear coefficients of CasinoWin and TimePlay for Tiers

Each tier has unique aggregative behavior as shown in Table 5.

- Tier 1: Tier 1 contains the most inactive (0 – or indecision) and has smallest positive and negative values. All indicate under-stimulated population.
- Tier 2: Tier 2 has inactive dropping from 60%+ to 30%. Negative coefficient percentage and positive coefficient percentage each increase ~15%.
- Tier 3: Most inactive percentage in Tier 3 reduces ~12% from Tier 2 to Tier 3. Negative coefficient percentage increases 12%.
- Tier 4: the positive coefficient for CasinoWin is leveled off with Tier 3.

Tiers	Total_CNT	MinutesPlayed PCT %			CasinoWin PCT %		
		Positive Coefficient	Negative Coefficient	Zero (Inactive)	Positive Coefficient	Negative Coefficient	Zero (Inactive)
Tier 1	70472	25.11	11.63	63.26	22.47	13.63	63.91
Tier 2	25414	42.78	26.65	30.57	39.64	30.07	30.29
Tier 3	4455	48.53	34.25	17.22	46.33	36.50	17.17
Tier 4	1934	53.10	35.78	11.12	46.90	41.99	11.12

Table 5: In-Tier activities measured by (+/-) coefficients

Information from this analysis could be used to identify and action taken to activate inactive players.

Tier 4 Clustering Analysis for Players and Players' Gaming Selection

Tier 4 is the high roller group most requires casino attention. For the average CasinoWin per player visit, it ranges Tier 1 with $7.91, Tier 2 with $12.95, Tier 3 with $24.15, and Tier 4 with $38.84. From the clustering analysis of Tier 4, the most important clustering factors are slot_cnt (number of slot machines played), table_cnt (number of table game played), Wday (Day of week), Hotel_nights (number of nights in hotel), Hotel_rooms (number of rooms), and Diff_day (day differences between purchase ticket and perform of the events) as shown in Table 6. Among 24,315 qualified samples, the clustering analytics created 5 distinct groups as shown in Figure 26.

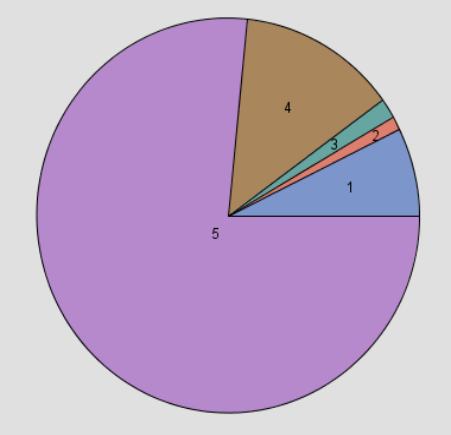


Figure 26: Tier 4 players segmentations. Five segmentations are established by the variables in the Table 6.

Table 6: Cluster details of mean and variance for each variable.

Cluster ID	Cluster Stat	Slot_cnt	Table_cnt	Diff_date_tck	Ticket_cnt	Hotel_nights	Room_cnt	Person_cnt
1	Mean	2.47	8.25	0.13	0.01	0.29	0.29	0.31
	Variance	15.30	9.66	13.22	0.03	0.59	0.59	0.76
2	Mean	2.68	24.44	0.00	0.00	0.36	0.36	0.37
	Variance	27.74	59.97	0.00	0.00	0.70	0.70	0.88
3	Mean	51.74	0.46	0.00	0.00	0.38	0.38	0.41
	Variance	297.56	1.91	0.01	0.01	0.64	0.64	0.87
4	Mean	18.64	0.38	0.38	0.01	0.27	0.27	0.29
	Variance	40.71	1.14	34.11	0.04	0.54	0.57	0.70
5	Mean	2.35	0.43	0.19	0.01	0.67	0.68	0.70
	Variance	8.46	0.94	16.46	0.03	0.89	0.90	1.03

- Group 1: contains 1763 samples. Players focus on the very select slot (mean = 2.4) and tables games (mean = 8.25)
- Group 2: contains 254 samples. Players focus primarily on table games (mean = 24.4) with wider choices. This is different from Group 1 with table game focused.
- Group 3: contains 514 samples. Players primarily focus on the slot machine games with large variety (mean =51.47)
- Group 4: contains 3257 samples. Players solely focus on slot machine games (mean = 18.63)
- Group 5: contains the largest group 18637 samples. Players tend to solely focus on specific slot machines (mean = 2.35) with higher hotel stays. It is very different from Group 3 that also focuses on the slot machine)

Players have different behaviors within the same Tier (4). Three distinct types of players emerged from the clusters of sample data: **The mentalist** – Core Table players, **The Spin Master** – Core Slot players, and **The DJ** – Mix Slot/Table players.

Samples are shown below.

Guest ID	Date	PlayTimeStart	Game Type Name
100172454	7/3/2014	7/3/2014 14:50	TABL---Double Deck Blackjack
100172454	7/3/2014	7/3/2014 18:09	TABL---Double Deck Blackjack
100172454	7/3/2014	7/3/2014 19:27	TABL---Double Deck Blackjack
100172454	7/3/2014	7/3/2014 19:53	TABL---Double Deck Blackjack
100172454	7/16/2014	7/16/2014 14:20	TABL---Double Deck Blackjack
100172454	7/16/2014	7/16/2014 16:10	TABL---Double Deck Blackjack
100172454	7/16/2014	7/16/2014 16:15	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 15:02	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 18:39	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 20:08	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 20:43	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 21:02	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 21:59	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 22:16	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 22:38	TABL---Double Deck Blackjack
100172454	7/20/2014	7/20/2014 23:14	TABL---Double Deck Blackjack
100172454	7/20/2014	7/21/2014 0:07	TABL---Double Deck Blackjack
100172454	7/20/2014	7/21/2014 0:20	TABL---Double Deck Blackjack
100172454	7/20/2014	7/21/2014 0:34	TABL---Manual Shoe Blackjack
100172454	7/20/2014	7/21/2014 0:38	TABL---Double Deck Blackjack
100172454	7/20/2014	7/21/2014 1:33	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 16:04	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 17:43	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 18:09	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 18:18	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 20:43	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 20:57	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 22:50	TABL---Double Deck Blackjack
100172454	7/23/2014	7/23/2014 23:01	TABL---Double Deck Blackjack

Table 7: Players exclusively play Table Games.

Guest ID	Date	PlayTimeStart	Game Type Name
10870054	7/5/2014	7/5/2014 15:39	SLOT---CLEOPATRA2
10870054	7/5/2014	7/5/2014 16:28	SLOT---CLEOPATRA2
10870054	7/5/2014	7/5/2014 16:43	SLOT---CLEOPATRA2
10870054	7/5/2014	7/5/2014 18:01	SLOT---CLEOPATRA2
10870054	7/5/2014	7/5/2014 18:34	SLOT---CLEOPATRA2
10870054	7/5/2014	7/5/2014 23:19	SLOT---TWINWIN
10870054	7/5/2014	7/5/2014 23:26	SLOT---CLEOPATRAII
10870054	7/5/2014	7/6/2014 1:30	SLOT---TWINWIN
10870054	7/5/2014	7/6/2014 1:36	SLOT---CLEOPATRAII
10870054	7/5/2014	7/6/2014 2:43	SLOT---COYOTEMOON
10870054	7/5/2014	7/6/2014 3:49	SLOT---CLEOPATRAII
10870054	7/6/2014	7/6/2014 4:29	SLOT---CLEOPATRA2
10870054	7/6/2014	7/6/2014 4:34	SLOT---CLEOPATRA2
10870054	7/6/2014	7/6/2014 4:37	SLOT---CARNIVALOFMYSTER
10870054	7/6/2014	7/6/2014 5:40	SLOT---TWINWIN
10870054	7/11/2014	7/11/2014 19:28	SLOT---CLEOPATRA2
10870054	7/11/2014	7/11/2014 19:34	SLOT---CLEOPATRA2
10870054	7/11/2014	7/11/2014 19:57	SLOT---CLEOPATRA2
10870054	7/12/2014	7/12/2014 17:52	SLOT---CLEOPATRA2
10870054	7/12/2014	7/12/2014 18:25	SLOT---CLEOPATRA2
10870054	7/23/2014	7/23/2014 23:07	SLOT---VALHALLA
10870054	7/23/2014	7/24/2014 0:13	SLOT---VALHALLA
10870054	7/23/2014	7/24/2014 0:14	SLOT---CLEOPATRAII
10870054	7/23/2014	7/24/2014 1:27	SLOT---TWINWIN
10870054	7/23/2014	7/24/2014 2:00	SLOT---CLEOPATRA2
10870054	7/23/2014	7/24/2014 2:07	SLOT---MWAZTECTEMPLE
10870054	7/23/2014	7/24/2014 2:31	SLOT---CLEOPATRA2
10870054	7/23/2014	7/24/2014 2:32	SLOT---TWINWIN
10870054	7/23/2014	7/24/2014 2:48	SLOT---TWINWIN
10870054	7/23/2014	7/24/2014 3:03	SLOT---BLZNG777QHP6L

Table 8: Players exclusively play Slot Machines.

Guest ID	Date	PlayTimeStart	Game Type Name
207714254	7/3/2014	7/3/2014 19:10	TABL---Roulette
207714254	7/3/2014	7/3/2014 19:26	TABL---Roulette
207714254	7/3/2014	7/3/2014 19:39	TABL---Roulette
207714254	7/3/2014	7/3/2014 19:42	TABL---Roulette
207714254	7/4/2014	7/4/2014 22:47	TABL---Roulette
207714254	7/4/2014	7/4/2014 23:00	TABL---Roulette
207714254	7/4/2014	7/4/2014 23:35	TABL---Emperor's Pai Gow
207714254	7/4/2014	7/4/2014 23:59	TABL---Roulette
207714254	7/4/2014	7/5/2014 0:02	TABL---Roulette
207714254	7/4/2014	7/5/2014 1:03	SLOT---PLANTSVSZOMBIES
207714254	7/4/2014	7/5/2014 1:18	TABL---Roulette
207714254	7/5/2014	7/5/2014 17:14	SLOT---BLZNG777SDBL1L
207714254	7/5/2014	7/5/2014 17:54	TABL---Roulette
207714254	7/5/2014	7/5/2014 21:16	TABL---Roulette
207714254	7/5/2014	7/5/2014 21:51	TABL---Roulette
207714254	7/5/2014	7/5/2014 23:18	TABL---Emperor's Pai Gow
207714254	7/5/2014	7/5/2014 23:48	SLOT---BLK&WHTDBL1L
207714254	7/5/2014	7/5/2014 23:55	SLOT---INDEPENDENCEPAY
207714254	7/5/2014	7/6/2014 0:12	SLOT---BLK&WHT5XPAY
207714254	7/5/2014	7/6/2014 0:25	TABL---Roulette
207714254	7/8/2014	7/8/2014 17:50	TABL---Roulette
207714254	7/8/2014	7/8/2014 18:07	TABL---Roulette
207714254	7/8/2014	7/8/2014 18:13	TABL---Fortune Pai Gow
207714254	7/8/2014	7/8/2014 18:24	TABL---Roulette
207714254	7/8/2014	7/8/2014 18:25	SLOT---QUEENOFTHEWILD
207714254	7/8/2014	7/8/2014 18:33	TABL---Roulette
207714254	7/8/2014	7/8/2014 19:08	SLOT---RTNOFTHESPHINX

Table 9: Players play both Slot Machines and Tables.

Tier 4 Sample Player Analysis and Simulation

For extreme personalized marketing, the following is an example of the potential business benefits from profiling an individual player [6].

Player K's profile (data has been masked to protect the identity of the player) attributes include the following (but not limited to):

Name: ----------
DOB: ----------
Ethnicity: ----------
Age: 63
Gender: Male
Address: ----------
Cell Phone: ----------
Phone: ----------

Enrollment Date: ----------
Last Activity Date: 08/01/2014
Tier: 4
Social Media: ----------
Email: ----------
Member ID: ----------
Host ID: ----------
Account ID: ----------

The transaction samples are shown in the Table 10.

Date	Game_Name	CNT
7/1/2014	SLOT--ROULETTESM	3
7/1/2014	SLOT--TWINWIN	1
7/1/2014	SLOT--ULTRASTACKDRAGON	1
7/1/2014	SLOT--ULTRASTACKLION	2
7/2/2014	SLOT--ROULETTESM	3
7/2/2014	SLOT--ULTRASTACKDRAGON	1
7/2/2014	SLOT--ULTRASTACKLION	1
7/4/2014	SLOT--BATMAN	1
7/4/2014	SLOT--COYOTEMOON	1
7/4/2014	SLOT--DIAOFDUBLIN	1
7/4/2014	SLOT--EASTERNCHARM	1
7/4/2014	SLOT--GOLDGOLDGOLD	1
7/4/2014	SLOT--JACKPOTFACTORY	1
7/4/2014	SLOT--NEPTUNEKINGDOM	1
7/4/2014	SLOT--ORIENTEXPRESSCJ	1
7/4/2014	SLOT--PALACERICHES2	1
7/4/2014	SLOT--RIVERBELLE	1
7/4/2014	SLOT--ROULETTESM	1
7/4/2014	SLOT--SOLSTICECELEBRAT	1
7/4/2014	SLOT--TRPLGLDNCHERRIES	1
7/4/2014	SLOT--TWINWIN	1
7/4/2014	SLOT--WHITEORCHID	1
7/4/2014	SLOT--ZEUS	1
7/5/2014	SLOT--BLACKPANTHER	1
7/5/2014	SLOT--ROULETTESM	4
7/5/2014	SLOT--TWINWIN	3

Date	Game_Name	CNT
7/6/2014	SLOT--CHINADREAMPTR	1
7/6/2014	SLOT--CHINASHORESBW&S	1
7/6/2014	SLOT--RIVERBELLE	1
7/6/2014	SLOT--TREASUREDIVER	1
7/6/2014	SLOT--TWINWIN	1
7/7/2014	SLOT--QUEENOFATLANTIS	1
7/7/2014	SLOT--ROULETTESM	2
7/7/2014	SLOT--TIKITORCH	1
7/7/2014	SLOT--ULTRASTACKLION	1
7/8/2014	SLOT--ROULETTESM	4
7/8/2014	SLOT--TWINWIN	1
7/9/2014	SLOT--ROULETTESM	5
7/9/2014	SLOT--TWINWIN	1
7/10/2014	SLOT--ROULETTESM	7
7/10/2014	SLOT--TWINWIN	1
7/11/2014	SLOT--EASTERNCHARM	1
7/11/2014	SLOT--QHWILDBLUEFGF	1
7/11/2014	SLOT--SOLSTICECELEBRAT	1
7/11/2014	SLOT--TWINWIN	1

Date	Game_Name	CNT
7/12/2014	SLOT--5X8.10XQH2L	2
7/12/2014	SLOT--AFRICANDIAMOND	1
7/12/2014	SLOT--BLACKGOLD	1
7/12/2014	SLOT--BONUSTIMES1L	2
7/12/2014	SLOT--ROULETTESM	3
7/12/2014	SLOT--TRIPLESTARS	1
7/12/2014	SLOT--TWINWIN	1
7/12/2014	SLOT--ULTRASTACKLION	1
7/12/2014	SLOT--WILDROSE	1
7/13/2014	SLOT--ANCIENTDRAGON	1
7/13/2014	SLOT--BUFFALO	1
7/13/2014	SLOT--GAMEOFDRAGONS2	1
7/13/2014	SLOT--GOLDENEMPEROR	1
7/13/2014	SLOT--GREATEAGLE2	1
7/13/2014	SLOT--JEWELSOFTHENIGHT	1
7/13/2014	SLOT--JUMPINJALAPENOS	1
7/13/2014	SLOT--OMG!KITTENS	1
7/13/2014	SLOT--PHOENIXRICHES	2
7/13/2014	SLOT--QUESTFORRICHES	1
7/13/2014	SLOT--ROULETTESM	1
7/13/2014	SLOT--SOLSTICECELEBRAT	1
7/13/2014	SLOT--SPHINX3D	1
7/13/2014	SLOT--SUN&MOON	1
7/13/2014	SLOT--THECHESHIRECAT	1
7/13/2014	SLOT--TIKITORCH	1
7/13/2014	SLOT--ZEUS	1

Date	Game_Name	CNT
7/14/2014	SLOT--ROULETTESM	2
7/14/2014	SLOT--TIKITORCH	1
7/14/2014	SLOT--TWINWIN	2
7/15/2014	SLOT--ROULETTESM	4
7/15/2014	SLOT--TWINWIN	1
7/16/2014	SLOT--ROULETTESM	2
7/16/2014	SLOT--TIKITORCH	2
7/16/2014	SLOT--ULTRASTACKLION	1
7/17/2014	SLOT--ROULETTESM	2
7/17/2014	SLOT--TWINWIN	1
7/18/2014	SLOT--ANCIENTDRAGON	1
7/18/2014	SLOT--ROULETTESM	2
7/18/2014	SLOT--TWINWIN	1
7/18/2014	SLOT--ULTRASTACKLION	1

Date	Game_Name	CNT
7/20/2014	SLOT--BANKHEIST	1
7/20/2014	SLOT--BLACKPANTHER	1
7/20/2014	SLOT--BLZNG7SQH1L	1
7/20/2014	SLOT--BRAZIL	1
7/20/2014	SLOT--BUFFALO	1
7/20/2014	SLOT--COUNTMONEY	1
7/20/2014	SLOT--DANCINGINRIO	1
7/20/2014	SLOT--EASTERNCHARM	1
7/20/2014	SLOT--ETERNALGOLD	1
7/20/2014	SLOT--GNOMEARNDWORLD	1
7/20/2014	SLOT--INCASPIRIT	1
7/20/2014	SLOT--NEPTUNESKINGDOM2	1
7/20/2014	SLOT--PALACERICHES2	1
7/20/2014	SLOT--THAITREASURES	1
7/20/2014	SLOT--THECHESHIRECAT	1
7/20/2014	SLOT--TWINWIN	1
7/20/2014	SLOT--WILDSTALLION	1
7/20/2014	SLOT--ZEUS3	1
7/21/2014	SLOT--ROULETTESM	4
7/21/2014	SLOT--TWINWIN	1
7/22/2014	SLOT--ROULETTESM	3
7/22/2014	SLOT--TIKITORCH	1
7/22/2014	SLOT--TWINWIN	1
7/22/2014	SLOT--WHITEORCHID	1
7/23/2014	SLOT--ROULETTESM	3
7/23/2014	SLOT--TREASUREVOYAGE	1
7/24/2014	SLOT--ROULETTESM	1
7/24/2014	SLOT--TREASUREVOYAGE	1

Date	Game_Name	CNT
7/25/2014	SLOT--ROULETTESM	1
7/25/2014	SLOT--TREASUREVOYAGE	1
7/27/2014	SLOT--BLACKGOLD	1
7/27/2014	SLOT--BLACKPANTHER	2
7/27/2014	SLOT--CHINASHORESBW&S	1
7/27/2014	SLOT--DANCINGINRIO	1
7/27/2014	SLOT--DRAGONLINES	1
7/27/2014	SLOT--KICKINASS	1
7/27/2014	SLOT--LIONFESTIVAL	1
7/27/2014	SLOT--OMG!KITTENS	1
7/27/2014	SLOT--REDHOTDRAGONS	1
7/27/2014	SLOT--ROULETTESM	2
7/27/2014	SLOT--THECHESHIRECAT	1
7/27/2014	SLOT--TREASUREDIVER	1
7/27/2014	SLOT--TWINWIN	2
7/27/2014	SLOT--WICKEDWINNINGS2	1
7/27/2014	SLOT--WILLYWONKA	1
7/28/2014	SLOT--ROULETTESM	2
7/28/2014	SLOT--TREASUREVOYAGE	1
7/29/2014	SLOT--ROULETTESM	4
7/29/2014	SLOT--TWINWIN	1
7/30/2014	SLOT--ROULETTESM	3
7/30/2014	SLOT--TIKITORCH	1
7/31/2014	SLOT--BLACKPANTHER	1
7/31/2014	SLOT--ROULETTESM	3
7/31/2014	SLOT--TREASUREVOYAGE	1
8/1/2014	SLOT--ROULETTESM	2
8/1/2014	SLOT--TWINWIN	2

Table 10: Player K detailed gaming transactions.

In summary:

- Player K's transactions behavior is classified as Spin Master due to his engagements in Slot Machines.
- Player K is a member of Tier 4 with the casino for 6 years.
- In the one month sample data set, Player K played in the casino 29 out of 32 days from July 1 to August 1. During this period, Player K was exclusively engaged in the Slot Machines.
- A Time Series analysis of Player K was performed which separated the longer term trends from the daily and weekly patterns.
- In this period, the casino won $2629.36. The highest amount the casino won is $994 via slot machine A111:BLACKGOLD with 39 minutes play. The highest amount the casino lost is $650 via slot machine XS08:5X&10XQH2L with 3 minutes play. Both occurred on 7/12.
- Player K's daily CasinoWin linear projected a strong trend with slope of 5.67.

  Y = 5.67X – 237090
- Player K's daily TimePlay linear projected a strong trend with trend variable of 2.30.

  Y = 2.30 X – 96194
- Thursday is the most profitable day. Monday and Saturday are the least.

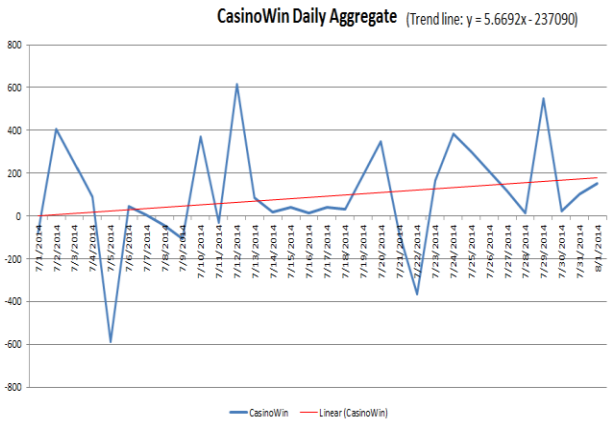


Figure 27: Player K Daily CasinoWin aggregation. Trend: Y = 5.67X – 237090

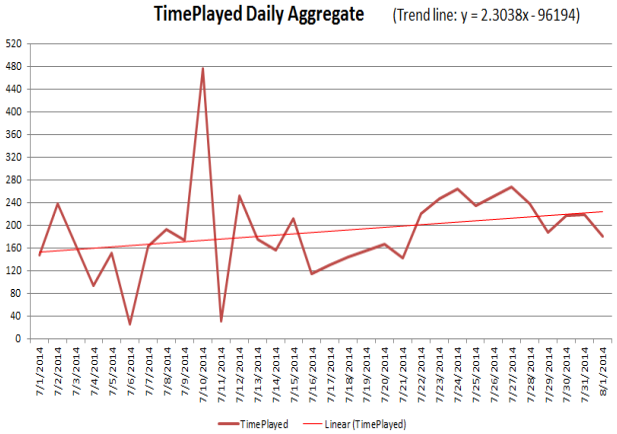


Figure 28: Player K Daily TimePlay aggregation. Trend: Y = 2.30 X – 96194

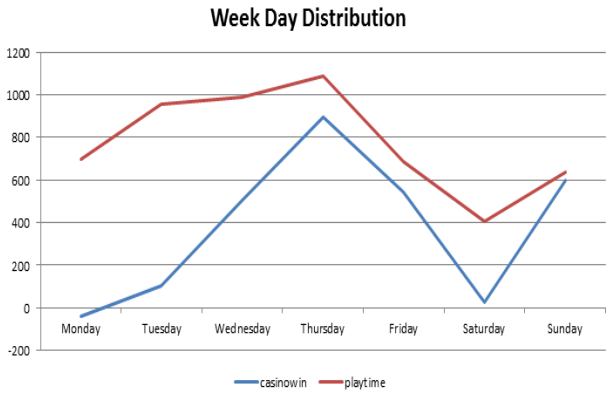


Figure 29: Player K Weekday CasinoWin aggregation. Thursday is the most important day for the casino.

Player K's Gaming Patterns

- Player K exhibited two distinct behaviors during his casino visits. One is "concentration slot game play" and the other is "exploration of multiple slot games". Figure 28 shows the high/low counts of the slot games.
- During Player K visiting, four crossing floor visits to multiple games occurred at 7/4, 7/13, 7/20, and 7/27. There are corresponding 16, 17, 18, 15 distinct games for each floor visit in that phase of exploration. Figure 28 shows the time intervals of high/low counts of the slot games occurrences.
- As for the concentration game engagement, Player K had limited 2-5 games engaged per visit.
- Comparing the per-machine per-day profit, the exploration mode has an average CasinoWin of $9.39 and the concentration mode has $15.93 CasinoWin. Figure 29 shows the difference of exploration/concentration CasinoWin behaviors.
- Comparing the PlayTime, the exploration mode has an average 10.35 minutes and the concentration mode has 38.04 minutes. Figure 29 shows the difference of exploration/concentration TimePlay behaviors.

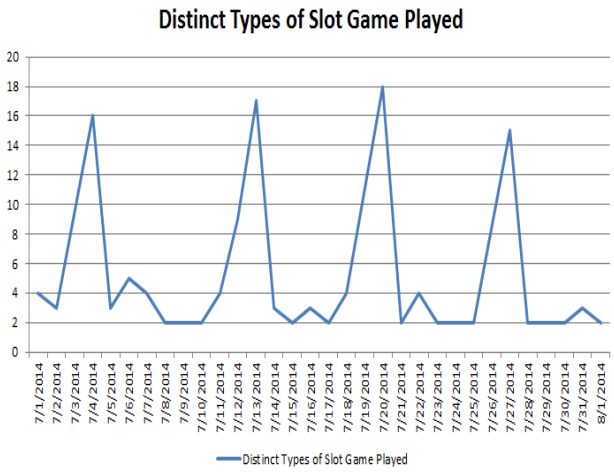


Figure 30: Player K Daily distinct counts of slot game played. Weekends game counts (exploration) has significant higher than the weekdays (concentration).

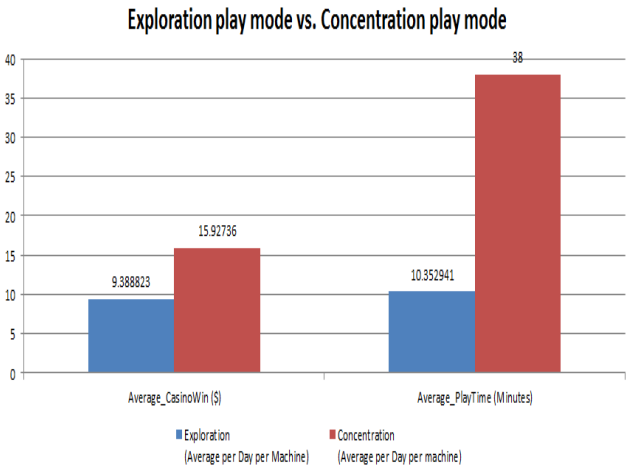


Figure 31: The ratio of CasinoWinwin and timeplay between the exploration (defined in figure 28) and concentration mode.

Player K Concentration Game Play Analysis

To understand Player K's gaming patterns, association rules analysis is used to analyze the strong relationships among the slot game types.

Association rule learning is a well-developed method for discovering interesting relations between variables in large data sets. To select interesting relations from the set of all possible rules, constraints on various measures of significance can be used. The best-known constraints are minimum thresholds on support and confidence.

Using July 1-3, 5-12, 14-19, 21-26, 28-31 (Player K has high amount of playtime with low number of slot machines engagements pattern), the rating transactions are used to build the association rules to study his concentration engagements.

For Concentration engagements, Player K was focusing on the slot machine types of ROULETTESM and TWINWIN primarily following by the TIKITORCH, ULTRASTACKLION, TREASUREVOYAGE, BLACKPANTHER, DANCINGINRIO, EASTERNCHARM, and PALACERICHES2.

The top six gaming sequences of Player K from association rule analysis strongly suggest that he had repeatedly played ROULETTESM, next, ROULETTESM to TWINWIN, and TWINWIN to ROULETTESM.

These insights could lead to special host-promotional treatments such as Seat reservation for ROULETTESM or TWINWIN on Thursday (Thursday is less busy than Saturday/Sunday). Thursday is also Player K's highest PlayTime and highest profit day for the Casino vs. Player K.

Additional host-promotional treatments could include "play more than one hour, the casino will provide a gift of bottle of wine". Table 11 shows the results of association rules.

Support(%)	Confidence(%)	PseudoLift	Rule
75.86206896551724	84.61538461538461	0.9437869822485208	SLOT---ROULETTESM ==> SLOT---ROULETTESM
51.724137931034484	78.94736842105263	0.8805668016194331	SLOT---TWINWIN ==> SLOT---ROULETTESM
48.275862068965516	63.63636363636363	0.7097902097902098	SLOT---ROULETTESM ==> SLOT---ROULETTESM ==> SLOT---ROULETTESM
41.37931034482759	46.15384615384615	0.7044534412955465	SLOT---ROULETTESM ==> SLOT---TWINWIN
34.48275862068966	66.66666666666666	0.7435897435897435	SLOT---TWINWIN ==> SLOT---ROULETTESM ==> SLOT---ROULETTESM
34.48275862068966	83.33333333333334	0.9294871794871796	SLOT---ROULETTESM ==> SLOT---TWINWIN ==> SLOT---ROULETTESM
20.689655172413794	100.0	1.1153846153846154	SLOT---TIKITORCH ==> SLOT---ROULETTESM
20.689655172413794	23.076923076923077	1.1153846153846154	SLOT---ROULETTESM ==> SLOT---ULTRASTACKLION
20.689655172413794	27.27272727272727	0.416267942583732	SLOT---ROULETTESM ==> SLOT---ROULETTESM ==> SLOT---TWINWIN
17.24137931034483	100.0	1.1153846153846154	SLOT---TREASUREVOYAGE ==> SLOT---ROULETTESM
17.24137931034483	19.230769230769234	0.9294871794871796	SLOT---ROULETTESM ==> SLOT---TIKITORCH
17.24137931034483	100.0	1.1153846153846154	SLOT---ROULETTESM ==> SLOT---TIKITORCH ==> SLOT---ROULETTESM
13.793103448275861	66.66666666666666	0.7435897435897435	SLOT---ULTRASTACKLION ==> SLOT---ROULETTESM
13.793103448275861	21.052631578947366	0.3213296398891966	SLOT---TWINWIN ==> SLOT---TWINWIN
13.793103448275861	66.66666666666666	0.7435897435897435	SLOT---ROULETTESM ==> SLOT---ULTRASTACKLION ==> SLOT---ROULETTESM
10.344827586206897	11.538461538461538	0.8365384615384615	SLOT---ROULETTESM ==> SLOT---BLACKPANTHER
10.344827586206897	15.789473684210526	1.144736842105263	SLOT---TWINWIN ==> SLOT---BLACKPANTHER
10.344827586206897	15.789473684210526	0.763157894736842	SLOT---TWINWIN ==> SLOT---ULTRASTACKLION
10.344827586206897	13.636363636363635	0.9886363636363635	SLOT---ROULETTESM ==> SLOT---ROULETTESM ==> SLOT---BLACKPANTHER
10.344827586206897	60.0	0.6692307692307693	SLOT---TREASUREVOYAGE ==> SLOT---ROULETTESM ==> SLOT---ROULETTESM
10.344827586206897	13.636363636363635	0.6590909090909091	SLOT---ROULETTESM ==> SLOT---ROULETTESM ==> SLOT---TIKITORCH
10.344827586206897	20.0	0.30526315789473685	SLOT---TWINWIN ==> SLOT---ROULETTESM ==> SLOT---TWINWIN
10.344827586206897	25.0	0.381578947368421	SLOT---ROULETTESM ==> SLOT---TWINWIN ==> SLOT---TWINWIN
10.344827586206897	13.636363636363635	0.6590909090909091	SLOT---ROULETTESM ==> SLOT---ROULETTESM ==> SLOT---ULTRASTACKLION
6.896551724137931	7.692307692307693	1.1153846153846154	SLOT---ROULETTESM ==> SLOT---BLACKGOLD
6.896551724137931	10.526315789473683	1.526315789473684	SLOT---TWINWIN ==> SLOT---BLACKGOLD
6.896551724137931	100.0	7.25	SLOT---DANCINGINRIO ==> SLOT---BLACKPANTHER
6.896551724137931	66.66666666666666	4.833333333333332	SLOT---THECHESHIRECAT ==> SLOT---BLACKPANTHER
6.896551724137931	66.66666666666666	9.666666666666664	SLOT---THECHESHIRECAT ==> SLOT---DANCINGINRIO
6.896551724137931	66.66666666666666	9.666666666666664	SLOT---EASTERNCHARM ==> SLOT---PALACERICHES2
6.896551724137931	10.526315789473683	1.526315789473684	SLOT---TWINWIN ==> SLOT---PALACERICHES2
6.896551724137931	10.526315789473683	1.526315789473684	SLOT---TWINWIN ==> SLOT---RIVERBELLE

Table 11: Player K's The Association rules results.

Player K Exploration Game Play Simulation

To study Player K's exploration gaming pattern, Markov Chain Analysis with Survival Estimation Framework is defined to simulate the behaviors and relationships among the slot game types.

Markov Chain [2] Analysis with Survival Estimation Framework has two core components. One is survival analysis (described in earlier sessions) and the other is Markov Chain.

A Markov chain is a stochastic process of the sequence of random variables X1, X2, X3, ... which a process moves through. The Markov property defines serial dependence only between adjacent periods (as in a "chain"). It can thus be used for describing systems that follow a chain of linked events, where what happens next depends only on the current state of the system. The changes of state of the system are called transitions. The probabilities associated with various state changes are called transition probabilities. The process is characterized by a state space, a transition matrix describing the probabilities of particular transitions, and an initial state (or initial distribution) across the state space.

Casino movement could be converted in Markov Chain format. Assume there is one player with four slot machines in scope. The modeling steps are:

1. Convert Customers Average Transaction locations into sequences, e.g. Player 1 has eight activities at machine 1, 2, 3, and 4 in that sequence. The location sequence will be 1->2->3->2->1->4->1->. The prior location and next location construct stage chaining relationships.
2. Calculate the frequency matrix and transition matrix.
3. Set up stages and select initial stages.
4. Calculate game t+1, t+2, …, t+n probability of continuing game playing.
5. Set up initial starting stage for maximum effectiveness
6. Model Player movement in the casino facility with player preference (association rules). Add multi-stage activities and Exit. Detail steps are listed in 6.1, 6.2, and 6.3.

    6.1. A player preference of the multi-stage games could be analyzed by association rules (Figure 32) which are defined individualized by the conditional probability of an individual player's activities in the casino. This is a key step to convert the transaction behavior into a more stationary stage for Markov chain model requirement.

Relationship	Confidence	Suport%	Lift	Rules
3	100	1.152738	6.196429	$25 slot & $1 slot ==> $5 slot
4	100	0.864553	4.957143	Show & $1 slot ==> $.25 slot
4	100	0.864553	4.957143	BJ & CRAP ==> $25 slots & Sports
3	83.33333333	1.440922	3.109319	Bingo & $5 slot ==> Show
2	75	0.864553	7.229167	$100 slot & $25 slot ==> Table & $25
4	75	0.864553	5.537234	Show ==> Food

$25 slot & $1 slot ==> $5 slot
Show & $1 slot ==> $.25 slot
BJ & CRAP ==> $25 slots & Sports
Bingo & $5 slot ==> Show
$100 slot & $25 slot ==> Table & $25

Figure 32: Example of convert transaction to stationary stages of Markov chain.

6.2. Assume that each potential next stage (engaged in play) could contain up to 10 internal stages (Figure 33). Next stages include:

6.2.1. Preferred slot machines using association support ratio base on the current stage as left side rule.

6.2.2. Post 6.2.1 rules, the remaining stages will be assigned to adjacent slot machines with equal probability to be engaged.

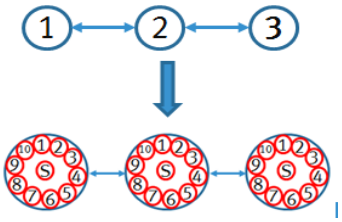


Figure 33: Convert each stage with 10 possible internal stages.

6.3. Exit stage is adding to the model (Figure 34) to represent player stop, engage, and leave. This is a set up using the last game played history.

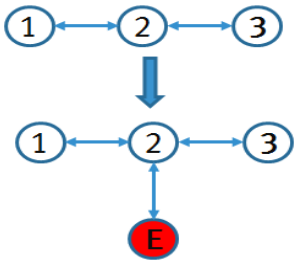


Figure 34: Add exit stage to the model.

7. Modify the Markov model to represent player engagements and stop.
8. Simulate the results and calculate survival values.
9. Map Traverse (movement) Patterns to casino floor. (Figure 35)
    a. Obtain Player Association Rules
    b. Identify Games
    c. Obtain Games corresponding “Bank” location ID
    d. Map Game Location to corresponding “Bank” location ID
    e. Map “Bank” location to Block ID

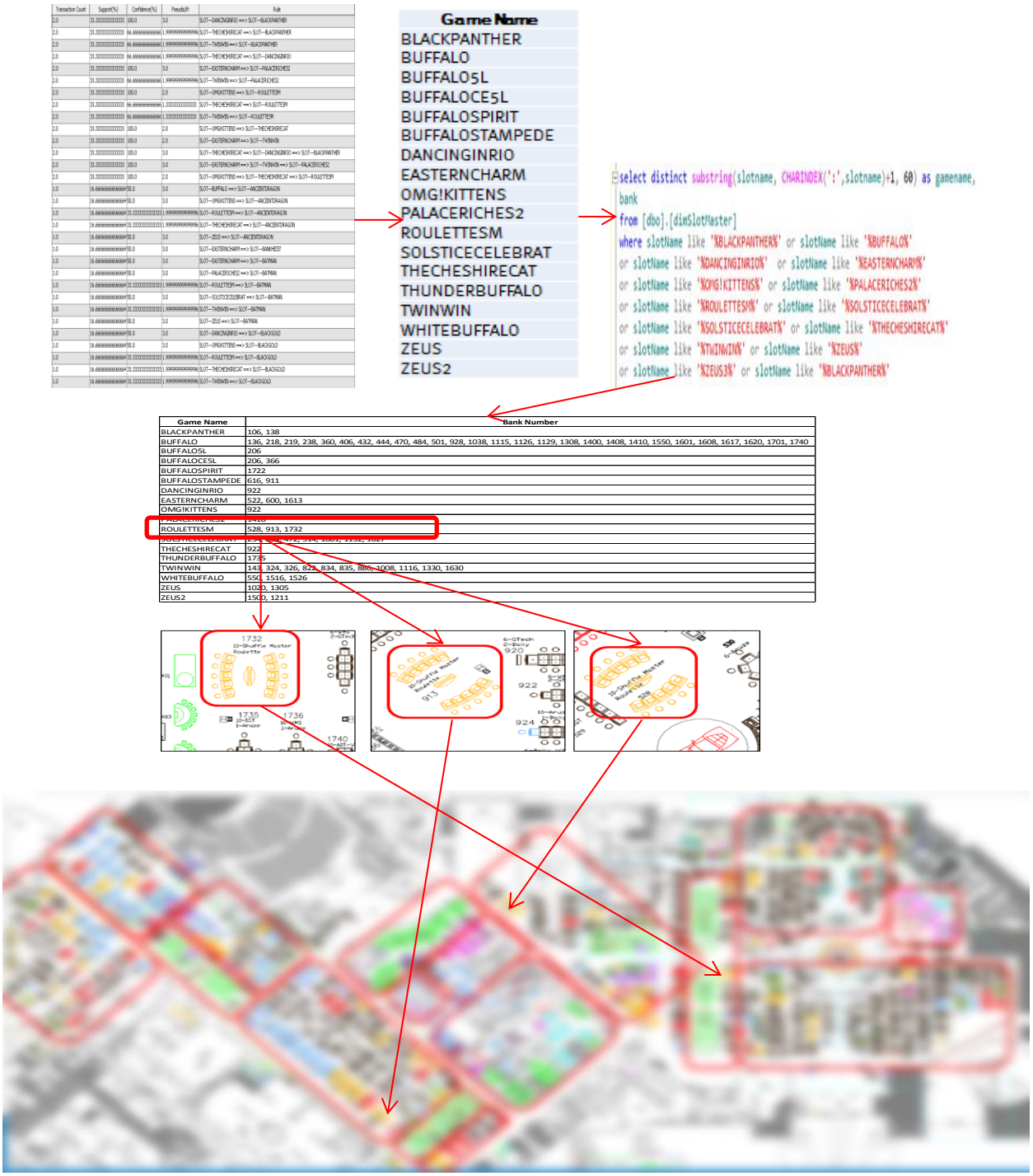


Figure 35: Map Traverse Patterns to the casino floor (Blurred floor layout) to form Markov stages.

Using Associations Markov chain and survival measurement with full casino floor movement, Player K could engage the entire 1758 installations of the casino. The theoretical survival model to project the number of plays per each visit is listed below (Figure 36, 37, 38, 39).

- Single customer floor visit: expected to engage 40.3 distinct slot games
- Group with two customers floor visit: expected to engage 28.5 distinct slot games
- Group with three customers floor visit: expected to engage 25.8 distinct slot games

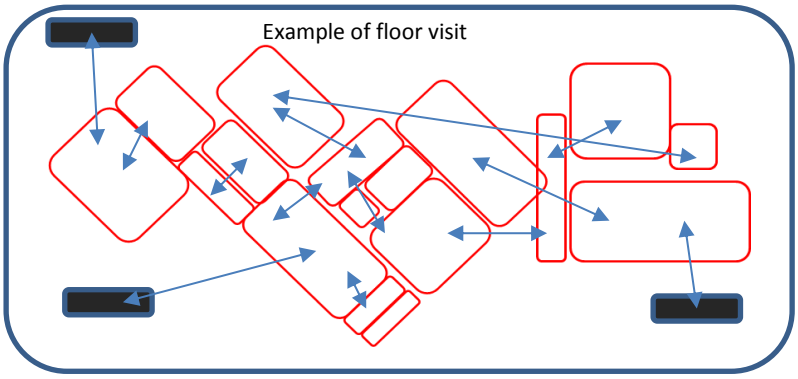


Figure 36: Player K of floor traversing patterns sample.

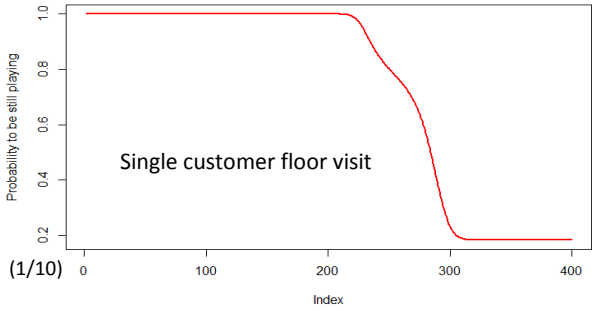


Figure 37: Player K floor slot machine visit patterns single player sample.

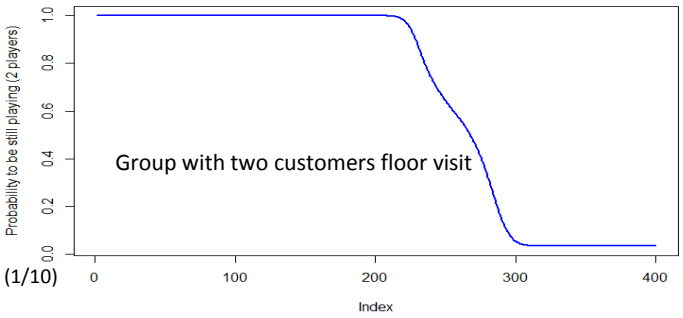


Figure 38: Player K and one company's floor slot machine visit patterns sample.

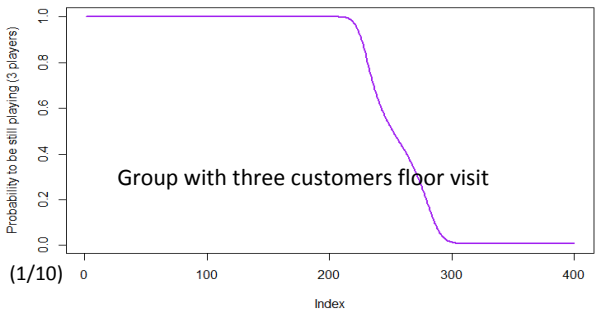


Figure 39: Player K and two companies' floor slot machine visit patterns sample.

Due to the weekend and holiday, the casino capacity may reach full capacity (80%). Player may involuntarily play less due to lack of availability for preferred slot machines. To emulate this, a limitation is placed on the model constraining player movement to only half the casino floor. For engaging 1/2 of the casino installations (800), the theoretical survival model to project the number of distinct slot games per each visit listed below (Figure 40, 41, 42).

- Player K association rules will be limited to half of the floor slot machines (rule elimination) only if both left or right rules existed within the available areas with multiple random start runs.
- Single customer floor visit: expected to engage average 9.2 distinct slot games.

- Group with two customers floor visit: expected to engage an average 6.7 distinct slot games.
- Group with three customers floor visit: expected to engage an average 5.4 distinct slot games.

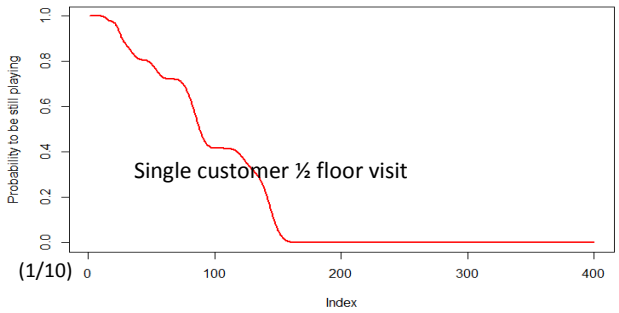


Figure 40: Player K half floor slot machine visit patterns sample.

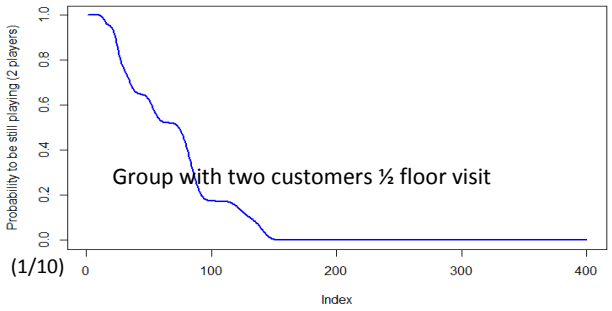


Figure 41: Player K and one company's half floor slot machine visit patterns sample.

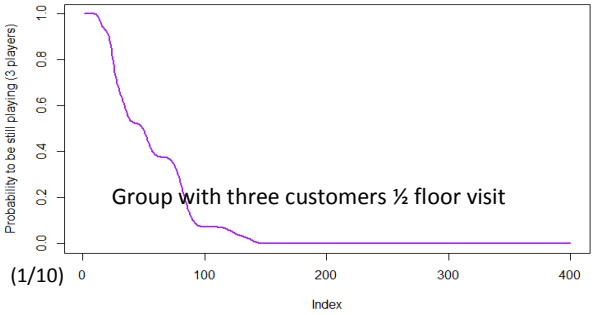


Figure 42: Player K and two companies' half floor slot machine visit patterns sample.

Again, due to the peak holiday weekend, the casino capacity may reach total capacity (~90%). Player may involuntarily play less due to lack of available slot machines. For engaging in 1/4 installations (400) simulations, the theoretical survival model to project the number of plays per each visit is listed below. (Figure 43, 44, 45)

- Player K association rules will be limited to quarter floor slot machines (rule elimination) only if both left or right rules existed within the available areas with multiple random start runs.
- Single customer floor visit: expected to engage an average 14.4 distinct slot games.
- Group with two customers floor visit: expected to engage an average 4.5 distinct slot games.

- Group with three customers floor visit: expected to engage an average 2.7 distinct slot games.

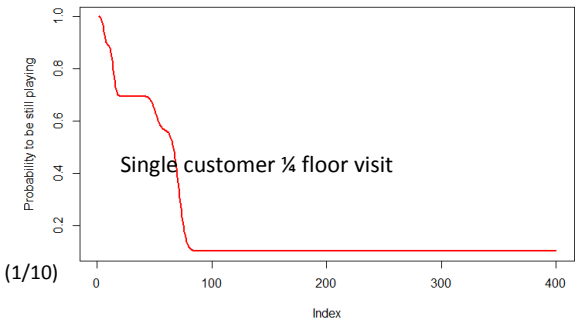


Figure 43: Player K quarter floor slot machine visit patterns sample.

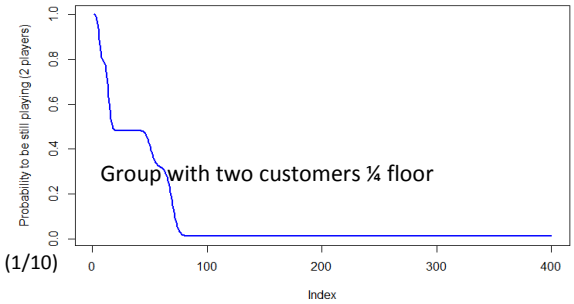


Figure 44: Player K and one company's quarter floor slot machine visit patterns sample.

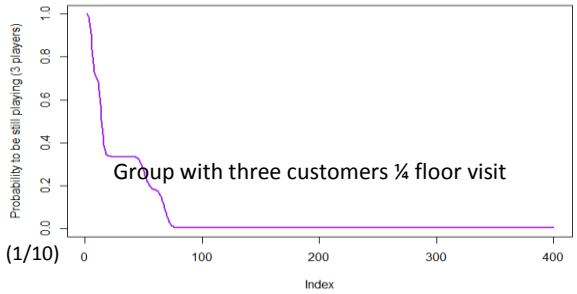


Figure 45: Player K and two companies' quarter floor slot machine visit patterns sample

Player K Time Series Analysis

In addition to the weekly patterns, the Player K Slot Gaming Time Series Analysis [4] from 03/08/2008 to 08/24/2014 is shown below revealing additional marketing opportunities that could be predicted to prepare Player K's arrival at the casino.

As shown in Figure 46:

- Player K prefers the dates of 2/7, 4/21, 6/22-23, 7/14, 9/16-26, 10/2, 12/31, 1/12
- Player K increases difference week by week. For the week of 246 – 250 (11/18/2014-12/16/2012), the behavior experiences a large change (age 62). It also appears on the visit Frequency per week (jump from 1-2 to 5-7 visits per week).

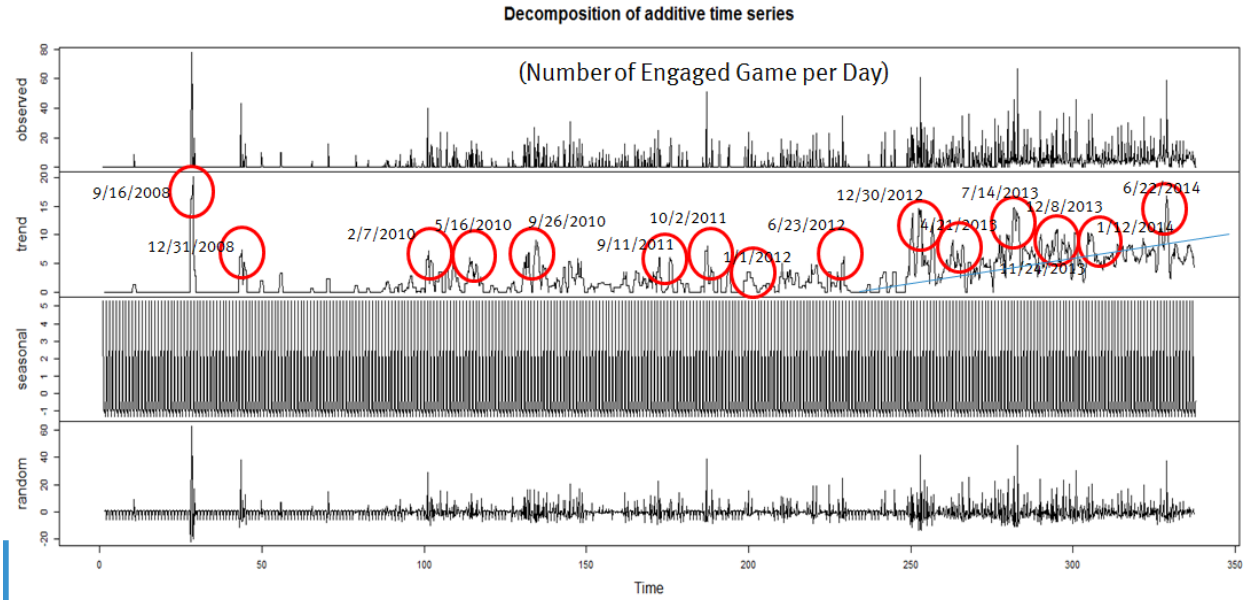


Figure 46: Player K time series analysis for Trend, Seasonal, and random behaviors.

Forecasting Player K's next 30 days of activity starting with the first Sunday in September 2014, the following are specific actionable forecasts of Player K's TimePlay: (Figure 47)

- For the projected duration of 30 days, Player K will be visiting the casino for 30 days (every day).
- The high counts of activities exiting at weekend (Sunday) with modeling cycle of 7 days.

Player K's forecasted 30 days starting on the first Sunday of September 2014, the following are forecasts for the casino win (Figure 48 and 49)

- For the duration of 30 days, Player K Casinowin will be $125 – 147 per day.

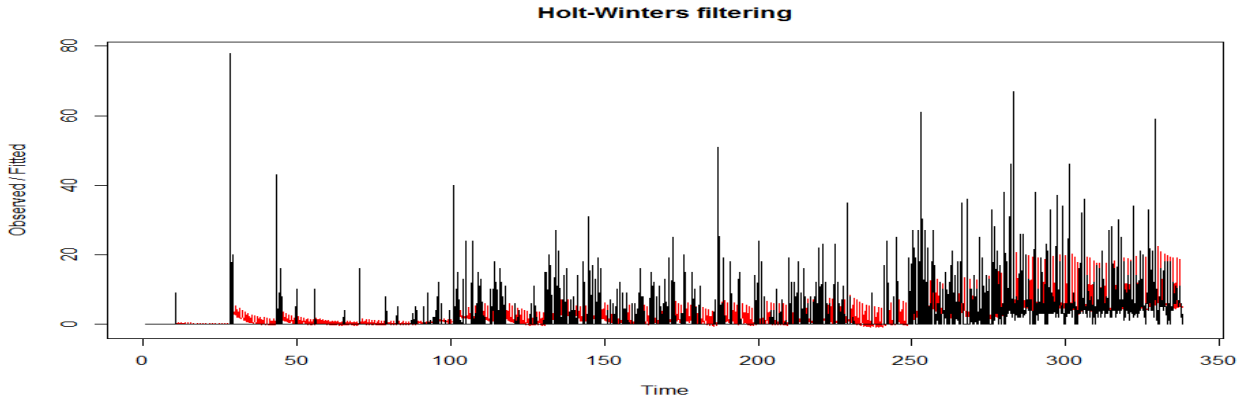


Figure 47: Player K time series forecast for visiting trend (via timeplay).

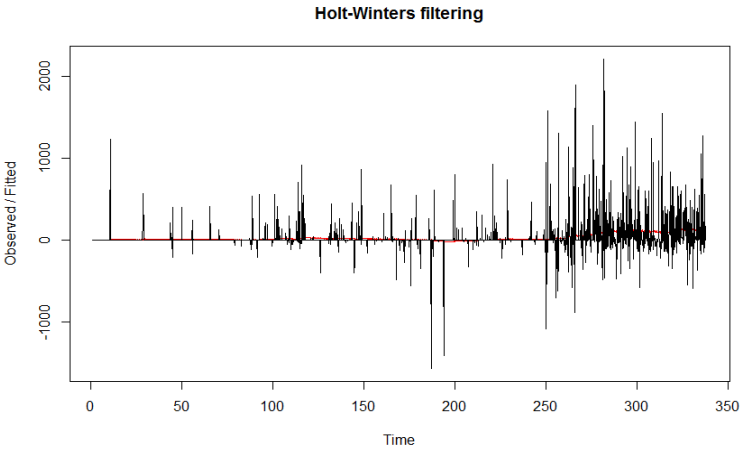


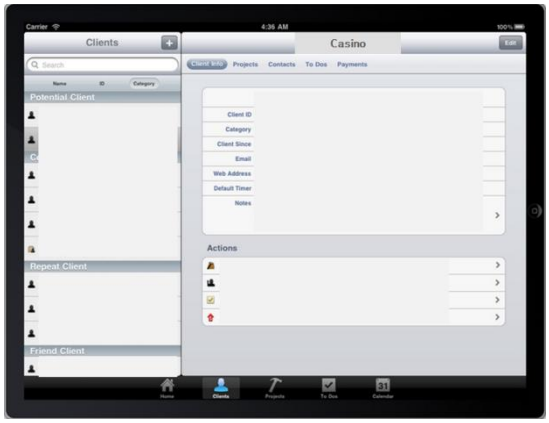
Figure 48: Player K time series forecast for CasinoWin trend.

```
> forecast(fit, 30)
         Point Forecast      Lo 80    Hi 80      Lo 95    Hi 95
338.0000       143.8087  -96.98764 384.6051 -224.4575 512.0750
338.1429       132.4183 -108.38477 373.2214 -235.8582 500.6949
338.2857       125.2291 -115.58080 366.0389 -243.0578 493.5160
338.4286       137.1523 -103.66431 377.9690 -231.1449 505.4496
338.5714       129.9349 -110.88852 370.7584 -238.3727 498.2426
338.7143       125.7638 -115.06646 366.5941 -242.5543 494.0819
338.8571       134.6545 -106.18265 375.4916 -233.6741 502.9831
339.0000       144.6334  -96.21449 385.4814 -223.7117 512.9785
339.1429       133.2430 -107.61180 374.0979 -235.1126 501.5987
339.2857       126.0538 -114.80800 366.9155 -242.3125 494.4200
339.4286       137.9770 -102.89169 378.8457 -230.3999 506.3539
339.5714       130.7596 -110.11607 371.6353 -237.6280 499.1472
339.7143       126.5885 -114.29418 367.4712 -241.8098 494.9868
339.8571       135.4792 -105.41055 376.3689 -232.9299 503.8882
340.0000       145.4581  -95.44261 386.3589 -222.9678 513.8840
340.1429       134.0677 -106.84009 374.9756 -234.3690 502.5045
340.2857       126.8785 -114.03647 367.7934 -241.5691 495.3260
340.4286       138.8017 -102.12033 379.7238 -229.6568 507.2602
340.5714       131.5843 -109.34489 372.5135 -236.8851 500.0538
340.7143       127.4132 -113.52318 368.3496 -241.0672 495.8936
340.8571       136.3039 -104.63972 377.2475 -232.1876 504.7953
341.0000       146.2828  -94.67201 387.2377 -222.2258 514.7915
341.1429       134.8924 -106.06967 375.8545 -233.6273 503.4122
341.2857       127.7032 -113.26623 368.6725 -240.8277 496.2340
341.4286       139.6264 -101.35026 380.6031 -228.9156 508.1685
341.5714       132.4090 -108.57500 373.3930 -236.1442 500.9623
341.7143       128.2379 -112.75347 369.2293 -240.3266 496.8024
341.8571       137.1286 -103.87019 378.1273 -231.4472 505.7044
342.0000       147.1075  -93.90270 388.1178 -221.4858 515.7009
342.1429       135.7171 -105.30054 376.7348 -232.8876 504.3218
>
```

Figure 49: Player K's detailed CasinoWin forecast.

Casino Front-line Floor Management approach for Player K

To improve Player K's player experience, these insights could be shared with the Host/Hostess in real time to their devices for prescription actions (recommendations).



Player K

- Demographic and important dates

Actionable Prescription for Player K

- **Preferred Game**: Roulettesm, Twinwin
- **Secondary preferred game**: Tikitorch, Ultrastacklion, Treasurevoyage, Blackpanther, Dancinginrio, Easterncharm, and Palaceriches2
- **Visiting Frequency**: 7 days a week
- **Preferred game day**: Wednesday, Thursday
- **Key Behavior pattern**:
    - Concentrated (< 5 games types): Average 4 games (Suggested play duration: 40+ minutes each)
    - Exploration (> 5 games types): average 16 games (Expected engaged games in exploration mode: 40 games)
- **Possible suggested next available* Game to Play**: Roulettesm, Twinwin
- **Most profitable condition**: Single Player
- **Player K prefers the dates**: 2/7, 4/21, 6/22-23, 7/14, 9/16-26, 10/2, 12/31, 1/12

Notes:

Player K in the month of September is projected to visit week 1-4 with possible average $137.

Player K should be able to engage more slot games from his average 16.5 to a theoretical expected 40.3.

Host could help Player K redirect his attention during game playing (Player K multi-persons group simulations) to other games. The Host could better manage available slot machine seats (casino capacity information) during peak days to increase Player K play time and levels of engagement.

If Player K engages more than five games (switch from focus to explore), he is expected to engage 40.3 distinct slot games for his theoretical single customer full-floor visit. However, the average distinct slot games for Player K is 16.5, less than half of the potential engagements. This may be due to insufficient encouragement or limited seats on the floor.

Player K's behaviors and playing preferences could be enhanced by his starting game, after which the casino may want to direct him towards higher margin games.

The entry game of the floor visit will be required to navigate to higher preference games (e.g. ROULETTESM and TWINWIN) to have higher probability in longer total engagement time. The entry game should avoid low preference games (e.g. games outside BLACKPANTHER, BUFFALO, BUFFALO5L, BUFFALOCE5L, BUFFALOSPIRIT, BUFFALOSTAMPEDE, DANCINGINRIO, EASTERNCHARM, OMG!KITTENS, PALACERICHES2, ROULETTESM, SOLSTICECELEBRAT, THECHESHIRECAT, THUNDERBUFFALO, TWINWIN, WHITEBUFFALO, ZEUS, ZEUS2) or higher loss rate (e.g. BLACKGOLD) for Player K.

Conclusion

One of the key challenges in the casino and resort business is to manage and maximize the players' flows and interactions to increase their time and gaming activities on the gaming floors. The business opportunity is to design and develop usable and useful prescriptions (recommendations) which can help front-line floor employees and sales achieve their profit objectives without the need for having extensive analytics knowledge.

Another challenge is to develop effective analytic approaches that can be integrated within the business environments and systems. Effective analytics approaches are thus those that minimize the time between analysis and action. Ideally, analytics can return answers within seconds to allow for an exploratory, real-time user experience, and to enable data exploration and visualization for the sales teams on the floor, managers, and front-line employees (waiters, valets, bar tenders).

Using Big Data facility and analytics, each individual player transactions could be analyzed and useful information extracted. In this case study, player tier analysis, gaming effectiveness analysis, player preferences analysis, and player floor traverse (movement) patterns analysis are demonstrated for sample data provided.

The analytics techniques used include descriptive analytics, trending, association rules, survival analysis, clustering analysis, Markov chain, time series analysis, and time series decomposition/forecast.

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