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Factors Affecting Slot Machine Performance in an Electronic Gaming Machine Facility

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***Abstract*—**A facility exploiting only electronic gambling machines (EGMs) opened in 2007 in Quebec City, Canada under the name of Salons de Jeux du Québec (SdjQ). This facility is one of the first worldwide to rely on that business model. This paper models the performance of such EGMs. The interest from a managerial point of view is to identify the variables that can be controlled or influenced so that a comprehensive model can help improve the overall performance of the business. The EGM individual performance model contains eight different variables under study (*Game Title, Progressive jackpot, Bonus Round, Minimum Coin-in, Maximum Coin-in, Denomination, Slant Top and Position*). Using data from Quebec City's SdjQ, a linear regression analysis explains 90.80% of the EGM performance. Moreover, results show a behavior slightly different than that of a casino. The addition of *GameTitle* as a factor to predict the EGM performance is one of the main contributions of this paper. The choice of the game (*GameTitle*) is very important. Games having better position do not have significantly better performance than games located elsewhere on the gaming floor. *Progressive jackpots* have a positive and significant effect on the individual performance of EGMs. The impact of *BonusRound* on the dependent variable is significant but negative. The effect of *Denomination* is significant but weakly negative. As expected, the *Language* of an EGMS does not impact its individual performance. This paper highlights some possible improvements by indicating which features are performing well. Recommendations are given to increase the performance of the EGMs performance.

***Keywords*—**EGM, linear regression, model prediction, slot operations.

I. Introduction

ELECTRONIC gambling became, over the last decades, a common form of gambling. It is now established everywhere in gaming institutions and is the most popular game among gamblers [1]. In the province of Québec, Canada, a business model exploiting only EGMs has been established since 2007 by Loto-Québec, the state's lottery that manages Québec's gambling industries [2]. This approach is relatively new since Quebec City and Trois-Rivières gaming halls have been created in 2007 [3] under the name "Salon de Jeux du Québec" (SdjQ). Quebec City's SdjQ only offers electronic gaming machines such as slot machines, electronic roulette, electronic poker tables, electronic blackjack, and Keno without any dealers on the gaming floors. This SdjQ possesses around 300 EGMs, mostly slot machines. This approach seems to be an attractive way to entertain customers. Over the last year, both SdjQs noticed an increase of 13.5% of the total income and 66% of customers visiting the installations. The performance of SdjQs went from a combined income of 30 million in 2014 to 34 million in 2015 [4], [5], and 2016 is expected to be even better.

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Literature around casinos has been abundant in recent decades. Not only factors that impact the slot machine performance have been studied in the gaming industry, but also customer behaviors and preferences are at the forefront of the research focus [6]-[12]. Although many studies exist regarding the gambling industries, especially about the optimization of the casino management and the understanding of the slot machine performance, there is still a gap in the literature about the performance and exploitation of gaming facilities using strictly EGMs [13].

Results from the casino literature, while being close in spirit, might not be fully transferable and exploited by SdjQ management team because of the unique situation Loto-Québec has created. Thus, one of the contributions of this paper is to bridge the findings with the casino literature. The results are expected to be similar in essence.

The main contribution of the paper is to provide a prediction model for the daily performance of individual EGMs of the SdjQ. Throughout this study, the emphasis is given on variables that can be influenced to allow floor optimization in future research.

The next section discusses the literature review, followed by a description of the methodology. Afterward the main results are analyzed, then comes a general discussion and a conclusion.

II. Literature Review

For the past decade, the main approach for casinos is the Full Service Theory (FST). It is based on the assumption that non-gaming amenities produce substantial indirect profits by attracting new customers into casino installations [14]-[16]. These customers would not visit casino installations otherwise. By adding interesting non-gaming amenities and EGMS, the FST claims that a gaming facility becomes more attractive to groups which contain at least one person interested into the interesting addition. Therefore, the FST suggests enlarging the variety of attractions into the facility in order to capture more customers. There are several non-gaming amenities in recent casinos. The list includes restaurants, bars & nightclubs, showrooms and recreational amenities such as bingo rooms, movies theaters and restaurants. While it proved beneficial for the casinos, the story is different for non-gaming facilities. In order to be

profitable, they must attract customers who are interested into slot machine wagering, which narrows their customers base.

Several studies show the relationship between casino-operated restaurant volume and slot machines business volume [17]-[20]. They find a positive and significant effect of restaurant volume on slot machine business volume. As such, casinos are willing to operate a non-profitable restaurant to increase the volume on slot machines.

The impact of bingo rooms within casinos has been considered in the literature The general perception is that bingo players do stop by slot machines while they visit casino installations [21]. However, daily bingo headcount and coin-in business volume indicate no evidence of a positive and significant effect between those variables. Such findings raise the question of casino floor utilization. As bingo rooms do not produce substantial indirect slot profits, the space required for a bingo room could potentially be used for more profitable activities.

Las Vegas gaming facilities often include impressive showroom installations presenting world-class shows, such as Céline Dion's show in Caesar's Palace Theater and Cirque du Soleil show in KA theater. Casino executives invest huge sums on showroom installations in attracting new customers and the literature seems to prove them right [22]-[24].

While internal choices of floor utilization clearly impact EGMs revenue, it is interesting to evaluate the impact of facilities neighboring casinos. For instance, nearby events, race and sports book wagering failed to prove a positive and significant effect on slot machine business [25]. This result supports the Cherry Picking Theory (CPT). Cherry pickers' goal is to obtain purchased goods at lower prices by changing their buying habit to get promotions. Indeed, they shift their purchase timing or quantities to a given store [26]. In the other words, cherry pickers have a special target in minds, such as making sports and race bets [14],[16]. They do not show interest in slot machine wagering. Thus, they take advantage of promotions without generating indirect benefits for gambling facilities. Therefore, cherry pickers do not contribute or minimally contribute to casino profits.

For SdjQ, there are several non-gaming amenities within and around such as restaurants, a showroom and a shopping mall. Indirect income from them has yet to be evaluated. Aside from external factors, the literature on slot machine performance is quite detailed.

While FST focusses on the relationship between non-gaming amenities and casino performance, which is usually highly correlated with daily slot machine wagering volume, other studies focus on the performance of slot machine individually [15], [27]. The list of the variables evaluated contains the spillover effect, position (micro-location) of the game on the floor, game's features (Game-within-a-game, Progressive jackpot, Slant top) and casinos promotions.

Blackjack is a very popular gambling activity in casinos. However, it does not provide good direct incomes. The PAR is very low compared to slot machines [28]. Of note, PAR is the casino's expected value associated with each slot machine's pay table and is commonly called the house advantage [29], [30]. It represents the average percentage of wagers an EGM is expected to win over a long run. Moreover, the indirect contribution of blackjack on casino performance does not seem to be clearly determined. Despite the unclear relationship between table games and slot machines performance, studies support the idea that the spillover effect positively affects slot machines performance. Spillover effect describes the condition where the sales of one store are found to affect those of another. It is usually attributed to the anchor store of a mall who attracts the biggest part of the customers while shops next to the anchor store enjoy the flow of customers and increase their sales. The spillover effect has been observed in the gaming industry. In general, table games or promotions generate spillover effect. However, a recent study concludes that poker room does not generate spillover [16]. Of importance, since there is no table game in SdjQ, the spillover effect might be harder to study.

The impact of position and micro-location on the performance of slot machines has been studied. As expected, they both impact the performance of slot machines [10], [31], [32]. Machines located next to a busy aisle, within a bank of machines or next to table games areas show better results than others. The arrangement, whether it is the layout, the disposition or the combination, of machines on the gaming floor can affect the performance of slot machines [33].

Game features have a substantial impact on slot machines performance. For instance, Game-within-a-game (GWG) proved to be among the most profitable feature for an EGM [10]. Others, such as slant top and progressive jackpots machines, fail to show a positive and significant effect on the slot machine performance.

Other variables could have been studied in this model. Variables such as slot machine service and servicescape could have an impact on the individual performance of the EGM. However, the service at the EGM is quite stable. Indeed, the numbers of employees available on the gaming floor evolve according to the traffic. Since it is an EGM only facility, there is no dealer on the gaming floor. Thus, the impact of the service at the EGM should be limited or null. Similarly, the effect of servicescape on the individual performance of the EGM should be quite limited. While the impact of the ambience, the easiness of navigation, the comfort of the seat, the interior décor and the cleanliness is known to have an impact on the desire to stay and intention to revisit a gaming facility [8], the difference of servicescape over the SdjQ is quite low and should not significantly impact the business volume of an EGM. Moreover, those characteristics are not related to the daily performance or to the individual performance of an EGM but are more related to the facility itself and to the customer satisfaction. For those reasons, slot machine service and servicescape have not been studied in this paper. Variable such as the clarity of the instructions could impact individual EGM performance. Indeed, customers are more likely to play a game that is easy to understand than a difficult one [9]. For this reason, SdjQ created an instruction sheet in French for all EGMs and provides it next to the machine to allow customers to understand each game. Thus,

this paper considers that the clarity of instruction is quite stable on the gambling floor and has not been studied. Sound level is another variable that could have an impact on the performance of an EGM and on the behavior of SdjQ customers [34], [35]. Over the gambling floor of Quebec City SdjQ, the sound level is quite stable. Technicians parameterize the EGMs to all have a similar sound level. Moreover, ambiance music is not really loud and its sound level is balanced over the facility. Aromas and odors also could have been studied in this paper. A previous study has shown that ambient aromas impact on consumers' [36], [37]. SdjQ did not odorize their gaming floor with different odorant over time. The ambient aroma was generally the same over the sample period. Thus, this paper does not study the impact of the sound level and ambient odors.

III. Methodology

This section describes the methodology. First, it gives information about the hypothesis of the study. Second, it presents the data source. Third, it discusses the natural log transformations to the continuous variable. Finally, it describes the dependent variable.

A. Hypotheses

This section describes the hypotheses based on the literature review. Of note, it is assumed that the behavior of SdjQ customers is in line with those of traditional casinos. Thus, variables that are important for casinos should be, to some levels, important for SdjQ as well. As it is the first study of its kind, a contribution of this paper is to explore the applicability of casinos literature for purely electronic gaming rooms.

Individual EGM performance model contains 8 independent variables. Table I provides a detailed description of each variable of this model. All these variables might be influenced by choices of the SdjQ management team. Ultimately the objective of the management team is to choose the best possible combination of games and features to display on the gaming floor with a layout that satisfies the majority of customers. EGM individual performance should help their decision-making process.

This study expects that some games have better performance than others. While the main bulk of the literature focusses on game features, this paper considers that given the same set of features, one game may be more popular than another. For instance, an EGM based on a popular show could draw more crowd and it should be evaluated. Moreover, based on the literature review, some game features provide better performance than others [38].

- H1: There is a significant relationship between the Game title and the individual performance of EGMs.

The Progressive jackpot (PRGSV) and SlantTop variables are also included in the model. SlantTop refers to games with a screen angle similar to the drawing surface of a drafting table [10].

- H2: There is a positive relationship between *PRGSV* and the individual EGM performance.
- H3: There is a negative relationship between Slant top and the individual EGM performance.

TABLE I
Description of EGM Individual Performance Model

Variable name	Hypothesis	Type of response	Description	Type of variable
HPUPD		**Dependent**	**Mean handle per unit per day for the sample period**	**Continuous**
GameTitle	H1	Independent	Group of games having similar characteristics	Level [0,19]
PRGSV	H2	Independent	EGM offering progressive jackpots	Binary
SlantTop	H3	Independent	EGM is a slant top machine	Binary
BonusRound	H4	Independent	EGM offering bonus round	Binary
Position	H5	Independent	EGM located into an optimal location	Binary
MinC	H6	Independent	Minimum number of coins an EGM will accept	Quasi-continuous [1,200]
MaxC	H7	Independent	Maximum number of coins an EGM will accept	Quasi-continuous [150, 900]
Deno	H8	Independent	Value of each credit played of a slot machine	Quasi-continuous [1,200]
Language	H9	Independent	Language of the program in the EGM	Binary
Brand	H10	Independent	Brand of the EGM	Level [1,5]

Games offering a bonus round as a reward for gamblers have not been explicitly studied. However, a game feature such as game-within-a-game can be considered a close match. Thus, similar results than the literature are expected. As such, this paper studies the effect of the bonus round on EGM performance.

- H4: There is a positive relationship between a game offering bonus round and the individual EGM performance.

Micro-location and position of the game on the gaming floor affect the performance of the game. Research showed that some locations provide better results than others [10], [31].

- H5: There is a positive relationship between the micro-location and position of the game on the gaming floor regarding its individual performance.

MinC represents the minimum number of coins a slot machine can accept for a single wager/spin.

- H6: There is a positive relationship between the minimum coin-in and the individual EGM performance.

MaxC is the exact opposite, as the maximum number of coins a slot machine can accept for a single spin/wager.

- H7: There is a positive relationship between the maximum number of coins a machine can accept and the performance of this EGM.

Denomination accounts for the value of each credit. In the case of SdjQ, denomination values go from 0.01$ to 2.00$.

- H8: There is a positive relationship between Denomination and the individual EGM performance.

Language can also be a barrier to utilization. While the main language in the province of Québec is French, the majority of EGMs are in English which could lead to a difference in the interest of EGMs. Studies on Chinese gambling behaviors and factors that discourage slot play discovered that the language and clarity of instructions impact the desire to play an EGMs [9]. Thus, a difference is expected between the individual performance of EGMs in French and in English. Of note, French served as a base for this study.

- H9: There is a negative relationship between Language and performance of individual EGM.

Brand of the games might have an impact on the individual performance of an EGM. Indeed, some brand offers features and includes characteristics that customers may like or dislike. Quebec City' SdjQ offers five different brands to its customers. Thus, this hypothesis is advanced.

- H10: There is a relationship between the brand and the performance of individual EGMs.

B. Data Source

The model studies the impact of game features and gaming floor decisions, such as *GameTitle* and *Position* of an asset on EGM performance.

The data come from SdjQ of Quebec City. The data collected represents 207 electronics gaming machines such as slot machines and slant top games. The dataset does not include video poker or multi-denominational units.

For EGM, individual performance model, the data covers a period of 760 days, from January 2nd, 2014 to February 1st, 2016. The data used in this paper were screened for outliers and missing values.

C. Natural Log Transformation

Natural log transformation is a common technique [10], [31], [32], [39]. It improves the quality of the regression, allows the results of the regression to be compared with many others studies and helps the ease of interpretation.

The dependent variable, *HPUPD*, and three of the ten independent variables (i.e. *MinC*, *MaxC* and *Deno*) are discrete as well yet can be seen as continuous [10]. A natural log transformation improves both skewness and kurtosis statistics for the *HPUPD* variable. Skewness statistic went from 0.90 to -0.22 which is a significant improvement to the model. Results are summarized in Table II.

After the transformation, the kurtosis value is 2.17. The natural log transformation did not have the same effect on continuous variables such as *MaxC*, *MinC*, and *Deno*. Thus, those variables are kept in their original format to improve the ease of interpretation.

TABLE II
LOG TRANSFORMATION IMPACT OF LHPUDP

Variable	Skewness Before	Skewness After	Kurtosis Before	Kurtosis After
LHPUPD	0.90	-0.22	3.83	2.17

D. Dependent Variable

The dependent variable is the mean handle per unit per day (*HPUPD*). It represents the summation of coin-in over the sample period for a specific asset divided by the number of days the asset was available on the gambling floor. This is in line with the literature [10], [31].

The statistical significance of both models is evaluated through the use of a linear regression analysis, with alpha equal to 0.05. The software SPSS (version 23.0) and Minitab 17 are used to execute the analysis.

IV. RESULTS

This section presents the results. Section IV. *A* provides the descriptive statistics of each model. Section IV.*B* presents the results of the regression.

A. Descriptive Statistics

Table III and Table IV provide general information about the variables. Tables are separated according to their model and format type. Variable starting with an "L" represent a natural log transformation, as mentioned in section Natural Log Transformation. Table III shows the average, median, standard deviation (SD), minimum and maximum of the variables. Table IV illustrates the percentage of use of each binary and level variable.

TABLE III
DESCRIPTIVE STATISTICS FOR CONTINUOUS VARIABLE (N = 207)

Variable	Average	Median	SD	Min	Max
LHPUPD	8.20	8.27	0.56	7.03	9.42
MinC	3.33	2.50	1.58	0.01	2.00
MaxC	0.50	0.50	0.32	1.50	9.00
Deno	0.10	0.02	0.26	0.01	2.00

EGM individual performance dependent variable *LHPUPD* has a mean of 8.20 and a median of 8.27, while the standard deviation is at 0.56. *LHPUPD's* minimum is 7.03 and its maximum is 9.42. MinC starts at 0,01 (1 coin) and ends at 2,00 (200 coins) while *MaxC* covers from 1.50 (150 coin) to 9 (900 coin). *Deno* goes from 1 to 200 coins. The optimal *position* represents 27.18% of all EGMs. 42.23% of all EGMs have a *PRGSV*, while 66.02% offer a *BonusRound*. *SlantTop* represents 24.27% of the EGM of this study. Obviously, each EGM could not be considered individually for their *GameTitle* because of experimental limitation. Instead of separating EGMs uniformly, the grouping focused on similar characteristics, thus explaining the difference in the percentage of representation. *GameTitle* percentage goes from nearly under 1% (Group 0 at 0.97%) to 18.93% for Group 19.

For the sake of simplicity, the representation of each group has been omitted. As much as 87% of the EGMs studied have their program in English, and only 13% are in French. Quebec City' SdjQ offers five different brands to its customers. The most represented one is Bally at around 50% of all EGMs, followed by WMS at more than 25%. Konami, Aristocrate, and IGT represent the remaining EGMs with 22% of the sample for those three brands.

TABLE IV
DESCRIPTIVE STATISTICS FOR NON-CONTINUOUS VARIABLE (N = 207)

Variable	Level	% of n
	Position	
Not optimal	0	72.82%
Optimal position	1	27.18%
PRGSV		
Not PRGSV	0	57.77%
PRGSV	1	42.23%
	BonusRound	
No BonusRound	0	33.98%
BonusRound	1	66.02%
SlantTop		
Not SlantTop	0	75.73%
SlantTop	1	24.27%
GameTitle*	0 - 19	0.97% - 18.93%
	Language	
French	0	13.11%
English	1	86.89%
Brand		
Bally	1	50.49%
WMS	2	27.67%
IGT	3	3.88%
Konami	4	11.17%
Aristocrate	5	6.80%

B. Linear Regression Results

Table V and Table VI present the regression for EGM individual performance and list the results of the regression analysis. The adjusted R^2 is 90.80% and the F value (66.23) is significant with an alpha of 0.05, also shown by the p-value ($p < 0.001$, $df = 31$).

TABLE V
DETAILED ANALYSIS OF LINEAR REGRESSION RESULTS

Variable	F-Value	P-value
MinC	**22.12**	**0.000**
MaxC	**15.82**	**0.000**
Deno	**4.90**	**0.028**
Position	0.17	0.683
PRGSV	**2.50**	**0.045**
BonusRound	**5.77**	**0.017**
GameTitle	**17.82**	**0.000**
Language	0.72	0.399
Brand	2.46	0.047

A subsequent Variance Inflation Factor (VIF) analysis on *SlantTop* indicates multicollinearity with some groups of the *GameTitle* variable (group #10, #18 and #19). Thus, *SlantTop* variable has been eliminated from the regression model to obtain a model that best fit the EGM individual performance regression model. Moreover, *SlantTop* does not produce a significant effect on the *LHPUPD* (p-value =0.789).

TABLE VI
DETAILED RESULTS OF LINEAR REGRESSION

Variable	Level	Beta coefficient	SE coef.
Constant	-	8.6600	0.1810
MinC	-	0.3720	0.0792
MaxC	-	0.0456	0.0115
Deno	-	-0.0019	0.0865
Position		-0.0156	0.0382
PRGSV	1	0.0625	0.0404
BonusRound	1	-0.1590	0.0662
GameTitle	1	0.2380	0.1620
	2	-0.1780	0.1510
	3	-0.2900	0.1510
	4	-0.3360	0.1520
	5	-0.3250	0.1500
	6	-0.3940	01.570
	7	-0.3940	0.1570
	8	-0.4020	0.1680
	9	-0.4730	0.1560
	10	-0.5270	0.1610
	11	-0.4810	0.1700
	12	-0.5800	0.1810
	13	-0.6250	0.1680
	14	-0.6010	0.1830
	15	-0.8710	0.1620
	16	-0.9590	0.1650
	17	-1.2050	0.1760
	18	-1.1670	0.1770
	19	-1.4540	0.1760
Language	1	0.0515	0.0609
Brand	2	-0.0695	0.0445
	3	-0.0315	0.0929
	4	0.1100	0.0595
	5	0.0550	0.0795

Position fails to affect the dependent variable (p-value = 0.683) which is somewhat surprising. This result supports the hypothesis that micro-location and position of the game do not affect the performance of the game, which is not quite in line with the literature. A deeper analysis on this variable is provided in the discussion section.

The continuous variables *MaxC* (p-value < 0.001) and *MinC* (p-value < 0.001) have a positive and significant effect on the *LHPUPD*. Between the two, *MinC* has a bigger impact on the LDailyCoinIn, as shown by their F-value (22.12 vs 15.82) and by the beta coefficient (0.372 vs 0.046). The null hypothesis cannot be accepted for *Deno* (p-value = 0.028). Both statistics, p-value and t-value, indicate a significant but negative relationship between the denomination and the dependent variable.

Variable *GameTitle* has a significant effect on the *LHPUPD*. Considering that the first group served as a base for the regression, only the second group produces a positive effect. All the others have a negative effect in comparison to the baseline. The null hypothesis is rejected for the variable *GameTitle* (p-value < 0.001).

Variable *PRGSV* produces a positive and significant impact on the LHPUPD (p-value = 0.045). This result is surprising since it is not in line with the literature.

BonusRound has a negative but significant effect on the dependent variable *LHPUPD* with a beta coefficient of -0.159 and a p-value of 0.017. Thus, the null hypothesis is rejected. The negative beta is further discussed in the discussion section.

Brand produces a significant effect on the dependent variable. Bally served as the base for the regression. In comparison to the baseline, Konami, and Aristocrate produce a positive effect on the *HPUPD*. Unfortunately, those two brands only represent around 17% of the EGMs on the gaming floor. WMS and IGT have a negative relationship with the individual performance of EGMs again when compared to the baseline. Finally, Konami offers the best performance of all brand while WMS has the worst one.

V. General Discussion

Results from regression show a slight difference with the casino literature regarding the behavior of certain variables. For instance, factor such as *MinC* is in line with the casino literature. However, variables such as *PRGSV* and *Position* are different. While most assumptions hold true, the difference justifies the need to further study the situation for pure EGMs gaming rooms specifically. The rest of the section discusses the results of the regressions.

Results indicate that the EGM performance is influenced by *GameTitle* and game features such as *BonusRound*, *PRGSV*, *Brand, MinC*, *MaxC,* and *Deno*. *SlantTop*, *Position,* and *Language* all fail to impact the *LHPUPD*.

It seems that the choice of the game (*GameTitle*) is of capital importance. Indeed, it is the most important factor (F-value = 23.15). Further studies on preferences of customers and foot traffic might help to choose optimal EGMs. However, it is a difficult problem since one must consider the notion of diversity, or portfolio of games, offered to customers to ensure most of them can be satisfied. It is a multi-objective optimization problem and should be studied as such.

SlantTop has been removed from the regression model because of multicollinearity with the variable *GameTitle*. Multicollinearity indicates that two or more variables are highly correlated. Thus, only one of the variable is needed to get a good prediction of the model. A linear regression model with multicollinearity can give a good prediction of the model but does not provide valid results when it comes to individual predictors. No multicollinearity is detected for all remaining variables.

Position and micro-location (*Position*) do not improve the prediction. Games located next to an aisle or within a bank of machines do not show better results than games located elsewhere on the gaming floor. These findings do not support the spillover effect theory relating that distinct areas where there is a buzz generate more foot traffic and generate higher volume. However, the SdjQ under study operates at full capacity over extended periods during the week. As such, customers may be compelled to play the first available EGM rather than waiting for a specific one. Consequently, it may remove any positive impact of a good positioning. This hypothesis was tested by separating days of the week where the establishment was as full capacity and those where it was not. A linear regression has been done on each set of data, and the result stays the same. On both sets, the position has no impact. Further studies of the movement and behavior of customers could help finalizing the case of the position and micro-location of EGMs on the gambling floor.

PRGSV is significant and has a positive beta coefficient. While being in line with the intuition of the management staff of SdjQ, this is different from the casino literature. Again, a possible explanation may lie in the full capacity utilization. The main drawback of a *PRGSV* is when the jackpot has just been won. There is little to no incentive to play such EGM. However, if it is the only available one, a customer may choose to play it rather than waiting.

BonusRound does impact the model, but its effect is negative on the dependent variable. It is surprising since intuitively this feature is closely related to the GWG from the literature which has shown to have a positive and significant effect on slot machine performance [10]. The only possible explanation to conciliate this finding with the casino literature is that, while being popular EGMs, the bonus rounds slow the net coin-in. Validation on the average number of games played per EGM supports this explanation. There is almost twice as many games played on EGMs with a bonus round than without.

MinC has a substantial impact on the model. According to the F-Value of 19.83, it is the second most important variable. An increase of 1% of the *MinC* could produce an increase of 1300 coins to the *HPUPD*. *MinC* has a potential for improving the SdjQ's performance. Typically, the main approach is to increase the foot traffic. However, given the situation of the SdjQ under study (operating at full capacity), increasing the *MinC* could be justified. However, there are other considerations before recommending such an action [40], [41]. Thus, we prefer recommending to focus on an increase either of the foot traffic or the number of assets rather than a change in the minimum coin-in. From a scientific point of view, it would be interesting to know its limit of variation. In the other words, when the value of *MinC* becomes too high (or too low) to prevent customers from playing an EGM.

With the variable *MaxC*, the null hypothesis is rejected. This variable does not have the same impact on the model than *MinC* but is still the third most important one. The regression indicates that when *MaxC* increases, *HPUPD* increases. Those findings support the fact that there is a group of high wages gamblers who prefer to play with the highest coin-in. Again, it would be interesting to know the limit of this variable.

Deno does have a statistically significant albeit small effect on the dependent variable. This result indicates that gamblers do take the denomination into consideration when they choose an EGM but with little effect on the overall model.

As expected, *Language* does not have a significant effect on the *HPUPD*. As mentioned in the section Hypotheses, all

EGMs having their program in English include a detailed instruction sheet in French.

A backward elimination regression and an analysis of variance allow this study to determine the contribution of each significant variable individually. Fig. 1 shows the ranking based on the contribution of each variable individually in the regression model. *MinC* is the most important variables among all model's variables according to its contribution of 31.6%. *GameTitle* follows the minimal coin-in variable as the second most important variable of the model at 29.67% of contribution. The third most important variable is the maximum coin-in (*MaxC*) with a contribution of 22.79%. *Deno*, *BonusRound, Brand,* and *PRGSV* end the ranking with a contribution of 6.91%, 0.55%, 0.42%, and 0.18%. All variables have a total contribution of 92.03% to the regression. Lack-of-fit represents 5.78%, and pure error is around 2.19%. The small lack-of-fit indicates that no important variable was missed out. The pure error, which corresponds to a purely random behavior of the response variable, has a value of 2.19%. This is a good indication that the process is predictable, can be modeled and controlled.

The top three variables (*MinC, GameTitle, MaxC*) represent around 84% of the contribution on the model. The typical mark to consider a model robust is above 90%. Thus, we only have to include the 4th variable, *Deno*, to achieve this threshold. Of note, all variables included in the backward regression were significant at the alpha level of 0.05.

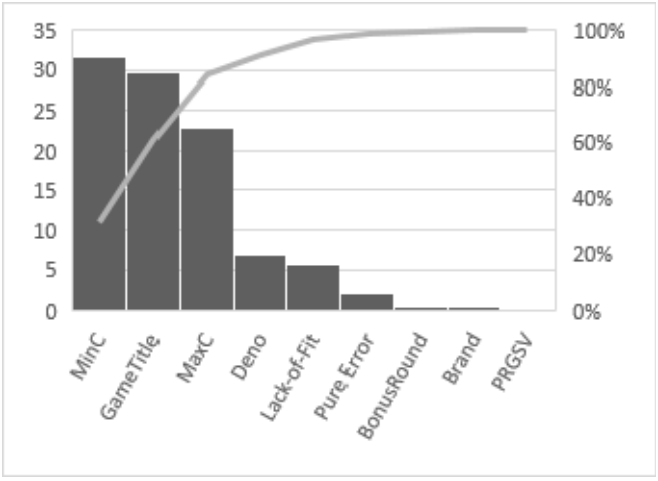

Fig. 1 Variables ranking by their contribution

VI. Conclusion

This study models the performance of EGMs. The list of variables that has been studied contains *GameTitle*, *PRGSV*, *SlantTop*, *BonusRound*, *Position*, *MinC, MaxC, Deno* and *Language*. In this list, *GameTitle*, *PRGSV, BonusRound, MinC, MaxC* and *Deno* are significant. Thus, a greater focus on those variables is required to improve the overall income.

A contribution of this paper is the introduction of *GameTitle* to predict an EGM performance. This variable is significant to predict *HPUPD*. Also, other features of an EGM have a substantial impact on the individual performance, generally in line with the literature. While it would be incorrect to recommend replacing all EGMs having non-significant features with EGMs that do, it is possible to point out possible improvement. For instance, Group 19 who is by far the most represented group over the gaming floor (18.93%) have poor performance and could be partially replaced by better EGMs in a near future. In parallel, this problem should be formalized as a multi-objective problem and solved to provide a much-needed tool for decision making for managers.

The contribution of *GameTitle* is important and SdjQ management team should focus on determining the optimal mix of games to display on the gambling floor since the choice of game is the second most important contributor. The daily income could be easily improved by replacing some games from groups that significantly underperformed.

MinC and *MaxC* both produce a significant and positive impact on the dependent variable. Given the fact that the SdjQ under study operates at full capacity, increasing them could be justified. However, there are other factors to consider before putting in place such an action. Thus, we recommend focusing on an increase in the number of assets or around smoothing the foot traffic by changing the frequency of promotions rather than a change in the minimum or maximum coin-in.

The stepwise backward elimination regression and the analysis of variance reveal that there is still only around 5% that cannot be explained by the current variables. Moreover, the purely random component of the model is around 2%, which indicates that the process is predictable, can be modeled and managed.

We also recommend trying different combinations of EGMs and layout to increase the amount of information available on these variables and prepare further studies. We also recommend analyzing the customer's baseline with the goal of understanding their behavior, intentions, preferences and the movement of each group of customers over the gambling floor.

A. Limitations

Results of the study are limited to gaming facilities that exclusively operate EGMs. Since a linear regression analysis does not explain causality [42], the beta coefficients may not represent the reality explicitly; rather they solely predict the current situation. This study only shows the behavior and performance of one particular SdjQ (Quebec City). Thus, we cannot conclude on the ability of the model to be general. However, given that adjusted R^2 is really high, it is likely to be the case.

B. Future Work

There are several future works. First and foremost, to execute a replication study on another SdjQ. Also, solving the optimization problem identified in this paper is also a next logical step. The literature focusses mostly on linear regression, which makes sense as each variable has a physical meaning. However, tools such as Principal component analysis (PCA), support vector machine (SVM) could be used to further synthesize data about the EGMs.

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