The Study of The Sufficiency of Course Reserve Collection in Terms of The Duration of Loan Policy for Circulation in SMU Libraries' Li Ka Shing Library

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Abstract

Libraries are quintessential to creating a holistic learning environment in schools, like how Li Ka Shing Library is to Singapore Management University. As such, SMU Libraries consistently mulls over how users' experience can be improved in their libraries. Therefore, given the available transactional and master data, this paper aims to investigate if the 1-hour extension in the loan policy implemented in 2017 from 2016 helped make it more sufficient for the undergraduate students at SMU and to propose if SMU Libraries should consider the option of extending this 3-hour loan policy by another hour. The concept of sufficiency is subjective; different people might have different perceptions on what they deem is a sufficient loan policy. As such, an informal primary research was conducted and it was found that when a loan policy is deemed to be insufficient, there are 2 possible courses of actions that follows; students would either overdue the books past the time it is due or borrow repeatedly in successions. Given the differences in behaviours, these 2 groups of users were analysed separately. The sufficiency level of those who overdue was measured through the length of overdue period and the percentage of overdue transactions over total transactions observed. The sufficiency level of those who borrows in successions (i.e. when the loan timestamp occurs by the same user for the same book title that is within 4 hours of the return timestamp) was measured using length of hours accumulated through succession borrowing and the frequency of succeeding borrows.

These measures are then compared across 2016 and 2017. Since the datasets are established to be non-normal, nonparametric Wilcoxon Signed-Rank tests were performed to establish if there were differences in the distribution of the length of overdue periods and the length of hours borrowed after considering user successions across 2016 and 2017. Given its nominal nature, contingency analyses were also performed to find out if there were differences in the distribution of the percentages of overdue transactions and the frequency of succeeding borrows across 2016 and 2017. This paper found strong statistical evidence indicating the effectiveness of the 1-hour increment in loan policy in helping the users who overdue, but further investigation is required for those with borrow in succession. Given that there is no evidence that SMU Libraries should not extend the loan policy, it is recommended that SMU Libraries implement a 4-hour loan policy and review the results after a 12-month cycle.

Introduction

SMU libraries' mission includes possessing the capability in providing seamless access to information using innovative and leading-edge technology. They are committed to delivering exceptional services and building dynamic relationships with the SMU community. As such, they are constantly seeking out ways in which they can improve users' experience in the libraries. Experience is derived not only in terms of the provision of space for users to study in, but also in terms of the quality of materials available to the users. This project focuses on the provision of printed course reserve materials by analysing the sufficiency of the loan periods assigned. A poor choice of loan period will result not only in dissatisfaction on the part of the library's patrons, but also in increased costs for the library such as those resulting from increased record keeping.

As such, SMU Libraries aim to align its loan policy with the expectations of the undergraduate students such that it would render the loan policy more sufficient for them. From 2016 to 2017, the 2-hour loan policy of course reserve collection was extended to 3 hours long. This paper then aims to investigate if this 1-hour extension in loan policy helped make it more sufficient for the SMU undergraduate students and with these insights found, propose if SMU Libraries should consider the option of extending this 3-hour loan policy by an additional hour.

Paper Outline

This paper will first start off with a literature review, detailing the insights from past research performed that is relevant to this project. This will provide the foundation of subsequent analysis methodologies and philosophy underlying insights. The data provided for this project will then be thoroughly explained and described. To ensure accuracy in insights, the data was properly cleaned and prepared. The data cleaning and preparation steps will be described and elaborated on before delving into the analysis. The analysis is performed in accordance to the 2 library user profiles that were established: users who overdue and users who borrow in succession. Insights found from this analysis would then be discussed and recommendations will be provided before concluding.

Literature Review

The following segment details the past research performed in the relevant field.

Research Paper Title	Learning Points
Modeling HIVAIDS Variables, A Case Of Contingency Analysis	• Contingency table is a type of table formatted in a matrix that displays the frequency distribution of variables. This way, they can provide a basic depiction of the interrelation between 2 variables and can help find interactions or associations between the variables. • Hypothesis testing could be performed on contingency tables to determine if interactions are present between variables.
Effective Access Management of Reserve and Normal Loan Materials	• Loan periods were the main determinant behind the lack of checkouts for books from the course reserve collection. This was because the students saw no point in checking the books out when they were only allowed to keep the book for several hours. • It is found that with a better understanding of teachers' instructional choices, the eventual access arrangement for all types of library materials will improve. This understanding can be obtained through the data exploration and analysis or through informal and formal communication with teachers. • The loan period is discipline and instructional choice sensitive, and hence the best arrangement should be worked out differently and accordingly.

Dataset

Data Collection

SMU libraries provided us with the datasets that were extracted from their system. Figure 1 shows the details the fields that were provided for each dataset.
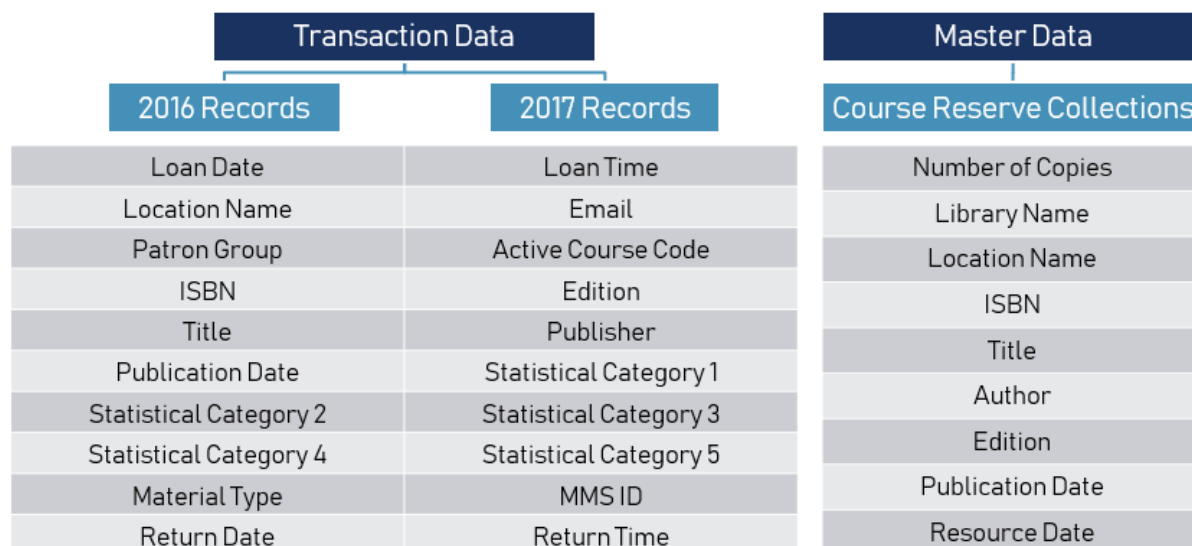

Figure 1: Breakdown of the Fields Provided in the Given Datasets

As can be seen in Figure 1, the transaction records are obtained from 2 different time periods: 12-month worth of data from year 2016 and 12-month worth of data from year 2017. In the 2016 dataset, loan policies are 2-hour and 3-day long while in the 2017 dataset, the loan policies are 3-hour and 3-day long. The transaction data amounts to 48,832 records in total while the master data has 528 records.

An informal primary research was also conducted. Through this, it was found that there were 2 distinct library user profiles. Should the undergraduate students find the loan policy insufficient, they would act in the following 2 ways:

1. They will **overdue** the books past the time the book is due and will return it only when they are done with it at a later time. The duration of the loan policy would be considered insufficient in this case as the users are unable to finish the usage of the books within the loan period.
2. They will **borrow in succession**. This group of users may borrow the same book title from the course reserves collection immediately after returning it. The duration of the loan policy would be considered insufficient in this case as the users are unable to finish the usage of the books within a single loan.

This observation will be taken into account when cleaning and preparing the data for analysis.

Data Cleaning and Preparation

Data cleaning and preparation is the most tedious, but most necessary task to perform before any analysis is conducted. Otherwise, the accuracy of insights may be compromised. This segment details the steps taken in cleaning and preparing the data for subsequent analyses. Unless otherwise stated, the same steps were applied for all transaction datasets: 2016 2-hour, 2016 3-day, 2017 3-hour, 2017 3-day.

Duplicated Data Values

Duplicates were found in the 'Title' field in the datasets. They were dealt with by lowercasing the strings, and removed unnecessary special characters like "/" and "." which appeared in some observations and not others for the same book title with the same "MMS ID". Figure 2 is an example.

Figure 2: Example of Duplications in 'Title' Column

Unnamed Columns

The columns that were labelled 'Statistical Category' were given more appropriate header titles. The column 'Statistical Category 5' was removed as it contained no observations.

Original Header Title	Updated Header Title
Statistical Category 1	School
Statistical Category 2	Degree
Statistical Category 3	Admission Year
Statistical Category 4	Graduation Year

Figure 3: Change in Header Titles

Missing Data Values

It was expected that for each transaction, deriving the hours borrowed would be required. As such, the columns 'loan_timestamp' and 'return_timestamp' were fields that were compulsory to have. It was noted that in the 2017 3-hour transaction dataset, there were 323 missing data values. Given that the proportion of missing data is relatively small, these instances were removed from the dataset with permission from SMU Libraries.

Calculation of New Variables

Additional columns were created to provide further analysis and aid with the investigation. All calculations were performed in JMP. This segment will detail all the new variables that were added.

Loan_Timestamp

This variable is a result of concatenating the 'loan_date' and 'loan_time' variables into a single field. This enhances the ease-of-use and aesthetic appeal.

Return_Timestamp

This variable is a result of concatenating the 'return_date' and 'return_time' variables into a single field. This enhances the ease-of-use and aesthetic appeal.

Hours_Borrowed

With both the 'loan_timestamp' and 'return_timestamp', the total hours borrowed for each transaction is known and calculated. This field is derived by calculating the date difference between the 'return_timestamp' and 'loan_timestamp' in terms of hours. This variable will be used primarily for investigation pertaining the users who overdue.

Assigned_Loan_Period

The assigned loan period is defined as the stipulated number of hours a library user is allowed to borrow the book for. The length of the assigned loan period varies depending on the time of day the loan occurs as this is depends on the library's Overnight Loan Policy detailed in Figure 4.

	Library Opening Hours	Overnight starts	To be returned... ...
Mon - Fri	8.00 am – 12 mn	9.00 pm	Next day, 10.30am
Sat	10.00 am – 9.00 pm	6.00 pm	Sun, 1.30pm
Sun	1.00 pm – 9.00 pm	6.00 pm	Mon, 10.30am

Figure 4: Library's Overnight Loan Policy

For example, if a user borrows a book at 10pm on Monday, he gets a total assigned loan period of 12.5 hours as he can have it until Tuesday morning at 10:30am. This field was derived using the IF() logical statement. This variable will be used primarily for investigation pertaining the users who overdue.

Overdue_Period

This variable was to take into account the varying assigned loan periods while in pursuit to analysing the sufficiency of the current loan policy. The column 'overdue_period' is derived by deducting 'assigned_loan_period' from 'hours_borrowed'. A positive value would indicate that the book was returned in advance and a negative value would indicate an overdue transaction. This variable will be used primarily for investigation pertaining the users who overdue.

Overdue?

This is a binary variable that classifies if a transaction is overdue or not. A value of 1 would indicate that the transaction was overdue and a value of 0 would indicate otherwise. This variable will be used primarily for investigation pertaining the users who overdue.

Time_Elapse

This variable calculates the time elapsed (in hours) between the borrowing of the same book from the previous time by the same user. It is derived through subtracting the 'loan_timestamp' of the current transaction with the previous 'return_timestamp' if the transaction is observed to be involving the same 'email' and 'title'. This variable will be used primarily for investigation pertaining the users who borrow in succession.

Transaction_Group

This variable was created with the purpose to serve as an identifier for transactions belonging to the same group. To be considered the same group, the fields 'email' and 'title' must remain the same while observing a 'time_elapsed' value of not more than 4. This means that transactions with the same user borrowing the same title within 4 hours of his preceding 'return_timestamp' would be considered as a single transaction. This variable will be used primarily for investigation pertaining the users who borrow in succession.

Hours_Borrowed_With_Successions

This variable sums up the 'hours_borrowed' that belongs to the same 'transaction group'. Duplication will be removed during the analysis. This is a field that is updated from 'hours_borrowed' to account for the succession borrowing behaviour that library users exhibit. This variable will be used primarily for investigation pertaining the users who borrow in succession.

Outliers

Parameters were set based on SMU Libraries' Overnight Loan Policy (Figure 4). The longest number of hours a library user can be assigned is 18.5 and 19.5 hours for a 2-hour loan policy in 2016 and a 3-hour loan policy in 2017 respectively. This occurs on Saturdays at 6pm.

In addition, SMU Libraries' Return Policy indicates that they do not accept the return of overdues exceeding 2 weeks, which translates to 336 hours. This then dictates that the maximum threshold for 'hours_borrowed' be 354.5 and 355.5 hours for a 2-hour loan policy in 2016 and a 3-hour loan policy in 2017 respectively. For books observing 3-day loan periods, the maximum threshold for 'hours_borrowed' would then be 336 hours from 72 hours, thereby rendering it to be 408 hours.

The table below states the number of transaction instances that were removed.

Dataset	Number of Transaction Instances Removed
2-hour loan policy in 2016	5
3-day loan policy in 2016	0
3-hour loan policy in 2017	12
3-day loan policy in 2017	0

Redefinition of Scope

As SMU Libraries' main group of users is the undergraduates, this paper would focus on the Year 1 to Year 4 undergraduates. As such, the following patron groups and years of study are filtered out:

> *Patron Group:* Adjunct, Admin Staff, Alumni, Faculty, Master, PhD, Others, Research Staff
> *Year of Study:* Year 0, Year 5 and above

A total of 2164 rows are being removed from the 2-hour, 3-hour and 3-days datasets.

Analysis

As established earlier, there are 2 distinct groups of library users; those who overdue the books they borrowed until they are done with it, and those who borrow in succession until they are done with it. These 2 groups will be analysed separately. Insights found from the 2016 transactional data will be compared against the 2017 transactional data with the objective of investigating if the 1-hour extension in loan policy helped made the loan policy more sufficient for each profile of undergraduate students.

Users Who Overdue

For this group of users, insufficiency would be measured through the frequency of overdue transactions and the length of the overdue periods.

Frequency of Overdue Transactions

With the 1-hour extension in loan policy from 2016 to 2017, a lower frequency of overdue transactions would be expected assuming that undergraduate students maintain the same definition of sufficiency. In the following segment, the frequency of overdue transactions will be derived for both 2016 and 2017 before delving into the following up on potential insights.
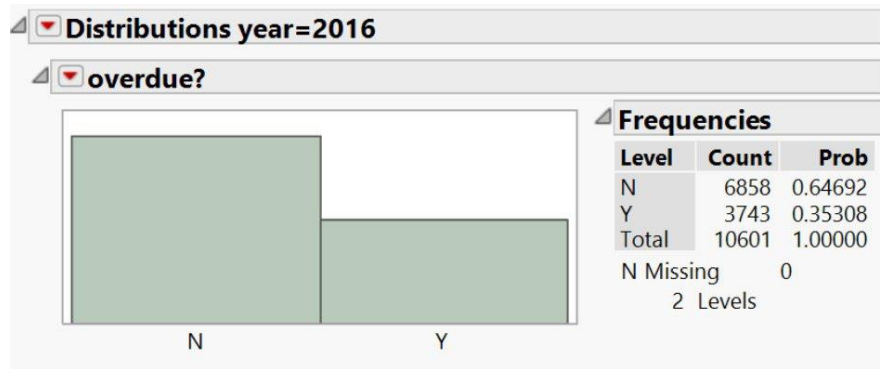
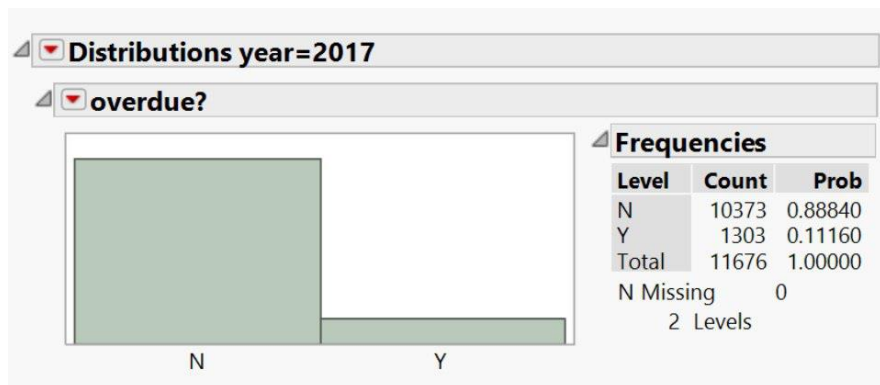*Figure 5: Distribution of Frequency of Overdue Transactions in 2016*

Figure 6: Distribution of Frequency of Overdue Transactions in 2017

35.31% of loan transactions were found to be overdue in 2016 (Figure 5) while 11.16% of loan transactions in 2017 were found to be overdue (Figure 6). This decrease in the percentage of overdue transactions could indicate towards the 1-hour extension in loan policy having a positive impact on such users. As such, it was of interest if this difference had statistical backing.

A Contingency Analysis was conducted with the intention of determining if there was statistical significance that the difference between the frequency distribution of overdue transactions across the years 2016 and 2017. The null hypothesis states that the frequency distribution of overdue transactions in 2016 and 2017 are equal. The Contingency report was derived and the results are described below.
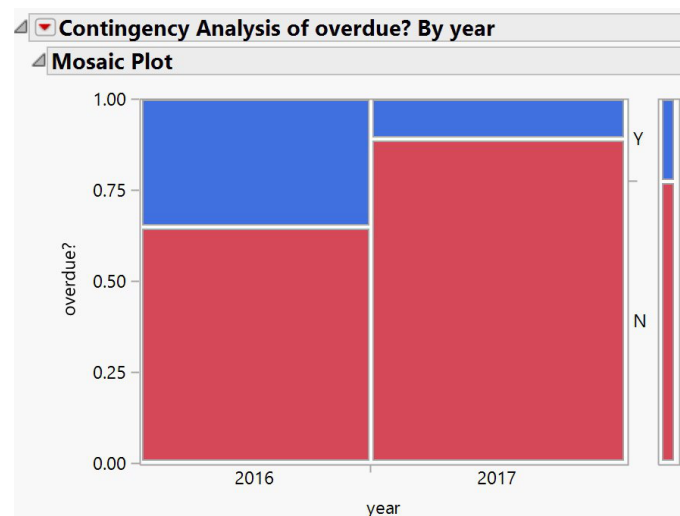

Figure 7: Mosaic Plot on the Frequency of Transactions that were Overdue across years 2016 and 2017

Contingency Table

		overdue?		
Count Total % Col % Row %		N	Y	Total
year	2016	6858 30.79 39.80 64.69	3743 16.80 74.18 35.31	10601 47.59
	2017	10373 46.56 60.20 88.84	1303 5.85 25.82 11.16	11676 52.41
	Total	17231 77.35	5046 22.65	22277

Figure 8: Contingency Table on the Frequency of Transactions that were Overdue across years 2016 and 2017

Tests

N	DF	-LogLike	RSquare (U)
22277	1	950.48724	0.0797

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	1900.974	<.0001*
Pearson	1849.331	<.0001*

Fisher's Exact Test

	Prob	Alternative Hypothesis
Left	<.0001*	Prob(overdue?=Y) is greater for year=2016 than 2017
Right	1.0000	Prob(overdue?=Y) is greater for year=2017 than 2016
2-Tail	<.0001*	Prob(overdue?=Y) is different across year

Figure 9: Tests Report on the Frequency of Transactions that were Overdue across years 2016 and 2017

At α=0.05, the test results show that the p-values of both Likelihood Ratio and Pearson tests are <.0001, hence rejecting the null hypothesis. This shows that there is a difference between the frequency distribution of overdue transactions in 2016 and 2017. This analysis was furthered with Fisher's Exact Test which tested for the alternative hypothesis that the distribution of overdue transactions is greater in 2016 than in 2017. At α=0.05, the test results show that the p-value is <0.0001, thereby rejecting the null hypothesis and allowing for the conclusion that the probability of a transaction that is overdue occurring was higher in 2016 than in 2017.

Duration of Overdue Period

In this segment, the distribution of the duration of overdue period observed in 2016 and 2017 are first derived and explored before delving into the following up on potential insights. With a 1-hour increment in loan policy, it is expected that the overdue period be shorter and its distribution skew to the left.
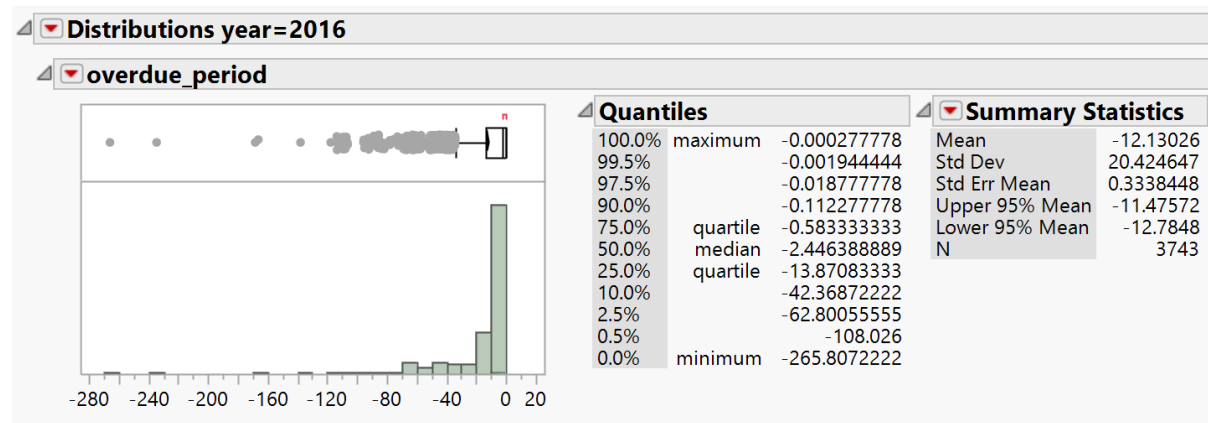
Distributions year=2016

overdue_period

Quantiles		
100.0%	maximum	-0.000277778
99.5%		-0.001944444
97.5%		-0.018777778
90.0%		-0.112277778
75.0%	quartile	-0.583333333
50.0%	median	-2.446388889
25.0%	quartile	-13.87083333
10.0%		-42.36872222
2.5%		-62.80055555
0.5%		-108.026
0.0%	minimum	-265.8072222

Summary Statistics	
Mean	-12.13026
Std Dev	20.424647
Std Err Mean	0.3338448
Upper 95% Mean	-11.47572
Lower 95% Mean	-12.7848
N	3743

Figure 10: Distribution of Overdue Period in 2016

50% of the borrowings were observed to overdue for more than 2.45 hours and 25% of the borrowings were overdue for more than 13.87 hours. When consulting the 'Summary Statistics' report, the skewness statistics is noted to be a value of -2.99. A negative skewness value indicates that the distribution is negatively skewed. This could be due to the instances where individuals are observed to have borrowed 2-hour loan policy books for more than 100 hours.
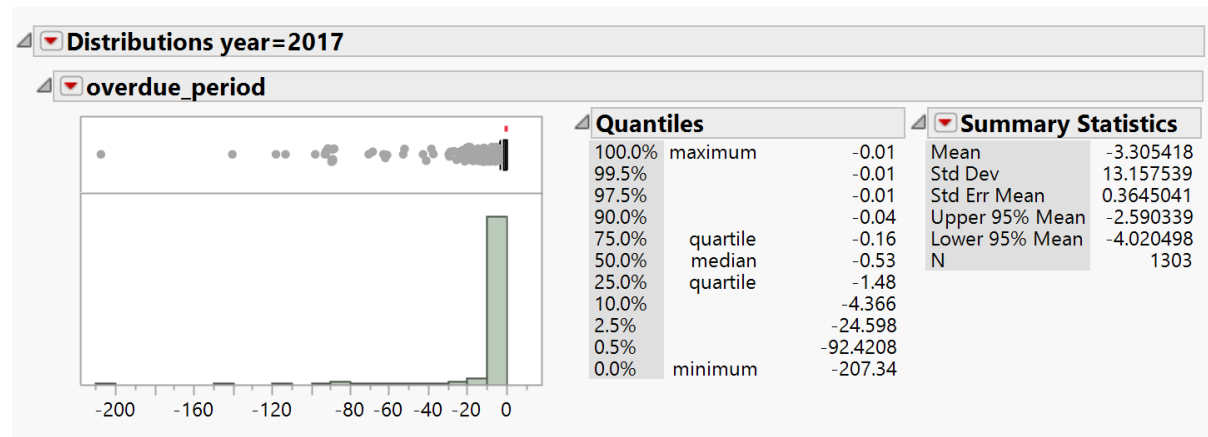

Distributions year=2017
overdue_period

Quantiles		
100.0%	maximum	-0.01
99.5%		-0.01
97.5%		-0.01
90.0%		-0.04
75.0%	quartile	-0.16
50.0%	median	-0.53
25.0%	quartile	-1.48
10.0%		-4.366
2.5%		-24.598
0.5%		-92.4208
0.0%	minimum	-207.34

Summary Statistics	
Mean	-3.305418
Std Dev	13.157539
Std Err Mean	0.3645041
Upper 95% Mean	-2.590339
Lower 95% Mean	-4.020498
N	1303

Figure 11: Distribution of Overdue Period in 2017

50% of the borrowings were overdue for up to 0.53 hours and 75% of the borrowings were overdue for up to 1.48 hours. When consulting the 'Summary Statistics' report, the skewness statistics shows itself as having a value of -7.97. The distribution of 'overdue_period' in 2017 appears to be more negatively skewed as compared to in 2016. This shows that in 2017, the transactions tend to observe an overdue period closer to 0, which indicates towards an increased sufficiency level for this user profile.

Following this discovery, the Goodness-of-Fit Test was conducted to determine if the distribution of 'overdue_period' in both years follow a normal distribution. The null hypothesis for such an analysis would state that the data follows the Normal distribution. The following figures detail the results:
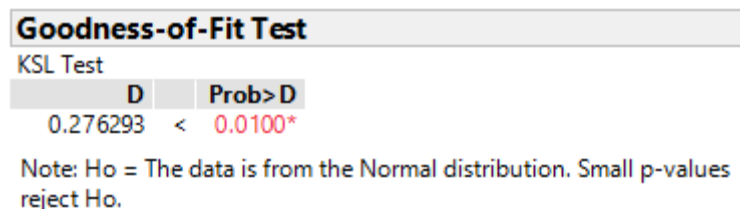
Goodness-of-Fit Test
KSL Test

D		Prob>D
0.276293	<	0.0100*

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 12: Goodness-of-Fit Test of Overdue Period in 2016

Goodness-of-Fit Test
Shapiro-Wilk W Test

W	Prob<W
0.231702	<.0001*

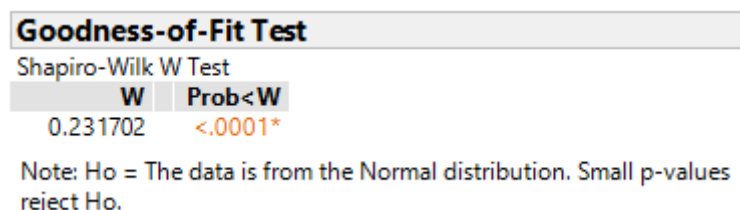Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 13: Goodness-of-Fit Test of Overdue Period in 2017

As can be seen in Figure 12 and 13, at $\alpha=0.05$, the test results show that both p-values are <0.0001, hence rejecting the null hypothesis. The stand of the alternative hypothesis can be adopted, and hence concluding that data for both overdue periods in 2016 and 2017 do not follow the Normal distribution.

Given the non-normality of the data, a nonparametric statistical test, the Wilcoxon Rank-Sums Test, was conducted to confirm if there is a significant difference between the distribution of overdue periods

observed in 2016 and 2017. The null hypothesis states that the distribution of the overdue periods observed in 2016 and 2017 are equal and the alternative hypothesis states that the distribution of the overdue periods observed in 2016 and 2017 are not equal.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
2016	589	237962	261516	404.010	-6.535
2017	298	155866	132312	523.040	6.535

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
155866	6.53548	<.0001*

1-Way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
42.7143	1	<.0001*

Figure 14: Wilcoxon Rank Sums Test Results for Overdue Period across Years 2016 and 2017

Both the normal and the chi-square approximations for the Wilcoxon test statistic indicate significance at a p-value of <.0001 (Figure 14). As such, at α =0.05, the null hypothesis is rejected and the alternative hypothesis is confirmed. The distributions in the overdue period in 2016 and 2017 are proven to be significantly different. With this, given that the median of overdue period in 2017 is smaller than in 2016, it can be inferred that transactions in 2017 overdue for an amount of time closer to 0 than in 2016 after the 1-hour extension in loan policy.

Users Who Borrow Successively

In the following discussion, the 2-hour and 3-day loan transactions were appended together for 2016 and 3-hour and 3-day loan transactions were appended together for 2017. SMU Libraries believed that this would provide a more accurate depiction as course reserve materials with the same titles could have different loan policies. Past studies and observations conducted by SMU Libraries have shown that undergraduate students prefer borrowing course reserves with the 3-day loan policy but should those books be unavailable, they would settle for those with 2-hour or 3-hour loan policy instead.

For this group of users, insufficiency would be measured through the frequency of succession borrows and the length of total hours borrowed after accounting for successive borrows.

Frequency of Succession Borrows

With a 1-hour extension in the loan policy from 2-hour in 2016 to 3-hour in 2017, a decrease in the frequency of succession borrows would be expected if the undergraduate students' definition of sufficiency remained constant. Thus, in this segment, the paper plans to investigate if the distribution of the frequency of succession borrows changed significantly between 2016 and 2017.

In this segment, the distribution of the frequency of succession borrows observed in 2016 and 2017 are first derived and explored before delving into the following up on potential insights.
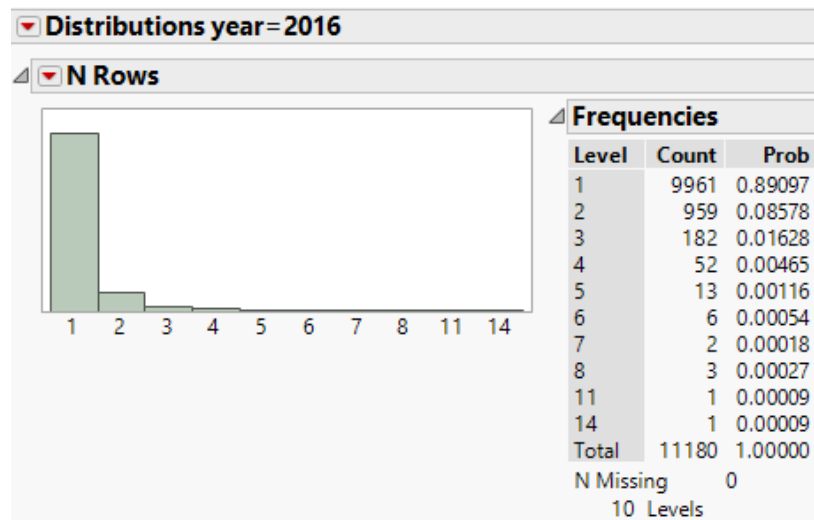
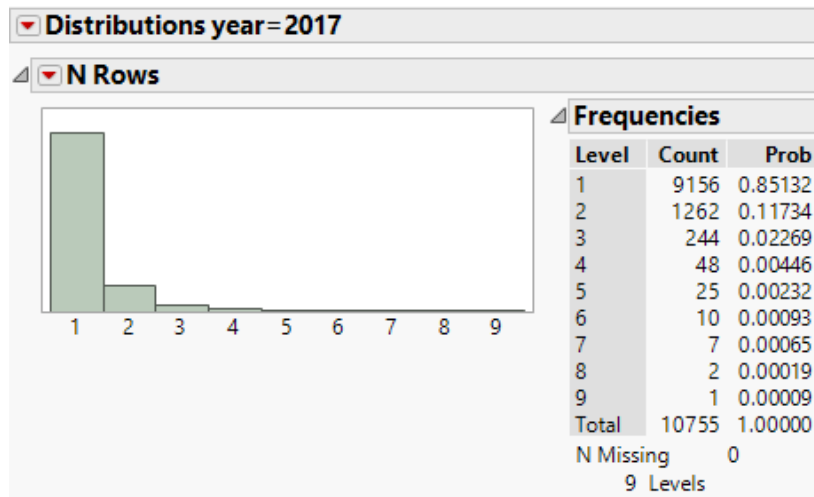*Figure 15: Distribution of the Frequency of Successive Borrows in 2016*

Figure 16: Distribution of the Frequency of Successive Borrows in 2017

Comparing the distribution of the data in 2016 and 2017 shown in Figure 16 and 17 respectively, it seems that the proportion of undergraduate students borrowing only once and not requiring a subsequent borrow was lower in 2016 than 2017. 89.10% of transactions were observed to be one-time off borrows in 2016 while in 2017, such transactions only make up 85.13% of the total recorded transactions. In addition, in both years, 99% of the transactions observe 3 or less borrowings in succession. It was then of interest if this finding is statistically significant as it might serve as a potential indication towards the futility of 1-hour extension policy implementation.

A contingency analysis was conducted to confirm if there is a difference in the frequency of succession borrows observed in 2016 and 2017. The null hypothesis hence states that the distribution of the frequency of succession borrows in 2016 and 2017 are equal and the alternative hypothesis states that the distribution of the frequency of succession borrows in 2016 and 2017 are not equal.
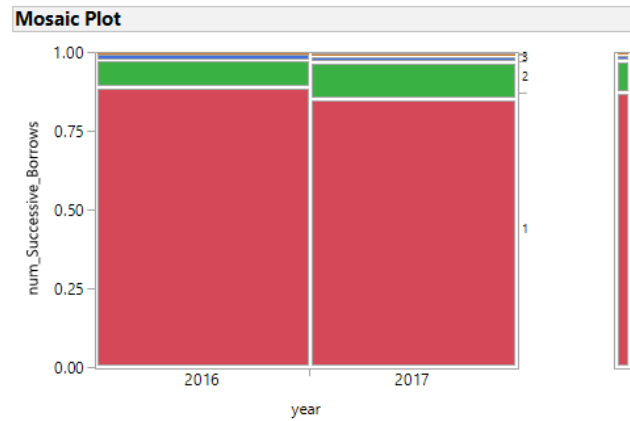
Figure 17: Mosaic Plot of the Number of Successive Borrows

Figure 18: Contingency Table of the Number of Successive Borrows

Figure 19: Tests of the Number of Successive Borrows

At α=0.05, the test results show that the p- values of both Likelihood Ratio and Pearson tests are <.0001, hence rejecting the null hypothesis. This shows that there is a difference between the frequency distribution in 2016 and 2017. These differences are not just by chance. Judging from the Mosaic Plot and Contingency Table in Figure 17 and 18, it can be inferred that the probability of undergraduate students borrowing only once is higher in 2016 than 2017. This means that the probability that an undergraduate student finding the loan policy insufficient and needing a succeeding borrow is higher in 2017 than in 2016.

Duration of Hours Borrowed with Successions

After accounting for successive borrowing behaviours that the undergraduate students exhibit, this segment aims to find out a more accurate depiction of the distribution of the hours the undergraduate students are using the course reserve materials for. Previously, each transaction was viewed as independent from one another. This field considers the underlying possibility that undergraduate students are returning the books only to check it out again as the loan period is insufficient.

In this segment, the paper will explore the distribution of the hours borrowed first before delving into the following up on potential insights.
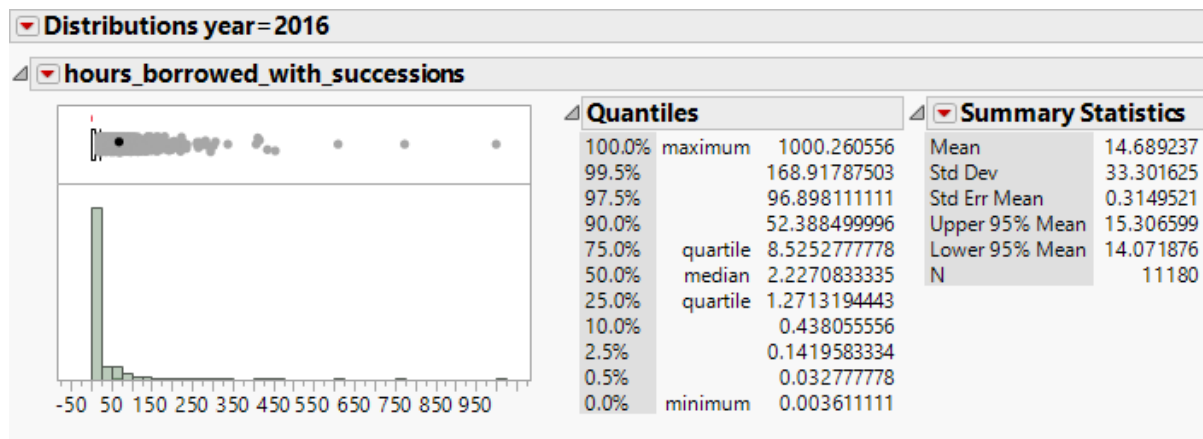

Figure 20: Distribution of Hours Borrowed with Successions in 2016

In 2016, after accounting for the possibility of user successions, 50% of the transactions are observed to have borrowed for at least 2.23 hours while 25% of the transactions observed borrowings of at least 8.53 hours long. These findings can be observed from Figure 20.
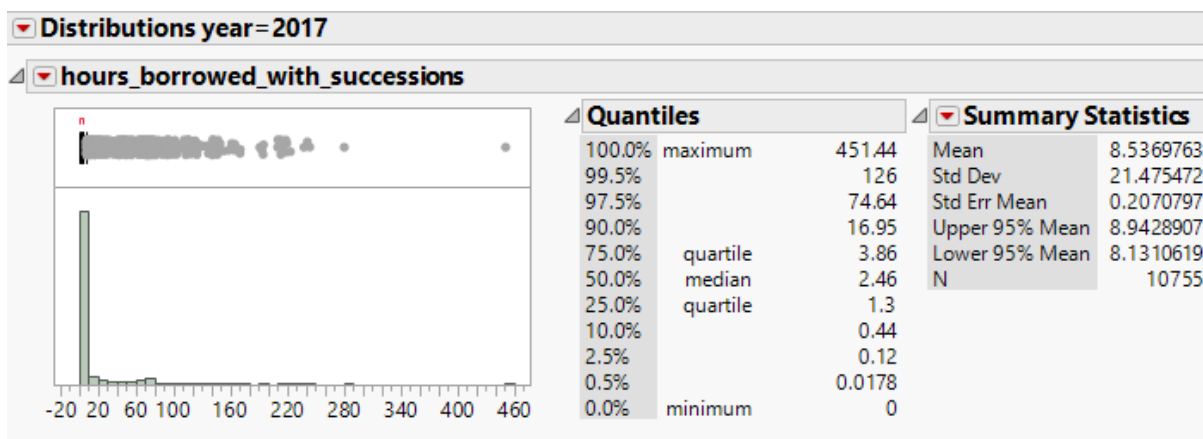

Figure 21: Distribution of Hours Borrowed with Successions in 2017

In 2017, after accounting for the possibility of user successions, 50% of the transactions are observed to have borrowed for at least 2.46 hours while 25% of the transactions observed borrowings of at least 3.86 hours long. These findings can be observed from Figure 21.

Following these discoveries, both the data from 2016 and 2017 are then tested for normality using the Goodness-of-Fit Test. The null hypothesis states that the data follows the Normal distribution.
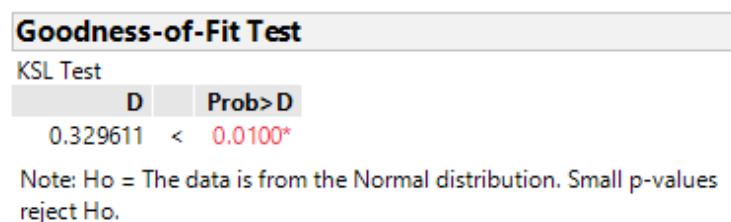
Figure 22: Goodness-of-Fit Test for Hours Borrowed with Successions in 2016

Goodness-of-Fit Test

KSL Test

D		Prob>D
0.381705	<	0.0100*

Note: Ho = The data is from the Normal distribution. Small p-values reject Ho.

Figure 23: Goodness-of-Fit Test for Hours Borrowed with Successions in 2017

As can be seen in Figure 22 and 23, at α=0.05, the test results show that both p-values are <0.0001, hence rejecting the null hypothesis. The stand of the alternative hypothesis can be adopted, and hence concluding that data for both overdue periods in 2016 and 2017 do not follow the Normal distribution.

Given that data from both 2016 and 2017 are found to lack normality, nonparametric test, Wilcoxon Rank Sums Test, was conducted to confirm the significance of the difference in hours borrowed with successions observed in 2016 and 2017. The null hypothesis, in this case, would be that the distribution of the hours borrowed with successions in 2016 and in 2017 are equal.

Wilcoxon / Kruskal-Wallis Tests (Rank Sums)

Level	Count	Score Sum	Expected Score	Score Mean	(Mean-Mean0)/Std0
2016	11180	1.26e+8	1.23e+8	11296.2	7.826
2017	10755	1.14e+8	1.18e+8	10626.9	-7.826

2-Sample Test, Normal Approximation

S	Z	Prob>|Z|
114291877	-7.82581	<.0001*

1-Way Test, ChiSquare Approximation

ChiSquare	DF	Prob>ChiSq
61.2433	1	<.0001*

Figure 24: Wilcoxon Rank Sums Test Results for Hours Borrowed with Successions

Both the normal and the chi-square approximations for the Wilcoxon test statistic indicate significance at a p-value of <.0001 as shown in Figure 24. As such, at α=0.05, there is sufficient evidence to reject the null hypothesis and confirm the alternative which is that the distribution in the hours borrowed with successions in 2016 and 2017 are different. It can be inferred that the distribution in the hours borrowed with successions became less negatively skewed in 2017 than in 2016.

The other main objective of this paper was to find out if there was sufficient evidence indicating towards the need to extend the loan policy further. Thus, a one-sample test for the mean using the nonparametric Wilcoxon Signed-Rank Test was conducted to aid with this analysis. Given that the current loan period is set at 3 hours, the probability of undergraduate students underutilising, fully utilising or over utilising the loan period was of much interest. Looking at just the 2017 data, the null hypothesis of the Wilcoxon Signed-Rank Test thus states that the median is equal to the postulated value set at 3.
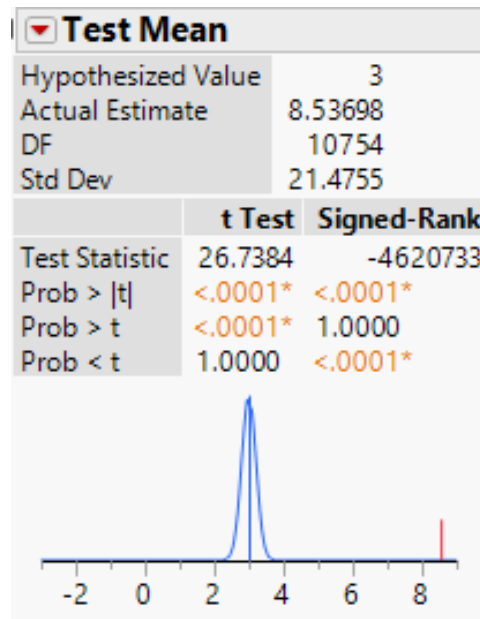
Figure 25: Wilcoxon Signed-Rank Test Results for Hours Borrowed with Successions

At α=0.05, the test results show a p-value of less than 0.001 as can be seen in Figure 25, thereby rejecting the null hypothesis. It can be concluded with 95% confidence that this population has a median distinct from 3.0 hours. In fact, when a lower tailed test is conducted, the p-value remains at <0.001, hence rejecting the null hypothesis and allowing for the conclusion that the median of the hours borrowed with successions is less than 3 hours.

Discussion

The library patrons can be profiled into 2 categories: users who overdue and users who exhibit succession borrowing behaviour. SMU Libraries implemented a 1-hour extension in loan policy in hopes of the loan policy becoming more aligned with the undergraduate students' expectations. The impact of the implementation of this update in the loan policy on the user profiles was analysed and the following conclusions were obtained:

1. Users who overdue
   - The probability of a transaction being overdue is higher in 2016 than in 2017. With a 1-hour extension in the loan policy, a higher proportion of the transactions did not overdue the course reserves and hence, it could be inferred that the loan policy became more sufficient for this group of users. This is a potential indication towards an increasing **alignment** with undergraduate students' loan policy expectations.
   - The distribution of hours borrowed in 2017 is less negatively skewed than in 2016. The loan transactions in 2017 observe a shorter overdue period than loan transactions in 2016. It can be inferred that undergraduate students overdue for a shorter amount of time closer to 0 in 2017 than in 2016. This is a potential indication towards an increasing **alignment** with undergraduate students' loan policy expectations.
2. Users who borrow in succession
   - It was established with statistical significance that there is a difference in the distribution in the hours borrowed with successions in 2016 and 2017. It was inferred that the distribution in the hours borrowed with successions became less negatively skewed in 2017 than in 2016, thereby indicating towards the potential **alignment** with undergraduate students' loan policy expectations.
   - In 2017, it was established with statistical significance that the median of hours borrowed with successions is less than 3 hours. In 2017, 50% of undergraduate students

do not fully utilise the 3-hour loan policy that is assigned to them. This could be a potential indication towards an **alignment** with undergraduate students' loan policy expectations.

- It was established with statistical significance that there is a difference between the frequency distribution of succession borrows in 2016 and 2017. Judging from the distribution, the probability that a transaction sees a succeeding borrow is potentially higher in 2017 than in 2016. This could be a potential indication towards a **deviation** from undergraduate students' loan policy expectations.

Further analysis concerning the users who borrow in succession is required. When it was found that the probability that a transaction sees a succeeding borrow is potentially higher in 2017 than in 2016, this claim was investigated further. It was found that there were many more transactions involving the 3-day loans in 2016 than in 2017. As can be seen in Figure 26, there was a decrease in the number of transactions involving the loan of 3-day course reserve collection in 2017.
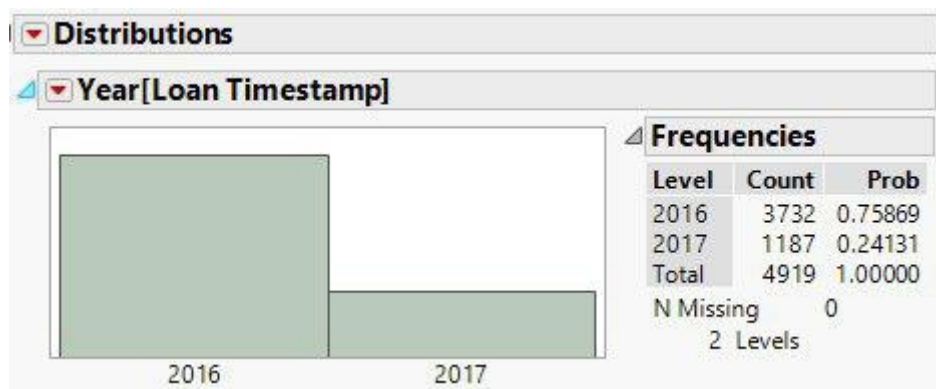
Figure 26: Frequency Distribution of Transactions Involving 3-Day Course Reserve Collection across 2016 and 2017

The distribution of the frequency of succession borrows involving the 3-day course reserve collection was further investigated.
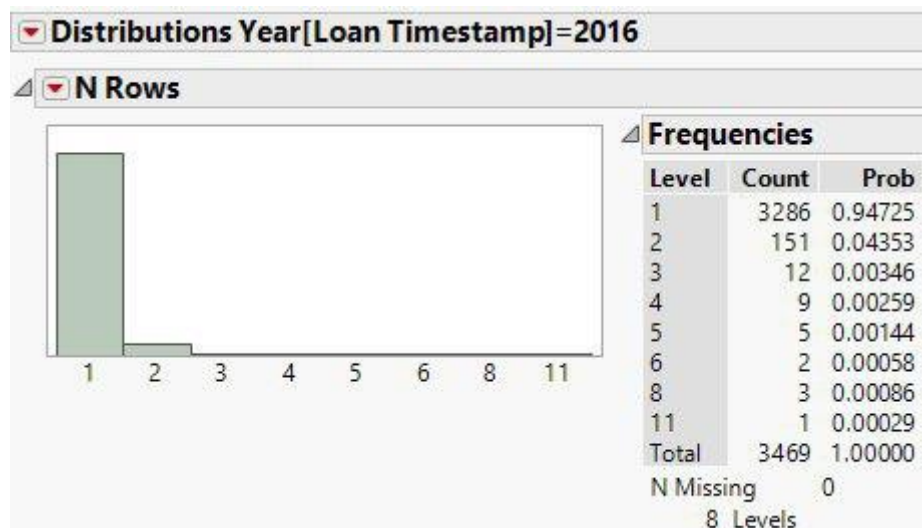

Figure 27: Distribution of the Frequency of Succession Borrow in 2016
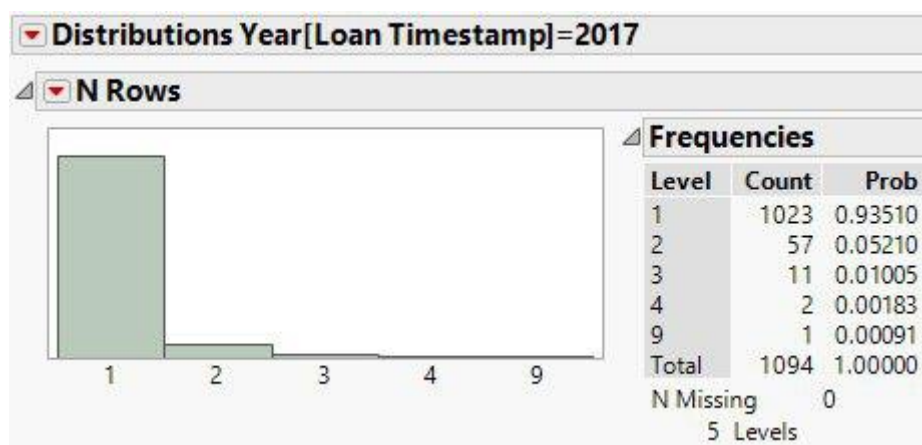
Figure 28: Distribution of the Frequency of Succession Borrow in 2017

For transactions involving the 3-day course reserve collection, undergraduate students typically do not require a successive borrowing. In 2016, 94.73% of the transactions did not observe a subsequent borrow (Figure 27). This trend was similar in 2017 as well where 93.51% of transactions did not observe a subsequent borrow (Figure 28). On this note, with at least 3 times more transactions involving 3-day course reserve collection in 2016 than in 2017, it is natural that the proportion of one time borrows becomes higher in 2016 than in 2017.

Upon discovery of this finding, new information came to light. In 2017, there was another major change happening that could have influenced these results. Since the implementation of the 1-hour extension in loan policy, SMU Libraries was noted to have shifted the 3-day course reserve collection to another location in the library, away from the 3-hour course reserve collection in 2017. In 2016, the 2-hour course reserve collection was together with the 3-day course reserve collection while in 2017, the collections were apart. This movement went largely unnoticed to SMU undergraduate students; the client found that students was unaware that at another part of the library, the same course reserve title with a longer loan policy was available for circulation. Further studies should investigate into the potential of the impact this change in location would have on the borrowing pattern of the undergraduate students in 2017.

When the distribution of the frequency of succession borrows was derived with datasets including the course reserves of only 2-hour and 3-hour loan policies, the distributions were not as different as can be seen in Figure 29 and 30 respectively.
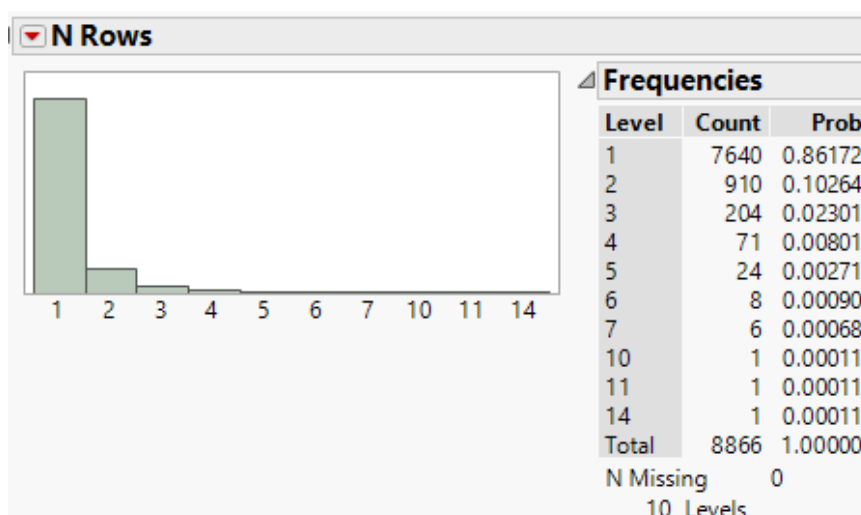

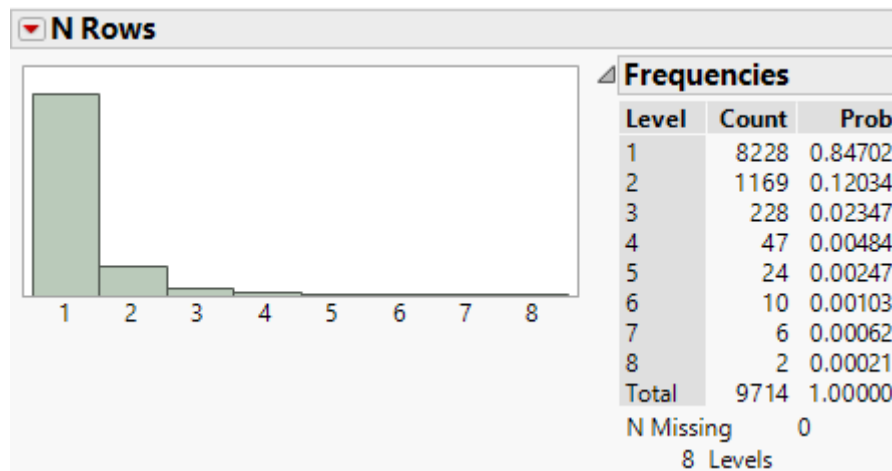*Figure 29: Distribution of Frequency of Succession Borrow in 2016*

Figure 30: Distribution of Frequency of Succession Borrow in 2017

Once the 3-day loans are excluded from the analysis, the proportion of transactions observed to borrow a book title only once dropped from 86.17% in 2016 (Figure 29) to 84.70% in 2017 (Figure 30). Additional observation includes 99% of the transactions observe 4 or less borrowings in succession in 2016 compared to 3 or less borrowings in succession in 2017.

A Contingency Analysis was conducted with the intention of determining if there was statistical significance that the difference between the frequency of successive borrows across the years 2016 and 2017. The null hypothesis states that the frequency of successive borrows in 2016 and 2017 are equal. The Contingency report was derived, and the results are described below.
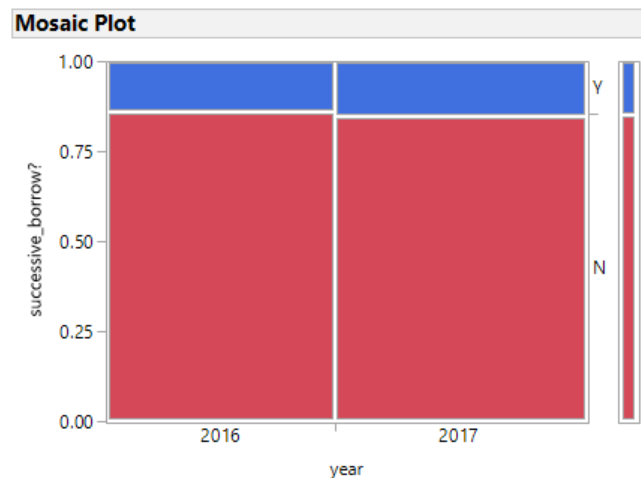
Figure 31: Mosaic Plot of successive borrows by year

Figure 32: Contingency Table of Successive Borrows by Year

Figure 33: Tests of the Successive Borrows

At α=0.05, the test results show that the p-values of both Likelihood Ratio and Pearson tests are <.0.05, hence rejecting the null hypothesis. This shows that there is a difference between the frequency of succession borrowings in 2016 and 2017.

This analysis was furthered with Fisher's Exact Right-Tail Test which tested for the alternative hypothesis that the distribution of succession borrows is greater in 2017 than in 2016. At α=0.05, the test results show that the p-value is <0.05, thereby rejecting the null hypothesis and allowing for the conclusion that the probability of a succession borrows occurring was higher in 2017 than in 2016.

Since the change in location seems to be a major contributing factor, the accuracy of the claim that the update in loan policy did not benefit the users who perform succession borrowing could have been compromised. As such, all the above considerations should be taken into account for a proper conclusion towards whether this is indeed an indication towards an insufficiency of the 3-hour loan policy for the users who borrow in succession.

Conclusion

On a whole, the 1-hour extension in loan policy from 2-hour to 3-hour in 2017 saw an improvement in the users who overdue where the probability of an overdue transaction became less and the length of overdue period became shorter. The impact of the 1-hour extension in loan policy from 2-hour to 3-hour in 2017 on the users who borrow in succession is inconclusive. Although the length of hours borrowed with successions became less negatively skewed given the smaller spread, it was noted that the 3-day course reserve collection was moved in 2017 and this might have compromised the insights found regarding the frequency of succession borrow and the hours borrowed with successions of undergraduate students. This should be further investigated to confirm the accuracy of this statement.

Given the increased sufficiency observed by the users who overdue, there is no evidence that SMU Libraries should not extend the loan policy by another hour given the existence of overdue transactions. Based on the overdue period in 2017, 50% of transactions observed to need up to 0.53 hours more. Based on the hours borrowed with succession, 25% of transactions observed to need at least 3.86 hours. It is proposed that SMU Libraries consider implementing a 4-hour loan policy and conducting another analysis after a 12-month cycle of implementation. The same steps should be taken and should the results show that the circumstances improve, the 1-hour extension in loan policy would be justified. In the 2017 data, the median of the hours borrowed with succession is proven with statistical significance that it is less than 3 hours. This test should be conducted once again against a stipulated value of 3. Should there be significant evidence to show that the median remains less than 3, this 1-hour extension in loan policy may not be justified and SMU Libraries can consider reverting to the 3-hour loan policy.

References

1. Leung, Y. (2010). Effective Access Management of Reserve and Normal Loan Materials. Journal of Access Services, 7(1), 1-14.
2. O. C. Asogwa. (2010). Modeling HIVAIDS Variables, A Case Of Contingency Analysis. West African Journal of Industrial & Academic Research, 14(1), 71-80.

Acknowledgments

Recommended Reading

- *Basic Analysis – SAS Support®*

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