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**PROJECT TITLE:**

**ANALYSIS OF TELCOM CUSTOMER DATA IN TELKOM COMPANY BY USING SAS  
ENTERPRISE MINER 15.1**

**GROUP: N4CS2414T3**

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## **CHAPTER 1**

### **OVERVIEW OF PROJECT**

#### **1.1 INTRODUCTION**

Customer churn is perhaps the biggest challenge in telco (telecommunication) industry. A churning customer quits the service provided by operators and yields no profit any longer. Prepaid customers have a significantly higher churn rate which is on average about 9.4% than the postpaid customer which is on average 5.2% because the prepaid customer is not bound to contract and can quit easily. For this project, we want to predict behavior to retain customers. We used the data to analyze all relevant customer data and develop focused customer retention programs.

We obtain the data for this project from Kaggle website. The data is about Telco Customer Data in Telkom Company. Telkom company is an information and communications technology service provider in South Africa. It is a South Africa wireline and wireless telecommunications provider, operating in more than 38 countries across the African continent. The company offering fixed line, mobile and data services and information technology services.

The data that we obtain have 7043 data details of Telkom customer from different backgrounds. The total variable in this data is 21 with 3 continuous variables, 16 categorical variables, one ID and one target variable with variable names which is churn. From the target variable, we can analyze where the customer is still loyal with the Telkom Company or not.

#### **1.2 DESCRIPTION OF DATA**

For this study, we obtain the data from Kaggle website. The data obtained from this study is about Telcom Customer Data in Telkom Company. Telkom Company is an information and communications technology service provider in South Africa. They provide a large scale of business about telco industry. The company offering fixed-line, mobile and data services and information technology services. About the data in this study, there is 7043 data details of telco customer from different backgrounds. The total number of variables in this data is 21 with 3 continuous variables, 16 categorical

variables, one ID and one target variable with variable name is churn. The target variable is about whether the customer is still loyal with the Telkom Company or not and want to predict to retain customers and to develop focused on customer retention programs.

### 1.3 DESCRIPTION OF THE VARIABLES

The role and level of data measurement of this study are shown in table 1.0 below:

Table 1.1: Attribute Information

| Variable Name   | Description                                                            | Level Measurement | Role Measurement |
|-----------------|------------------------------------------------------------------------|-------------------|------------------|
| CustomerID      | Unique id for each customer                                            | Nominal           | Rejected         |
| Gender          | Gender of the customer<br>(‘Female’, ‘Male’)                           | Binary            | Input            |
| SeniorCitizen   | Elderly customer who is 60 years and above<br>(‘0’ – No, ‘1’ – Yes)    | Binary            | Input            |
| Partner         | MarriedCustomer<br>(‘Yes’, ‘No’)                                       | Binary            | Input            |
| Dependents      | Customer that relies on another for financial support<br>(‘Yes’, ‘No’) | Binary            | Input            |
| Tenure          | How long they have been customer                                       | Interval          | Input            |
| PhoneService    | Service phone subscription<br>(‘Yes’, ‘No’)                            | Binary            | Input            |
| MultipleLines   | Various type of telco<br>(‘Yes’, ‘No’, ‘No phone service’)             | Nominal           | Input            |
| InternetService | Type of internet<br>(‘DSL’, ‘Fiber optic’, ‘No’)                       | Nominal           | Input            |
| OnlineSecurity  | Online security subscription<br>(‘Yes’, ‘No’, ‘No internet service’)   | Nominal           | Input            |
| OnlineBackup    | Online Backup subscription<br>(‘Yes’, ‘No’, ‘No internet service’)     | Nominal           | Input            |

|                  |                                                                                                               |          |        |
|------------------|---------------------------------------------------------------------------------------------------------------|----------|--------|
| DeviceProtection | Device protection subscription<br>(‘Yes’, ‘No’, ‘No internet service’)                                        | Nominal  | Input  |
| TechSupport      | Technical support subscription<br>(‘Yes’, ‘No’, ‘No internet service’)                                        | Nominal  | Input  |
| StreamingTV      | TV streaming subscription<br>(‘Yes’, ‘No’, ‘No internet service’)                                             | Nominal  | Input  |
| StreamingMovies  | Movies streaming subscription<br>(‘Yes’, ‘No’, ‘No internet service’)                                         | Nominal  | Input  |
| Contract         | Period for renewal<br>(‘Month-to-month’, ‘One year’, ‘Two year’)                                              | Nominal  | Input  |
| PaperlessBilling | Receive bill through email or online account<br>(‘Yes’, ‘No’)                                                 | Binary   | Input  |
| PaymentMethod    | Type of payment<br>(‘Electric check’, ‘Mailed check’, ‘Bank transfer (automatic)’, ‘Credit card (automatic)’) | Nominal  | Input  |
| MonthlyCharges   | Bill excluding taxes and surcharges                                                                           | Interval | Input  |
| TotalCharges     | Bill including taxes and surcharges                                                                           | Interval | Input  |
| Churn            | Customer who left within the last month<br>(‘Yes’, ‘No’)                                                      | Binary   | Target |

## 1.4 PROBLEM STATEMENT

In recent years, Telcom customer churn become a serious problem and one among most important concerns for large companies. It became difficulties when effect on the revenues of the companies especially within the telecom field. Company will face to seeking to develop to predict potential customer to churn. Not only in Malaysia but in all country face this problem and struggling to increase the revenues in all Telcom company. On top of that, as we all know China telecom company have a large problem of customer churn which contains about 5.23 million customers. The prediction accuracy standard was the overall accuracy rate and reached 91.1%. Many researchers studied the problem of unbalanced data sets where the churned customer classes are smaller than the active customer classes, because it may be a major issue

in churn prediction problem. However, customer complaints' database provides all complaints has been submitted and statistics inquiries associated with to coverage, problems in offers and packages, and any problem related to the telecom business.

From this study, most of the findings will benefit to telecommunications service industry when we touch on the evaluation of customer experience on Telcom services. One of survey report A survey report published by Frost & Sullivan's Malaysia Telecommunications Services Customer Experience online, between the months of October to November 2014 shows that in the fourth place about 58%, is the complaint on the absence of customer experience among mobile operators is one of the causes that Malaysians discontinued their subscription. Another 83% of the consumers will choose another telecommunication service provider if there is an uncertain issue on the pricing and subscription plans. Whilst 66%, of the survey respondent insists for a better speed internet or data connectivity and will not hesitate to terminate their subscription plan from the prevailing mobile operator with poor internet speed experience. Hence, many problems that face on Telcom company give more strategies to retain their existing customers while ensuring a continuous growth also improving customer loyalty.

## **1.5 RESEARCH QUESTIONS OF THE STUDY**

The research questions of this study are outlined as follows:

- i. What is the variable importance between the three model ?
- ii. Which model is an overfit and underfit?
- iii. Which model is the best model between decision tree, logistics regression and neural network?

## **1.6 RESEARCH OBJECTIVES OF THE STUDY**

The research objectives of this study are outlined as follows:

- i. To analyze the variable importance between the three model.
- ii. To find the overfit and underfit model.
- iii. To determine the best fit among the model; decision tree, logistic regression model and artificial neural network.

## **1.7 SIGNIFICANCE OF THE STUDY**

This study might be important to the Telco companies since it might provide an understanding on the importance of adopting customer experience management to mitigate customer churn. It will expose how the tenure of a customer used telco (telecommunication) services is significantly related to the customer's loyalty. These findings are very important and ease for the companies to find out and creating marketing strategies that appeal to many potential consumers.

The companies might be able to understand the important customer experience management methods that they can use as to customer experience management. The telco industry is broad but fierce competition between carriers may reduce the market share of each of them. The telco space is increasingly becoming more competitive, which means consumers have many options. So that, the customer will choose the best telco as their services for their advantages with affordable price and more usage services

The operators can increase the customer's loyalty by improving their services in deliver quality content, invest in an improved customer experience and plan the strategies to drive in customer engagement. In the meantime, this study will highlight the tenure of a customer with their loyalty. Thus, the study might be a source of reference for future related studies. Further, gaps can be identified so that other studies closely related to this one can be conducted.

## **1.8 SCOPE AND LIMITATIONS OF THE STUDY**

Telkom Company is a company that offering a data services for the customer. The scope for this study is the customer who is using the telco in Telkom Company and to predict whether the customer is loyal or not for using the services that provided from the company. There are 7043 customer details that using the services by this company. There are a few variables that affect the customer for choosing this service. For the limitations of the study, there is also a different kind of customers if want to determine the loyalty because every customer has a different kind of interest for choosing the telco services. Other than that, by using the secondary data for this study the results may not be truly accurate since there might be an error in the data. Besides that, there is a limit of variables that can be predict the loyalty of the customers.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 10 GOOD JOURNAL PAPERS**

From the journal entitled “A Survey on Customer Churn Prediction in Telecom Industry : Datasets, Methods and Metrics ” we know that communication technologies are one of the business that have the highest competitive in this world. Customer churn is the major issue that almost all the Telecommunication Industries in the world faces now. It has become a challenging task to retain the customers because it due to dissatisfaction of the services and due to better offering from other network providers within the affordable price tag of the customer. Therefore, it has become very difficult to them to retain existing customers since the cost of acquiring new customers is much higher than the cost of retaining the existing customers. Companies are going behind introducing new state of the art and technologies to offer their customer as much better services as possible to retain them intact. Before they are doing that, it is very necessary to identify those customers who are likely to leave the company in the future because losing them would results in significant loss of profit for the company. Building an effective customer churn prediction model using various techniques has become a significant topic for business and academics in recent years. The identification of why customers give up their relationships has been focusing of marketing research in the past few years. It is the time for telecom industries to take necessary steps to retain the customers to stabilize their market value.

However, for a journal entitled “Telco Production with Big Data” show that the telco operators create enormous amounts of data every day. BSS is the major IT components that telco operator uses to run its business operations towards customers. They have deployed this churn prediction system in one of the biggest mobile operators in China. This system can provide a list of prepaid customers who are likely the most to churn in the next month. As we know, one of the biggest challenges in telecom industry is customer churn. It is urgent to build churn prediction systems to predict the most likely churners for proper retention campaigns because as far as millions of customers are concerned can reducing 1% churn rate that will lead to a significant profit increase. Sophisticated techniques have been applied in churn prediction for years, and it is getting harder to make a breakthrough to further lift the accuracy through advances of prediction techniques and this motivates to seek opportunities of telco big data. The real reasons for churn that we can see is not the

technology but the competitors. It is the competitors who develop new networks, new offerings, introduce newer technologies and most importantly, reduce prices.

According to the journal entitled “User Experience Transformation in Telco Companies: Turkcell Case (Seda Alpkaya and Cem Sakarya)”, adding value to the lives of customers by focusing on technology and focusing on people is the vision for the Turkcell companies which is a one of a telecommunications company in Turkey who is very emphasize about their customer’s experience. Customers physically interact with Turkcell through physical touch points like Call Center, Turkcell shops, Turkcell web site ([www.turkcell.com.tr](http://www.turkcell.com.tr)), mobile devices or applications. Through a real commitment to the customer, Turkcell business units align themselves with the customer and emphasize long term relationships in order to satisfy customer needs. This method can be used to help reduce customer churn by identifying the most profitable customers and what can be done to maintain their loyalty. Value is created both for the customer and the company by going well beyond selling products but providing comprehensive solutions. Competitive advantage is not based on Turkcell’s products and services itself but also in understanding the behaviours of the customer.

Next, for a the journal entitled “Exploiting the Diversity, Mass and Speed of Territorial Data by Telco Operator for Better User Services”, a crucial factor for the survival and good profitability of any telco company is to develop effective strategies to win more customers and to retain the existing customers through reducing the percentage of churn. Just like Telecom Italia, one of the biggest telecommunication companies in Italy recorded for every information regarding the data traffic that is handled through the mobile phones for instance, the client id and phone number, the connection plan that the client is using, the duration time and the volume of data downloaded per connection. Individual departments of Telecom will analyze these internal datasets targeting certain business interests of the company by improving the cellular network, produce statistics and billing papers for its own customers.

However, in a journal entitled “Telco Services for End Customers: European Perspective” written by Antonio Sanchez, Belen Carro and Stefan Wesner, every telco companies must differentiate their products by doing the promotion packages that are best at attracting those customers which will remain loyal to grow and maintain a large customer base to harvest good profits through economically providing telco services. However, such strategies cannot be developed without the proper understanding about the reasons why an existing consumer chooses to discontinue its telco service

plan. Customers in the telecommunications market expect a high level of service and reliability from their suppliers. It is becoming increasingly difficult to differentiate between the technologies the telcos use. Therefore, a move towards some form of standardized performance ratings between operators will do much to improve customer choice. Such timely understanding is particularly important for a company to stay competitive in today's dynamic world with the fast advances of telco technologies, products and services.

For the journal entitled "Customer churn prediction in telecom using machine learning in big data platform", customers' churn is a considerable concern in service sectors with highly competitive services. On the other hand, the data that used in this research contains all customers' information throughout nine months before baseline. They built the social network of all customers and calculated features like degree centrality measures, similarity values and customers' network connectivity for each customer. For this analysis, they focused on evaluating and analyzing the performance of a set of tree-based machine learning methods and algorithms for predicting churn in telecommunications companies. Since now the telecom sector becomes one of the main industries in developed countries, while the number of operators will be increase and raised the level of competition. In this case were reported that china's has largest telecommunications company in big data platform. For each transaction in Telecom operator needed to open a session for the internet and in Telecom have network logs data that contains the internal sessions related to internet, calls, and SMS. In this type of research, the importance thing is to help companies make more profit hence to build a system that predicts the churn of customers in telecom company.

Furthermore, in a journal entitled "Systematic Review of Customer Churn Prediction in the Telecom" focusing on customer retention and churn prevention. Telecom companies currently face a lot of competition due to many industry players. Telecom churn prediction datasets become a minority thus causing a data imbalance problem and this problem affects the performance of the prediction models because of biased and hence affects the model performance. Therefore, the Telcom company needed requires skilled personnel as well as complex big data tools and techniques to draw meaningful and actionable insights from it. While telecom datasets have big data due to their large volumes, high velocity, veracity and variety. Customer churn in the telecom industry is indeed a serious issue that needs timely detection so that competitive retention strategies are taken. Telecom datasets should be handled carefully due to their imbalanced nature, large volumes and high dimensional structure.

Next, in a journal entitled “Customer churn prediction in Telecommunication”. In recent years, estimating churners before they leave has become valuable in the environment of increased competition among companies. Customer churn has become highly important for companies because of increasing competition among companies and increased importance of marketing strategies and conscious behavior of customers in the recent years. Customers can easily trend toward alternative services. Companies must develop various strategies to stop these possible trends, counting on the services they supply. Many researches are conducted to extend the prediction rates of customer churns within the telecommunication industry. Based on this research the researchers found that in wireless network telecommunication industry, the monthly rate of customer churn is 2.2% and the annual rate of customer churn is 27%.

In the journal entitled “Relevant Drivers for Customers’ Churn and Retention Decision in the Nigerian Mobile Telecommunication Industry”, logistic regression has been used to evaluate the data. Six chosen campuses of higher institution of learning in Lagos-state, Nigeria who is the users of mobile telecommunication are the population of this study. According to Oyatoye, Adebisi & Amole (2015), said that the telecommunication is very importance to the people even though it is time for sleeping because they are using it to communicate with other people that far away from them. Therefore, the mobile telecommunication company need to compete with so many other mobile telecommunication services because the users usually choose the telco by looked at the better rates or services from other users or by themselves (Kolajo & Adeyemo, 2012). For the method of data collection, this journal using a questionnaire to collect the data that consists of 408 questions that been asked. Then, the data is analyzed by using STATA 12 software and it shown that the result of this journal that there is a positive significant relationship between the coefficients of mobile number portability services and dubious promotions. Therefore, the mobile telecom company needs to upgrade the quality of call provided to increase the loyalty of the customer by retention. Based on the results also, 18.9% will increase the customers’ loyalty.

As well as in the journal entitled “Churn and loyalty behavior of Turkish digital natives”, according to Keramati and Ardabili (2011); Seo et al. (2008), there is more benefit that the company will receive from the retaining customers rather than get new customers. According to Kisioglu and Topcu (2011), there is a few things that affect the customer churn such as amount of telco billing, repetition of calls and time taken on call. However, disappointment of the customer with the telco, factors on

demographic and usage of the telco are the things that affect the customer churn based on the study from Keramati & Ardabili (2011). In this study, the sample is randomly chosen from the undergraduate students in Ankara, Turkey from 18-25 years old. This study using a survey form to collect the data and the response rate is about 60 percent from 2000 forms. Method used to find the results is by using an econometric model based on discrete choice theory which is the Binomial method. For this study, the data is analyzed by using SPSS software to predict the factors that influence the loyalty and churn customers and the results stated that fulfillment of the customer needed affect both loyalty and churn to the telco company. Therefore, the telco company need to prevent churn by getting more information about their customers' preference and satisfaction.

## **CHAPTER 3**

### **RESEARCH METHODOLOGY**

#### **3.1 EXPLORATORY ANALYSIS**

There are a few things that we need to do to the data before we can proceed to come out with the results because the data may be having some errors that can affect the results. Therefore, we need to explore, modify and do some adjustment to the data to make the results be more accurate. A few examples of error are typing error, missing values, outlier and too many groups in the data. In general, for the error of missing values, we can use the impute node to do the adjustment and we also using a filter node to adjust the problem for the outlier. Replacement node, it can be used to solve the problem when there are too many groups in a variable.

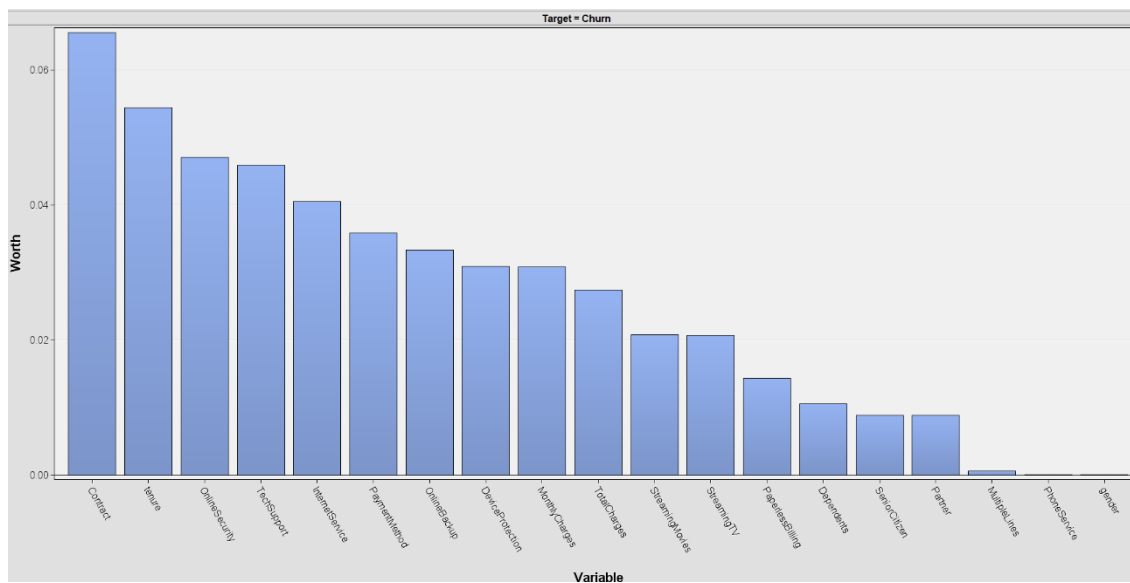
Table 3.1 Nodes that suitable with the problems

| <b>PROBLEM</b>                 | <b>SOLUTIONS</b>                                                                                                   |
|--------------------------------|--------------------------------------------------------------------------------------------------------------------|
| Missing Value                  | <ul style="list-style-type: none"> <li>- Imputation (Impute Node)</li> <li>- Filter Node</li> </ul>                |
| Outlier                        | <ul style="list-style-type: none"> <li>- Filter Node</li> </ul>                                                    |
| Typing Error                   | <ul style="list-style-type: none"> <li>- Replacement Node</li> <li>- Impute Node</li> <li>- Filter Node</li> </ul> |
| Too Many Group (category > 10) | <ul style="list-style-type: none"> <li>- Replacement Node</li> </ul>                                               |

### 3.1.1 STAT EXPLORE NODE

By using a StatExplore Node, we can know which variables is the most importance level to the least importance level. The output below shows that the most importance in the project is Contract while the least importance is Gender.

Figure 3.1 Graph Variable vs Worth

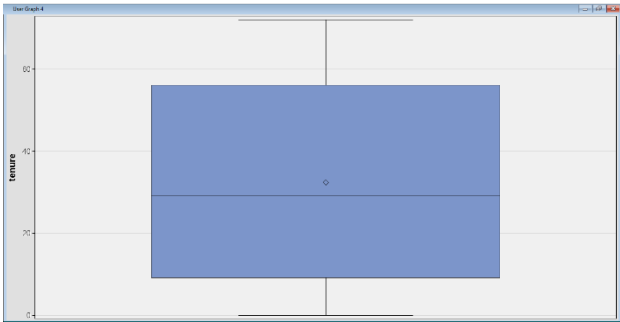
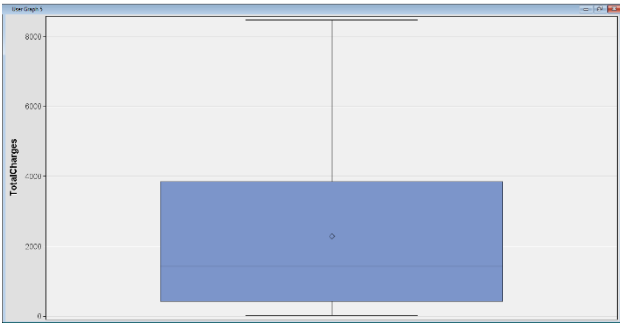


### 3.1.2 GRAPH EXPLORE

For Graph Explore Node, we can use it to check the problem of the outlier that occur in this data.

Table 3.2 Graph Explore

| GRAPH | ANALYSIS                                                                  |
|-------|---------------------------------------------------------------------------|
|       | <p>The graph shows that there is no outlier outside from the boxplot.</p> |

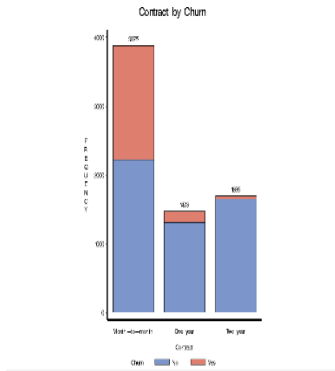
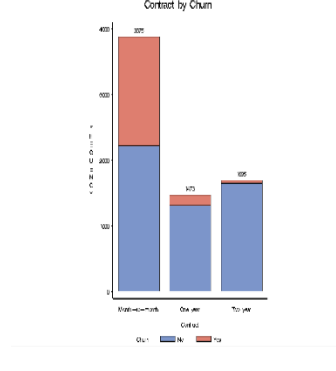
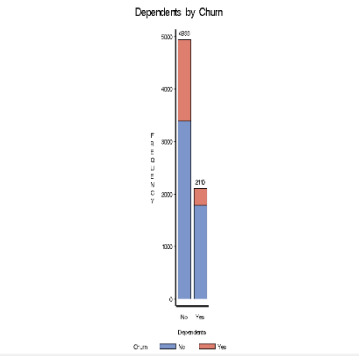
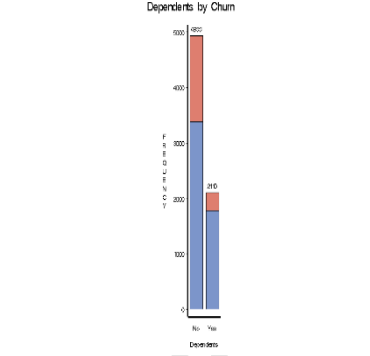
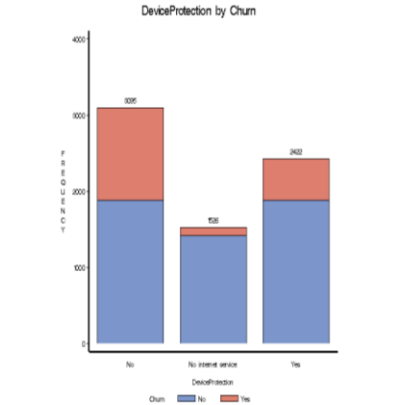
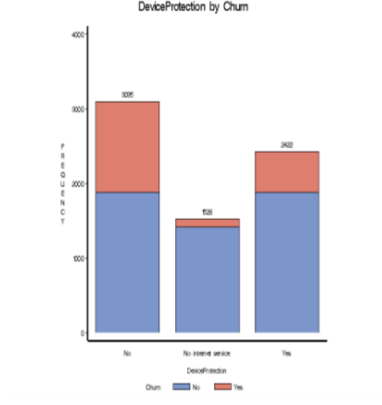
|                                                                                                                                                                                                                                                                                                                                                                  |                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
|  <p>A boxplot for the 'tenure' variable. The y-axis is labeled 'tenure' and ranges from 0 to 60. The boxplot shows a median around 35, with the interquartile range (IQR) spanning from approximately 25 to 55. Whiskers extend from 0 to 60. There are no outliers shown.</p>  | <p>The graph shows that there is no outlier outside from the boxplot.</p> |
|  <p>A boxplot for the 'TotalCharges' variable. The y-axis is labeled 'TotalCharges' and ranges from 0 to 8000. The boxplot shows a median around 2500, with the IQR spanning from approximately 1000 to 4000. Whiskers extend from 0 to 8000. There are no outliers shown.</p> | <p>The graph shows that there is no outlier outside from the boxplot.</p> |

### 3.1.3 FILTER NODE

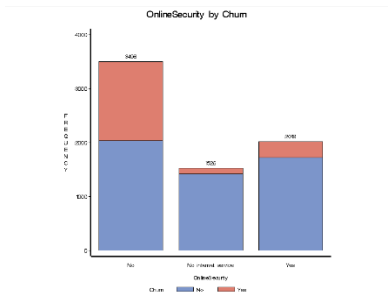
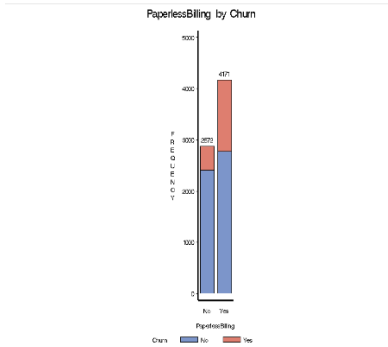
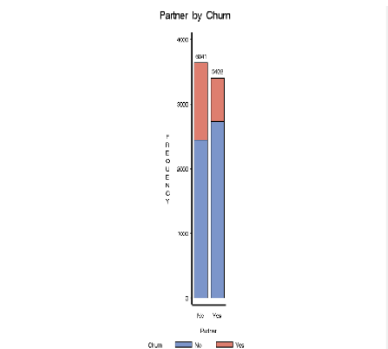
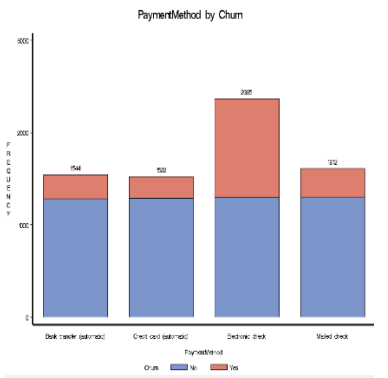
Next, for Filter Node, we used it to remove the outlier that occur in the data so that the data will have no outlier and the data will become normal form but since the data does not have any outlier, therefore, we do not use filter node in this project. Next, we also do not use Replacement Node since the variables does not have too many groups. After that, Impute Node is used to replace any data that has any missing values and the missing values will be replaced by the mean value for interval variables or frequent mode for class variables. Other than that, we used Transform Variables to change the skewness of the data to the normal form.

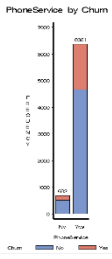
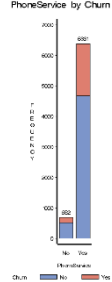
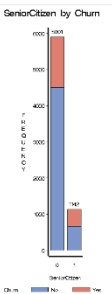
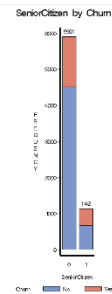
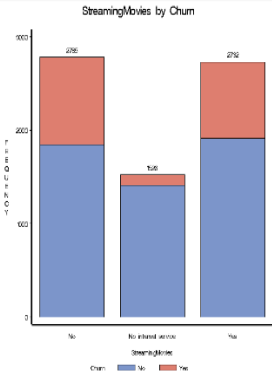
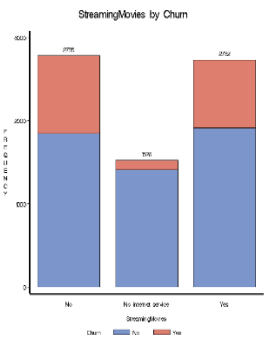
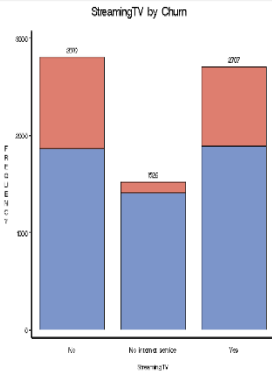
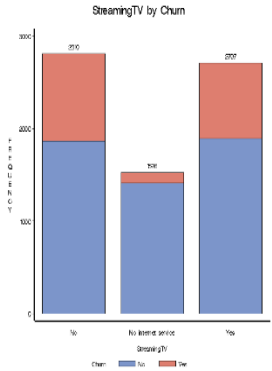
### 3.1.4 IMPUTE NODE

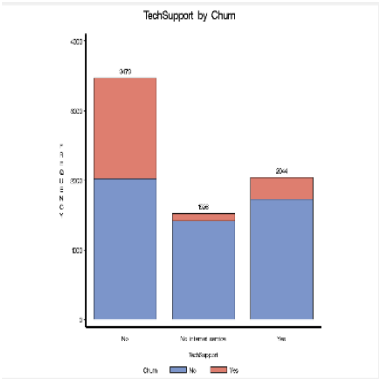
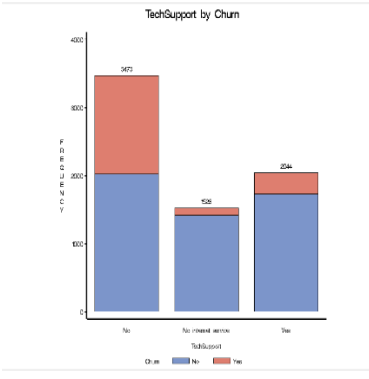
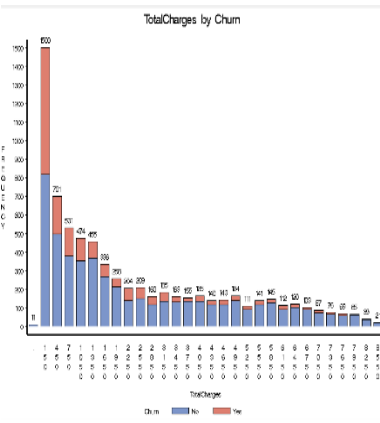
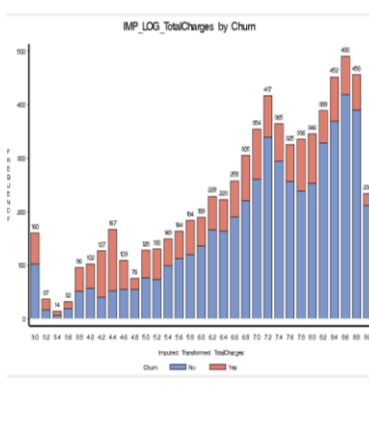
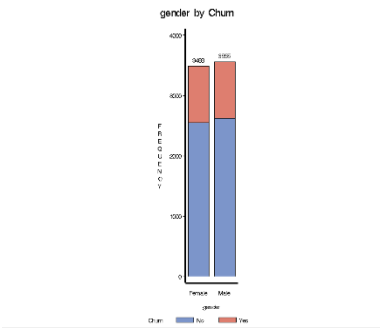
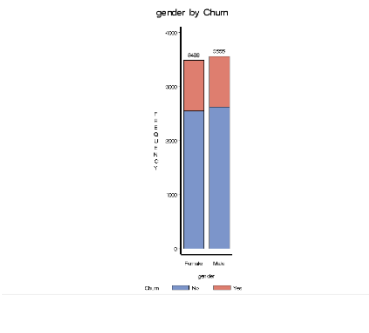
Table 3.3 Result of Impute Node and Transform Variable

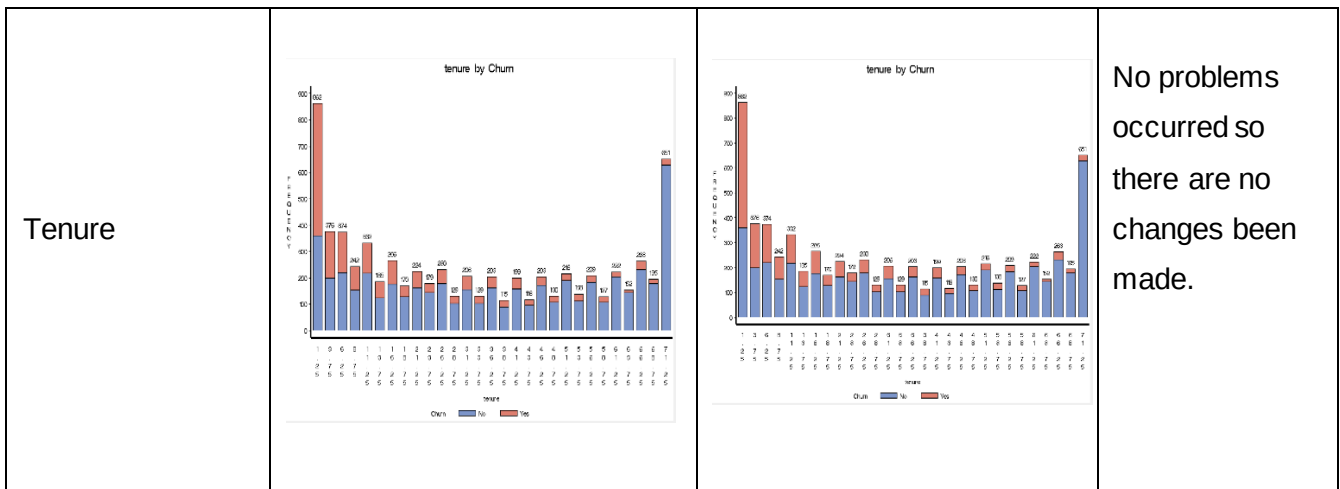
| INPUT            | BEFORE                                                                              | AFTER                                                                                | EXPLANATION                                             |
|------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------|
| Contract         |    |    | No problems occurred so there are no changes been made. |
| Dependents       |   |   | No problems occurred so there are no changes been made. |
| DeviceProtection |  |  | No problems occurred so there are no changes been made. |

| InternetService     | <p>InternetService by Churn</p> <table><tr><th>InternetService</th><th>Churn: No</th><th>Churn: Yes</th></tr><tr><td>DSL</td><td>2421</td><td>1000</td></tr><tr><td>Fiber optic</td><td>1800</td><td>1200</td></tr><tr><td>No</td><td>1500</td><td>500</td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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1000 | Fiber optic         | 1800 | 1200 | No  | 1500 | 500  | No problems occurred so there are no changes been made. |    |   |    |     |    |    |     |    |    |     |    |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |   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| InternetService     | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| DSL                 | 2421                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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| Fiber optic         | 1800                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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| No                  | 1500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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| MonthlyCharges      | <p>MonthlyCharges by Churn</p> <table><tr><th>MonthlyCharges</th><th>Churn: No</th><th>Churn: Yes</th></tr><tr><td>11</td><td>679</td><td>107</td></tr><tr><td>12</td><td>366</td><td>7</td></tr><tr><td>13</td><td>34</td><td>4</td></tr><tr><td>14</td><td>34</td><td>4</td></tr><tr><td>15</td><td>250</td><td>27</td></tr><tr><td>16</td><td>111</td><td>11</td></tr><tr><td>17</td><td>158</td><td>97</td></tr><tr><td>18</td><td>340</td><td>221</td></tr><tr><td>19</td><td>340</td><td>404</td></tr><tr><td>20</td><td>330</td><td>221</td></tr><tr><td>21</td><td>350</td><td>407</td></tr><tr><td>22</td><td>350</td><td>407</td></tr><tr><td>23</td><td>275</td><td>275</td></tr><tr><td>24</td><td>275</td><td>275</td></tr><tr><td>25</td><td>275</td><td>275</td></tr><tr><td>26</td><td>275</td><td>275</td></tr><tr><td>27</td><td>275</td><td>275</td></tr><tr><td>28</td><td>275</td><td>275</td></tr><tr><td>29</td><td>275</td><td>275</td></tr><tr><td>30</td><td>275</td><td>275</td></tr><tr><td>31</td><td>275</td><td>275</td></tr><tr><td>32</td><td>275</td><td>275</td></tr><tr><td>33</td><td>275</td><td>275</td></tr><tr><td>34</td><td>275</td><td>275</td></tr><tr><td>35</td><td>275</td><td>275</td></tr><tr><td>36</td><td>275</td><td>275</td></tr><tr><td>37</td><td>275</td><td>275</td></tr><tr><td>38</td><td>275</td><td>275</td></tr><tr><td>39</td><td>275</td><td>275</td></tr><tr><td>40</td><td>275</td><td>275</td></tr><tr><td>41</td><td>275</td><td>275</td></tr><tr><td>42</td><td>275</td><td>275</td></tr><tr><td>43</td><td>275</td><td>275</td></tr><tr><td>44</td><td>275</td><td>275</td></tr><tr><td>45</td><td>275</td><td>275</td></tr><tr><td>46</td><td>275</td><td>275</td></tr><tr><td>47</td><td>275</td><td>275</td></tr><tr><td>48</td><td>275</td><td>275</td></tr><tr><td>49</td><td>275</td><td>275</td></tr><tr><td>50</td><td>275</td><td>275</td></tr><tr><td>51</td><td>275</td><td>275</td></tr><tr><td>52</td><td>275</td><td>275</td></tr><tr><td>53</td><td>275</td><td>275</td></tr><tr><td>54</td><td>275</td><td>275</td></tr><tr><td>55</td><td>275</td><td>275</td></tr><tr><td>56</td><td>275</td><td>275</td></tr><tr><td>57</td><td>275</td><td>275</td></tr><tr><td>58</td><td>275</td><td>275</td></tr><tr><td>59</td><td>275</td><td>275</td></tr><tr><td>60</td><td>275</td><td>275</td></tr><tr><td>61</td><td>275</td><td>275</td></tr><tr><td>62</td><td>275</td><td>275</td></tr><tr><td>63</td><td>275</td><td>275</td></tr><tr><td>64</td><td>275</td><td>275</td></tr><tr><td>65</td><td>275</td><td>275</td></tr><tr><td>66</td><td>275</td><td>275</td></tr><tr><td>67</td><td>275</td><td>275</td></tr><tr><td>68</td><td>275</td><td>275</td></tr><tr><td>69</td><td>275</td><td>275</td></tr><tr><td>70</td><td>275</td><td>275</td></tr><tr><td>71</td><td>275</td><td>275</td></tr><tr><td>72</td><td>275</td><td>275</td></tr><tr><td>73</td><td>275</td><td>275</td></tr><tr><td>74</td><td>275</td><td>275</td></tr><tr><td>75</td><td>275</td><td>275</td></tr><tr><td>76</td><td>275</td><td>275</td></tr><tr><td>77</td><td>275</td><td>275</td></tr><tr><td>78</td><td>275</td><td>275</td></tr><tr><td>79</td><td>275</td><td>275</td></tr><tr><td>80</td><td>275</td><td>275</td></tr><tr><td>81</td><td>275</td><td>275</td></tr><tr><td>82</td><td>275</td><td>275</td></tr><tr><td>83</td><td>275</td><td>275</td></tr><tr><td>84</td><td>275</td><td>275</td></tr><tr><td>85</td><td>275</td><td>275</td></tr><tr><td>86</td><td>275</td><td>275</td></tr><tr><td>87</td><td>275</td><td>275</td></tr><tr><td>88</td><td>275</td><td>275</td></tr><tr><td>89</td><td>275</td><td>275</td></tr><tr><td>90</td><td>275</td><td>275</td></tr><tr><td>91</td><td>275</td><td>275</td></tr><tr><td>92</td><td>275</td><td>275</td></tr><tr><td>93</td><td>275</td><td>275</td></tr><tr><td>94</td><td>275</td><td>275</td></tr><tr><td>95</td><td>275</td><td>275</td></tr><tr><td>96</td><td>275</td><td>275</td></tr><tr><td>97</td><td>275</td><td>275</td></tr><tr><td>98</td><td>275</td><td>275</td></tr><tr><td>99</td><td>275</td><td>275</td></tr><tr><td>100</td><td>275</td><td>275</td></tr><tr><td>101</td><td>275</td><td>275</td></tr><tr><td>102</td><td>275</td><td>275</td></tr><tr><td>103</td><td>275</td><td>275</td></tr><tr><td>104</td><td>275</td><td>275</td></tr><tr><td>105</td><td>275</td><td>275</td></tr><tr><td>106</td><td>275</td><td>275</td></tr><tr><td>107</td><td>275</td><td>275</td></tr><tr><td>108</td><td>275</td><td>275</td></tr><tr><td>109</td><td>275</td><td>275</td></tr><tr><td>110</td><td>275</td><td>275</td></tr><tr><td>111</td><td>275</td><td>275</td></tr><tr><td>112</td><td>275</td><td>275</td></tr><tr><td>113</td><td>275</td><td>275</td></tr><tr><td>114</td><td>275</td><td>275</td></tr><tr><td>115</td><td>275</td><td>275</td></tr><tr><td>116</td><td>275</td><td>275</td></tr><tr><td>117</td><td>275</td><td>275</td></tr><tr><td>118</td><td>275</td><td>275</td></tr><tr><td>119</td><td>275</td><td>275</td></tr></table> | MonthlyCharges  | Churn: No | Churn: Yes | 11  | 679  | 107  | 12                  | 366  | 7    | 13  | 34   | 4    | 14                                                      | 34 | 4 | 15 | 250 | 27 | 16 | 111 | 11 | 17 | 158 | 97 | 18 | 340 | 221 | 19 | 340 | 404 | 20 | 330 | 221 | 21 | 350 | 407 | 22 | 350 | 407 | 23 | 275 | 275 | 24 | 275 | 275 | 25 | 275 | 275 | 26 | 275 | 275 | 27 | 275 | 275 | 28 | 275 | 275 | 29 | 275 | 275 | 30 | 275 | 275 | 31 | 275 | 275 | 32 | 275 | 275 | 33 | 275 | 275 | 34 | 275 | 275 | 35 | 275 | 275 | 36 | 275 | 275 | 37 | 275 | 275 | 38 | 275 | 275 | 39 | 275 | 275 | 40 | 275 | 275 | 41 | 275 | 275 | 42 | 275 | 275 | 43 | 275 | 275 | 44 | 275 | 275 | 45 | 275 | 275 | 46 | 275 | 275 | 47 | 275 | 275 | 48 | 275 | 275 | 49 | 275 | 275 | 50 | 275 | 275 | 51 | 275 | 275 | 52 | 275 | 275 | 53 | 275 | 275 | 54 | 275 | 275 | 55 | 275 | 275 | 56 | 275 | 275 | 57 | 275 | 275 | 58 | 275 | 275 | 59 | 275 | 275 | 60 | 275 | 275 | 61 | 275 | 275 | 62 | 275 | 275 | 63 | 275 | 275 | 64 | 275 | 275 | 65 | 275 | 275 | 66 | 275 | 275 | 67 | 275 | 275 | 68 | 275 | 275 | 69 | 275 | 275 | 70 | 275 | 275 | 71 | 275 | 275 | 72 | 275 | 275 | 73 | 275 | 275 | 74 | 275 | 275 | 75 | 275 | 275 | 76 | 275 | 275 | 77 | 275 | 275 | 78 | 275 | 275 | 79 | 275 | 275 | 80 | 275 | 275 | 81 | 275 | 275 | 82 | 275 | 275 | 83 | 275 | 275 | 84 | 275 | 275 | 85 | 275 | 275 | 86 | 275 | 275 | 87 | 275 | 275 | 88 | 275 | 275 | 89 | 275 | 275 | 90 | 275 | 275 | 91 | 275 | 275 | 92 | 275 | 275 | 93 | 275 | 275 | 94 | 275 | 275 | 95 | 275 | 275 | 96 | 275 | 275 | 97 | 275 | 275 | 98 | 275 | 275 | 99 | 275 | 275 | 100 | 275 | 275 | 101 | 275 | 275 | 102 | 275 | 275 | 103 | 275 | 275 | 104 | 275 | 275 | 105 | 275 | 275 | 106 | 275 | 275 | 107 | 275 | 275 | 108 | 275 | 275 | 109 | 275 | 275 | 110 | 275 | 275 | 111 | 275 | 275 | 112 | 275 | 275 | 113 | 275 | 275 | 114 | 275 | 275 | 115 | 275 | 275 | 116 | 275 | 275 | 117 | 275 | 275 | 118 | 275 | 275 | 119 | 275 | 275 | No problems occurred so there are no changes been made. |
| MonthlyCharges      | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| 11                  | 679                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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|     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |                                                         |
| 12                  | 366                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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|     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |                                                         |
| 13                  | 34                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               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| 14                  | 34                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               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| 15                  | 250                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 35                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 36                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 37                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 38                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 39                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 40                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 41                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 42                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 44                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 46                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 47                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 48                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| 53                  | 275                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              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| MultipleLines       | <p>MultipleLines by Churn</p> <table><tr><th>MultipleLines</th><th>Churn: No</th><th>Churn: Yes</th></tr><tr><td>No</td><td>3380</td><td>1000</td></tr><tr><td>No phone service</td><td>600</td><td>100</td></tr><tr><td>Yes</td><td>2071</td><td>1000</td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         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1000 | No phone service    | 600  | 100  | Yes | 2071 | 1000 | No problems occurred so there are no changes been made. |    |   |    |     |    |    |     |    |    |     |    |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |   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| MultipleLines       | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| Yes                 | 2071                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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| OnlineBackup        | <p>OnlineBackup by Churn</p> <table><tr><th>OnlineBackup</th><th>Churn: No</th><th>Churn: Yes</th></tr><tr><td>No</td><td>1800</td><td>1200</td></tr><tr><td>No internet service</td><td>1500</td><td>100</td></tr><tr><td>Yes</td><td>1800</td><td>1200</td></tr></table>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       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1200 | No internet service | 1500 | 100  | Yes | 1800 | 1200 | No problems occurred so there are no changes been made. |    |   |    |     |    |    |     |    |    |     |    |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |   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| OnlineBackup        | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        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| No                  | 1800                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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|     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |    |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |                                                         |
| No internet service | 1500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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| Yes                 | 1800                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             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| OnlineSecurity            |  <table><caption>OnlineSecurity by Churn</caption><thead><tr><th>OnlineSecurity</th><th>Churn: No</th><th>Churn: Yes</th></tr></thead><tbody><tr><td>No</td><td>2500</td><td>1400</td></tr><tr><td>No internet access</td><td>1000</td><td>100</td></tr><tr><td>Yes</td><td>1800</td><td>200</td></tr></tbody></table>                                                                                                 | OnlineSecurity   | Churn: No | Churn: Yes | No                        | 2500 | 1400 | No internet access      | 1000 | 100 | Yes                                                     | 1800 | 200  | No problems occurred so there are no changes been made. |      |     |                                                         |
|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|-----------|------------|---------------------------|------|------|-------------------------|------|-----|---------------------------------------------------------|------|------|---------------------------------------------------------|------|-----|---------------------------------------------------------|
| OnlineSecurity            | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Churn: Yes       |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| No                        | 2500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 1400             |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| No internet access        | 1000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 100              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Yes                       | 1800                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 200              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| PaperlessBilling          |  <table><caption>PaperlessBilling by Churn</caption><thead><tr><th>PaperlessBilling</th><th>Churn: No</th><th>Churn: Yes</th></tr></thead><tbody><tr><td>No</td><td>3500</td><td>500</td></tr><tr><td>Yes</td><td>1000</td><td>400</td></tr></tbody></table>                                                                                                                                                           | PaperlessBilling | Churn: No | Churn: Yes | No                        | 3500 | 500  | Yes                     | 1000 | 400 | No problems occurred so there are no changes been made. |      |      |                                                         |      |     |                                                         |
| PaperlessBilling          | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Churn: Yes       |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| No                        | 3500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 500              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Yes                       | 1000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 400              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Partner                   |  <table><caption>Partner by Churn</caption><thead><tr><th>Partner</th><th>Churn: No</th><th>Churn: Yes</th></tr></thead><tbody><tr><td>No</td><td>3500</td><td>500</td></tr><tr><td>Yes</td><td>1000</td><td>400</td></tr></tbody></table>                                                                                                                                                                           | Partner          | Churn: No | Churn: Yes | No                        | 3500 | 500  | Yes                     | 1000 | 400 | No problems occurred so there are no changes been made. |      |      |                                                         |      |     |                                                         |
| Partner                   | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Churn: Yes       |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| No                        | 3500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 500              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Yes                       | 1000                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 400              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| PaymentMethod             |  <table><caption>PaymentMethod by Churn</caption><thead><tr><th>PaymentMethod</th><th>Churn: No</th><th>Churn: Yes</th></tr></thead><tbody><tr><td>Bank transfer (automatic)</td><td>1500</td><td>500</td></tr><tr><td>Credit card (automatic)</td><td>1500</td><td>500</td></tr><tr><td>Electronic check</td><td>1500</td><td>2000</td></tr><tr><td>Mailed check</td><td>1500</td><td>500</td></tr></tbody></table> | PaymentMethod    | Churn: No | Churn: Yes | Bank transfer (automatic) | 1500 | 500  | Credit card (automatic) | 1500 | 500 | Electronic check                                        | 1500 | 2000 | Mailed check                                            | 1500 | 500 | No problems occurred so there are no changes been made. |
| PaymentMethod             | Churn: No                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Churn: Yes       |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Bank transfer (automatic) | 1500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 500              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Credit card (automatic)   | 1500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 500              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Electronic check          | 1500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 2000             |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |
| Mailed check              | 1500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | 500              |           |            |                           |      |      |                         |      |     |                                                         |      |      |                                                         |      |     |                                                         |

|                        |                                                                                     |                                                                                      |                                                                |
|------------------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|----------------------------------------------------------------|
| <p>PhoneService</p>    |    |    | <p>No problems occurred so there are no changes been made.</p> |
| <p>SeniorCitizen</p>   |    |    | <p>No problems occurred so there are no changes been made.</p> |
| <p>StreamingMovies</p> |  |  | <p>No problems occurred so there are no changes been made.</p> |
| <p>StreamingTV</p>     |  |  | <p>No problems occurred so there are no changes been made.</p> |

|              |                                                                                     |                                                                                      |                                                                                                                                                                                                                     |
|--------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| TechSupport  |    |    | No problems occurred so there are no changes been made.                                                                                                                                                             |
| TotalCharges |   |   | Based on the graph shows that there is a missing value, so we need to do imputation and after that, since the graph is skew to the right, so we need to use transform variable to adjust the skewness by using log. |
| Gender       |  |  | No problems occurred so there are no changes been made.                                                                                                                                                             |



### 3.1.5 REPLACEMENT NODE

Replacement node are used to reassign the categorical input to improve performance of predictive models. The use of replacement node is to replace the typo error or outliers with missing values and merge variable with too many categories. Since the data does not have any outlier, therefore, we do not use filter node in this project. We also do not use Replacement Node since the variables does not have too many groups.

### 3.1.6 DATA PARTITION

Lastly, we will use the Data Partition Node to divide the training set, validation set and test set. In this project the data were partitioned into 70% of training set and 30% of validation set.

| Partition Summary |                     |                        |
|-------------------|---------------------|------------------------|
| Type              | Data Set            | Number of Observations |
| DATA              | EMWS1.Ids_DATA      | 7043                   |
| TRAIN             | EMWS1.Part_TRAIN    | 4929                   |
| VALIDATE          | EMWS1.Part_VALIDATE | 2114                   |

Figure 3.2 Partition Summary

## 3.2 DATA MINING TECHNIQUES

### 3.2.1 LOGISTIC REGRESSION MODEL

Logistics regression is one of the regression models. In this method we have two which is linear regression and logistics regression. Linear regression models have a form while logistic regression is a regression model suitable for modelling binary outcomes such as yes/no or good/bad. These properties make linear regression models well-suited to estimating continuous quantities that can take a wide range of values.

In this method which is logistics regression model is when modelling a binary outcome tries to answer, “What is the probability that this record belongs to yes or no?”. the probabilities are numbers and the modelling binary outcome is an estimation task for the study. We decided the goal is to estimate the probability that an event occur,  $p$ ,  $P(Y=1)$ . The first step to use this model should be transform the probability,  $p$  into odds, by taking the ratio of  $p$  over  $1-p$ . The odds in favor of an event or a proposition is the ratio of the probability that the event will happen to the probability that the event will not happen.

$$Odds = \frac{P(Y = 1)}{P(Y = 0)} = \frac{p}{1 - p}$$

Next, by an explanation of logistic regression begins with an explanation of the logistic function, which always takes on values between zero and one.

$$\text{The logistic function: } \text{logit} = \ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X$$

This equation is the logistic function. That method called maximum likelihood is used, to find the best-fit line for logistic regression.

$$\text{Thus, odds now become: } Odds = \left(\frac{p}{1-p}\right) = e^{(\beta_0 + \beta_1 X)}$$

$$\text{Solving for the probability: } p = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X)}}$$

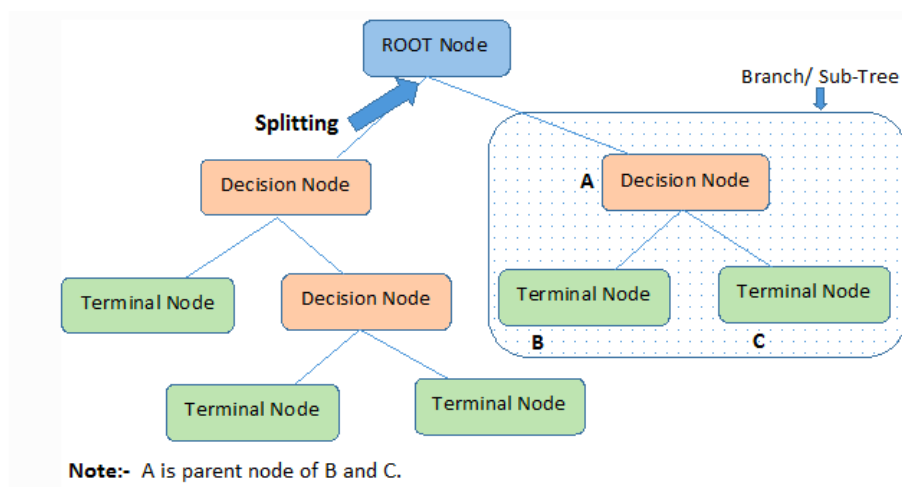
To interpreting the coefficients, we can use either the original or the exponentiated logistic coefficients for interpretation.

### 3.2.2 DECISION TREE

Decision tree is used to build classification and regression models. It is used to create data models that will predict class labels or values for the decision-making process. Using a decision tree, we can visualize the decisions that make it easy to understand and thus it is a popular data mining technique. A decision tree is a structure that includes:

1. **Root Node:** This attribute is used for dividing the data into two or more sets. The feature attribute in this node is selected based on attribute selection techniques.
2. **Branch or Sub-Tree:** A part of the entire decision tree is called a branch or sub-tree.
3. **Splitting:** Dividing a node into two or more sub-nodes based on if-else conditions.
4. **Decision Node:** After splitting the sub-nodes into further sub-nodes, then it is called the decision node.
5. **Leaf or Terminal Node:** This is the end of the decision tree where it cannot be split into further sub-nodes.
6. **Pruning:** Removing a sub-node from the tree is called pruning

Decision tree also representation to solve the problem in which each leaf node corresponds to a class label and attributes are represented on the internal node of the tree. Below is showing the example of a decision tree:



Source: [Kdnuggets](#)

Figure 3.3 Example of Decision Tree

## **I. Classification and Regression Trees (CART)**

Classification and regression trees (CART) produce either classification or regression trees, depending on whether the dependent variable is categorical or numeric, respectively. Decision trees are formed by a collection of rules based on variables' values are selected to get the best split to differentiate observations based on the dependent variable and once a rule is selected and splits a node into two, the same process is applied to each "child" node. Splitting stops when CART detects no further gain can be made or some pre-set stopping rules are met. Each branch of the tree ends in a terminal node. Each observation falls into one and exactly one terminal node and each terminal node is uniquely defined by a set of rules.

## **II. Chi-square Automatic Interaction Detector (CHAID)**

CHAID analysis builds to help determine how variables best merge to explain the outcome in the given dependent variable. In the CHAID technique, it finds out the statistical significance between the differences between sub-nodes and parent node. We measure it by the sum of squares of standardized differences between observed and expected frequencies of the target variable. CHAID analysis splits the target into two or more categories that are called parent nodes and then the nodes are split using statistical algorithms into child nodes. The higher the value of Chi-Square, the higher the statistical significance of differences between sub-node and Parent node. Mathematically, Chi-squared is represented as:

$$\text{Chi-Square} = \sum \frac{(O - E)^2}{E}$$

where: O = observed score

E = expected score

### III. Logworth

Logworth is the best split where it is categorical target by compute the chi-square statistic association between the binary targets and all potential splits of each competing input. To determine split for each input, we must select the highest logworth of the chi-square statistics. Below is the formula of logworth:

$$\text{Logworth} = -\log p$$

### IV. Entropy

A decision tree is built top-down from a root node and involves partitioning the data into subsets that contain instances with similar values (homogeneous) and when the target variables is categorical. Entropy is a measure of the randomness in the information being processed. Decision trees algorithm will always try to maximize information gain. The higher the entropy, the harder it is to draw any conclusions from that information. An attribute with highest Information gain will split first. The entropy of a split is simply the weighted average of the entropies of all the children. When entropy reduction is the splitting the criteria, the decision tree algorithm selects the split that reduces entropy by the greatest amount. Below is the formula to find entropy value:

$$\text{Total entropy reduction} = -\sum p \log_2 p$$

$$\text{Total entropy} = \sum \text{entropy (parent)} - [\text{weight average}] * \text{entropy (children)}$$

### V. GINI

Gini score as a cost function used to evaluate splits in the dataset and used for categorical target variables. It is calculated by subtracting the sum of the squared probabilities of each class from one. It favors larger partitions and easy to implement whereas information gain favors smaller partitions with distinct values. Below is showing Gini score formula:

$$\text{Gini} = 1 - \sum p^2$$

Gini score performs only binary splits. A perfectly pure node has a Gini score of 1 and a node that is evenly balanced has a Gini score of 0.5. The higher the value of Gini score, the higher the homogeneity.

### **3.2.3 ARTIFICIAL NEURAL NETWORK**

Artificial Neural Network is the piece of a computing system designed to simulate the way human the brain human analyzes and analyses and process information. It is the foundation of artificial intelligence and solves problems that would prove impossible or difficult by human or statistical standards. Neural networks are very powerful when you have massive datasets. This means that the neural network has enough data to create statistical models of the data which has been imputed Artificial neural network inspired by the way biological nervous systems, such as the brain, process information.

Artificial Neural Network used for variety of tasks. We can collect datasets of images. Neural network is also use in Self Driving cars, Character Recognition and lots of other interesting application. The combination function combines the inputs into a single value, which passes to the transfer function to produce an output. A transfer function is a mathematical representation of the relationship between inputs and outputs. Four common transfer function are the steps, linear , logistic, and hyperbolic tangent functions. The training process is an iterative learning process in which data cases are presented to the network one at a time. The weights of a neural network with hidden layers are highly interdependent. If we tweak the weight on the connection slightly, it will impact not only the euron it propagates to directly.

#### **I. Neural Network : with hidden layers**

The most important aspect of the design of a neural network is a structure or topology, since this is crucial to its generalization capability. Artificial neural network has two main hyperparameters that control the architecture or topology of the network: the numbers of layers and the number of nodes in each hidden layer. It has been shown that two-hidden layer can outperform than single-hidden layer in some cases. A single-layer neural network can only be used to represent linearly separable functions. If the problem relatively simple, perhaps a single layer network would be

enough. Indeed, there is some evidence that certain problems can only be solved with a second hidden layer. Two or fewer layers will often suffice with simple data sets. However, with complex datasets involving time-series or computer vision, additional layers can be helpful. Therefore, on each layer we learn different representation that gets more complicated with later hidden layers. A multilayer perceptron is an artificial neural network with more than a single layer. It has an input layer that connects to the input variables, one or more hidden layers and an output layers that produces the output variable.

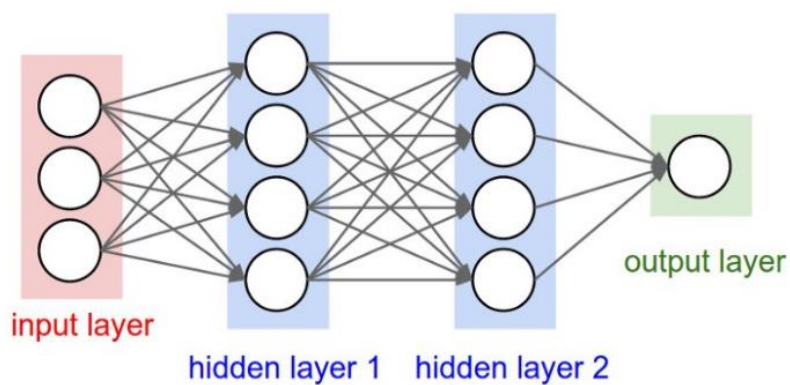


Figure 3.4 Neural Network with 2 hidden layers

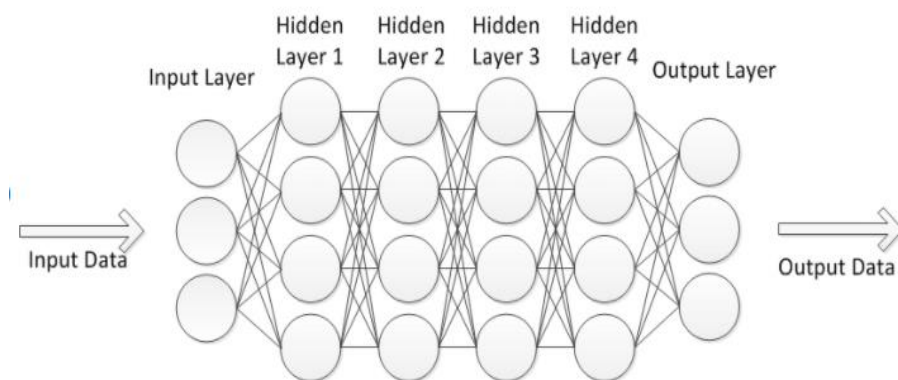


Figure 3.5 Neural Network with 4 hidden layers

## CHAPTER 4

### DATA ANALYSIS AND FINDINGS

#### 4.1 DATA ANALYSIS

The data will be used to create 3 model where the model estimation is done:

Table 4.1 Type of Model

| Model                      | Type of model                                                                                                                                                                                                                                                     |
|----------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Decision tree              | <ul style="list-style-type: none"><li>- CART</li><li>- CHAID</li><li>- Logworth</li><li>- Entropy</li><li>- GINI</li><li>- Maximal Tree</li><li>- Probability Tree</li></ul>                                                                                      |
| Logistic regression        | <ul style="list-style-type: none"><li>- Main Effect</li><li>- Interaction Effect</li><li>- Polynomial Effect</li><li>- Main Effect Polynomial</li><li>- Main Effect Interaction</li><li>- Main Interaction Effect</li><li>- Main Interaction Polynomial</li></ul> |
| Artificial neutral network | <ul style="list-style-type: none"><li>- Neural Network 2: with 2 Hidden Layers</li><li>- Neural Network 4: with 4 Hidden Layers</li><li>- Neural Network 6: with 6 Hidden Layers</li><li>- Neural Network 8: with 8 Hidden Layers</li></ul>                       |

## 4.2 LOGISTIC REGRESSION ANALYSIS

### 4.2.1 Model Comparison

Logistic regression is closely related to linear regression. In logistic regression, the expected value of the target is transformed by a link function to restrict its value to the unit interval. Thus, model predictions can be viewed as primary outcome probabilities. A linear combination of inputs generates a logit score, the log of the odds of primary outcome. There will be 10 different Logistic Regression Models (LR Main, LR Inter, LR Poly, LR Main Inter, LR Main Poly, LR Inter Poly, LR me Backward, LR me Forward, and LR me Stepwise) that will be describe. Each model properties have been checked according to the type of model. In our study the result as shown below:

Table 4.2 Model Comparison for each Logistic Regression Model

| Model Description           | Train: Average Squared Error | Valid: Average Squared Error | GAP ASE      | Train: Misclassification Rate | Valid: Misclassification Rate | GAP MR       | Train: Roc Index | Valid: Roc Index | GAP ROC |
|-----------------------------|------------------------------|------------------------------|--------------|-------------------------------|-------------------------------|--------------|------------------|------------------|---------|
| LR (MAIN POLY EFFECT)       | 0.132607779                  | 0.129483276                  | -0.003124503 | 0.190302293                   | 0.188741722                   | -0.001560571 | 0.8510           | 0.8600           | 0.0090  |
| LR (MAIN EFFECT)            | 0.133148166                  | 0.129198647                  | -0.003949518 | 0.191925340                   | 0.192526017                   | 0.000600677  | 0.8500           | 0.8610           | 0.0110  |
| LR (MAIN INTER EFFECT)      | 0.126377048                  | 0.136011845                  | 0.009634797  | 0.187461960                   | 0.192999054                   | 0.005537094  | 0.8670           | 0.8440           | -0.0230 |
| LR (INTER POLY)             | 0.126357198                  | 0.136468587                  | 0.010111389  | 0.187056198                   | 0.195364238                   | 0.008308040  | 0.8670           | 0.8430           | -0.0240 |
| LR (MAIN INTER POLY EFFECT) | 0.126138636                  | 0.136386369                  | 0.010247733  | 0.186244674                   | 0.197256386                   | 0.011011712  | 0.8680           | 0.8430           | -0.0250 |
| LR (POLY EFFECT)            | 0.145457984                  | 0.144257601                  | -0.001200383 | 0.211199026                   | 0.207190161                   | -0.004008865 | 0.8140           | 0.8190           | 0.0050  |
| LR (INTER EFFECT)           | 0.136158231                  | 0.145255519                  | 0.009097288  | 0.206127003                   | 0.216177862                   | 0.010050858  | 0.8470           | 0.8240           | -0.0230 |

|                |                                            |
|----------------|--------------------------------------------|
| UNDERFIT MODEL | LR (MAIN POLY EFFECT) AND LR (POLY EFFECT) |
| OVERFIT MODEL  | LR (MAIN INTER POLY EFFECT)                |
| BEST MODEL     | LR (MAIN EFFECT)                           |

Misclassification rate, average squared error and roc index are chosen to calculate the gap between valid and train to identify the underfit, overfit and the best fit of the model. Since the misclassification rate(-), average squared error(-) and roc index(+) for the model LR Main Poly Effect and LR Poly Effect, so we could say that these two models is underfit model. After that we need to remove these two models because we want to

select the best model of logistic regression model. While, LR Main Inter Poly Effect have the largest gap compare to others, therefore, the overfit model is LR Main Inter Poly Effect. Also, we need to remove LR Main Inter Poly Effect to find the best model of logistic regression model. Lastly, by looking at the value of validation set, LR Main Effect have the lowest value of validation in misclassification rate and average squared error. It also has the largest value of validation of ROC Index. So, we can conclude that the best model for logistic regression is LR Main Effect. Since the best model is the LR Main Effect, therefore, we will only choose this model to do the analysis of the model.

#### 4.2.2 Comparison of ROC Chart

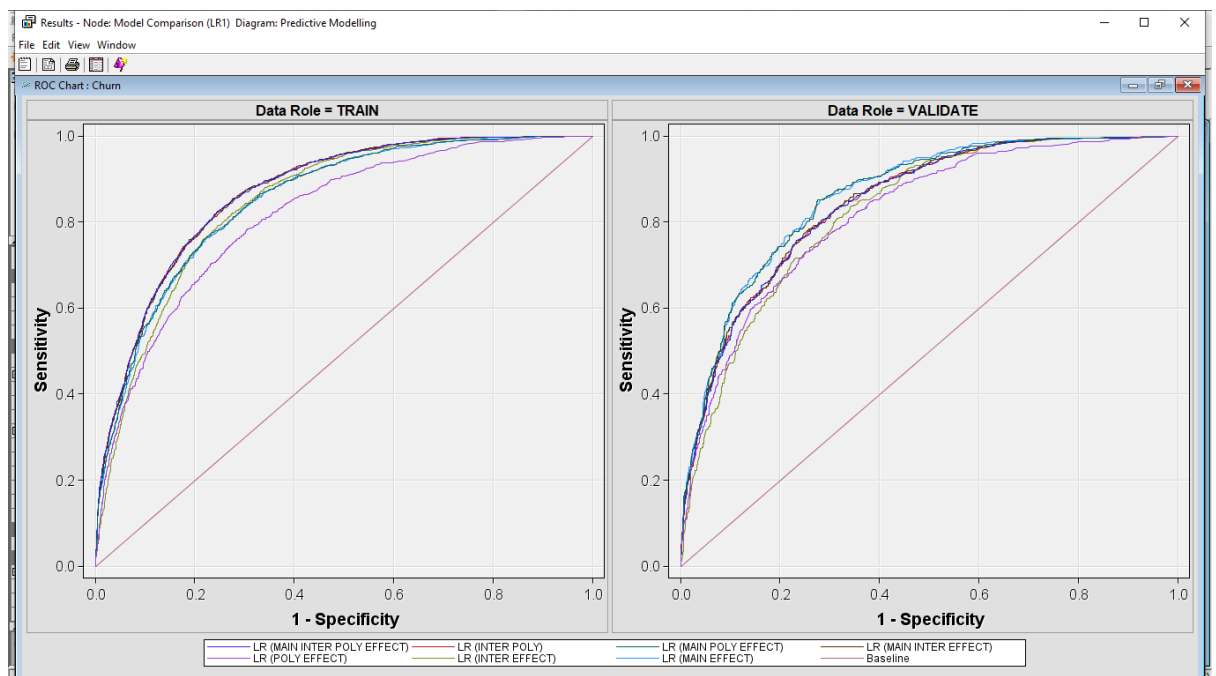


Figure 4.1 ROC chart

In Receiver Operating Characteristic (ROC) Chart, when the graph is closer to the asterisk mark, it indicates that the model has high performance. In this graph, LR Main Effect indicate the model has highest performance since it is the most far apart model from the baseline and thus has the highest sensitivity.

### 4.2.3 Comparison of Lift and Cumulative Chart

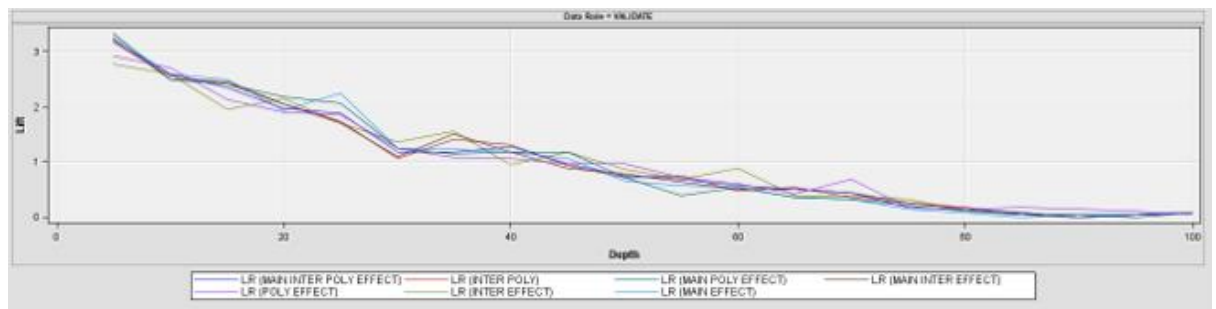


Figure 4.2 Lift Chart

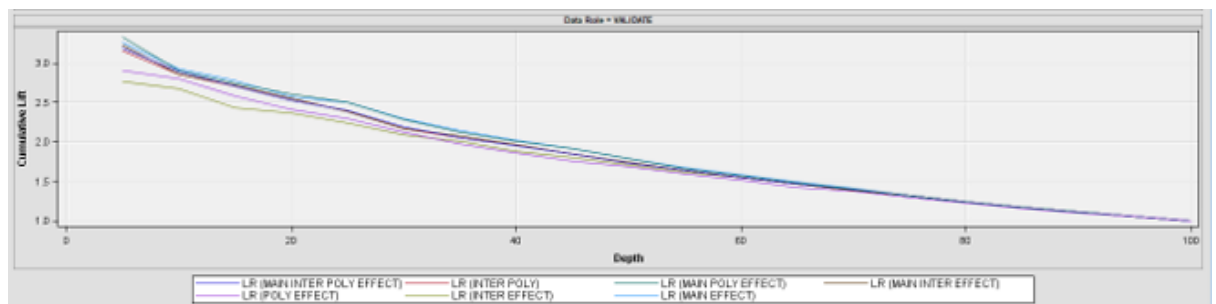


Figure 4.3 Cumulative Lift Chart

Lift is a measure of the effectiveness of a predictive model calculated as the ratio between the results obtained with and without the predictive model. Cumulative gains and lift charts are visual aids for measuring model performance. Both charts consist of a lift curve and a baseline. The greater the area between the lift curve and the baseline, the better the model. In this graph, LR Main Effect indicate the best model.

### 4.2.4 Confusion Matrix (8 models)

#### Model Selection

Event Classification Table  
Model Selection based on Valid: Misclassification Rate (\_VMISC\_)

| Model Node | Model Description           | Data Role | Target | Target Label | False Negative | True Negative | False Positive | True Positive |
|------------|-----------------------------|-----------|--------|--------------|----------------|---------------|----------------|---------------|
| Reg7       | LR (MAIN INTER POLY EFFECT) | TRAIN     | Churn  | Churn        | 580            | 3284          | 338            | 727           |
| Reg7       | LR (MAIN INTER POLY EFFECT) | VALIDATE  | Churn  | Churn        | 269            | 1404          | 148            | 293           |
| Reg6       | LR (INTER POLY)             | TRAIN     | Churn  | Churn        | 579            | 3279          | 343            | 728           |
| Reg6       | LR (INTER POLY)             | VALIDATE  | Churn  | Churn        | 267            | 1406          | 146            | 295           |
| Reg5       | LR (MAIN POLY EFFECT)       | TRAIN     | Churn  | Churn        | 615            | 3299          | 323            | 692           |
| Reg5       | LR (MAIN POLY EFFECT)       | VALIDATE  | Churn  | Churn        | 269            | 1422          | 130            | 293           |
| Reg4       | LR (MAIN INTER EFFECT)      | TRAIN     | Churn  | Churn        | 579            | 3277          | 345            | 728           |
| Reg4       | LR (MAIN INTER EFFECT)      | VALIDATE  | Churn  | Churn        | 264            | 1408          | 144            | 298           |
| Reg3       | LR (POLY EFFECT)            | TRAIN     | Churn  | Churn        | 717            | 3298          | 324            | 590           |
| Reg3       | LR (POLY EFFECT)            | VALIDATE  | Churn  | Churn        | 311            | 1425          | 127            | 251           |
| Reg2       | LR (INTER EFFECT)           | TRAIN     | Churn  | Churn        | 616            | 3222          | 400            | 691           |
| Reg2       | LR (INTER EFFECT)           | VALIDATE  | Churn  | Churn        | 279            | 1374          | 178            | 283           |
| Reg        | LR (MAIN EFFECT)            | TRAIN     | Churn  | Churn        | 619            | 3295          | 327            | 688           |
| Reg        | LR (MAIN EFFECT)            | VALIDATE  | Churn  | Churn        | 274            | 1419          | 133            | 288           |

Figure 4.4 Model Selection 8 models

Table 4.3 Confusion Matrix LR (MAIN POLY EFFECT)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 293          | 269          | 562   |
|                  | Negative (0) | 130          | 1422         | 1552  |

Table 4.4 Confusion Matrix LR (MAIN EFFECT)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 288          | 274          | 562   |
|                  | Negative (0) | 133          | 1419         | 1552  |

Table 4.5 Confusion Matrix LR (MAIN INTER EFFECT)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 298          | 264          | 562   |
|                  | Negative (0) | 144          | 1408         | 1552  |

Table 4.6 Confusion Matrix LR (INTER POLY)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 295          | 267          | 562   |
|                  | Negative (0) | 146          | 1406         | 1552  |

Table 4.7 Confusion Matrix LR (MAIN INTER POLY EFFECT)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 293          | 269          | 562   |
|                  | Negative (0) | 148          | 1404         | 1552  |

Table 4.8 Confusion Matrix LR (POLY EFFECT)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 251          | 311          | 562   |
|                  | Negative (0) | 127          | 1425         | 1552  |

Table 4.9 Confusion Matrix LR (INTER EFFECT)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 283          | 279          | 562   |
|                  | Negative (0) | 178          | 1374         | 1552  |

### The Best Sensitivity and Specificity

Table 4.10 Sensitivity, Specificity and Accuracy 8 models

| Calculation | LR(Main poly effect) | LR(Main Effect) | LR(Main Inter Effect) | LR(Inter Poly) | LR(Main Inter Poly Effect) | LR(Poly Effect) | LR(Inter Effect) |
|-------------|----------------------|-----------------|-----------------------|----------------|----------------------------|-----------------|------------------|
| SENSITIVITY | 0.5214               | 0.5125          | 0.5302                | 0.5249         | 0.5214                     | 0.4466          | 0.5036           |
| SPECIFICITY | 0.9162               | 0.9143          | 0.9072                | 0.9059         | 0.9046                     | 0.9182          | 0.8853           |
| ACCURACY    | 0.8113               | 0.8075          | 0.8070                | 0.8046         | 0.8027                     | 0.7928          | 0.7838           |

LR(Main Inter Effect) model is chosen the best model to predict positive events since it has higher value of sensitivity. While, LR(Poly Effect) is chosen the best model to predict negative events since the specificity is the highest value compared to another model.

## 4.2.5 Multiple Regression Model

### Model Selection (Forward, Backward and Stepwise)

Table 4.11 Model Comparison for Forward, Backward and Stepwise

| Model Description  | Train: Average Squared Error | Valid: Average Squared Error | GAP ASE      | Train: Misclassification Rate | Valid: Misclassification Rate | GAP MR            | Train: Roc Index | Valid: Roc Index | GAP ROC |
|--------------------|------------------------------|------------------------------|--------------|-------------------------------|-------------------------------|-------------------|------------------|------------------|---------|
| LR (MAIN BACKWARD) | 0.133147871                  | 0.129195378                  | -0.003952493 | 0.192128221                   | 0.19205298                    | -7.5240601978E-05 | 0.85             | 0.861            | 0.011   |
| LR (MAIN EFFECT)   | 0.133148166                  | 0.129198647                  | -0.003949518 | 0.19192534                    | 0.192526017                   | 6.0067720381E-04  | 0.85             | 0.861            | 0.011   |
| LR (MAIN FORWARD)  | 0.133148166                  | 0.129198647                  | -0.003949518 | 0.19192534                    | 0.192526017                   | 6.0067720381E-04  | 0.85             | 0.861            | 0.011   |
| LR (MAIN STEPWISE) | 0.133148166                  | 0.129198647                  | -0.003949518 | 0.19192534                    | 0.192526017                   | 6.0067720381E-04  | 0.85             | 0.861            | 0.011   |

|                |                                                            |
|----------------|------------------------------------------------------------|
| UNDERFIT MODEL | LR (MAIN BACKWARD)                                         |
| OVERFIT MODEL  | LR (MAIN EFFECT), LR (MAIN FORWARD) AND LR (MAIN STEPWISE) |
| BEST MODEL     | NO BEST MODEL                                              |

Misclassification rate, average squared error and roc index are chosen to calculate the gap between valid and train to identify the underfit, overfit and the best fit of the model. Since the misclassification rate(-), average squared error(-) and roc index(+) for the model LR Main Backward, so we could say that this model is underfit model. After that we need to remove this model because we want to select the best model of logistic regression model. While, LR Main Effect, LR Main Forward and LR Main Stepwise have the largest gap, therefore, the overfit model is LR Main Effect, LR Main Forward and LR Main Stepwise. Also, we need to remove LR Main Effect, LR Main Forward and LR Main Stepwise to find the best model of logistic regression model. Lastly, since all the model has been removed so, we can conclude that there is no best model for logistic regression. Also, we can conclude that logistic regression model is not suitable to use for this data analysis.

### Comparison of ROC Chart

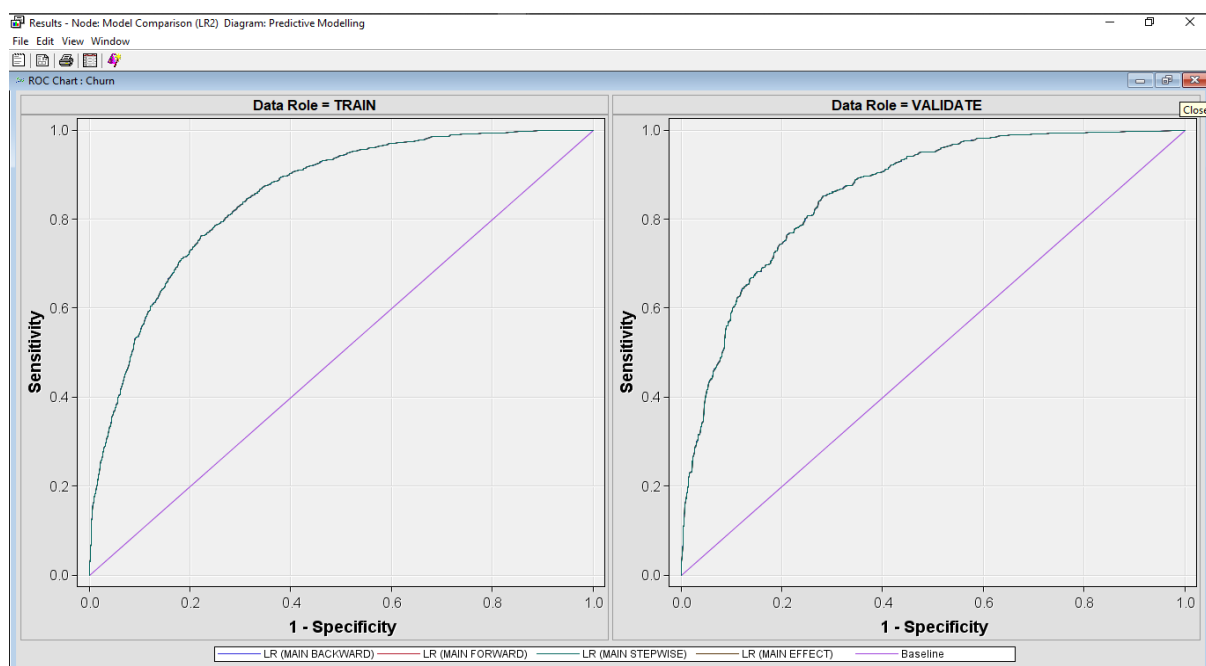


Figure 4.5 ROC chart

Based on the ROC chart, there are 4 models used in multiple regression which are LR Main Effect, LR Main Forward, LR Main Stepwise and LR Main Backward. In this graph, we can conclude that LR Main Stepwise indicate the model has highest performance since it is the most far apart model from the baseline and thus has the highest sensitivity.

## Comparison of Lift and Cumulative Chart

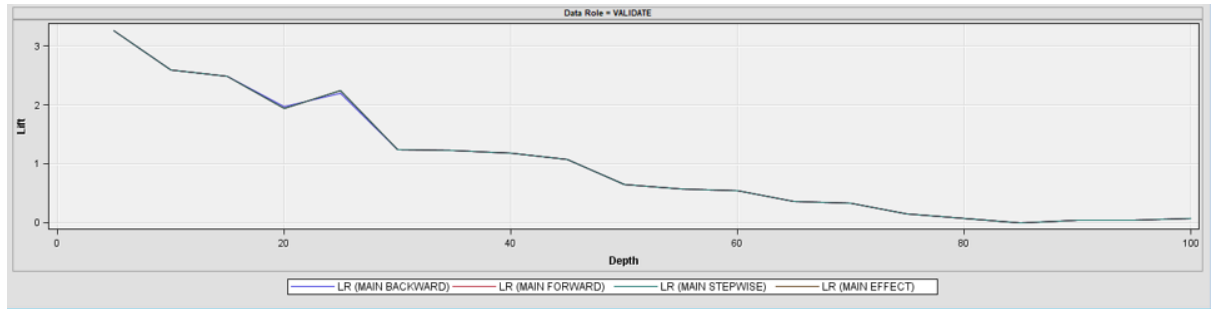


Figure 4.6 Lift Chart

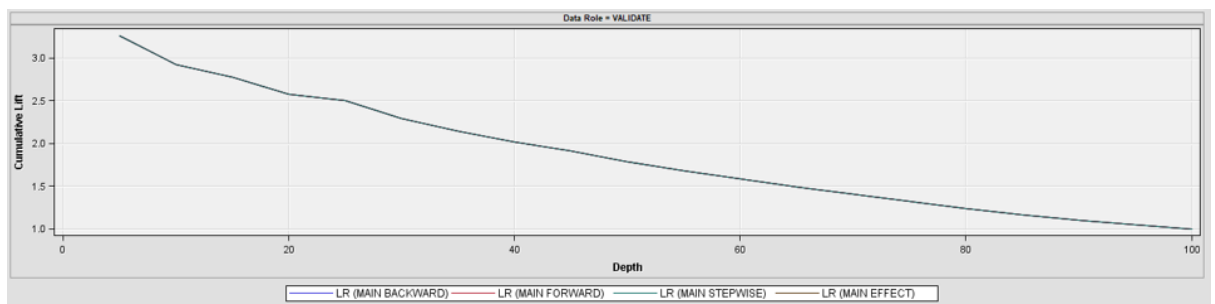


Figure 4.7 Cumulative Chart

Lift is a measure of the effectiveness of a predictive model calculated as the ratio between the results obtained with and without the predictive model. Cumulative gains and lift charts are visual aids for measuring model performance. Both charts consist of a lift curve and a baseline. The greater the area between the lift curve and the baseline, the better the model. In this graph, there is no best model.

## **Confusion Matrix for Main Effect, Main Stepwise, Main Forward and Main Backward**

### **Model Selection**

Event Classification Table

Model Selection based on Valid: Misclassification Rate (\_VMISC\_)

| Model Node | Model Description  | Data Role | Target | Target Label | False Negative | True Negative | False Positive | True Positive |
|------------|--------------------|-----------|--------|--------------|----------------|---------------|----------------|---------------|
| Reg        | LR (MAIN EFFECT)   | TRAIN     | Churn  | Churn        | 619            | 3295          | 327            | 688           |
| Reg        | LR (MAIN EFFECT)   | VALIDATE  | Churn  | Churn        | 274            | 1419          | 133            | 288           |
| Reg8       | LR (MAIN FORWARD)  | TRAIN     | Churn  | Churn        | 619            | 3295          | 327            | 688           |
| Reg8       | LR (MAIN FORWARD)  | VALIDATE  | Churn  | Churn        | 274            | 1419          | 133            | 288           |
| Reg10      | LR (MAIN STEPWISE) | TRAIN     | Churn  | Churn        | 619            | 3295          | 327            | 688           |
| Reg10      | LR (MAIN STEPWISE) | VALIDATE  | Churn  | Churn        | 274            | 1419          | 133            | 288           |
| Reg9       | LR (MAIN BACKWARD) | TRAIN     | Churn  | Churn        | 619            | 3294          | 328            | 688           |
| Reg9       | LR (MAIN BACKWARD) | VALIDATE  | Churn  | Churn        | 273            | 1419          | 133            | 289           |

Figure 4.8 Model Selection

Table 4.12 Confusion Matrix LR (MAIN EFFECT)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 288          | 274          | 562   |
|                  | Negative (0) | 133          | 1419         | 1552  |

Table 4.13 Confusion Matrix LR (MAIN FORWARD)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 288          | 274          | 562   |
|                  | Negative (0) | 133          | 1419         | 1552  |

Table 4.14 Confusion Matrix LR (MAIN STEPWISE)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 288          | 274          | 562   |
|                  | Negative (0) | 133          | 1419         | 1552  |

Table 4.15 Confusion Matrix LR (MAIN BACKWARD)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 289          | 273          | 562   |
|                  | Negative (0) | 133          | 1419         | 1552  |

### The Best Sensitivity and Specificity

Table 4.16 Sensitivity, Specificity and Accuracy

| Calculation | LR(Main Effect) | LR(Main Forward) | LR(Main Stepwise) | LR(Main Backward) |
|-------------|-----------------|------------------|-------------------|-------------------|
| SENSITIVITY | 0.5125          | 0.5125           | 0.5125            | 0.5142            |
| SPECIFITY   | 0.9143          | 0.9143           | 0.9143            | 0.9143            |
| ACCURACY    | 0.8075          | 0.8075           | 0.8075            | 0.8079            |

LR Main Backward model is chosen the best model to predict positive events since it has higher value of sensitivity. While, all the model is chosen the best model to predict negative events since the value of specificity is the same. But, for the overall LR Main Backward is chosen since the value of accuracy is the highest compared to another model.

### 4.2.6 Odds Ratio

| Odds Ratio Estimates |                                           |                |
|----------------------|-------------------------------------------|----------------|
| Effect               |                                           | Point Estimate |
| Contract             | Month-to-month vs Two year                | 5.273          |
| Contract             | One year vs Two year                      | 2.817          |
| IMP_LOG_TotalCharges |                                           | 0.535          |
| InternetService      | DSL vs No                                 | 4.683          |
| InternetService      | Fiber optic vs No                         | 14.743         |
| MultipleLines        | No vs Yes                                 | 0.649          |
| MultipleLines        | No phone service vs Yes                   | 0.823          |
| OnlineSecurity       | No vs Yes                                 | 1.360          |
| OnlineSecurity       | No internet service vs Yes                | .              |
| PaperlessBilling     | No vs Yes                                 | 0.718          |
| PaymentMethod        | Bank transfer (automatic) vs Mailed check | 1.223          |
| PaymentMethod        | Credit card (automatic) vs Mailed check   | 1.147          |
| PaymentMethod        | Electronic check vs Mailed check          | 1.620          |
| SeniorCitizen        | 0 vs 1                                    | 0.802          |
| StreamingMovies      | No vs Yes                                 | 0.696          |
| StreamingMovies      | No internet service vs Yes                | .              |
| StreamingTV          | No vs Yes                                 | 0.679          |
| StreamingTV          | No internet service vs Yes                | .              |
| TechSupport          | No vs Yes                                 | 1.227          |
| TechSupport          | No internet service vs Yes                | .              |

Figure 4.13 Odds Ratio Estimate

## 4.2.7 Model Significant

- LIKELIHOOD RATIO

Likelihood Ratio Test for Global Null Hypothesis: BETA=0

| -2 Log Likelihood |                        | Likelihood |    |            |
|-------------------|------------------------|------------|----|------------|
| Intercept Only    | Intercept & Covariates | Chi-Square | DF | Pr > ChiSq |
| 5701.775          | 4045.558               | 1656.2171  | 16 | <.0001     |

Figure 4.10 Likelihood Ratio Test

Based on figure 4.5, since p-value (0.001) is less than alpha (0.05), the model is significant. Therefore, we can proceed with identifying the significant input.

- ESTIMATED LOGISTICS REGRESSION MODEL

Analysis of Maximum Likelihood Estimates

| Parameter                               | DF | Estimate | Standard Error | Wald Chi-Square | Pr > ChiSq | Standardized Estimate | Exp(Est) |
|-----------------------------------------|----|----------|----------------|-----------------|------------|-----------------------|----------|
| Intercept                               | 1  | 2.1269   | 0.2815         | 57.07           | <.0001     |                       | 8.389    |
| Contract Month-to-month                 | 1  | 0.7632   | 0.0876         | 75.84           | <.0001     |                       | 2.145    |
| Contract One year                       | 1  | 0.1363   | 0.0924         | 2.18            | 0.1402     |                       | 1.146    |
| IMP_LOG_TotalCharges                    | 1  | -0.6259  | 0.0396         | 250.04          | <.0001     | -0.5371               | 0.535    |
| InternetService DSL                     | 1  | 0.1324   | 0.0773         | 2.93            | 0.0870     |                       | 1.142    |
| InternetService Fiber optic             | 1  | 1.2792   | 0.0860         | 221.24          | <.0001     |                       | 3.594    |
| MultipleLines No                        | 1  | -0.2229  | 0.0658         | 11.48           | 0.0007     |                       | 0.800    |
| MultipleLines No phone service          | 1  | 0.0138   | 0.1026         | 0.02            | 0.8929     |                       | 1.014    |
| OnlineSecurity No                       | 1  | 0.1537   | 0.0503         | 9.33            | 0.0022     |                       | 1.166    |
| OnlineSecurity No internet service      | 0  | 0        | .              | .               | .          | .                     | .        |
| PaperlessBilling No                     | 1  | -0.1656  | 0.0453         | 13.37           | 0.0003     |                       | 0.847    |
| PaymentMethod Bank transfer (automatic) | 1  | -0.00394 | 0.0796         | 0.00            | 0.9606     |                       | 0.996    |
| PaymentMethod Credit card (automatic)   | 1  | -0.0681  | 0.0814         | 0.70            | 0.4030     |                       | 0.934    |
| PaymentMethod Electronic check          | 1  | 0.2772   | 0.0625         | 19.67           | <.0001     |                       | 1.319    |
| SeniorCitizen 0                         | 1  | -0.1103  | 0.0493         | 5.01            | 0.0252     |                       | 0.896    |
| StreamingMovies No                      | 1  | -0.1813  | 0.0481         | 14.21           | 0.0002     |                       | 0.834    |
| StreamingMovies No internet service     | 0  | 0        | .              | .               | .          | .                     | .        |
| StreamingTV No                          | 1  | -0.1937  | 0.0484         | 16.03           | <.0001     |                       | 0.824    |
| StreamingTV No internet service         | 0  | 0        | .              | .               | .          | .                     | .        |
| TechSupport No                          | 1  | 0.1023   | 0.0517         | 3.92            | 0.0476     |                       | 1.108    |
| TechSupport No internet service         | 0  | 0        | .              | .               | .          | .                     | .        |

Figure 4.11 Table Estimated Logistic Regression Model

$$\ln\left(\frac{p}{1-p}\right) = 2.1269 + 0.7632\text{Month-to-month} + 0.1363\text{Oneyear} - 0.6259\text{IMP\_LOG\_TotalCharges} + 0.1324\text{DSL} + 1.2792\text{Fiberoptic} - 0.2229\text{MultipleLines} + 0.0138\text{Nophoneservice} + 0.1537\text{OnlineSecurity} - 0.1656\text{PaperlessBilling} - 0.00394\text{Banktransfer(automatic)} - 0.0681\text{Creditcard(automatic)} + 0.2772\text{Electroniccheck} - 0.1103\text{SeniorCitizen} - 0.1813\text{StreamingMovies} - 0.1937\text{StreamingTV} + 0.1023\text{TechSupport}$$

- SIGIFICANCE INPUT

The input that has p-value < alpha (0.05) is significant. Based on figure .... there are 11 significant inputs from this result out of 20. The significant inputs are Contract(Month-to-month), IMP\_LOG\_TotalCharges, InternetService(Fiber optic), MultipleLines, OnlineSecurity, PaperlessBilling, PaymentMethod (Electronic check), SeniorCitizen, StreamingMovies, StreamingTV and TechSupport

- INTERPRETATION

Table 4.17 Interpretation

| <b>X</b>                     | <b>Estimate<br/>(b)</b> | <b>e<sup>b</sup></b> | <b>e<sup>b</sup> – 1</b> | <b>% change<br/>in odds</b> | <b>Interpretation</b>                                                                 |
|------------------------------|-------------------------|----------------------|--------------------------|-----------------------------|---------------------------------------------------------------------------------------|
| Contract(Month-to-month)     | 0.7632                  | 2.1451               | 1.1451                   | 114.51                      | 1 unit changes in Contract(Month-to-month) will increase the odds of churn by 114.51% |
| Contract(One year)           | 0.1363                  | 1.1460               | 0.1460                   | 14.60                       | 1 unit changes in Contract(One year)will increase the odds of churn by 14.60%         |
| IMP_LOG_TotalCharges         | -0.6259                 | 0.5348               | -0.4652                  | 46.52                       | 1 unit changes in IMP_LOG_TotalCharges will decrease the odds of churn by 46.52%      |
| InternetService(DSL)         | 0.1324                  | 1.1416               | 0.1416                   | 14.16                       | 1 unit changes in InternetService(DSL)will increase the odds of churn by 14.16%       |
| InternetService(Fiber optic) | 1.2792                  | 3.5938               | 2.5938                   | 259.38                      | 1 unit changes in InternetService(Fiber optic) will increase the                      |

|                                             |          |        |         |       |                                                                                                              |
|---------------------------------------------|----------|--------|---------|-------|--------------------------------------------------------------------------------------------------------------|
|                                             |          |        |         |       | odds of churn by<br>259.38%                                                                                  |
| MultipleLines                               | -0.2229  | 0.8002 | -0.1998 | 19.98 | 1 unit changes in<br>MultipleLines will<br>decrease the odds of<br>churn by 19.98%                           |
| MultipleLines(No phone<br>service)          | 0.0138   | 1.0139 | 0.0139  | 1.39  | 1 unit changes in<br>MultipleLines(No phone<br>service) will increase the<br>odds of churn by 1.39%          |
| OnlineSecurity                              | 0.1537   | 1.1661 | 0.1661  | 16.61 | 1 unit changes in<br>OnlineSecurity will<br>increase the odds of<br>churn by 16.61%                          |
| PaperlessBilling                            | -0.1656  | 0.8474 | -0.1526 | 15.26 | 1 unit changes in<br>PaperlessBilling will<br>decrease the odds of<br>churn by 15.26%                        |
| PaymentMethod (Bank<br>transfer(automatic)) | -0.00394 | 0.9961 | -0.0039 | 0.39  | 1 unit changes in<br>Contract(Month-to-<br>month) will increase the<br>odds of churn by<br>114.51%           |
| PaymentMethod<br>(Creditcard(automatic))    | -0.0681  | 0.9342 | -0.0658 | 6.58  | 1 unit changes in<br>PaymentMethod<br>(Creditcard(automatic))<br>will decrease the odds of<br>churn by 6.58% |
| PaymentMethod<br>(Electronic check)         | 0.2772   | 1.3194 | 0.3194  | 31.94 | 1 unit changes in<br>PaymentMethod<br>(Electronic check) will<br>increase the odds of<br>churn by 31.94%     |
| SeniorCitizen                               | -0.1103  | 0.8956 | -0.1044 | 10.44 | 1 unit changes in<br>SeniorCitizen will                                                                      |

|                 |         |        |         |       |                                                                             |
|-----------------|---------|--------|---------|-------|-----------------------------------------------------------------------------|
|                 |         |        |         |       | decrease the odds of churn by 10.44%                                        |
| StreamingMovies | -0.1813 | 0.8342 | -0.1658 | 16.58 | 1 unit changes in StreamingMovies will decrease the odds of churn by 16.58% |
| StreamingTV     | -0.1937 | 0.8239 | -0.1761 | 17.61 | 1 unit changes in StreamingTV will decrease the odds of churn by 17.61%     |
| TechSupport     | 0.1023  | 1.1077 | 0.1077  | 10.77 | 1 unit changes in TechSupport will increase the odds of churn 10.77%        |

## 4.3 DECISION TREE ANALYSIS

### 4.3.1 Model Comparison

This section will demonstrate the interactive construction of a decision tree model. It begins with a seven different of description such as Decision Tree Algorithm (GINI), Decision Tree Algorithm (CART), Decision Tree Algorithm (ENTROPY), Decision Tree Algorithm (LOGWORTH), Maximal Tree, Probability Tree AND Decision Tree Algorithm (CHAID). The properties for each decision tree algorithm had been included by referring to the manual of data mining. By using the guideline, we get this following table as the result.

Table 4.18 Model Comparison for each Decision Tree Model

| Model Description | Valid: Misclassification Rate | Train: Misclassification Rate | GAP                  | Valid: Average Squared Error | Train: Average Squared Error | GAP                  | Valid: Roc Index | Train: Roc Index | GAP   |
|-------------------|-------------------------------|-------------------------------|----------------------|------------------------------|------------------------------|----------------------|------------------|------------------|-------|
| DT (GINI)         | 0.19299<br>9054               | 0.1949685<br>53               | -<br>0.001969<br>5   | 0.136513<br>789              | 0.137635<br>755              | -<br>0.001121<br>966 | 0.829            | 0.82             | 0.009 |
| DT (CART)         | 0.19441<br>8165               | 0.2006492<br>19               | -<br>0.006231<br>054 | 0.134300<br>91               | 0.135838<br>963              | -<br>0.001538<br>054 | 0.846            | 0.84             | 0.006 |
| DT (ENTROPY)      | 0.19441<br>8165               | 0.1965916<br>01               | -<br>0.002173<br>436 | 0.138970<br>746              | 0.140617<br>152              | -<br>0.001646<br>406 | 0.825            | 0.814            | 0.011 |
| DT (LOG WORTH)    | 0.19725<br>6386               | 0.2018665<br>04               | -<br>0.004610<br>118 | 0.138453<br>209              | 0.139918<br>391              | -<br>0.001465<br>182 | 0.825            | 0.815            | 0.01  |
| Maximal Tree      | 0.19725<br>6386               | 0.2018665<br>04               | -<br>0.004610<br>118 | 0.138453<br>209              | 0.139918<br>391              | -<br>0.001465<br>182 | 0.825            | 0.815            | 0.01  |
| Probability Tree  | 0.20529<br>8013               | 0.1998376<br>95               | 0.005460<br>318      | 0.133965<br>763              | 0.133517<br>901              | 0.000447<br>862      | 0.849            | 0.846            | 0.003 |
| DT (CHAID)        | 0.21144<br>7493               | 0.2043010<br>75               | 0.007146<br>418      | 0.139896<br>916              | 0.134847<br>202              | 0.005049<br>714      | 0.836            | 0.846            | -0.01 |

|                |                                                            |
|----------------|------------------------------------------------------------|
| UNDERFIT MODEL | DT GINI, DT CART, DT ENTROPY, DT LOGWORTH AND Maximal Tree |
| OVERFIT MODEL  | DT CHAID                                                   |
| BEST MODEL     | Probability Tree                                           |

DT GINI, DT CART, DT ENTROPY, DT LOGWORTH and Maximal Tree are classified as underfit model since there is negative value for MR gap and MSE gap, also a positive value for ROC gap for every model. DT CHAID has the largest gap compare to Probability Tree, therefore, the overfitted model is DT CHAID. Probability Tree is the only model that can be chosen as the best model so that we can conclude Probability Tree as the best model. Since the best model is the Probability Tree, therefore, we will only choose this model to do the analysis of the model.

#### 4.3.2 Comparison ROC Chart

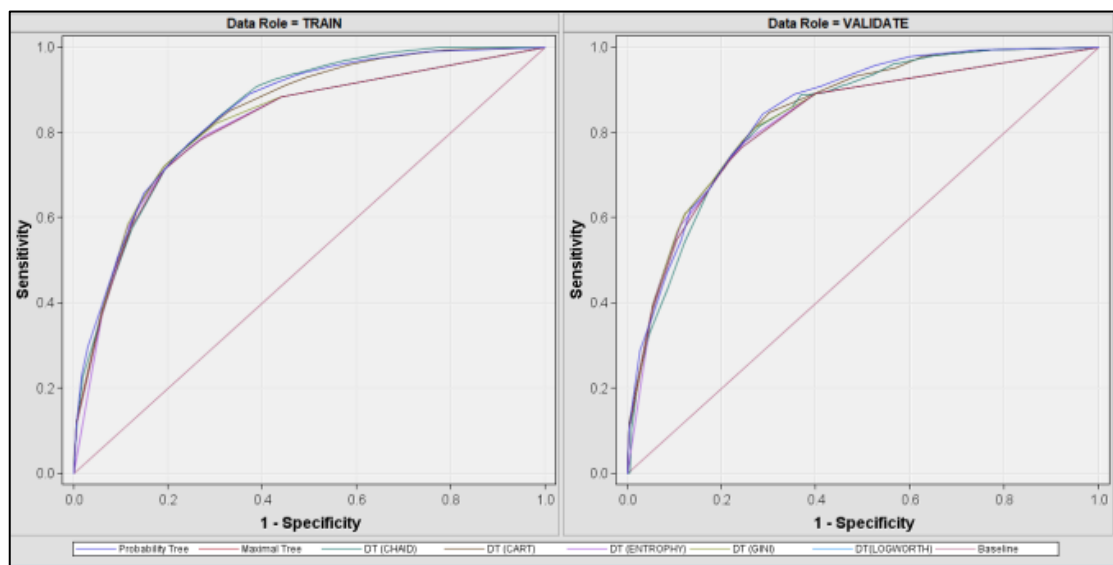


Figure 4.12 ROC chart Decision Tree

In Receiver Operating Characteristic (ROC) Chart, when the graph is closer to the asterisk mark, it indicates that the model has high performance. In this graph, Probability Tree indicate the model has highest performance since it is the most far apart model from the baseline and thus has the highest sensitivity.

### 4.3.3 Comparison of Lift Chart and Cumulative Lift Chart

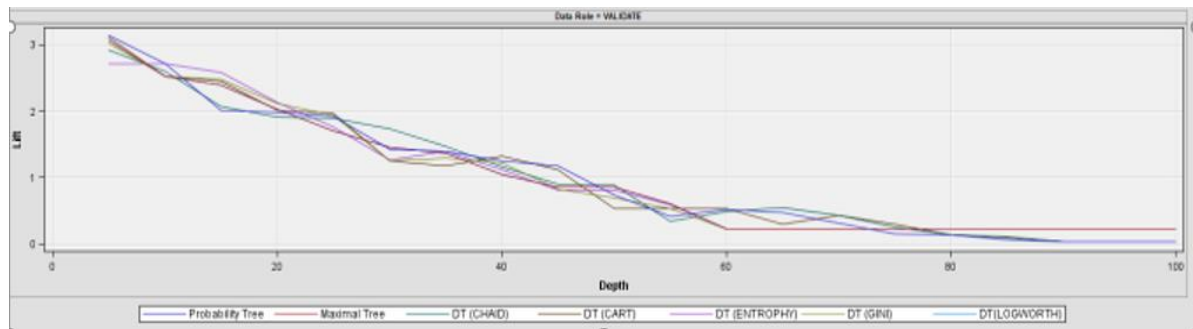


Figure 4.13 Lift Chart

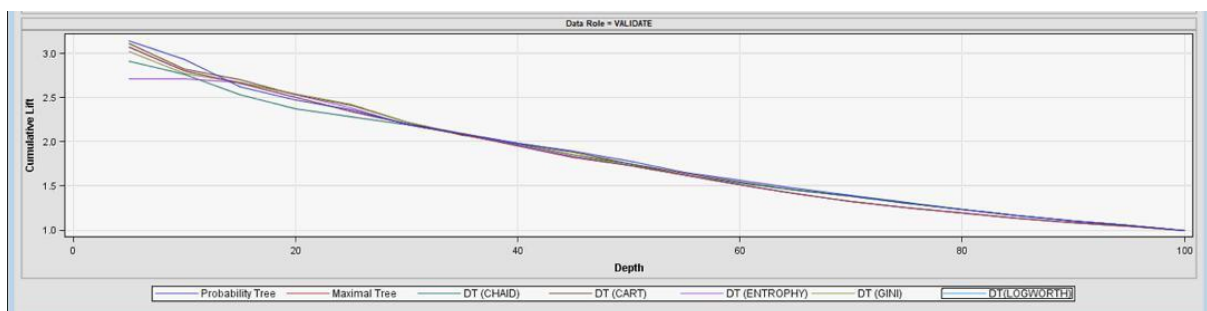


Figure 4.14 Cumulative Lift Chart

Lift is a measure of the effectiveness of a predictive model calculated as the ratio between the results obtained with and without the predictive model. Cumulative gains and lift charts are visual aids for measuring model performance. Both charts consist of a lift curve and a baseline. The greater the area between the lift curve and the baseline, the better the model. In this graph, Probability Tree indicate the best model.

### 4.3.4 Variable Importance

| Variable Importance |                 |                           |            |                       |                                            |
|---------------------|-----------------|---------------------------|------------|-----------------------|--------------------------------------------|
| Variable Name       | Label           | Number of Splitting Rules | Importance | Validation Importance | Ratio of Validation to Training Importance |
| Contract            | Contract        | 3                         | 1.0000     | 1.0000                | 1.0000                                     |
| tenure              | tenure          | 5                         | 0.6245     | 0.5453                | 0.8731                                     |
| InternetService     | InternetService | 1                         | 0.5717     | 0.4639                | 0.8114                                     |
| OnlineSecurity      | OnlineSecurity  | 2                         | 0.2681     | 0.0866                | 0.3230                                     |
| StreamingTV         | StreamingTV     | 2                         | 0.2008     | 0.1156                | 0.5757                                     |
| MonthlyCharges      | MonthlyCharges  | 1                         | 0.1848     | 0.1709                | 0.9243                                     |
| SeniorCitizen       | SeniorCitizen   | 2                         | 0.1661     | 0.1594                | 0.9597                                     |
| PaymentMethod       | PaymentMethod   | 1                         | 0.1580     | 0.1210                | 0.7659                                     |
| PhoneService        | PhoneService    | 1                         | 0.1374     | 0.1510                | 1.0989                                     |
| MultipleLines       | MultipleLines   | 1                         | 0.1243     | 0.1045                | 0.8408                                     |
| Dependents          | Dependents      | 1                         | 0.1047     | 0.0410                | 0.3916                                     |
| OnlineBackup        | OnlineBackup    | 1                         | 0.1014     | 0.1117                | 1.1008                                     |
| TechSupport         | TechSupport     | 1                         | 0.0930     | 0.0904                | 0.9727                                     |

Figure 4.15 Variable Importance

From on the figure above, it was shown that the most important variable is Contract. There are 13 variables to grow the tree and have ranked in the “Importance” column.

#### 4.3.5 Tree Report

| Node Id | Depth | Training Observations | Training Percent YES | Validation Observations | Validation Percent YES |
|---------|-------|-----------------------|----------------------|-------------------------|------------------------|
| 13      | 3     | 915                   | 0.02                 | 400                     | 0.01                   |
| 24      | 4     | 510                   | 0.05                 | 232                     | 0.04                   |
| 14      | 3     | 270                   | 0.23                 | 128                     | 0.20                   |
| 41      | 5     | 264                   | 0.08                 | 107                     | 0.14                   |
| 21      | 4     | 260                   | 0.55                 | 90                      | 0.53                   |
| 15      | 3     | 250                   | 0.08                 | 130                     | 0.08                   |
| 25      | 4     | 231                   | 0.14                 | 102                     | 0.11                   |
| 48      | 6     | 228                   | 0.50                 | 90                      | 0.47                   |
| 38      | 5     | 223                   | 0.25                 | 97                      | 0.36                   |
| 49      | 6     | 219                   | 0.32                 | 83                      | 0.30                   |
| 34      | 5     | 211                   | 0.54                 | 90                      | 0.54                   |
| 46      | 6     | 184                   | 0.79                 | 76                      | 0.74                   |
| 23      | 4     | 178                   | 0.29                 | 74                      | 0.36                   |
| 51      | 6     | 176                   | 0.13                 | 72                      | 0.14                   |
| 44      | 6     | 174                   | 0.48                 | 75                      | 0.57                   |
| 31      | 5     | 164                   | 0.87                 | 63                      | 0.90                   |
| 45      | 6     | 143                   | 0.65                 | 63                      | 0.73                   |
| 50      | 6     | 135                   | 0.27                 | 61                      | 0.31                   |
| 36      | 5     | 87                    | 0.31                 | 43                      | 0.40                   |
| 37      | 5     | 62                    | 0.13                 | 23                      | 0.13                   |
| 47      | 6     | 30                    | 0.53                 | 12                      | 0.58                   |
| 39      | 5     | 8                     | 0.75                 | 2                       | 1.00                   |
| 30      | 5     | 7                     | 0.43                 | 1                       | 0.00                   |

Figure 4.16 Tree Leaf Report

Based on the above leaf report, there are 23 leaves to predict the target variable Y = 0 and Y = 1.

#### 4.3.6 English Rule

The result below shows the rule use to predict y = 0, 1. Note that the grey indicates the rule that use to predict y=1 and the blue indicate the rule that is used to predict y=0.

\*-----\*

Node = 13

\*-----\*

if MonthlyCharges < 93.675 or MISSING

AND Contract IS ONE OF: TWO YEAR or MISSING

then

Tree Node Identifier = 13  
Number of Observations = 915  
Predicted: Churn = Yes = 0.02  
Predicted: Churn = No = 0.98

\*-----\*

Node = 14

\*-----\*

if MonthlyCharges >= 93.675  
AND Contract IS ONE OF: ONE YEAR or MISSING  
then

Tree Node Identifier = 14  
Number of Observations = 270  
Predicted: Churn = Yes = 0.23  
Predicted: Churn = No = 0.77

\*-----\*

Node = 15

\*-----\*

if MonthlyCharges >= 93.675  
AND Contract IS ONE OF: TWO YEAR  
then

Tree Node Identifier = 15  
Number of Observations = 250  
Predicted: Churn = Yes = 0.08  
Predicted: Churn = No = 0.92

\*-----\*

Node = 21

\*-----\*

if tenure < 4.5  
AND OnlineSecurity IS ONE OF: NO or MISSING  
AND InternetService IS ONE OF: DSL, NO  
AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING  
then

Tree Node Identifier = 21  
Number of Observations = 260

Predicted: Churn = Yes = 0.55

Predicted: Churn = No = 0.45

\*-----\*

Node = 23

\*-----\*

if tenure  $\geq 4.5$  or MISSING

AND PhoneService IS ONE OF: NO

AND InternetService IS ONE OF: DSL, NO

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 23

Number of Observations = 178

Predicted: Churn = Yes = 0.29

Predicted: Churn = No = 0.71

\*-----\*

Node = 24

\*-----\*

if OnlineSecurity IS ONE OF: YES, NO INTERNET SERVICE or MISSING

AND MonthlyCharges  $< 93.675$  or MISSING

AND Contract IS ONE OF: ONE YEAR

then

Tree Node Identifier = 24

Number of Observations = 510

Predicted: Churn = Yes = 0.05

Predicted: Churn = No = 0.95

\*-----\*

Node = 25

\*-----\*

if OnlineSecurity IS ONE OF: NO

AND MonthlyCharges  $< 93.675$  or MISSING

AND Contract IS ONE OF: ONE YEAR

then

Tree Node Identifier = 25

Number of Observations = 231

Predicted: Churn = Yes = 0.14

Predicted: Churn = No = 0.86

\*-----\*

Node = 30

\*-----\*

if tenure < 1.5

AND TechSupport IS ONE OF: YES

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 30

Number of Observations = 7

Predicted: Churn = Yes = 0.43

Predicted: Churn = No = 0.57

\*-----\*

Node = 31

\*-----\*

if tenure < 1.5

AND TechSupport IS ONE OF: NO or MISSING

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 31

Number of Observations = 164

Predicted: Churn= Yes = 0.87

Predicted: Churn = No = 0.13

\*-----\*

Node = 34

\*-----\*

if tenure < 51.5 AND tenure >= 14.5 or MISSING

AND SeniorCitizen IS ONE OF: 1

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 34  
Number of Observations = 211  
Predicted: Churn = Yes = 0.54  
Predicted: Churn = No = 0.46

\*-----\*

Node = 36

\*-----\*

if tenure >= 51.5

AND StreamingTV IS ONE OF: YES or MISSING

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 36

Number of Observations = 87

Predicted: Churn = Yes = 0.31

Predicted: Churn = No = 0.69

\*-----\*

Node = 37

\*-----\*

if tenure >= 51.5

AND StreamingTV IS ONE OF: NO

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 37

Number of Observations = 62

Predicted: Churn = Yes = 0.13

Predicted: Churn = No = 0.87

\*-----\*

Node = 38

\*-----\*

if tenure < 4.5

AND SeniorCitizen IS ONE OF: 0 or MISSING

AND OnlineSecurity IS ONE OF: YES, NO INTERNET SERVICE

AND InternetService IS ONE OF: DSL, NO  
AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING  
then

Tree Node Identifier = 38  
Number of Observations = 223  
Predicted: Churn = Yes = 0.25  
Predicted: Churn = No = 0.75

\*-----\*

Node = 39

\*-----\*

if tenure < 4.5  
AND SeniorCitizen IS ONE OF: 1  
AND OnlineSecurity IS ONE OF: YES, NO INTERNET SERVICE  
AND InternetService IS ONE OF: DSL, NO  
AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING  
then

Tree Node Identifier = 39  
Number of Observations = 8  
Predicted: Churn = Yes = 0.75  
Predicted: Churn = No = 0.25

\*-----\*

Node = 41

\*-----\*

if tenure >= 17.5  
AND PhoneService IS ONE OF: YES or MISSING  
AND InternetService IS ONE OF: DSL, NO  
AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING  
then

Tree Node Identifier = 41  
Number of Observations = 264  
Predicted: Churn = Yes = 0.08  
Predicted: Churn = No = 0.92

\*-----\*

Node = 44

\*-----\*

if tenure < 14.5 AND tenure >= 1.5 or MISSING  
AND StreamingTV IS ONE OF: NO or MISSING  
AND MultipleLines IS ONE OF: NO or MISSING  
AND InternetService IS ONE OF: FIBER OPTIC or MISSING  
AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING  
then

Tree Node Identifier = 44

Number of Observations = 174

Predicted: Churn = Yes = 0.48

Predicted: Churn = No = 0.52

\*-----\*

Node = 45

\*-----\*

if tenure < 14.5 AND tenure >= 1.5 or MISSING  
AND StreamingTV IS ONE OF: NO or MISSING  
AND MultipleLines IS ONE OF: YES  
AND InternetService IS ONE OF: FIBER OPTIC or MISSING  
AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING  
then

Tree Node Identifier = 45

Number of Observations = 143

Predicted: Churn = Yes = 0.65

Predicted: Churn = No = 0.35

\*-----\*

Node = 46

\*-----\*

if tenure < 14.5 AND tenure >= 1.5 or MISSING  
AND StreamingTV IS ONE OF: YES  
AND InternetService IS ONE OF: FIBER OPTIC or MISSING  
AND Dependents IS ONE OF: NO or MISSING  
AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING  
then

Tree Node Identifier = 46

Number of Observations = 184

Predicted: Churn = Yes = 0.79

Predicted: Churn = No = 0.21

\*-----\*

Node = 47

\*-----\*

if tenure < 14.5 AND tenure >= 1.5 or MISSING

AND StreamingTV IS ONE OF: YES

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Dependents IS ONE OF: YES

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 47

Number of Observations = 30

Predicted: Churn = Yes = 0.53

Predicted: Churn = No = 0.47

\*-----\*

Node = 48

\*-----\*

if tenure < 51.5 AND tenure >= 14.5 or MISSING

AND SeniorCitizen IS ONE OF: 0 or MISSING

AND PaymentMethod IS ONE OF: ELECTRONIC CHECK or MISSING

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 48

Number of Observations = 228

Predicted: Churn = Yes = 0.50

Predicted: Churn = No = 0.50

\*-----\*

Node = 49

\*-----\*

if tenure < 51.5 AND tenure >= 14.5 or MISSING

AND SeniorCitizen IS ONE OF: 0 or MISSING

AND PaymentMethod IS ONE OF: BANK TRANSFER (AUTOMATIC), CREDIT CARD (AUTOMATIC), MAILED CHECK

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 49

Number of Observations = 219

Predicted: Churn = Yes = 0.32

Predicted: Churn = No = 0.68

\*-----\*

Node = 50

\*-----\*

if tenure < 17.5 AND tenure >= 4.5 or MISSING

AND PhoneService IS ONE OF: YES or MISSING

AND OnlineBackup IS ONE OF: NO

AND InternetService IS ONE OF: DSL, NO

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 50

Number of Observations = 135

Predicted: Churn = Yes = 0.27

Predicted: Churn = No = 0.73

\*-----\*

Node = 51

\*-----\*

if tenure < 17.5 AND tenure >= 4.5 or MISSING

AND PhoneService IS ONE OF: YES or MISSING

AND OnlineBackup IS ONE OF: YES, NO INTERNET SERVICE or MISSING

AND InternetService IS ONE OF: DSL, NO

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 51

Number of Observations = 176

Predicted: Churn = Yes = 0.13

Predicted: Churn = No = 0.87

From the above result, it was shown that there are 23 rules in the decision tree. 15 rules predicting  $Y=0$  while 7 rules predicted  $Y=1$ . The total number of observation used to grow the tree are 7044 observations which is the summation of number of observation in every leaf.

#### 4.3.7 Leaf Statistics

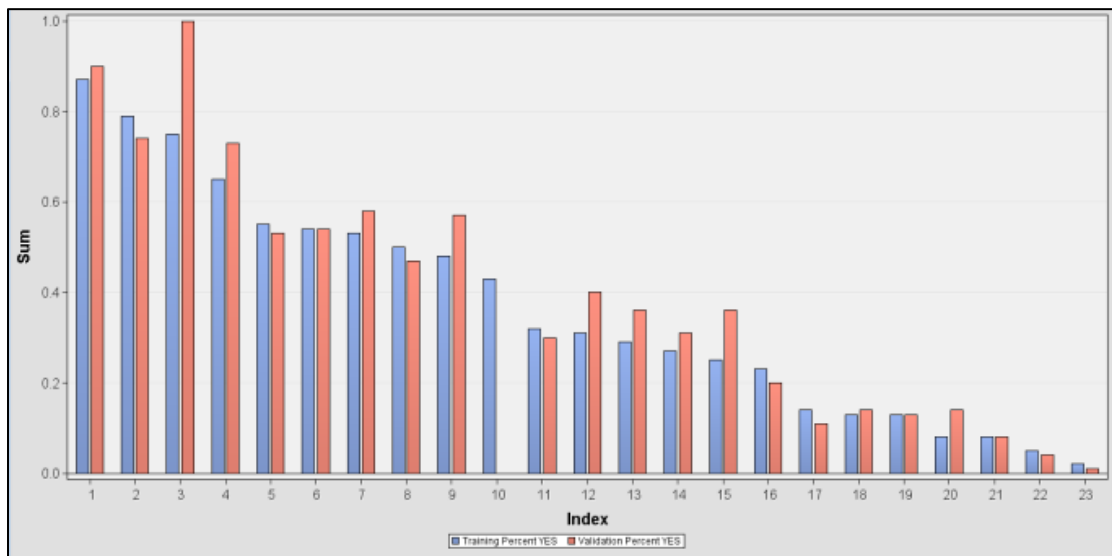


Figure 4.17 Leaf Statistics

The above graph shows the comparison of the predicted outcome percentage from the training set, presented by the blue bars while the observed outcome percentage from the validation set, presented by the red bars. These bars illustrate how well the training set responds to the validation set. From the graph, there are 3 indexes which shows the same height. On further note, the differences in the bar height are the results of small case counts in the corresponding leaf.

### 4.3.8 Subtree Assessment Plot: Average Squared Error

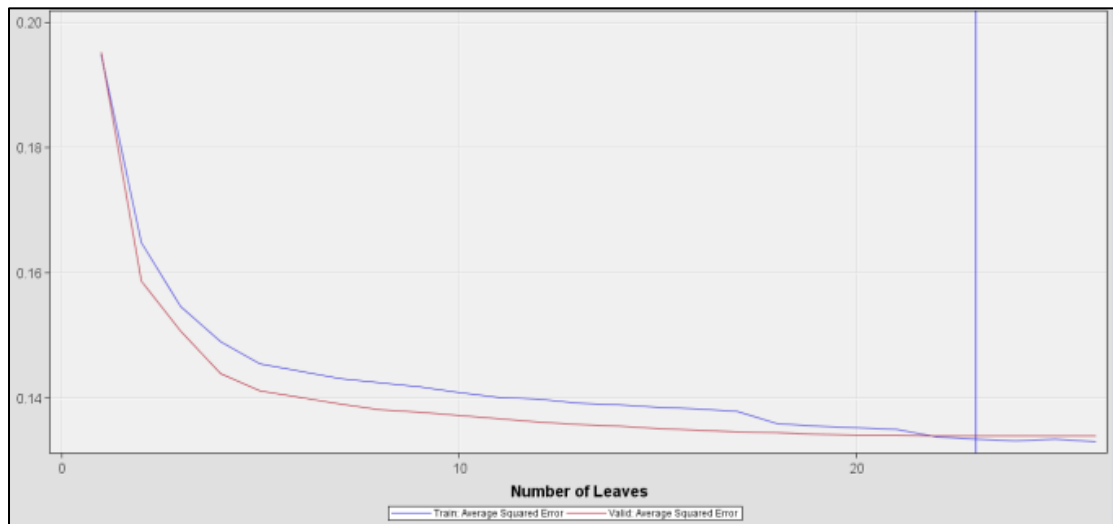


Figure 4.18 Average Squared Error

The plot graph above shows the Average Squared Error of every number of leaves. The optimal decision tree can be assessed by the performance of the tree leaves which is obtained by observing the lowest value of the Average Squared Error, which is 0.133965763. Therefore, the optimal decision tree is at 23 number of leaves.

### 4.3.9 Model Selection

Event Classification Table  
Model Selection based on Valid: Misclassification Rate (VMISC)

| Model<br>Node | Model<br>Description | Data<br>Role | Target<br>Target | Target<br>Label | False<br>Negative | True<br>Negative | False<br>Positive | True<br>Positive |
|---------------|----------------------|--------------|------------------|-----------------|-------------------|------------------|-------------------|------------------|
| Tree5         | DT (CART)            | TRAIN        | Churn            | Churn           | 499               | 3132             | 490               | 608              |
| Tree5         | DT (CART)            | VALIDATE     | Churn            | Churn           | 227               | 1368             | 184               | 335              |
| Tree4         | DT (ENTROPY)         | TRAIN        | Churn            | Churn           | 564               | 3217             | 485               | 743              |
| Tree4         | DT (ENTROPY)         | VALIDATE     | Churn            | Churn           | 258               | 1399             | 153               | 304              |
| Tree3         | DT (GINI)            | TRAIN        | Churn            | Churn           | 539               | 3208             | 422               | 768              |
| Tree3         | DT (GINI)            | VALIDATE     | Churn            | Churn           | 244               | 1388             | 164               | 318              |
| Tree2         | DT (LOGODDS)         | TRAIN        | Churn            | Churn           | 564               | 3191             | 431               | 743              |
| Tree2         | DT (LOGODDS)         | VALIDATE     | Churn            | Churn           | 254               | 1389             | 163               | 308              |
| Tree7         | Maximal Tree         | TRAIN        | Churn            | Churn           | 564               | 3191             | 431               | 743              |
| Tree7         | Maximal Tree         | VALIDATE     | Churn            | Churn           | 254               | 1389             | 163               | 308              |
| Tree6         | DT (CHAID)           | TRAIN        | Churn            | Churn           | 560               | 3175             | 447               | 747              |
| Tree6         | DT (CHAID)           | VALIDATE     | Churn            | Churn           | 258               | 1363             | 189               | 304              |
| Tree8         | Probability Tree     | TRAIN        | Churn            | Churn           | 532               | 3169             | 453               | 775              |
| Tree8         | Probability Tree     | VALIDATE     | Churn            | Churn           | 255               | 1373             | 179               | 307              |

Figure 4.19 Model Selection

Table 4.19 Confusion Matrix DT (CART)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 335          | 227          | 562   |
|                  | Negative (0) | 184          | 1368         | 1552  |

Table 4.20 Confusion Matrix DT (ENTROPY)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 304          | 258          | 562   |
|                  | Negative (0) | 153          | 1399         | 1552  |

Table 4.21 Confusion Matrix DT (GINI)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 318          | 244          | 562   |
|                  | Negative (0) | 164          | 1388         | 1552  |

Table 4.22 Confusion Matrix DT (LOGWORTH)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 308          | 254          | 562   |
|                  | Negative (0) | 163          | 1389         | 1552  |

Table 4.23 Confusion Matrix Maximal Tree

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 308          | 254          | 562   |
|                  | Negative (0) | 163          | 1389         | 1552  |

Table 4.24 Confusion Matrix DT (CHAID)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 304          | 258          | 562   |
|                  | Negative (0) | 189          | 1363         | 1552  |

Table 4.25 Confusion Matrix Probability Tree

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 307          | 255          | 562   |
|                  | Negative (0) | 179          | 1373         | 1552  |

Table 4.26 Sensitivity, Specificity and Accuracy

|             | DT<br>(CART) | DT<br>(ENTROPY) | DT<br>(GINI) | DT<br>(LOGWORTH) | Maximal<br>Tree | DT<br>(CHAID) | Probability<br>Tree |
|-------------|--------------|-----------------|--------------|------------------|-----------------|---------------|---------------------|
| Sensitivity | 0.5961       | 0.5409          | 0.5658       | 0.5480           | 0.5480          | 0.5409        | 0.5463              |
| Specificity | 0.8814       | 0.9014          | 0.8943       | 0.8950           | 0.8950          | 0.8782        | 0.8847              |
| Accuracy    | 0.8056       | 0.8056          | 0.8070       | 0.8027           | 0.8027          | 0.7886        | 0.7947              |

DT (CART) model is better in predicting positive target because the sensitivity value is highest while DT (ENTROPY) model is better in predicting negative target since the specificity value is higher compared to other model.

#### 4.3.10 Model Scoring

- Observation 231

| No | Variable         | Details |
|----|------------------|---------|
| 1  | gender           | 1       |
| 2  | SeniorCitizen    | 0       |
| 3  | Partner          | 1       |
| 4  | Dependents       | 0       |
| 5  | tenure           | 54      |
| 6  | PhoneService     | 1       |
| 7  | MultipleLines    | 2       |
| 8  | InternetService  | 1       |
| 9  | OnlineSecurity   | 1       |
| 10 | OnlineBackup     | 0       |
| 11 | DeviceProtection | 0       |
| 12 | TechSupport      | 1       |

|    |                  |         |
|----|------------------|---------|
| 13 | StreamingTV      | 1       |
| 14 | StreamingMovies  | 1       |
| 15 | Contract         | 2       |
| 16 | PaperlessBilling | 0       |
| 17 | PaymentMethod    | 3       |
| 18 | MonthlyCharges   | 108     |
| 19 | TotalCharges     | 5760.65 |
| 20 | Churn            | 0       |

Table 4.27 Observation 231

\*-----\*

Node = 25

\*-----\*

if OnlineSecurity IS ONE OF: NO  
AND MonthlyCharges < 93.675 or MISSING  
AND Contract IS ONE OF: ONE YEAR  
then

Tree Node Identifier = 25

Number of Observations = 231

Predicted: Churn = Yes = 0.14

Predicted: Churn = No = 0.86

From the above node, it shows that the predicted Churn is 0.

- Observation 7

| No | Variable        | Details |
|----|-----------------|---------|
| 1  | gender          | 1       |
| 2  | SeniorCitizen   | 0       |
| 3  | Partner         | 1       |
| 4  | Dependents      | 1       |
| 5  | tenure          | 22      |
| 6  | PhoneService    | 1       |
| 7  | MultipleLines   | 2       |
| 8  | InternetService | 1       |

|    |                  |        |
|----|------------------|--------|
| 9  | OnlineSecurity   | 0      |
| 10 | OnlineBackup     | 0      |
| 11 | DeviceProtection | 0      |
| 12 | TechSupport      | 0      |
| 13 | StreamingTV      | 1      |
| 14 | StreamingMovies  | 0      |
| 15 | Contract         | 0      |
| 16 | PaperlessBilling | 0      |
| 17 | PaymentMethod    | 3      |
| 18 | MonthlyCharges   | 89.1   |
| 19 | TotalCharges     | 1949.4 |
| 20 | Churn            | 0      |

Table 4.28 Observation 7

\*-----\*

Node = 30

\*-----\*

if tenure < 1.5

AND TechSupport IS ONE OF: YES

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 30

Number of Observations = 7

Predicted: Churn = Yes = 0.43

Predicted: Churn = No = 0.57

From the above node, it shows that the predicted Churn is 0.

- Observation 164

| No | Variable         | Details |
|----|------------------|---------|
| 1  | gender           | 1       |
| 2  | SeniorCitizen    | 0       |
| 3  | Partner          | 1       |
| 4  | Dependents       | 0       |
| 5  | tenure           | 53      |
| 6  | PhoneService     | 1       |
| 7  | MultipleLines    | 2       |
| 8  | InternetService  | 0       |
| 9  | OnlineSecurity   | 0       |
| 10 | OnlineBackup     | 0       |
| 11 | DeviceProtection | 1       |
| 12 | TechSupport      | 1       |
| 13 | StreamingTV      | 0       |
| 14 | StreamingMovies  | 1       |
| 15 | Contract         | 2       |
| 16 | PaperlessBilling | 0       |
| 17 | PaymentMethod    | 2       |
| 18 | MonthlyCharges   | 73.9    |
| 19 | TotalCharges     | 3958.25 |
| 20 | Churn            | 0       |

Table 4.29 Observation 164

\*-----\*

Node = 31

\*-----\*

if tenure < 1.5

AND TechSupport IS ONE OF: NO or MISSING

AND InternetService IS ONE OF: FIBER OPTIC or MISSING

AND Contract IS ONE OF: MONTH-TO-MONTH or MISSING

then

Tree Node Identifier = 31

Number of Observations = 164

Predicted: Churn = Yes = 0.87

Predicted: Churn = No = 0.13

From the above node, it shows that the predicted Churn is 1.

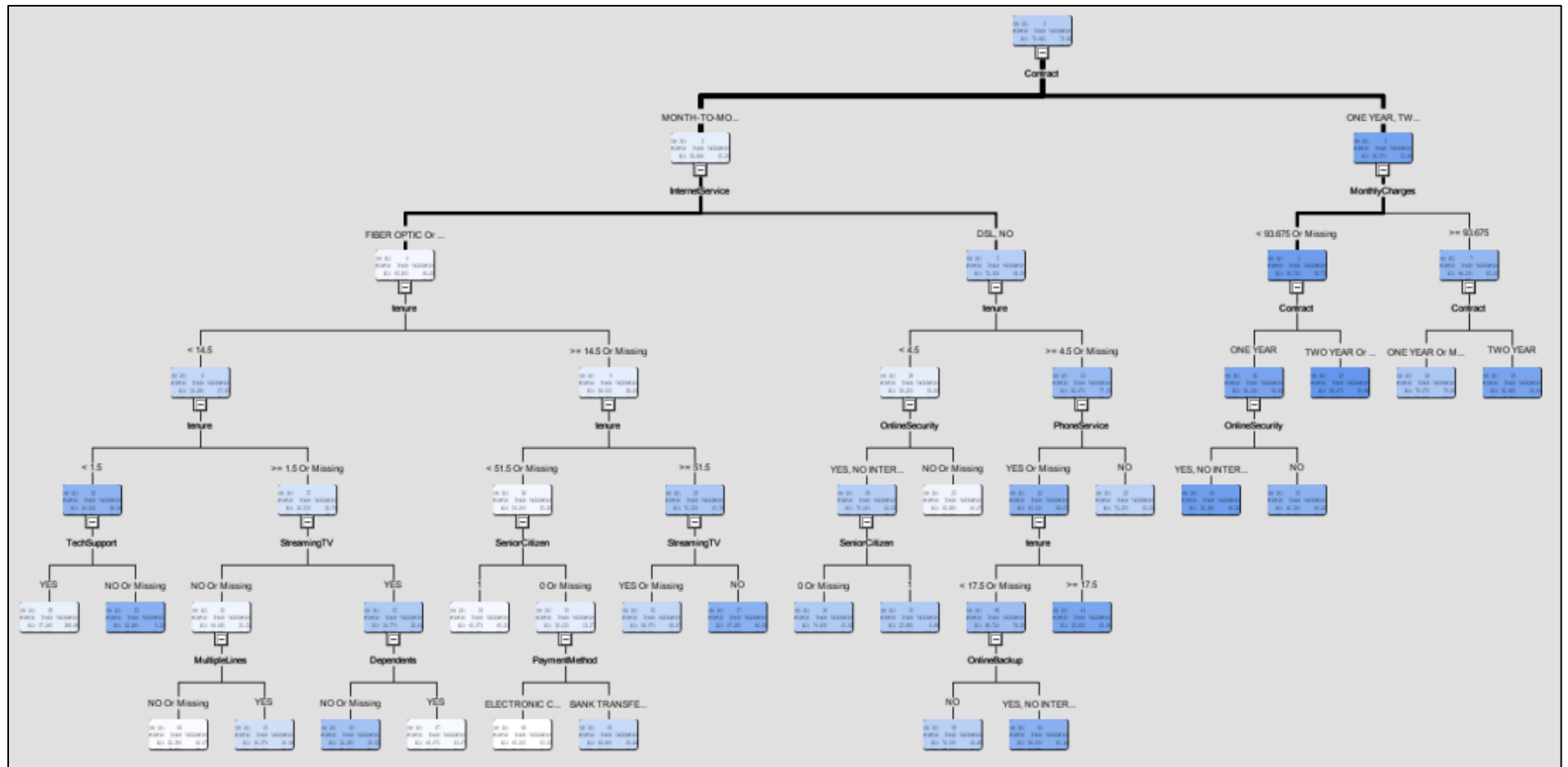


Figure 4.20 Decision Tree

There are 23 English rules with 7044 observations. From this output, we also can identify the most important input in the decision tree. Next, the number of rules to predict  $Y = 0$  also can be determine. Lastly, the number of splitting rules can be found.

## 4.4 ARTIFICIAL NEURAL NETWORK ANALYSIS

### 4.4.1 Model Comparison

There are different types of neural network (NN) model can be created (NN2, NN4, NN6, NN 8). The same process of creating predictive model with neural network node had done by rename each node with different types of NN by changing the number of layers allowable for each model. By using the guideline that we had stated before, we get this following table as the result,

Table 4.30 Model Comparison for each neural network model

| MODEL          | TRAIN ASE | VALID ASE | GAP ASE | TRAIN MR | VALID MR | GAP MR  | TRAIN ROC | VALID ROC | GAP ROC |
|----------------|-----------|-----------|---------|----------|----------|---------|-----------|-----------|---------|
| ANN(8 LAYERS)  | 0.1312    | 0.1302    | -0.0009 | 0.1905   | 0.1883   | -0.0022 | 0.854     | 0.859     | 0.005   |
| ANN(11 LAYERS) | 0.1307    | 0.1308    | 0.0002  | 0.1893   | 0.1883   | -0.0010 | 0.855     | 0.855     | 0       |
| ANN(3 LAYERS)  | 0.1309    | 0.1314    | 0.0005  | 0.1929   | 0.1892   | -0.0037 | 0.855     | 0.856     | 0.001   |
| ANN(5 LAYERS)  | 0.1317    | 0.1305    | -0.001  | 0.1931   | 0.1897   | -0.0035 | 0.853     | 0.857     | 0.004   |

|                |                                   |
|----------------|-----------------------------------|
| UNDERFIT MODEL | ANN (8 layers) and ANN (5 layers) |
| OVERFIT MODEL  | ANN (3 layers)                    |
| BEST MODEL     | ANN (11 layers)                   |

Since ANN(3 layers) has the largest gap compare to others, therefore, the overfit model is ANN(3 layers). While for underfit, choose the model with positive value gap for ROC and negative value gap for ASE and MR. ANN(8 layers) and ANN(5 layers) is underfit model in Artificial Neural Network. Lastly, since ANN(3 layers), ANN(8 layers) and ANN(5 layers) had been chosen, we need to remove it when to select the best model of neural network model. By looking at the value of validation set, ANN(11 layers) has the lowest value of validation in misclassification rate and average squared error. It also has the largest value of validation of ROC Index. So, we can conclude that the best model for neural network is ANN(11 layers).

#### 4.4.2 Comparison of ROC Chart

The information below shows the best model of Artificial Neural Network between ANN(8 layers), ANN(11 layers), ANN(3 layers), ANN(5 layers).

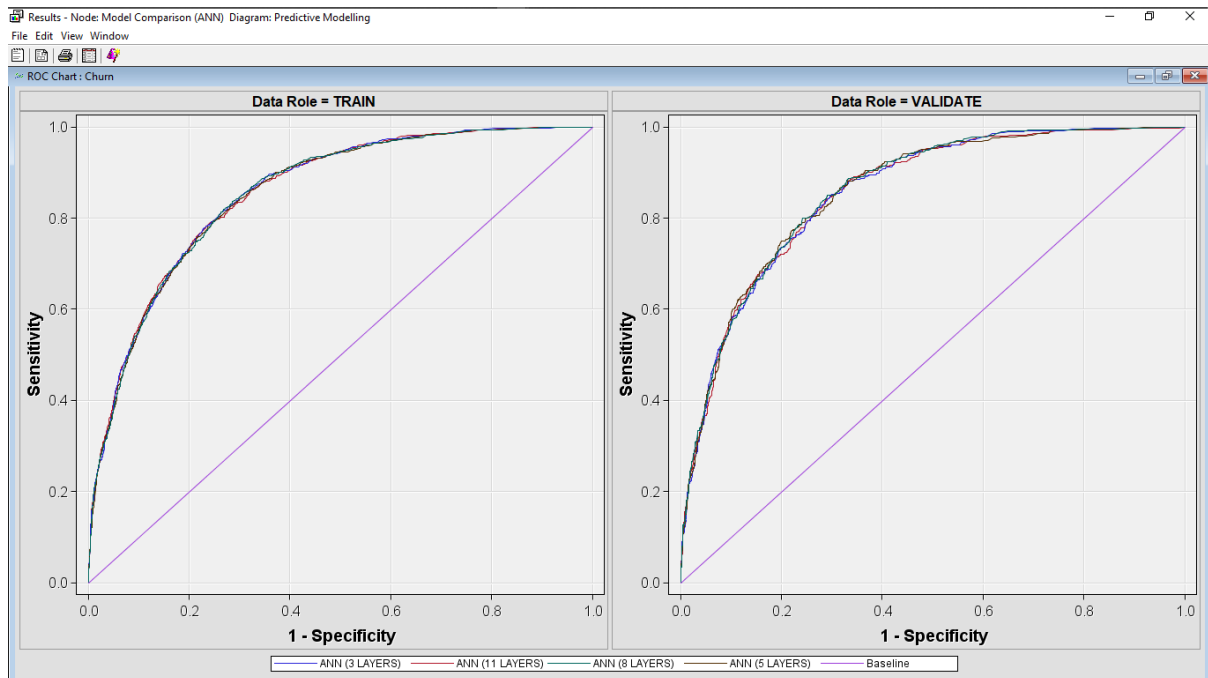


Figure 4.21 Roc chart of best model for Artificial Neural Network

In ROC, when the graph is closer to the asterisk mark, it indicates that the model has high performance. In this graph, ANN (3 layers) indicates the highest performance since it is the most part far apart model from the baseline and thus has the highest sensitivity.

#### 4.4.3 Comparison of Lift and Cumulative Chart

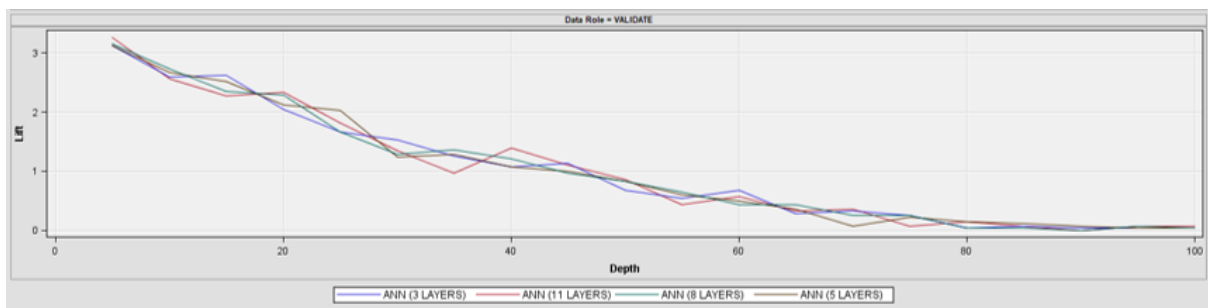


Figure 4.22 Lift Chart

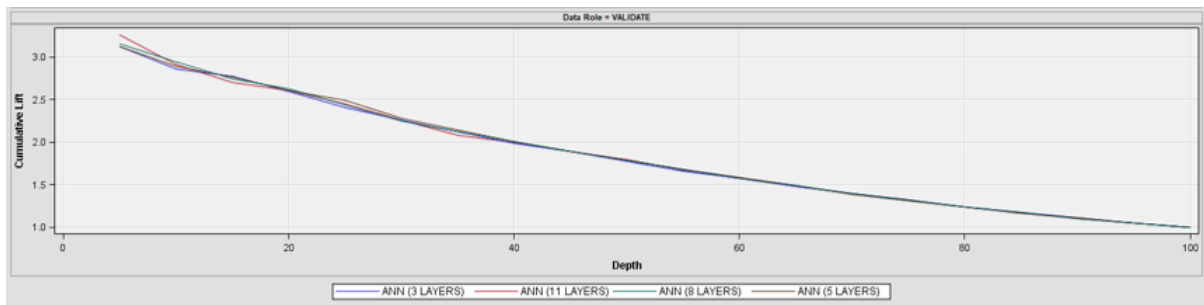


Figure 4.23 Cumulative Chart

Lift Chart graphically represents the improvement that a mining model provides when compared against a random guess and measures the change in terms of a lift score. Cumulative gains and lift charts are visual aids for measuring model performance. Both charts consist of a lift curve and a baseline. The greater the area between the lift curve and the baseline, the better the model. In this graph, ANN(11 layers) indicate the best model.

#### 4.4.4 Model Selection

Event Classification Table

Model Selection based on Valid: Misclassification Rate (\_VMISC\_)

| Model Node | Model Description | Data Role | Target | Target Label | False Negative | True Negative | False Positive | True Positive |
|------------|-------------------|-----------|--------|--------------|----------------|---------------|----------------|---------------|
| Neural14   | ANN (11 LAYERS)   | TRAIN     | Churn  | Churn        | 591            | 3280          | 342            | 716           |
| Neural14   | ANN (11 LAYERS)   | VALIDATE  | Churn  | Churn        | 266            | 1420          | 132            | 296           |
| Neural13   | ANN (8 LAYERS)    | TRAIN     | Churn  | Churn        | 623            | 3306          | 316            | 684           |
| Neural13   | ANN (8 LAYERS)    | VALIDATE  | Churn  | Churn        | 273            | 1427          | 125            | 289           |
| Neural12   | ANN (5 LAYERS)    | TRAIN     | Churn  | Churn        | 611            | 3281          | 341            | 696           |
| Neural12   | ANN (5 LAYERS)    | VALIDATE  | Churn  | Churn        | 269            | 1420          | 132            | 293           |
| Neural15   | ANN (3 LAYERS)    | TRAIN     | Churn  | Churn        | 592            | 3263          | 359            | 715           |
| Neural15   | ANN (3 LAYERS)    | VALIDATE  | Churn  | Churn        | 259            | 1411          | 141            | 303           |

Figure 4.24 Model Selection

Table 4.31 Confusion Matrix ANN (8 LAYERS)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 289          | 273          | 562   |
|                  | Negative (0) | 125          | 1427         | 1552  |

Table 4.32 Confusion Matrix ANN (11 LAYERS)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 296          | 266          | 562   |
|                  | Negative (0) | 132          | 1420         | 1552  |

Table 4.33 Confusion Matrix ANN (3 LAYERS)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 303          | 259          | 562   |
|                  | Negative (0) | 141          | 1411         | 1552  |

Table 4.34 Confusion Matrix ANN (5 LAYERS)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 293          | 269          | 562   |
|                  | Negative (0) | 132          | 1420         | 1552  |

Table 4.35 Sensitivity, Specificity, Accuracy and Misclassification

| MODEL          | SENSITIVITY | SPECIFICITY | ACCURACY | MISSCLASSIFICATION |
|----------------|-------------|-------------|----------|--------------------|
| ANN(8 LAYERS)  | 0.6981      | 0.8394      | 0.8117   | 0.1883             |
| ANN(11 LAYERS) | 0.6916      | 0.8422      | 0.8117   | 0.1883             |
| ANN(3 LAYERS)  | 0.6824      | 0.8449      | 0.8108   | 0.1892             |
| ANN(5 LAYERS)  | 0.6894      | 0.8407      | 0.8103   | 0.1897             |

Based on the table above, ANN(5 layers) model has the worst overall performance with value accuracy 0.8103. ANN(8 layers) and ANN(11 layers) model has the same overall performance also the highest performance with value of accuracy 0.8117. From this table also, it can be concluded that the overall performance of these models has small differences.

#### 4.4.5 Iteration



Figure 4.25 Graph Iteration Plot

Based on the graph above, the iteration is at point 100 which is the last training iteration and the valid line will start increasing.

#### 4.4.6 Topology Network

INPUT NODES

OUTPUT NODES

HIDDEN NODES

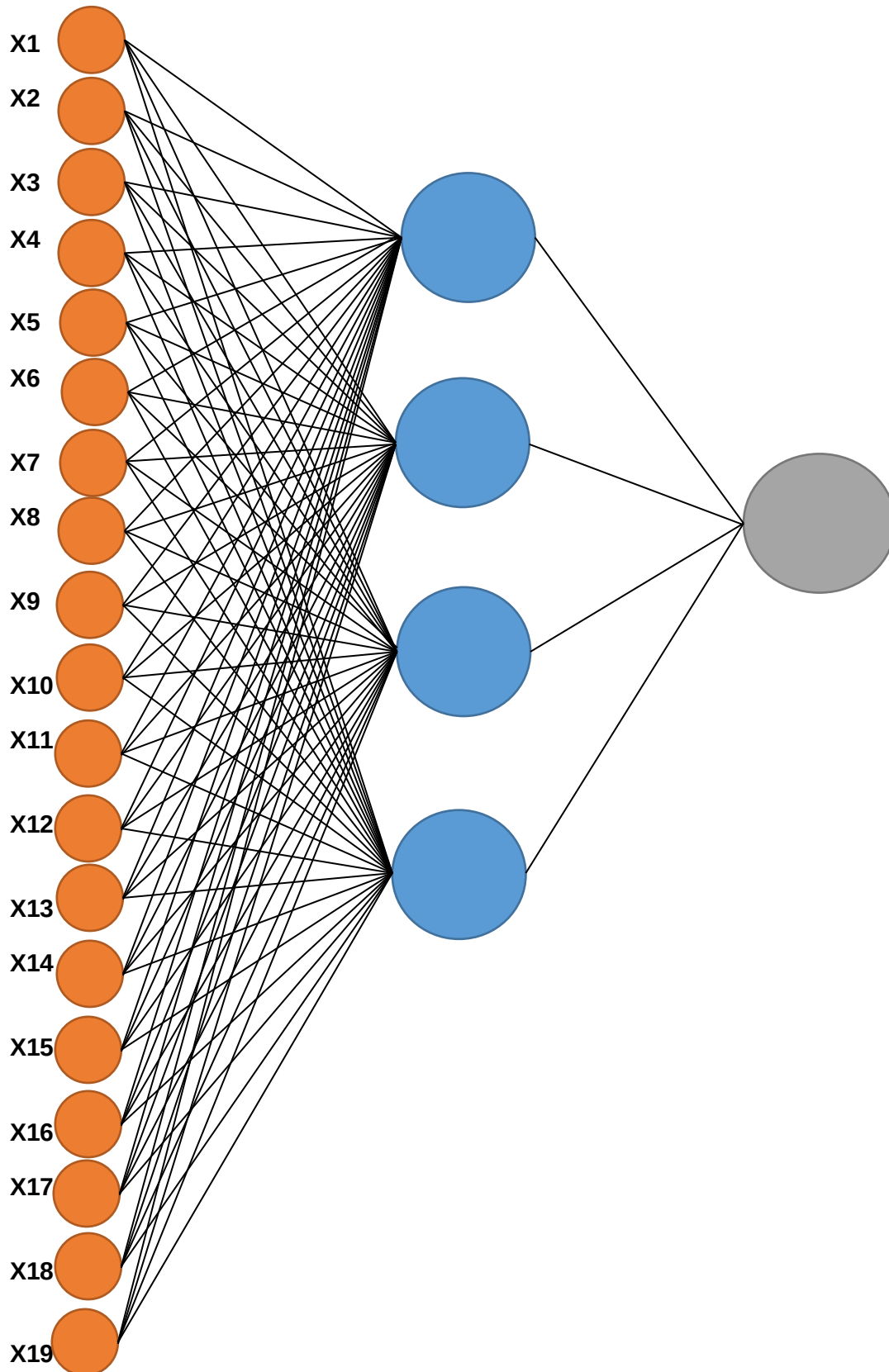


Figure 4.26 Topology Network

## CHAPTER 5

### CONCLUSION

Comparing the best among the best. Here, another Model Comparison Node needs to be created to compare the best among the best model from each predictive model. The best model from Decision Tree, the best model from Logistic Regression and the best model from Neural Network were again compared by using model comparison criteria. From the previous chapter, we get there is no best model for Logistic Regression, so we compare another model which is Decision Tree and Artificial Neural Network only. So, we get ANN (11 LAYERS) and Probability Tree as the best model for each predictive modelling. By using the guideline that we had stated before, we get this following table as the result;

Table 5.1 Model Evaluation and Comparison for each best predictive model

| MODEL DESCRIPTION | VALID: AVERAGE SQUARED ERROR | TRAIN: AVERAGE SQUARED ERROR | VALID: MISCLASSIFICATION RATE | TRAIN: MISCLASSIFICATION RATE | VALID: ROC INDEX | TRAIN: ROC INDEX |
|-------------------|------------------------------|------------------------------|-------------------------------|-------------------------------|------------------|------------------|
| ANN (11 LAYERS)   | 0.1308                       | 0.1307                       | 0.1883                        | 0.1893                        | 0.8550           | 0.8550           |
| PROBABILITY TREE  | 0.1340                       | 0.1335                       | 0.2053                        | 0.1998                        | 0.8490           | 0.8460           |

Table 5.2 Gap Of Model Comparison

| MODEL DESCRIPTION | AVERAGE SQUARED ERROR | MISCLASSIFICATION RATE | ROC INDEX |
|-------------------|-----------------------|------------------------|-----------|
| ANN (11 LAYERS)   | 0.0002                | -0.0010                | 0.0000    |
| PROBABILITY TREE  | 0.0004                | 0.0055                 | 0.0030    |

|                |                  |
|----------------|------------------|
| UNDERFIT MODEL | NONE             |
| OVERFIT MODEL  | PROBABILITY TREE |
| BEST MODEL     | ANN (11 layers)  |

Since PROBABILITY TREE has the largest gap compare to others, therefore, the overfit model PROBABILITY TREE. While for underfit, there is no model that has

smaller value of error in validation set than training set. It makes the underfit model is NONE. Lastly, since PROBABILITY TREE had been chosen, we need to remove it when to select the best model for the best of predictive model. By looking at the value of validation set, ANN (11 layers) has the lowest value of validation in misclassification rate and average squared error. It also has the largest value of validation of ROC Index. So, we can conclude that the best model for the best of predictive model is ANN (11 layers).

## 5.1 Comparison of Confusion Matrix

### MODEL SELECTION

Table 5.3 Model Selection Best Model

| Event Classification Table                                       |                   |           |               |       |                |               |                |               |
|------------------------------------------------------------------|-------------------|-----------|---------------|-------|----------------|---------------|----------------|---------------|
| Model Selection based on Valid: Misclassification Rate (_VMISC_) |                   |           |               |       |                |               |                |               |
| Model Node                                                       | Model Description | Data Role | Target Target | Label | False Negative | True Negative | False Positive | True Positive |
| Tree8                                                            | Probability Tree  | TRAIN     | Churn         | Churn | 532            | 3169          | 453            | 775           |
| Tree8                                                            | Probability Tree  | VALIDATE  | Churn         | Churn | 255            | 1373          | 179            | 307           |
| Neural4                                                          | ANN (11 LAYERS)   | TRAIN     | Churn         | Churn | 591            | 3280          | 342            | 716           |
| Neural4                                                          | ANN (11 LAYERS)   | VALIDATE  | Churn         | Churn | 266            | 1420          | 132            | 296           |

Table 5.4 Confusion Matrix ANN (5 LAYERS)

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 296          | 266          | 562   |
|                  | Negative (0) | 132          | 1420         | 1552  |

Table 5.5 Confusion Matrix PROBABILITY TREE

| Confusion Matrix |              | Predicted    |              | Total |
|------------------|--------------|--------------|--------------|-------|
|                  |              | Positive (1) | Negative (0) |       |
| Actual           | Positive (1) | 307          | 255          | 562   |
|                  | Negative (0) | 179          | 1373         | 1552  |

Table 5.6 Sensitivity, Specificity, Accuracy and Misclassification

| MODEL            | SENSITIVITY | SPECIFICITY | ACCURACY |
|------------------|-------------|-------------|----------|
| ANN (11 LAYERS)  | 0.5267      | 0.9149      | 0.8117   |
| PROBABILITY TREE | 0.5463      | 0.8847      | 0.7947   |

Model Probability Tree is chosen since the value of the sensitivity is higher compared to Model ANN (11 LAYERS) while Model ANN (11 LAYERS) is chosen since the value of specificity and accuracy is higher compared to Model Probability Tree. Therefore, the greatest overall performance in Model ANN (11 LAYERS).

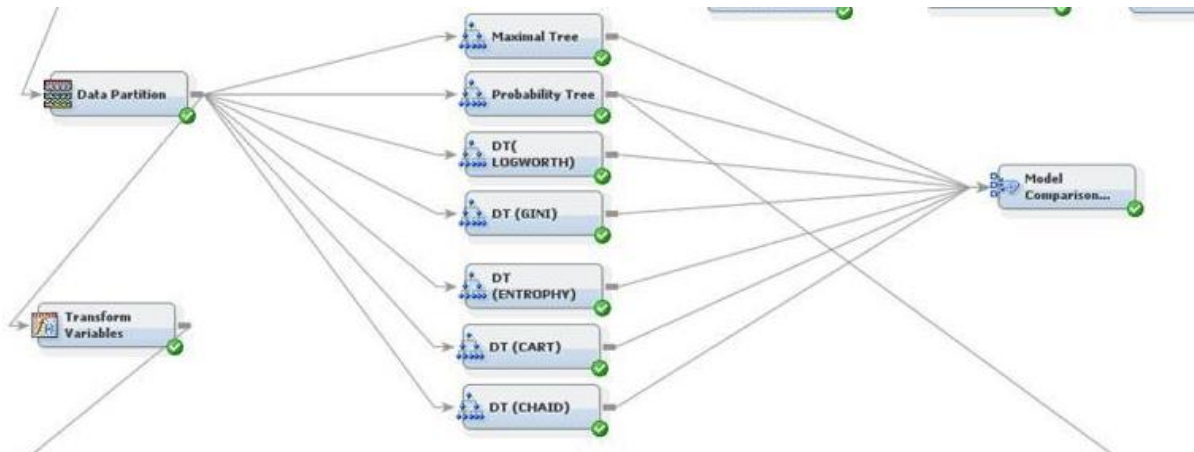
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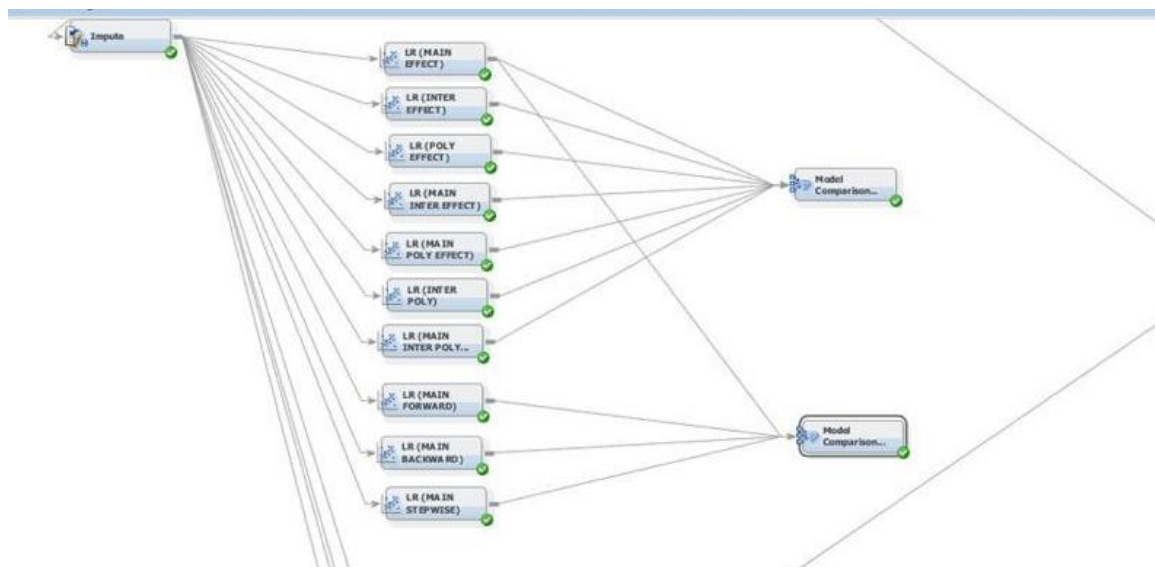
## APPENDIX

Output from SAS Enterprise Miner 14.1

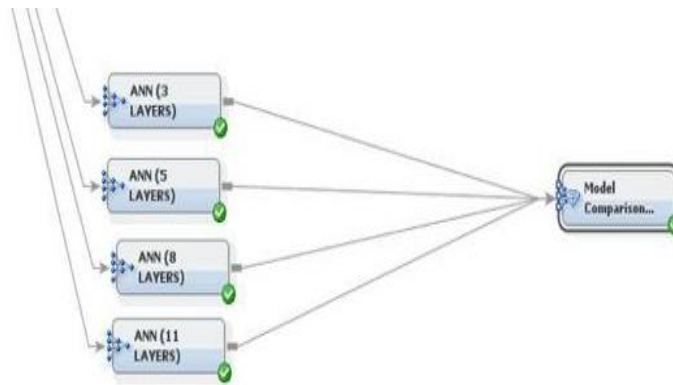
### Decision Tree



### Logistics Regression



## Artificial Neural Network



## Model Evaluation and Comparison

