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Renewal Propensity Modelling in Health Insurance

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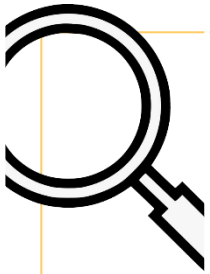
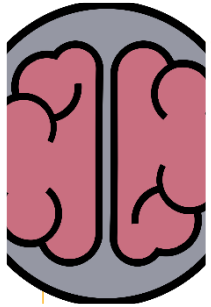
Problem Statement

Low customer persistency in health insurance poses a major challenge in building a sustainable portfolio in the long run



Identify segment of customers who are less/more likely to renew, prior to their renewal period



Understand the mindset of non-renewing & renewing customers to provide better service

Method 1

This can be done using basic statistical tools. E.g., one-way/ two-way

Method 2

However, there are multiple parameters, hence a multivariate analysis is better. E.g., GLM/ ML modelling

Brushing up some ML Concepts

Supervised v/s Un-supervised

- **Supervised learning** has labelled data. i.e. There are (X) inputs and (Y) output.
- Goal is to predict Y basis the X variables – learn the function Y = f(X)
- **Unsupervised learning** has un-labelled data. i.e. There is no output (Y) variable.
- Goal is to detect the underlying pattern and structure of the data

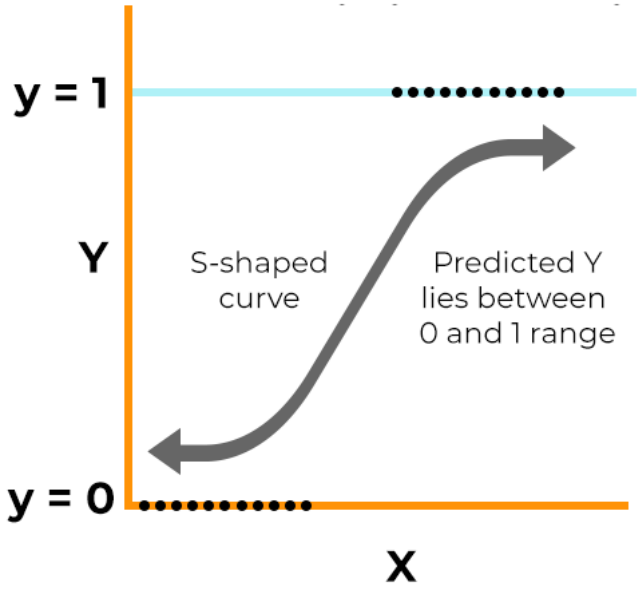
Classification v/s Regression

- **Regression algorithm** is used when our target variable (Y) is continuous in nature. E.g., Age, Salary etc.
- **Classification algorithm** is used when our target variable (Y) is categorical in nature. E.g., Gender, Fraud (Y/N), Renewed/Non-Renewed. Classification can be:
  - Binary: Classification task with two possible outcomes
  - Multinominal: Classification with more than two classes

Commonly used Algorithms

- Unsupervised:
  - K-means, K-mode, Hierarchical Clustering etc.
- Supervised:
  - GLM (logistic regression), SVM, KNN, Decision Tree – Random Forest, XG-Boost etc.

Classification using Logistic Regression



- Logistic Regression uses sigmoid function (S shaped curve) to convert the predicted output (Y) into a probability (between 0 and 1)

$$Y = \frac{1}{1 + e^{-(\beta_0 + \beta_1 X)}}$$

- Coefficients of logistic regression are **Log of Odd Ratios**

Few Data assumptions while using Logistic regression

Linearity: Predictor should be linear with the link-function of Y

No Perfect Multicollinearity: No X variables should be perfectly correlated to each other

Independence: Observations should be independent of each other. i.e., residuals should not be correlated

Advantages

- Simple and interpretable
- Efficient - Fast
- Can handle multiple classes

Disadvantages

- Requires large data set
- Outlier sensitive
- Cannot handle non-linear data

Data Creation and EDA

Step 1: Data Preparation:

- **Target variable** – Renewal Flag
- **Predictors:**
  - Policy details, Customer Demography, Distribution
  - Service-related information
  - Claim experience
  - External data – Credit Rating etc.

	Target (Y)	Predictors (X)		
Policy	**Renewal**	**Age**	**Gender**	**…**
a1	Y	35	M	..
a1	Y	17	M	..
b1	N	22	M	..
b2	Y	56	F	..

Main Dimensions to capture:
1) Affordability of customer 2) Willingness & Interest of customer

Data Cleaning and Data massaging:
Includes outlier detection and removal, missing value treatment

. **Step 2: EDA and Feature Engineering:**

Exploratory Data Analysis (EDA) is the process of analysis and visualizing the dataset to understand:

- Any underlying trends, seasonality
- Relationship and pattern among the predictor variables (X)
- Relationship and pattern among the target (Y) and predictor (X)
- Outlier and anomalies

Tools used for EDA include:

- Correlation matrix/ Correlation Plot
- One-way/ Two-way tables.
- Histogram & line charts

Feature Engineering and Segmentation

Step 2: Feature Engineering:

Feature Engineering: process of transforming raw data into features that better represent the underlying problem to the predictive models, resulting in improved model performance on unseen data

Example:

1) Portability and Policy Year
2) Customer Touchpoints
3) Riders attached with the base policy

Segmentation

Data may show materially different renewal behavior for:

1) Different Products – E.g., HNI v/s Basic Product
2) Different Regions – E.g., Tier 1 v/s Tier 2 City
3) Different time periods. – Covid v/s Post Covid

Solution:

1) Separate Models
2) Segment as a flag

Proper EDA and Feature Engineering will ensure that data created is in line with business intuition and understanding.

Model Development

Step 3: Model Development:

Once the data is ready, following model steps are used:

- Divide dataset into **training data (70%)** and **test data (30%)** in a statistically random manner
- Running the model and analyzing the output –
  - Variable coefficients
  - Variable importance (p-value)
  - Model KPI : Confusion Matrix and its derivatives like accuracy, specificity, sensitivity etc.

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- The model provides its output (Y-pred) in terms of a probability – **propensity score**

- This score is converted into a class label, governed by a parameter known as the decision **threshold** - 0.5 is the default for normalized predicted probabilities
- For our case if output >= 0.5 = Class 1 (Renew), output < 0.5 = Class 0 (Non-Renew)

*Confusion Matrix**		**Predicted**	
		Renewed	**Non-Renewed**
Actual	**Renewed**	**TP**	**FN**
	Non-Renewed	**FP**	**TN**

Vetting the actual and predicted output we get multiple **KPI** like:
Accuracy: (TP+TN) /(TP+TN+FP+FN)
Sensitivity: TP/(TP+FN)
Specificity: TN/(TN+FP)

***Note : TP : True Positive, TN : True Negative, FP : False Positive, FN : False Negative**

Inference & validation

Step 4: Model tweaking and Validation:

Default threshold (0.5) may not represent an optimal interpretation, due to:

- The class imbalance in data
- The cost of one type of misclassification is more than another type of misclassification

Optimal Cut-off can be selected using the following methods:

- **ROC (Receiver Operating Characteristics)**
  - ROC helps to find the optimal cut-off that maximizes TPR and minimizes FPR*
- **Decile / Percentile**
  - Ranking the propensity scores, we can get the top/ bottom x percentile of customers basis their propensity of renewal

Out of Sample Validation:

When the model is ready, the final step is to run the model on a out of sample data-set (usually 3-6 months) to ensure:

- Model output is stable over time
- Model output is in lines with expectations

Step 5: Model Maintenance:

Once deployed, model needs to be retuned, refreshed on a periodic basis to:

- Increase the available data points (More the data the better)
- Capture any recent renewal pattern and trends

***Note : TPR – True Positive Rate = TP / (TP + FN) | FPR – False Positive Rate = FP / (FP + TN)**

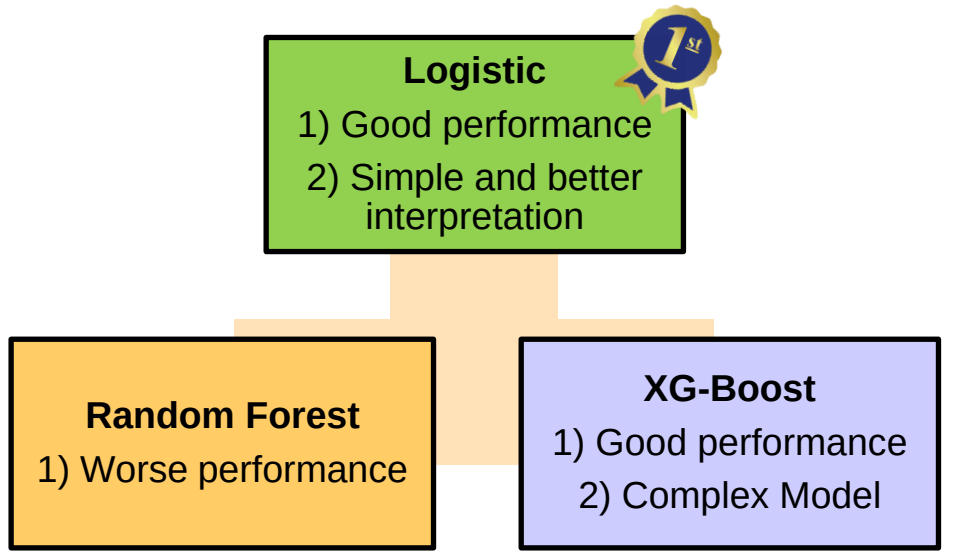
Choosing Best Model - Why Logistic?

During development of the renewal model, multiple algorithm needs to be tested. For our case, the following were tested:

1) **Logistic Regression**
2) **Tree Based Model**
   I. **Random Forest**
   II. **XG-Boosting Model**

Things to keep in mind while selecting models:

1. **Final Model Performance** – Accuracy, TPR, FPR, AUC-ROC etc.
2. **Target variable balance** – Tree models are better with class imbalance
3. **Overfitting, Underfitting**
4. **Model simplicity** – Ease of interpretation



Hence, Logistic Regression is chosen for our use case

Predicting Renewal – Action Items

Once the model is ready and deployed, it can be used (scored) on set of customers who are **due for renewal.**

Green customer

- Customers with high propensity score- Highly likely to renew

Amber customer

- Customer with average propensity score- Slightly less likely to renew.

Red customer

- Customer with low propensity score- Least likely to renew/ high lapse rate

Basis the optimal cut-off chosen, the output for the customers can be split into 2 or more sections to segment the customers according to their renewal behavior

Use Case:

1) **Increase renewal rate by designing retention strategy for the Red Customers**
2) **Optimize Operational Cost for each segments**

Key Take-away

Success of the model depends on:

- The variety of data available (data depth)
- The usability of the available data
- Robust model maintenance to capture new patterns

- ML Models are trained on existing renewal patterns
- Patterns may vary for separate cohorts. Hence data engineering and segmentation may be necessary

Predictive quality depends more on data than on algorithm

- There is no single BEST algorithm
- Selection of model varies case by case basis.

Model Output can be used to

- Improve Retention rate
- Improve operational efficiency