Tackling Churn Rate Challenges & Customer Retention

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Churn Rate Project

1. Context and objetive of the project

Churn rate refers to the rate of customer's attrition, which means how many customers stop using a company's service within a certain period of time. The aim of this project is to understand better what characteristics or behaviours are related to the customers when they leave company's services.

Having understood this, the company is able to take into consideration new measures to improve customer retention, such as enhacing its services or personalizing offers.

2. Tools used

To develop this analysis, it has been used several different tools and libraries:

```
library(corrplot)

## Warning: package 'corrplot' was built under R version 4.3.3

## corrplot 0.92 loaded

library(ggplot2)
library(reshape2)

## Warning: package 'reshape2' was built under R version 4.3.3

library(tidyr)

##
## Attaching package: 'tidyr'

## The following object is masked from 'package:reshape2':
##
##     smiths

library(dplyr)

##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union

library(DataExplorer)
library(caret)

## Loading required package: lattice

library(randomForest)

## randomForest 4.7-1.1

## Type rfNews() to see new features/changes/bug fixes.

##
## Attaching package: 'randomForest'

## The following object is masked from 'package:dplyr':
##
##     combine

## The following object is masked from 'package:ggplot2':
##
##     margin

library(ROCR)
```

· *Readxl:* It allows to read any database from Excel. In this project, it is used to read the data from a file .xlsx

· *Corrplot:* This library is used to create correlation plots. It helps to visualize how are the variable's interactions.

· *Ggplot2 and Reshape2:* These are libraries for data visualization. ggplot2 is used to create advanced plots, while reshape2 helps reorganize data to make it easier to plot.

· *Tidyr and Dplyr:* Two powerful tools that helps so much in terms of organization and manipulation.

· *DataExplorer:* A tool that facilitates the initial exploration of the data to understand its structure and characteristics.

· *Caret:* A library of predictive modeling tools. It is used here to prepare the data and build models that can predict customer churn.

· *RandomForest:* An advanced analysis method that creates multiple "decision trees" and uses them to make predictions. It is useful for understanding complex patterns in the data.

· *ROCR:* It is used to evaluate the accuracy of predictive models, helping to determine how well the model is predicting the churn rate.

3. Analysis steps

Step 1: Data Loading and Cleaning

The project begins by loading customer data from an Excel file (BankChurners.csv). This data contains various pieces of information about each customer, such as:

```
library(readr)
BankChurners <- read_csv("G:/Datos Sandra/Descargas/BankChurners.csv")

## Rows: 10127 Columns: 23
## ── Column specification ────────────────────────────────────────────────
─────────
## Delimiter: ","
## chr  (6): Attrition_Flag, Gender, Education_Level, Marital_Status, Inc
ome_Ca...
## dbl (17): CLIENTNUM, Customer_Age, Dependent_count, Months_on_book, To
tal_Re...
##
## ℹ Use `spec()` to retrieve the full column specification for this da
ta.
## ℹ Specify the column types or set `show_col_types = FALSE` to quiet
this message.

View(BankChurners)
options(scipen=999)
BankChurners <- BankChurners %>% select(-Naive_Bayes_Classifier_Attrition
_Flag_Card_Category_Contacts_Count_12_mon_Dependent_count_Education_Level
_Months_Inactive_12_mon_1, -Naive_Bayes_Classifier_Attrition_Flag_Card_Ca
tegory_Contacts_Count_12_mon_Dependent_count_Education_Level_Months_Inact
ive_12_mon_2)
```

· Gender.

· Customer's age.

· Their marital status and education level.

· Customer's card category..

· Call duration at different times of the day (day, night, evening).

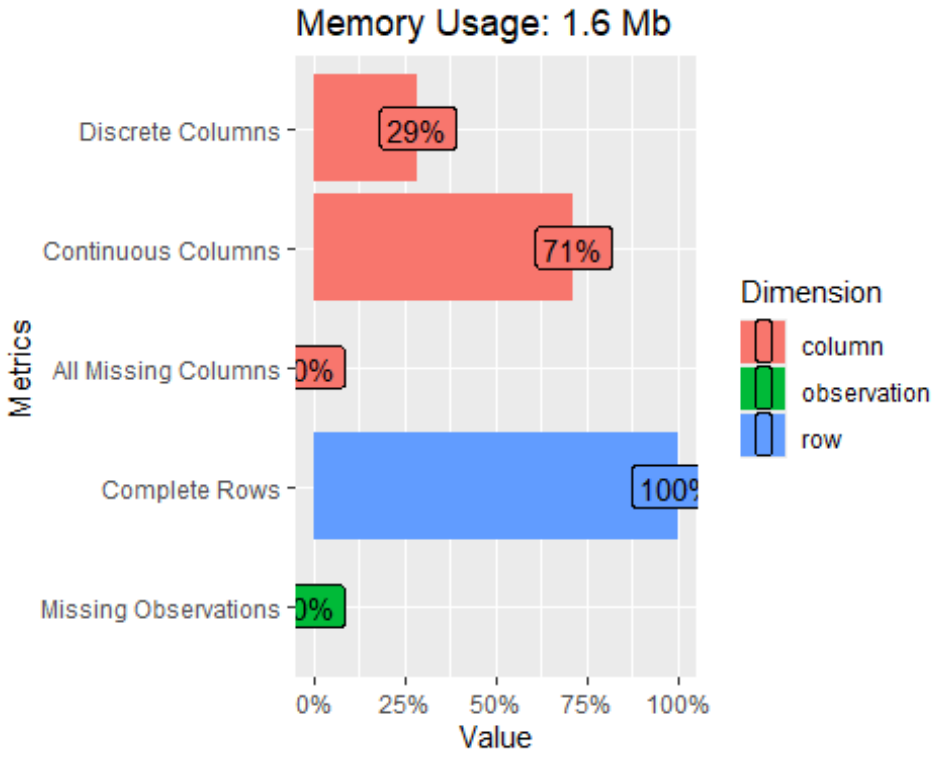
· Number of months the customer is inactive.

· Whether or not they churned (left the company).

```
summary_bc <- sapply(BankChurners[sapply(BankChurners, is.factor) | sappl
y(BankChurners, is.character)], summary)
summary_bc <- t(summary_bc)
print(summary_bc)
```

```
##                 Length  Class       Mode
## Attrition_Flag  "10127" "character" "character"
## Gender          "10127" "character" "character"
## Education_Level "10127" "character" "character"
## Marital_Status  "10127" "character" "character"
## Income_Category "10127" "character" "character"
## Card_Category   "10127" "character" "character"
```

```
plot_intro(BankChurners)
```



Here we have a brief that shows that the database hasn't got any missing value. If the database had contained a missing value, it'd have been necessary to prepare a more extensive analysis, including NA's substitution.

```
object_columns <- names(BankChurners)[sapply(BankChurners, is.factor) | s
apply(BankChurners, is.character)]
print(object_columns)
```

```
## [1] "Attrition_Flag"  "Gender"          "Education_Level" "Marital_Sta
tus"
## [5] "Income_Category" "Card_Category"
```

```r
for (col in object_columns) {
  d_type <- class(BankChurners[[col]])

  counts <- table(BankChurners[[col]])
  cat("Counts for", col, ":\n")
  print(counts)
  cat("============================================================\n")
}
```

```
## Counts for Attrition_Flag :
##
## Attrited Customer Existing Customer
##              1627              8500
## ============================================================
## Counts for Gender :
##
##    F    M
## 5358 4769
## ============================================================
## Counts for Education_Level :
##
##       College     Doctorate      Graduate   High School Post-Graduate
##          1013           451          3128          2013           516
##    Uneducated       Unknown
##          1487          1519
## ============================================================
## Counts for Marital_Status :
##
## Divorced  Married   Single  Unknown
##      748     4687     3943      749
## ============================================================
## Counts for Income_Category :
##
##        $120K +    $40K - $60K    $60K - $80K   $80K - $120K Less than
$40K
##            727           1790           1402           1535
3561
##        Unknown
##           1112
## ============================================================
## Counts for Card_Category :
##
##     Blue     Gold Platinum   Silver
##     9436      116       20      555
## ============================================================
```

```r
num_columns <- names(BankChurners)[sapply(BankChurners, is.numeric)]
print(num_columns)
```

```
##  [1] "CLIENTNUM"                "Customer_Age"
##  [3] "Dependent_count"          "Months_on_book"
```

```
##  [5] "Total_Relationship_Count" "Months_Inactive_12_mon"
##  [7] "Contacts_Count_12_mon"    "Credit_Limit"
##  [9] "Total_Revolving_Bal"      "Avg_Open_To_Buy"
## [11] "Total_Amt_Chng_Q4_Q1"     "Total_Trans_Amt"
## [13] "Total_Trans_Ct"           "Total_Ct_Chng_Q4_Q1"
## [15] "Avg_Utilization_Ratio"
```

With the next chunk, it will be demonstrated that there are no missing values.

```
missing_columns <- names(BankChurners)[sapply(BankChurners, function(x) s
um(is.na(x)) > 0)]
bc_missing_info <- BankChurners[, missing_columns]
str(bc_missing_info)
```

```
## tibble [10,127 × 0] (S3: tbl_df/tbl/data.frame)
##  Named list()
```

Here, it will be demonstrated the same but with duplicated values.

```
BankChurners <- BankChurners[!duplicated(BankChurners), ]
duplicated_rows <- duplicated(BankChurners)
print(duplicated_rows)
```

```
##     [1] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [13] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [25] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [37] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [49] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [61] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [73] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [85] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##    [97] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [109] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [121] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [133] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [145] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [157] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
```

```
##   [169] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [181] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [193] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [205] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [217] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [229] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [241] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [253] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [265] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [277] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [289] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [301] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [313] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [325] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [337] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [349] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [361] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
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LSE FALSE
##   [385] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [397] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [409] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [421] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [433] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [445] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [457] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
```

```
##   [469] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [481] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [493] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [505] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [517] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [529] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
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##   [541] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
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##   [721] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
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LSE FALSE
##   [745] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
LSE FALSE
##   [757] FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FALSE FA
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```

Step 2: Correlation Analysis

A correlation matrix is created to identify the most important variables that are tightly linked to the churn rate.

What is a correlation matrix? Imagine a table that compares all the customer characteristics against each other. Each cell in the table shows how strongly two characteristics are related. A high value may indicate that two characteristics tend to increase or decrease together. For example, if the number of months inactive and the clients who churned are highly correlated, it means when one increases, the other does as well.

Why is it important? It helps us identify which characteristics might be influencing a customer's decision to leave the company. For instance, if we find a high correlation between the number of months inactive and churn, we might infer that unresolved issues could be pushing customers to leave.

```
BankChurners$Churners <- BankChurners$Attrition_Flag == "Attrited Custome
r"

print(BankChurners)
```

```
## # A tibble: 10,127 × 22
##    CLIENTNUM Attrition_Flag  Customer_Age Gender Dependent_count Educa
tion_Level
##        <dbl> <chr>                  <dbl> <chr>            <dbl> <chr>
##  1 768805383 Existing Custo…           45 M                    3 High
School
##  2 818770008 Existing Custo…           49 F                    5 Gradu
ate
##  3 713982108 Existing Custo…           51 M                    3 Gradu
ate
##  4 769911858 Existing Custo…           40 F                    4 High
School
##  5 709106358 Existing Custo…           40 M                    3 Unedu
cated
##  6 713061558 Existing Custo…           44 M                    2 Gradu
ate
##  7 810347208 Existing Custo…           51 M                    4 Unkno
```

```
wn
##  8 818906208 Existing Custo…           32 M                    0 High
School
##  9 710930508 Existing Custo…           37 M                    3 Unedu
cated
## 10 719661558 Existing Custo…           48 M                    2 Gradu
ate
## # ⓘ 10,117 more rows
## # ⓘ 16 more variables: Marital_Status <chr>, Income_Category <chr>,
## #   Card_Category <chr>, Months_on_book <dbl>, Total_Relationship_Coun
t <dbl>,
## #   Months_Inactive_12_mon <dbl>, Contacts_Count_12_mon <dbl>,
## #   Credit_Limit <dbl>, Total_Revolving_Bal <dbl>, Avg_Open_To_Buy <db
l>,
## #   Total_Amt_Chng_Q4_Q1 <dbl>, Total_Trans_Amt <dbl>, Total_Trans_Ct
<dbl>,
## #   Total_Ct_Chng_Q4_Q1 <dbl>, Avg_Utilization_Ratio <dbl>, Churners <
lgl>
```

```
numeric_cols <- BankChurners[, c("Months_on_book", "Total_Relationship_Co
unt", "Months_Inactive_12_mon", "Contacts_Count_12_mon", "Credit_Limit","
Total_Revolving_Bal","Avg_Open_To_Buy","Total_Amt_Chng_Q4_Q1","Total_Tran
s_Amt","Total_Trans_Ct","Total_Ct_Chng_Q4_Q1","Avg_Utilization_Ratio","At
trition_Flag","Churners")]

df <- mutate_if(BankChurners, is.character, as.numeric)
```

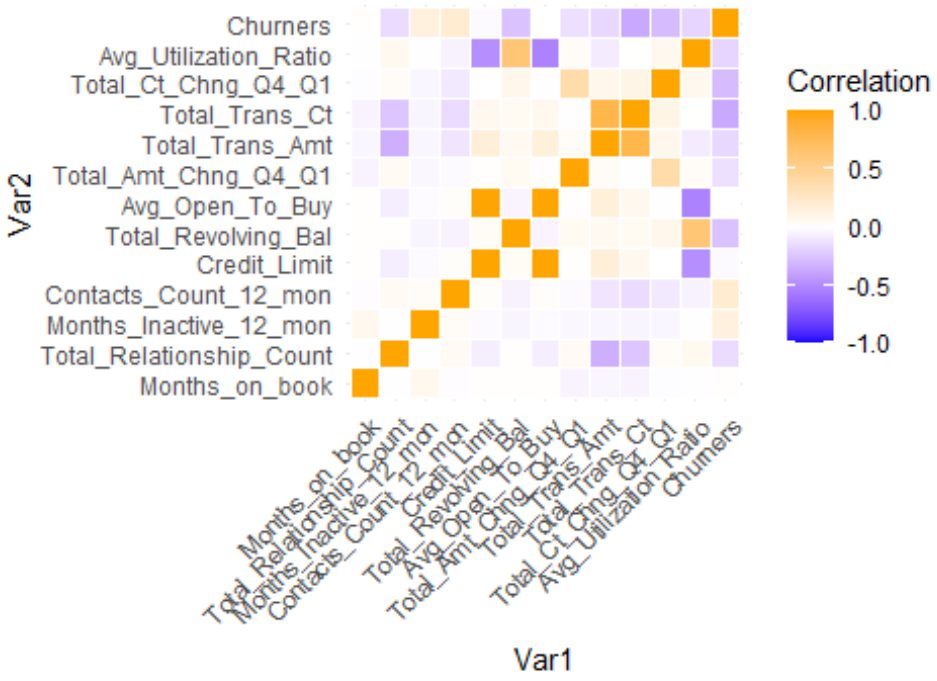
```
## Warning: There were 6 warnings in `mutate()`.
## The first warning was:
## ⓘ In argument: `Attrition_Flag = .Primitive("as.double")(Attrition_F
lag)`.
## Caused by warning:
## ! NAs introducidos por coerción
## ⓘ Run `dplyr::last_dplyr_warnings()` to see the 5 remaining warnings
.
```

```
str(df)
```

```
## tibble [10,127 × 22] (S3: tbl_df/tbl/data.frame)
##  $ CLIENTNUM               : num [1:10127] 768805383 818770008 7139821
08 769911858 709106358 ...
##  $ Attrition_Flag          : num [1:10127] NA NA NA NA NA NA NA NA NA
NA ...
##  $ Customer_Age            : num [1:10127] 45 49 51 40 40 44 51 32 37
48 ...
##  $ Gender                  : num [1:10127] NA NA NA NA NA NA NA NA NA
NA ...
##  $ Dependent_count         : num [1:10127] 3 5 3 4 3 2 4 0 3 2 ...
##  $ Education_Level         : num [1:10127] NA NA NA NA NA NA NA NA NA
NA ...
```

```
##  $ Marital_Status          : num [1:10127] NA NA NA NA NA NA NA NA NA
NA ...
##  $ Income_Category         : num [1:10127] NA NA NA NA NA NA NA NA NA
NA ...
##  $ Card_Category           : num [1:10127] NA NA NA NA NA NA NA NA NA
NA ...
##  $ Months_on_book          : num [1:10127] 39 44 36 34 21 36 46 27 36
36 ...
##  $ Total_Relationship_Count: num [1:10127] 5 6 4 3 5 3 6 2 5 6 ...
##  $ Months_Inactive_12_mon  : num [1:10127] 1 1 1 4 1 1 1 2 2 3 ...
##  $ Contacts_Count_12_mon   : num [1:10127] 3 2 0 1 0 2 3 2 0 3 ...
##  $ Credit_Limit            : num [1:10127] 12691 8256 3418 3313 4716 .
..
##  $ Total_Revolving_Bal     : num [1:10127] 777 864 0 2517 0 ...
##  $ Avg_Open_To_Buy         : num [1:10127] 11914 7392 3418 796 4716 ..
.
##  $ Total_Amt_Chng_Q4_Q1    : num [1:10127] 1.33 1.54 2.59 1.4 2.17 ...
##  $ Total_Trans_Amt         : num [1:10127] 1144 1291 1887 1171 816 ...
##  $ Total_Trans_Ct          : num [1:10127] 42 33 20 20 28 24 31 36 24
32 ...
##  $ Total_Ct_Chng_Q4_Q1     : num [1:10127] 1.62 3.71 2.33 2.33 2.5 ...
##  $ Avg_Utilization_Ratio   : num [1:10127] 0.061 0.105 0 0.76 0 0.311
0.066 0.048 0.113 0.144 ...
##  $ Churners                : logi [1:10127] FALSE FALSE FALSE FALSE FA
LSE FALSE ...
```

```
numeric_cols <- BankChurners[, c("Months_on_book", "Total_Relationship_Co
unt", "Months_Inactive_12_mon", "Contacts_Count_12_mon", "Credit_Limit","
Total_Revolving_Bal","Avg_Open_To_Buy","Total_Amt_Chng_Q4_Q1","Total_Tran
s_Amt","Total_Trans_Ct","Total_Ct_Chng_Q4_Q1","Avg_Utilization_Ratio","Ch
urners")]
correlation_matrix <- cor(numeric_cols)

correlation_df <- melt(correlation_matrix)
ggplot(correlation_df, aes(x = Var1, y = Var2, fill = value)) +
geom_tile(color = "white") +
scale_fill_gradient2(low = "blue", high = "orange", mid = "white", midpoi
nt = 0,
limit = c(-1,1), space = "Lab", name="Correlation") +
theme_minimal() +
theme(axis.text.x = element_text(angle = 45, vjust = 1, hjust=1)) +
coord_fixed()
```



It has been showed that the variables called "Contact_counts_12_mon" and "Months_Inactive_12_mon" have a high correlation with Churners, so they will be the objetive of this study.

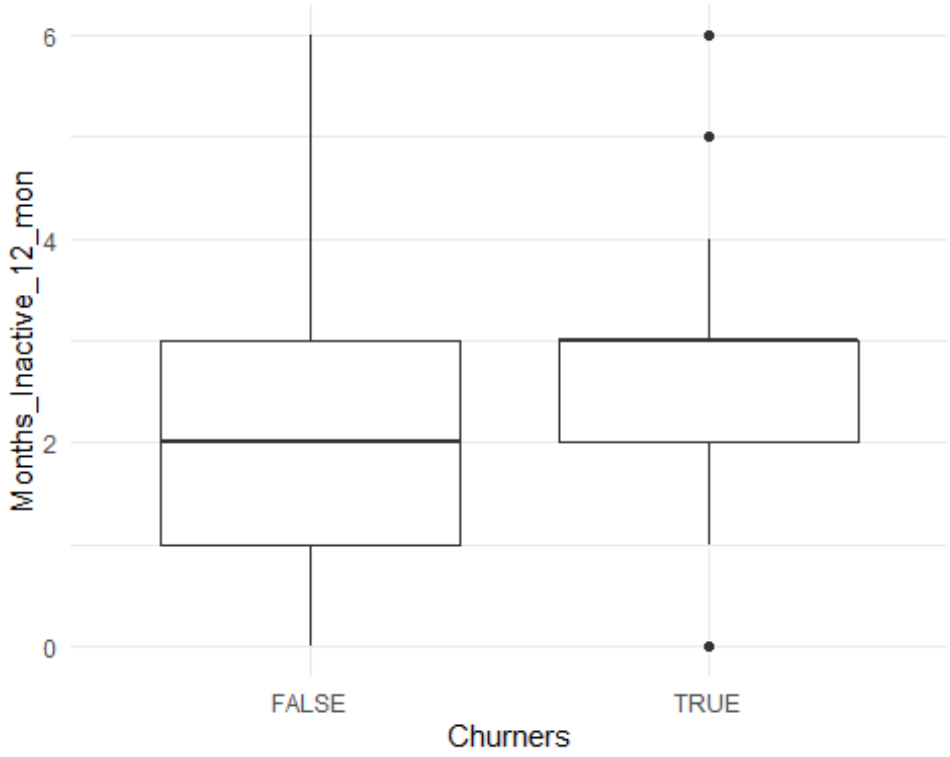
Step 3: Data Visualization

Charts are created to visualize the results of the correlation analysis.

What is visualized? The charts could show which characteristics are more related to churn. Using colors, sizes, and shapes, it becomes clear which relationships are stronger.

Why is it useful? Data visualization allows to quickly understand the results of the analysis without the need to interpret complex numbers.

```
ggplot(BankChurners, aes(x = factor(Churners), y = Months_Inactive_12_mon
)) +
  geom_boxplot() +
  labs(x = "Churners", y = "Months_Inactive_12_mon") +
  theme_minimal()
```



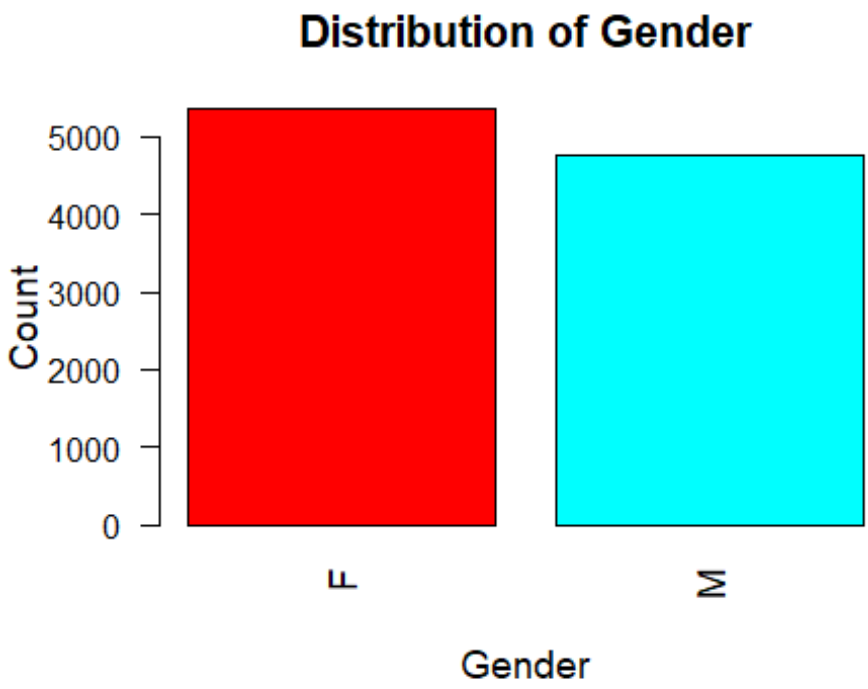

```
gr<- BankChurners %>%
     gather() %>%
     ggplot(aes(value, fill = key)) +
     geom_bar() +
     facet_wrap(~ key, scales = "free") +
     theme(
         axis.text = element_text(size = 5),
         axis.title = element_text(size = 6),
         legend.text = element_text(size = 6),
         legend.position = "bottom")
print(gr)
```


```
ggsave("BankChurners_plot.png", plot =gr, width = 12, height = 8, units =
"in", dpi = 300)
```

At this point, it may be so useful to split up the clients into churners, genders,...

```
churned <- BankChurners[BankChurners$Attrition_Flag == "Attrited Customer
", ]
non_churned <- BankChurners[BankChurners$Attrition_Flag == "Existing Cust
omer", ]

female <- BankChurners[BankChurners$Gender == "F", ]
male <- BankChurners[BankChurners$Gender == "M", ]

#We can also determine the churn rate based on gender:

churn_male <- mean(male$Churners == TRUE)

churn_female <- mean(female$Churners == TRUE)
```

```
plot_bar_single <- function(column) {
  target_column <- table(BankChurners[["Gender"]])


  barplot(target_column,
          col = rainbow(length(target_column)),
          main = paste("Distribution of", "Gender"),
          xlab = "Gender",
          ylab = "Count",
          cex.names = 1.2,
          cex.lab = 1.2,
          cex.main = 1.4,
          las = 2)
}

plot_bar_single("name_of_the_column")
```



This is the distribution of customers that have churned by gender.

```
summary_churned <- summary(churned)

transposed_summary_churned <- t(summary_churned)

print(transposed_summary_churned)
```

```
##
##   CLIENTNUM              Min.   :708083283   1st Qu.:712371258
## Attrition_Flag           Length:1627         Class :character
##  Customer_Age            Min.   :26.00       1st Qu.:41.00
##    Gender                Length:1627         Class :character
## Dependent_count          Min.   :0.000       1st Qu.:2.000
## Education_Level          Length:1627         Class :character
## Marital_Status           Length:1627         Class :character
## Income_Category          Length:1627         Class :character
## Card_Category            Length:1627         Class :character
## Months_on_book           Min.   :13.00       1st Qu.:32.00
## Total_Relationship_Count Min.   :1.00        1st Qu.:2.00
## Months_Inactive_12_mon   Min.   :0.000       1st Qu.:2.000
## Contacts_Count_12_mon    Min.   :0.000       1st Qu.:2.000
##  Credit_Limit            Min.   : 1438       1st Qu.: 2114
## Total_Revolving_Bal      Min.   :   0.0      1st Qu.:   0.0
## Avg_Open_To_Buy          Min.   :    3       1st Qu.: 1587
## Total_Amt_Chng_Q4_Q1     Min.   :0.0000      1st Qu.:0.5445
## Total_Trans_Amt          Min.   :  510       1st Qu.: 1904
## Total_Trans_Ct           Min.   :10.00       1st Qu.:37.00
## Total_Ct_Chng_Q4_Q1      Min.   :0.0000      1st Qu.:0.4000
## Avg_Utilization_Ratio    Min.   :0.0000      1st Qu.:0.0000
## Churners                 Mode:logical        TRUE:1627
##
##   CLIENTNUM              Median :716564433   Mean   :735261381
## Attrition_Flag           Mode  :character
##  Customer_Age            Median :47.00       Mean   :46.66
##    Gender                Mode  :character
## Dependent_count          Median :2.000       Mean   :2.403
## Education_Level          Mode  :character
## Marital_Status           Mode  :character
## Income_Category          Mode  :character
## Card_Category            Mode  :character
## Months_on_book           Median :36.00       Mean   :36.18
## Total_Relationship_Count Median :3.00        Mean   :3.28
## Months_Inactive_12_mon   Median :3.000       Mean   :2.693
## Contacts_Count_12_mon    Median :3.000       Mean   :2.972
##  Credit_Limit            Median : 4178       Mean   : 8136
## Total_Revolving_Bal      Median :   0.0      Mean   : 672.8
## Avg_Open_To_Buy          Median : 3488       Mean   : 7463
## Total_Amt_Chng_Q4_Q1     Median :0.7010      Mean   :0.6943
## Total_Trans_Amt          Median : 2329       Mean   : 3095
## Total_Trans_Ct           Median :43.00       Mean   :44.93
## Total_Ct_Chng_Q4_Q1      Median :0.5310      Mean   :0.5544
## Avg_Utilization_Ratio    Median :0.0000      Mean   :0.1625
## Churners
##
##   CLIENTNUM              3rd Qu.:768373683   Max.   :828294933
## Attrition_Flag
##  Customer_Age            3rd Qu.:52.00       Max.   :68.00
```

```
##    Gender
## Dependent_count          3rd Qu.:3.000       Max.   :5.000
## Education_Level
## Marital_Status
## Income_Category
## Card_Category
## Months_on_book           3rd Qu.:40.00       Max.   :56.00
## Total_Relationship_Count 3rd Qu.:5.00        Max.   :6.00
## Months_Inactive_12_mon   3rd Qu.:3.000       Max.   :6.000
## Contacts_Count_12_mon    3rd Qu.:4.000       Max.   :6.000
##  Credit_Limit            3rd Qu.: 9934       Max.   :34516
## Total_Revolving_Bal      3rd Qu.:1303.5      Max.   :2517.0
## Avg_Open_To_Buy          3rd Qu.: 9258       Max.   :34516
## Total_Amt_Chng_Q4_Q1     3rd Qu.:0.8560      Max.   :1.4920
## Total_Trans_Amt          3rd Qu.: 2772       Max.   :10583
## Total_Trans_Ct           3rd Qu.:51.00       Max.   :94.00
## Total_Ct_Chng_Q4_Q1      3rd Qu.:0.6920      Max.   :2.5000
## Avg_Utilization_Ratio    3rd Qu.:0.2310      Max.   :0.9990
## Churners
```

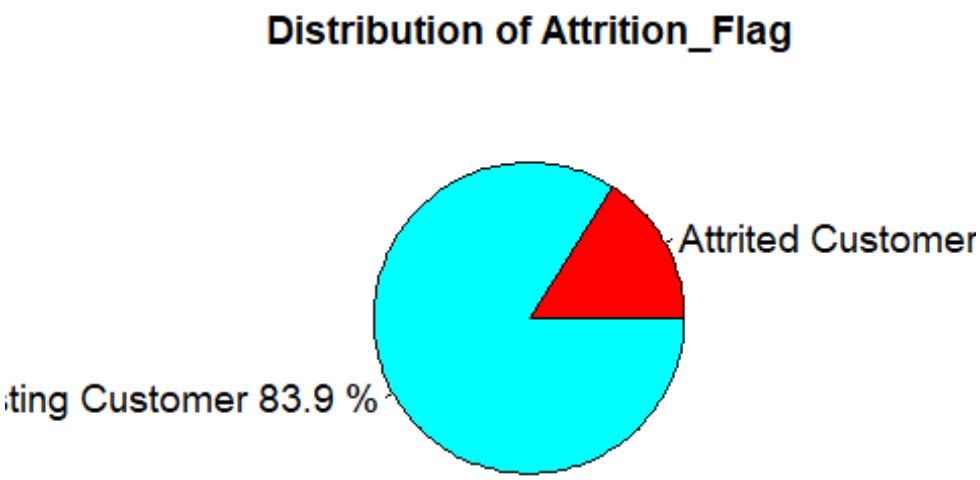
```
summary_non_churned <- summary(non_churned)

transposed_summary_non_churned <- t(summary_non_churned)

print(transposed_summary_non_churned)
```

```
##
##   CLIENTNUM              Min.   :708082083   1st Qu.:713219658
## Attrition_Flag           Length:8500         Class :character
##  Customer_Age            Min.   :26.00       1st Qu.:41.00
##    Gender                Length:8500         Class :character
## Dependent_count          Min.   :0.000       1st Qu.:1.000
## Education_Level          Length:8500         Class :character
## Marital_Status           Length:8500         Class :character
## Income_Category          Length:8500         Class :character
## Card_Category            Length:8500         Class :character
## Months_on_book           Min.   :13.00       1st Qu.:31.00
## Total_Relationship_Count Min.   :1.000       1st Qu.:3.000
## Months_Inactive_12_mon   Min.   :0.000       1st Qu.:1.000
## Contacts_Count_12_mon    Min.   :0.000       1st Qu.:2.000
##  Credit_Limit            Min.   : 1438       1st Qu.: 2602
## Total_Revolving_Bal      Min.   :   0        1st Qu.: 800
## Avg_Open_To_Buy          Min.   :   15       1st Qu.: 1184
## Total_Amt_Chng_Q4_Q1     Min.   :0.2560      1st Qu.:0.6430
## Total_Trans_Amt          Min.   :  816       1st Qu.: 2385
## Total_Trans_Ct           Min.   : 11.00      1st Qu.: 54.00
## Total_Ct_Chng_Q4_Q1      Min.   :0.0280      1st Qu.:0.6170
## Avg_Utilization_Ratio    Min.   :0.0000      1st Qu.:0.0550
##  Churners                Mode :logical       FALSE:8500
##
```

```
##   CLIENTNUM              Median :718164333   Mean   :739927218
## Attrition_Flag           Mode  :character
##  Customer_Age            Median :46.00       Mean   :46.26
##    Gender                Mode  :character
## Dependent_count          Median :2.000       Mean   :2.335
## Education_Level          Mode  :character
## Marital_Status           Mode  :character
## Income_Category          Mode  :character
## Card_Category            Mode  :character
## Months_on_book           Median :36.00       Mean   :35.88
## Total_Relationship_Count Median :4.000       Mean   :3.915
## Months_Inactive_12_mon   Median :2.000       Mean   :2.274
## Contacts_Count_12_mon    Median :2.000       Mean   :2.356
##  Credit_Limit            Median : 4644       Mean   : 8727
## Total_Revolving_Bal      Median :1364        Mean   :1257
## Avg_Open_To_Buy          Median : 3470       Mean   : 7470
## Total_Amt_Chng_Q4_Q1     Median :0.7430      Mean   :0.7725
## Total_Trans_Amt          Median : 4100       Mean   : 4655
## Total_Trans_Ct           Median : 71.00      Mean   : 68.67
## Total_Ct_Chng_Q4_Q1      Median :0.7210      Mean   :0.7424
## Avg_Utilization_Ratio    Median :0.2110      Mean   :0.2964
##  Churners
##
##   CLIENTNUM              3rd Qu.:778341539   Max.   :828343083
## Attrition_Flag
##  Customer_Age            3rd Qu.:52.00       Max.   :73.00
##    Gender
## Dependent_count          3rd Qu.:3.000       Max.   :5.000
## Education_Level
## Marital_Status
## Income_Category
## Card_Category
## Months_on_book           3rd Qu.:40.00       Max.   :56.00
## Total_Relationship_Count 3rd Qu.:5.000       Max.   :6.000
## Months_Inactive_12_mon   3rd Qu.:3.000       Max.   :6.000
## Contacts_Count_12_mon    3rd Qu.:3.000       Max.   :5.000
##  Credit_Limit            3rd Qu.:11253       Max.   :34516
## Total_Revolving_Bal      3rd Qu.:1807        Max.   :2517
## Avg_Open_To_Buy          3rd Qu.: 9978       Max.   :34516
## Total_Amt_Chng_Q4_Q1     3rd Qu.:0.8600      Max.   :3.3970
## Total_Trans_Amt          3rd Qu.: 4781       Max.   :18484
## Total_Trans_Ct           3rd Qu.: 82.00      Max.   :139.00
## Total_Ct_Chng_Q4_Q1      3rd Qu.:0.8330      Max.   :3.7140
## Avg_Utilization_Ratio    3rd Qu.:0.5292      Max.   :0.9940
##  Churners
```

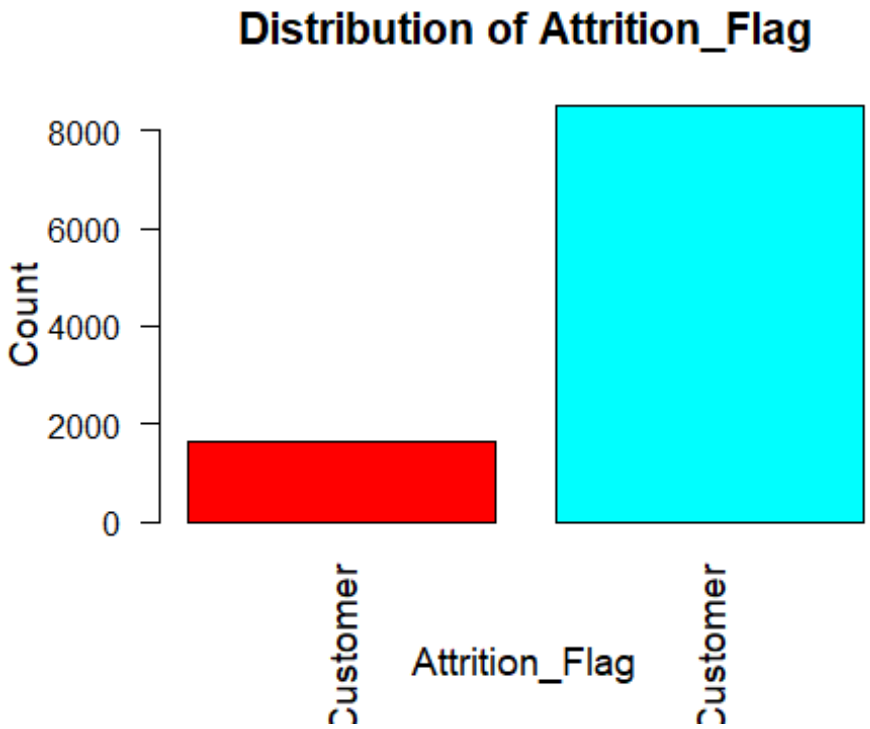
```r
plot_pie_single <- function(column) {
  target_column <- table(BankChurners[["Attrition_Flag"]])
  pie_percent <- round(100 * target_column / sum(target_column), 1)
```

```
  pie(target_column,
      labels = paste(names(target_column), pie_percent, "%"),
      main = paste("Distribution of", "Attrition_Flag"),
      col = rainbow(length(target_column)),
      cex = 1.2)
}


plot_pie_single("name_of_the_column")
```

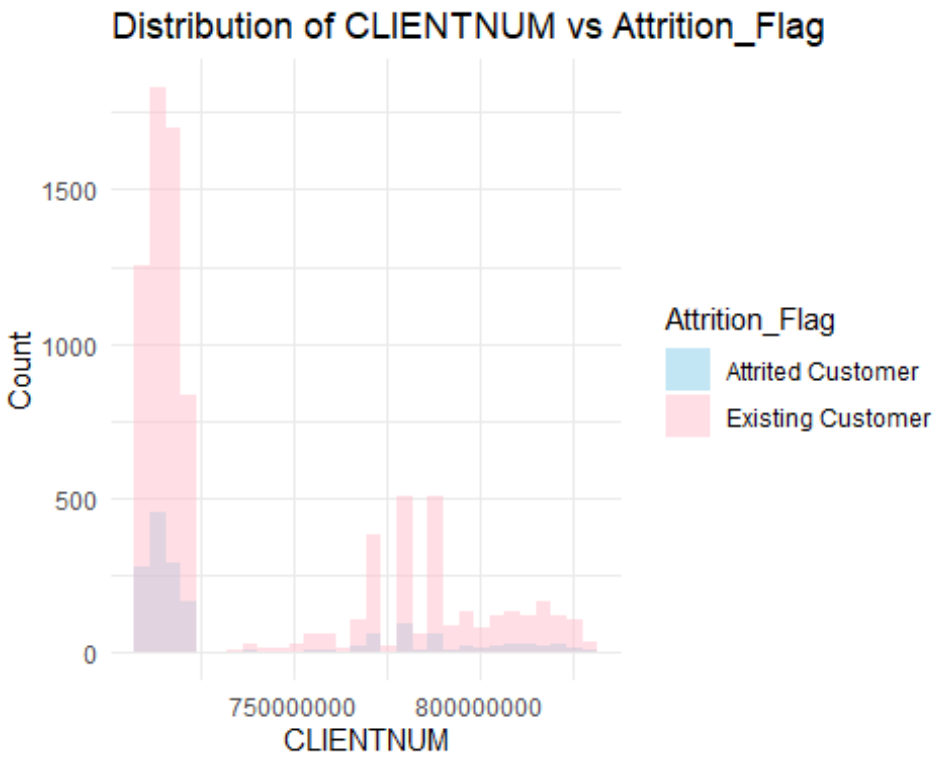


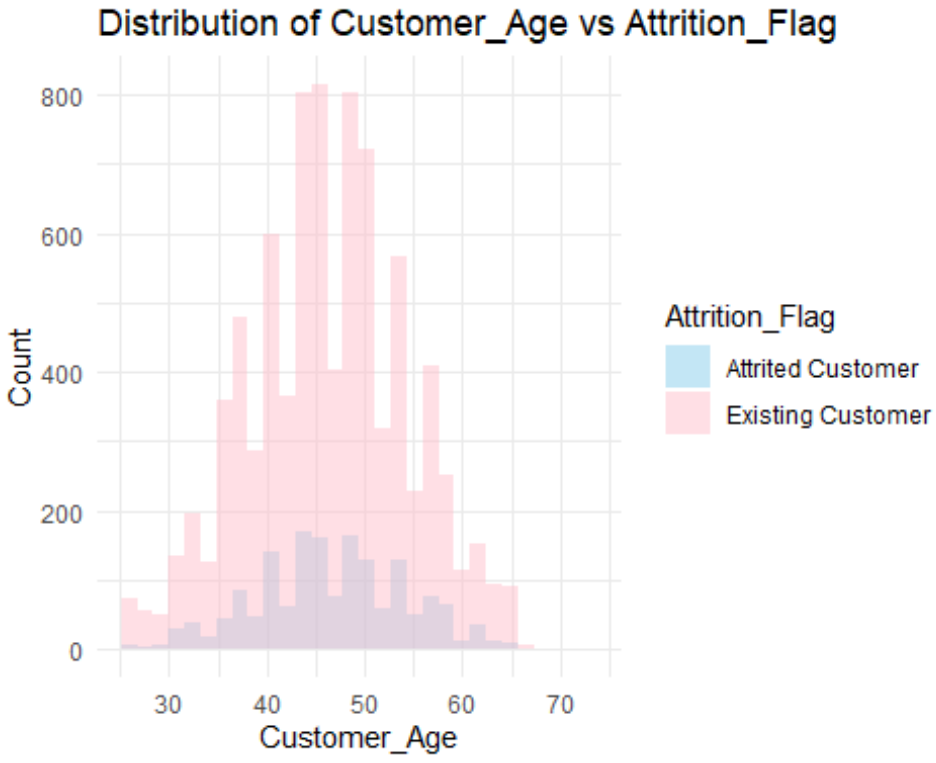

```
plot_bar_single <- function(column) {
  target_column <- table(BankChurners[["Attrition_Flag"]])


  barplot(target_column,
          col = rainbow(length(target_column)),
          main = paste("Distribution of", "Attrition_Flag"),
          xlab = "Attrition_Flag",
          ylab = "Count",
          cex.names = 1.2,
          cex.lab = 1.2,
          cex.main = 1.4,
          las = 2)
}
```

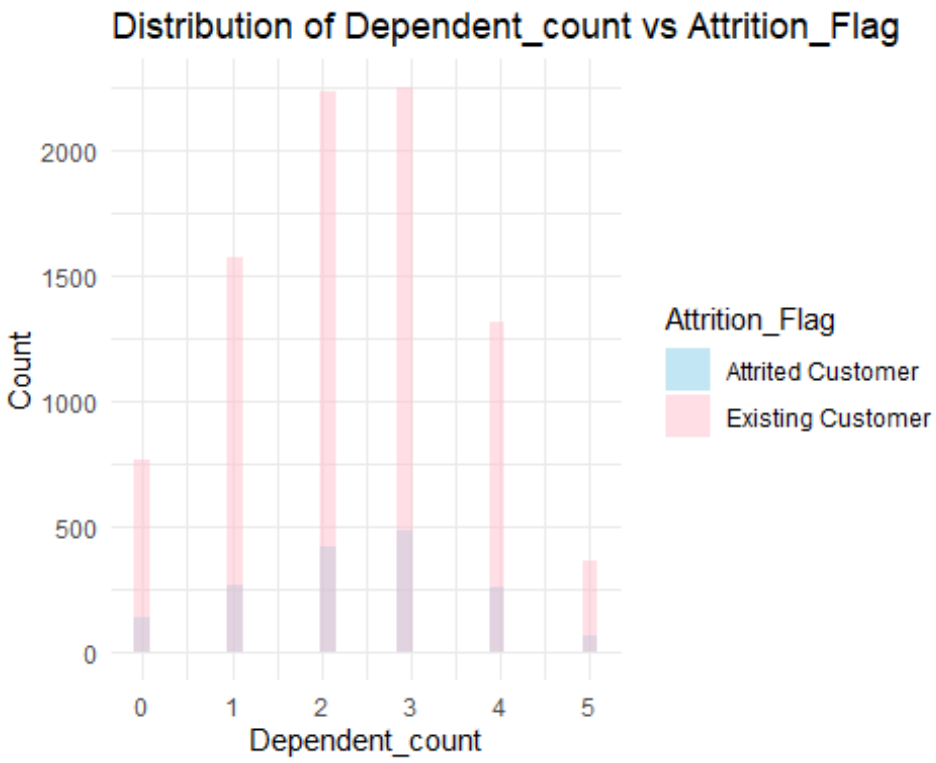
```
plot_bar_single("name_of_the_column")
```

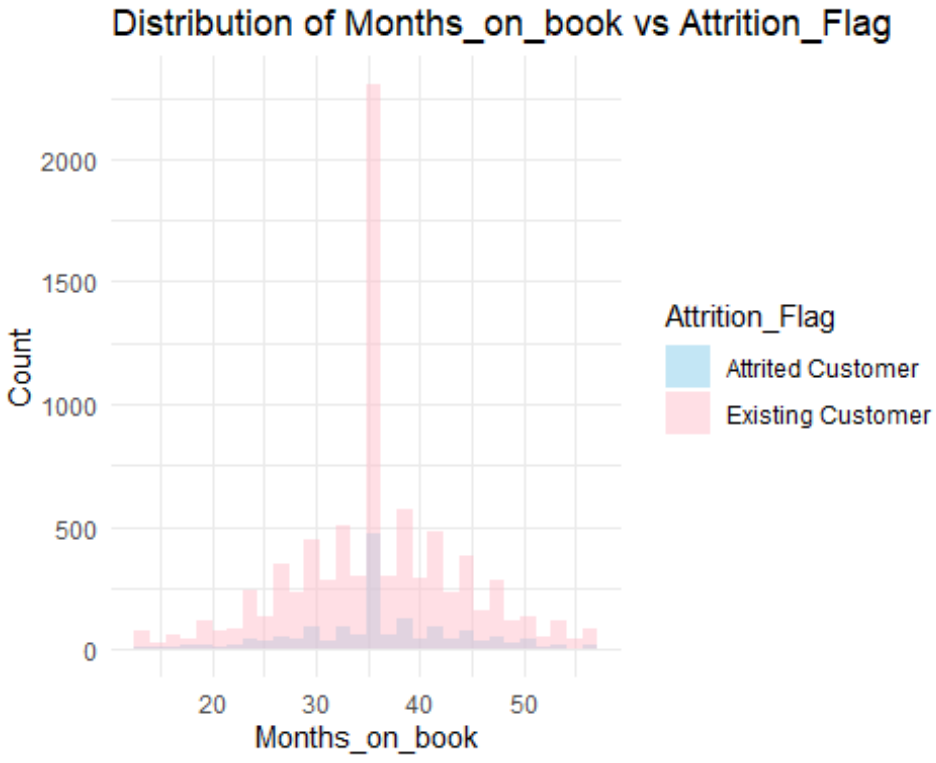


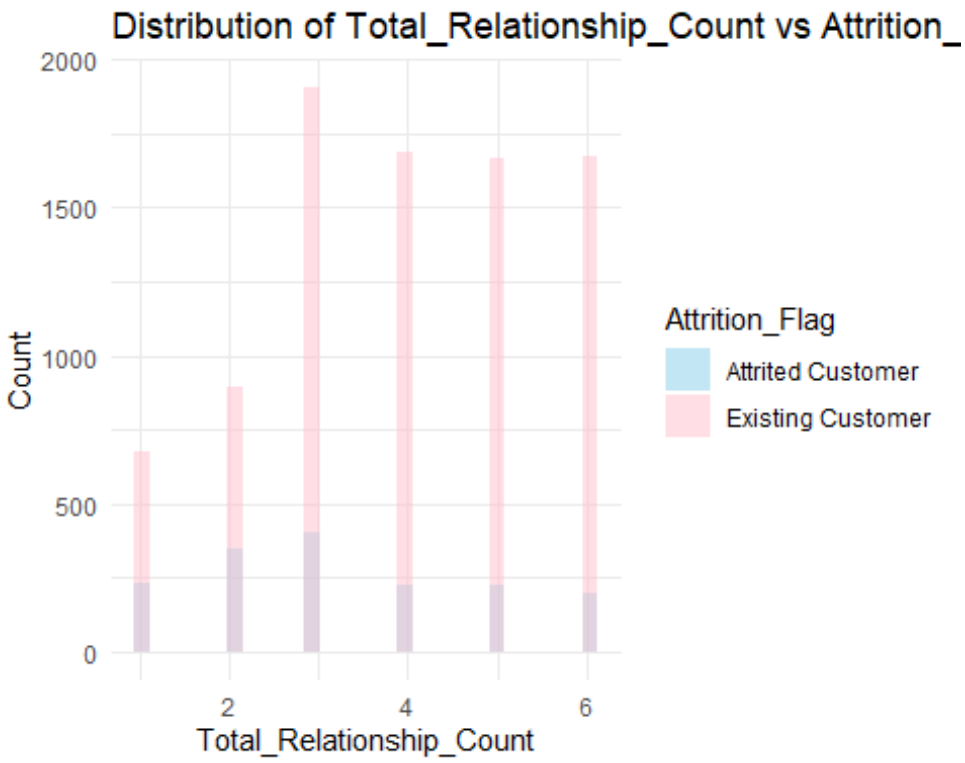

```
num_col <- names(BankChurners)[sapply(BankChurners, is.numeric)]

custom_colors <- c("sky blue", "pink")

# Generate histograms for each numerical column:
for (col in num_col) {

  p <- ggplot(BankChurners, aes(x = .data[[col]], fill = Attrition_Flag))
+
    geom_histogram(position = "identity", alpha = 0.5, bins = 30) +
    labs(title = paste("Distribution of", col, "vs Attrition_Flag"),
         x = col,
         y = "Count") +
    scale_fill_manual(values = custom_colors) +
    theme_minimal()

  print(p)
}
```

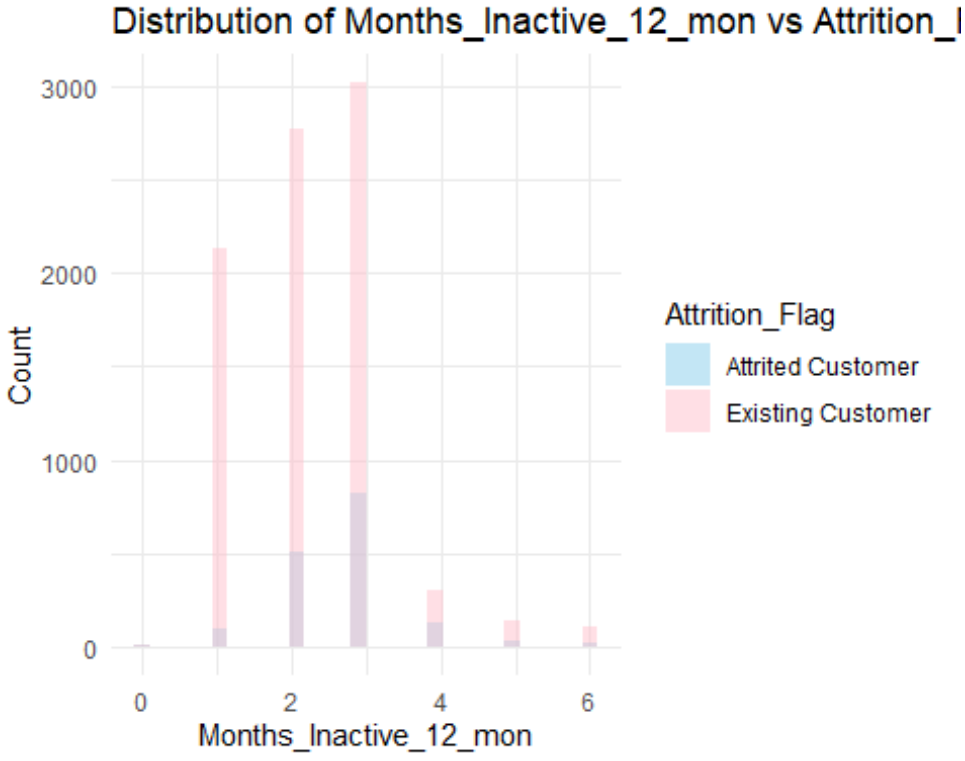

Distribution of CLIENTNUM vs Attrition_Flag
Count
1500
1000
500
0
750000000
800000000
CLIENTNUM
Attrition_Flag
Attrited Customer
Existing Customer

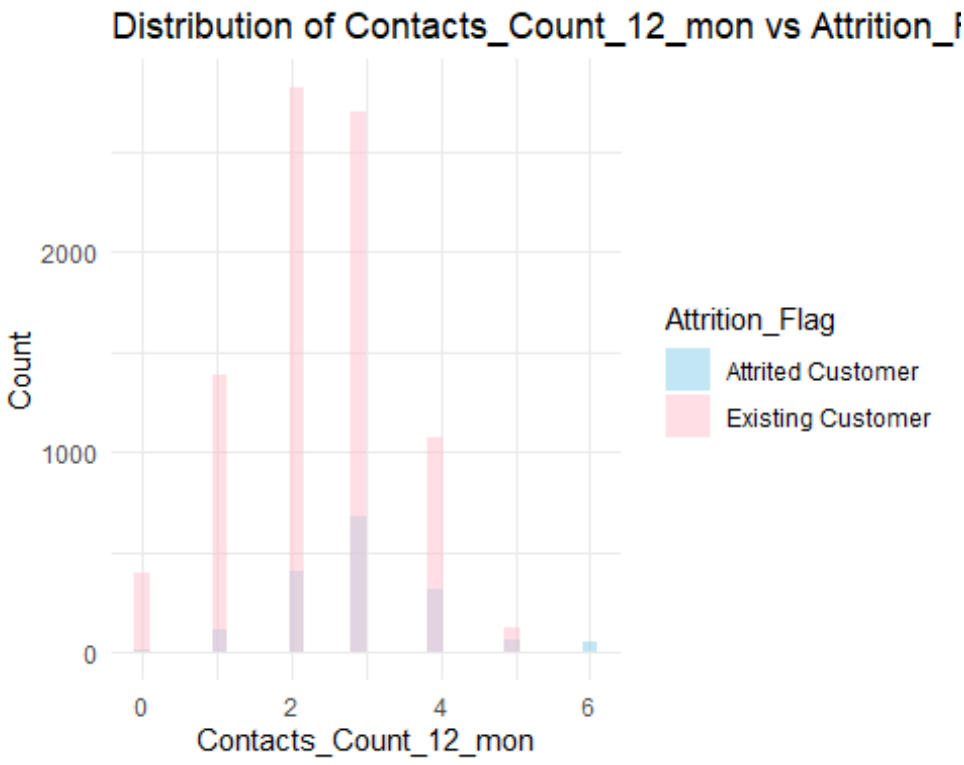

Distribution of Customer_Age vs Attrition_Flag
Count
800
600
400
200
0
30
40
50
60
70
Customer_Age
Attrition_Flag
Attrited Customer
Existing Customer

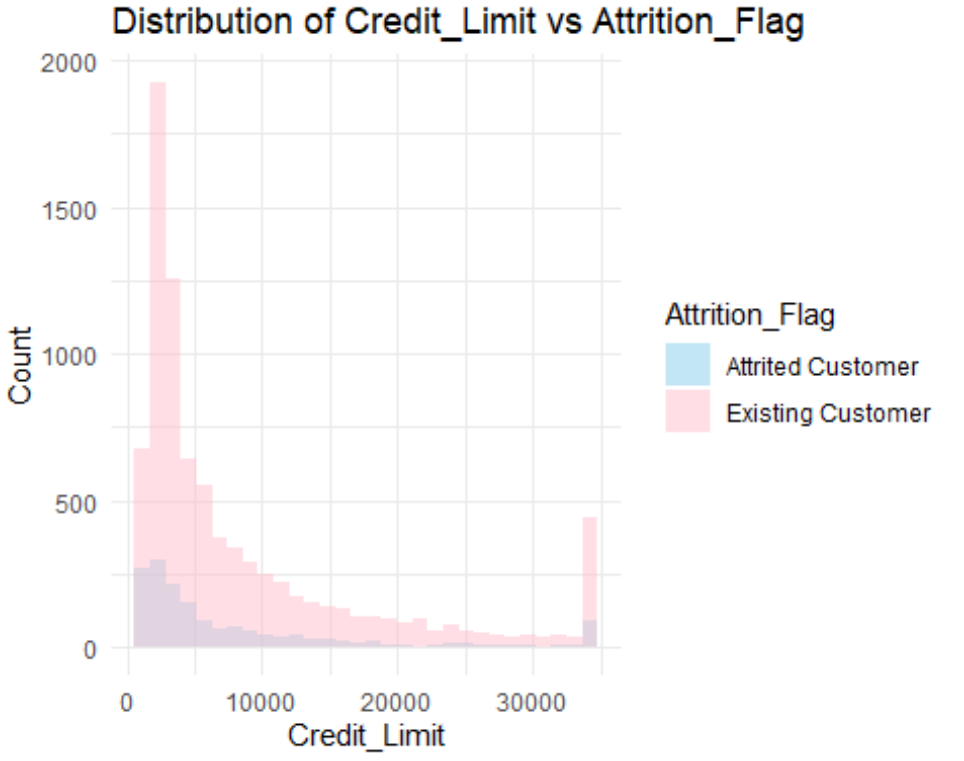

Distribution of Dependent_count vs Attrition_Flag
Count
2000
1500
1000
500
0
0
1
2
3
4
5
Dependent_count
Attrition_Flag
Attrited Customer
Existing Customer

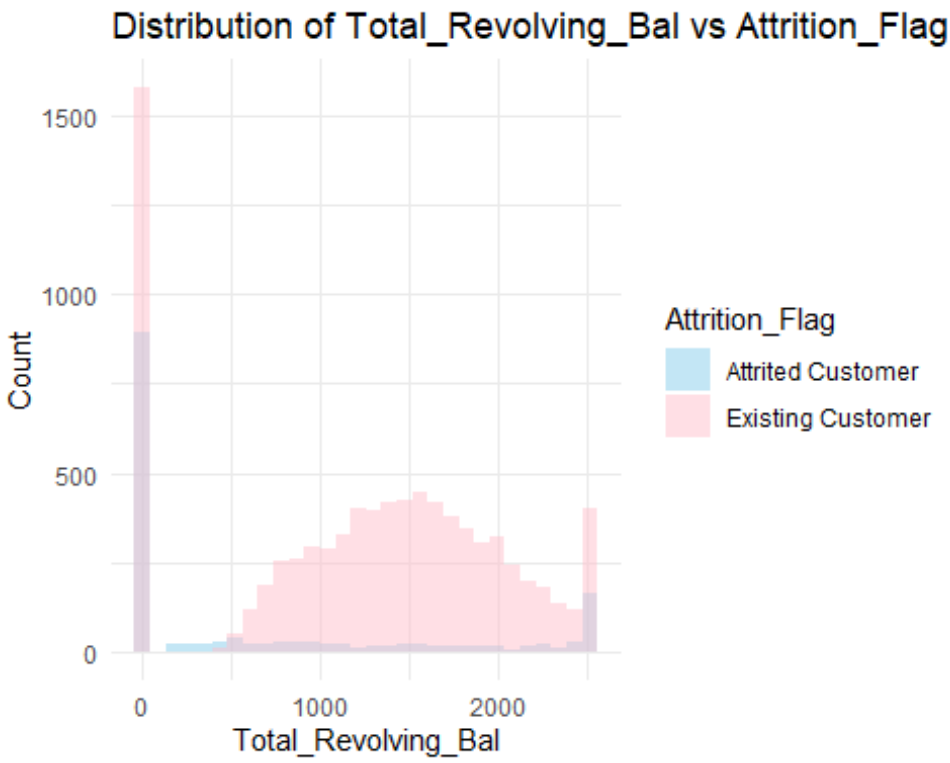

Distribution of Months_on_book vs Attrition_Flag
Count
2000
1500
1000
500
0
20
30
40
50
Months_on_book
Attrition_Flag
Attrited Customer
Existing Customer

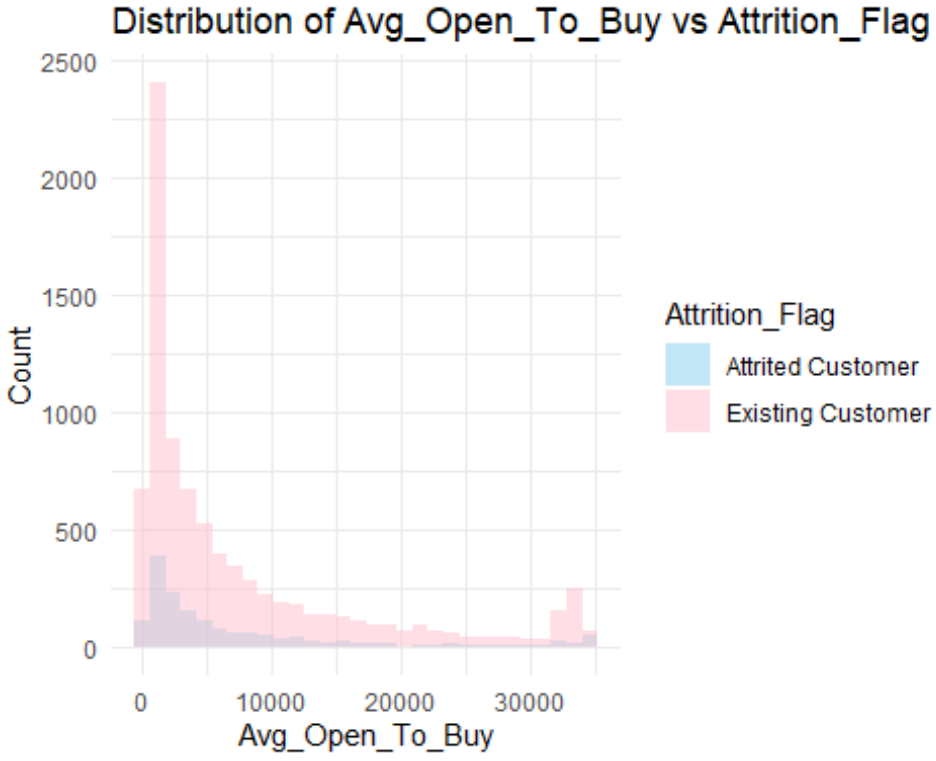

Distribution of Total_Relationship_Count vs Attrition_
2000
1500
1000
500
0
Count
2
4
6
Total_Relationship_Count
Attrition_Flag
Attrited Customer
Existing Customer

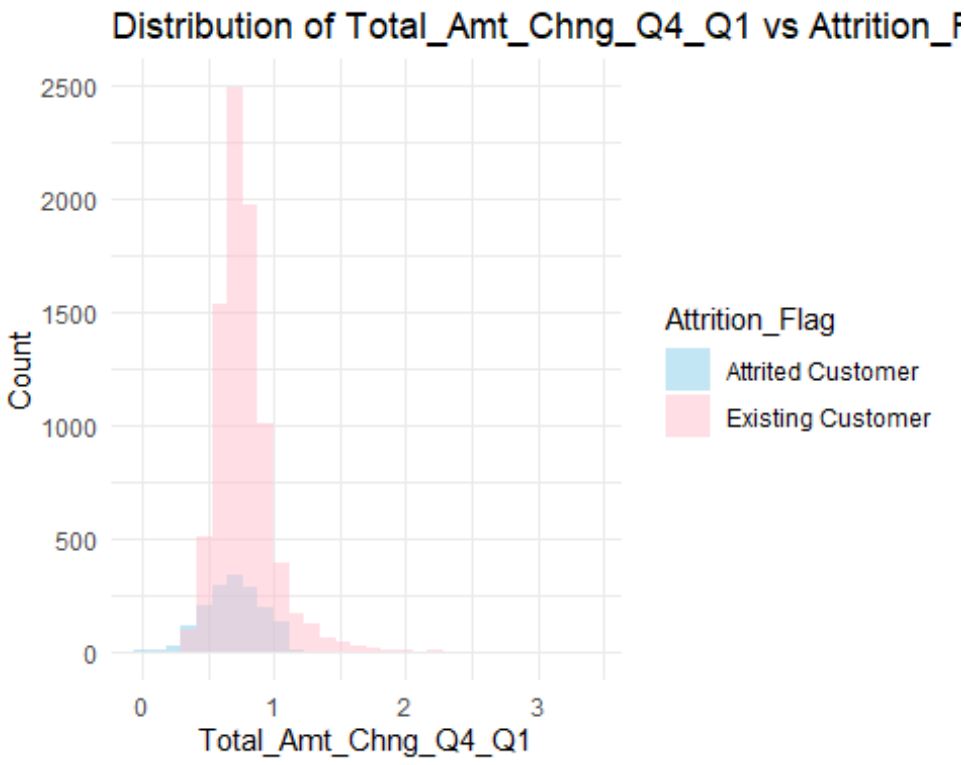

Distribution of Months_Inactive_12_mon vs Attrition_
3000
2000
1000
0
Count
0
2
4
6
Months_Inactive_12_mon
Attrition_Flag
Attrited Customer
Existing Customer

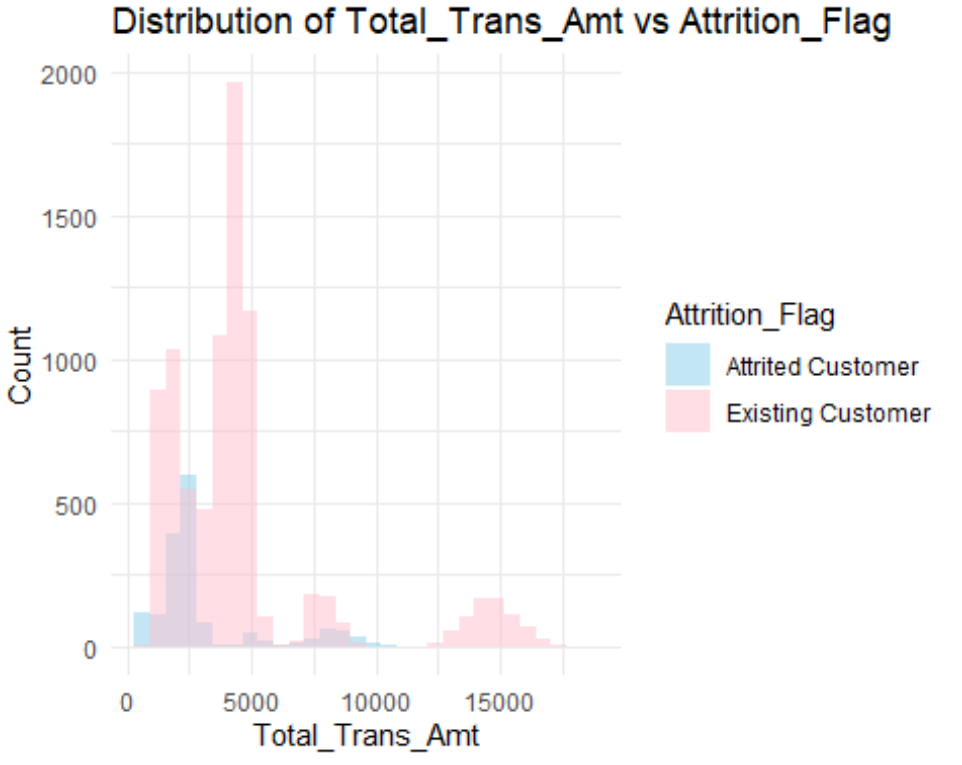

Distribution of Contacts_Count_12_mon vs Attrition_F
Count
2000
1000
0
0
2
4
6
Contacts_Count_12_mon
Attrition_Flag
Attrited Customer
Existing Customer

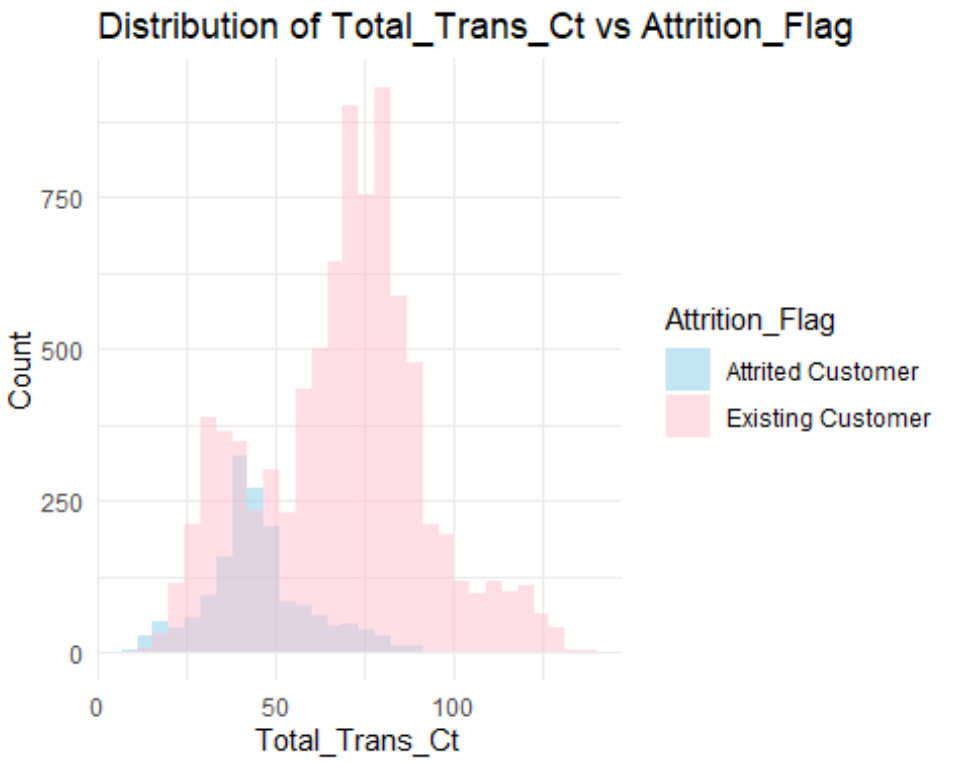

Distribution of Credit_Limit vs Attrition_Flag
Count
2000
1500
1000
500
0
0
10000
20000
30000
Credit_Limit
Attrition_Flag
Attrited Customer
Existing Customer

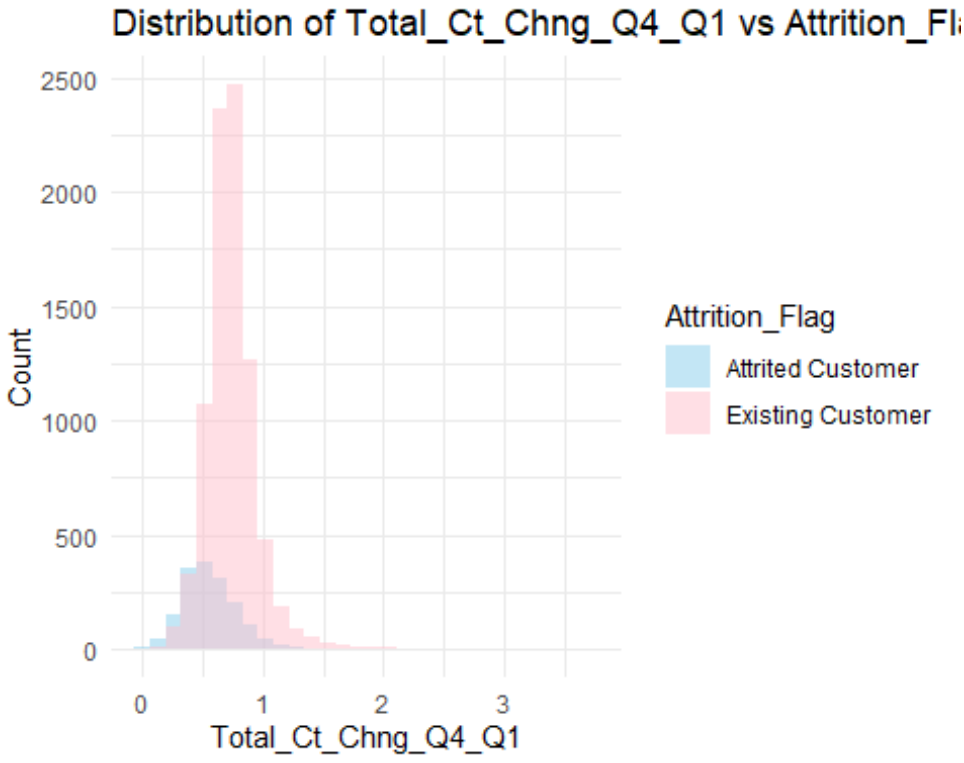

Distribution of Total_Revolving_Bal vs Attrition_Flag
1500
1000
500
0
Count
0
1000
2000
Total_Revolving_Bal
Attrition_Flag
Attrited Customer
Existing Customer

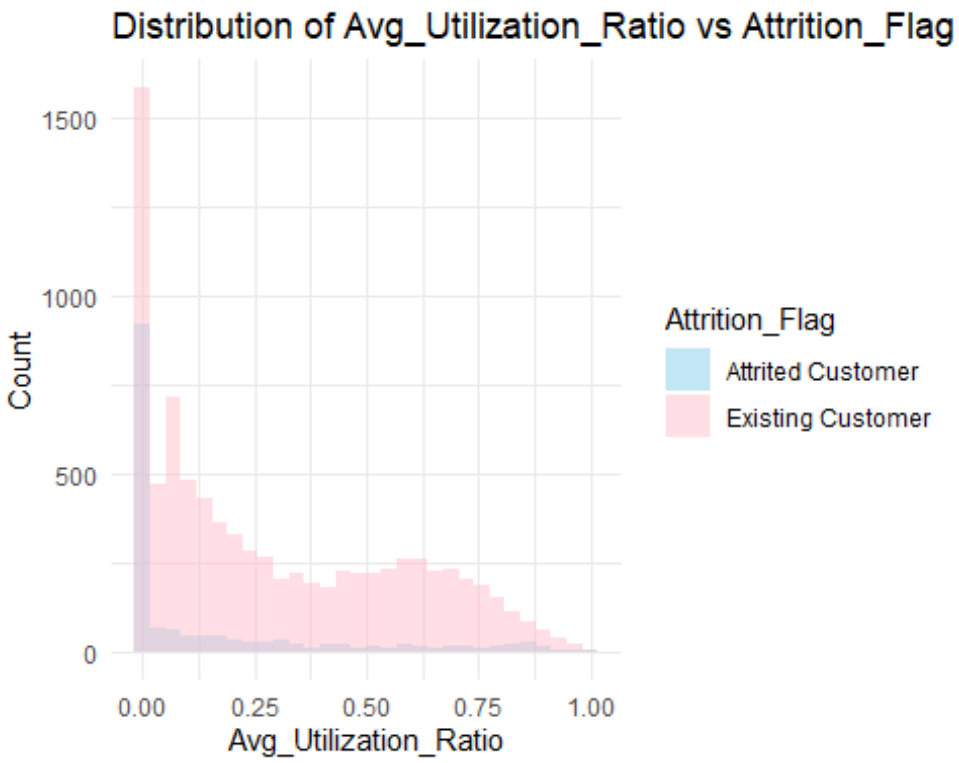

Distribution of Avg_Open_To_Buy vs Attrition_Flag
2500
2000
1500
1000
500
0
Count
0
10000
20000
30000
Avg_Open_To_Buy
Attrition_Flag
Attrited Customer
Existing Customer


Distribution of Total_Amt_Chng_Q4_Q1 vs Attrition_F
2500
2000
1500
1000
500
0
Count
0
1
2
3
Total_Amt_Chng_Q4_Q1
Attrition_Flag
Attrited Customer
Existing Customer


Distribution of Total_Trans_Amt vs Attrition_Flag
2000
1500
1000
500
0
Count
0
5000
10000
15000
Total_Trans_Amt
Attrition_Flag
Attrited Customer
Existing Customer


Distribution of Total_Trans_Ct vs Attrition_Flag
Count
750
500
250
0
0
50
100
Total_Trans_Ct
Attrition_Flag
Attrited Customer
Existing Customer

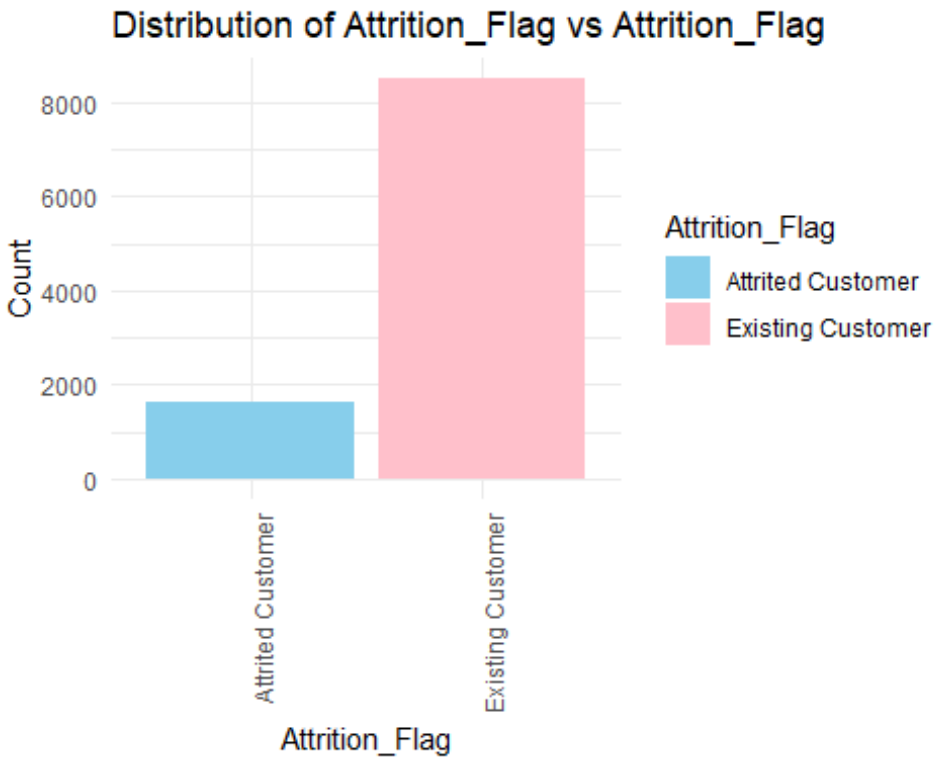

Distribution of Total_Ct_Chng_Q4_Q1 vs Attrition_Fl
Count
2500
2000
1500
1000
500
0
0
1
2
3
Total_Ct_Chng_Q4_Q1
Attrition_Flag
Attrited Customer
Existing Customer

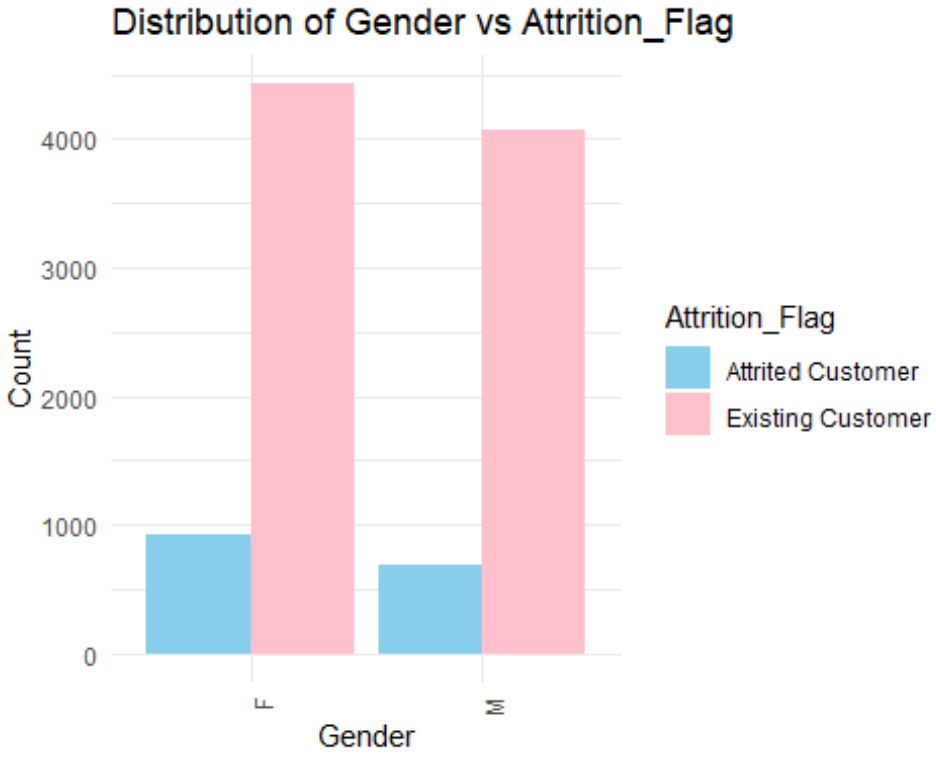


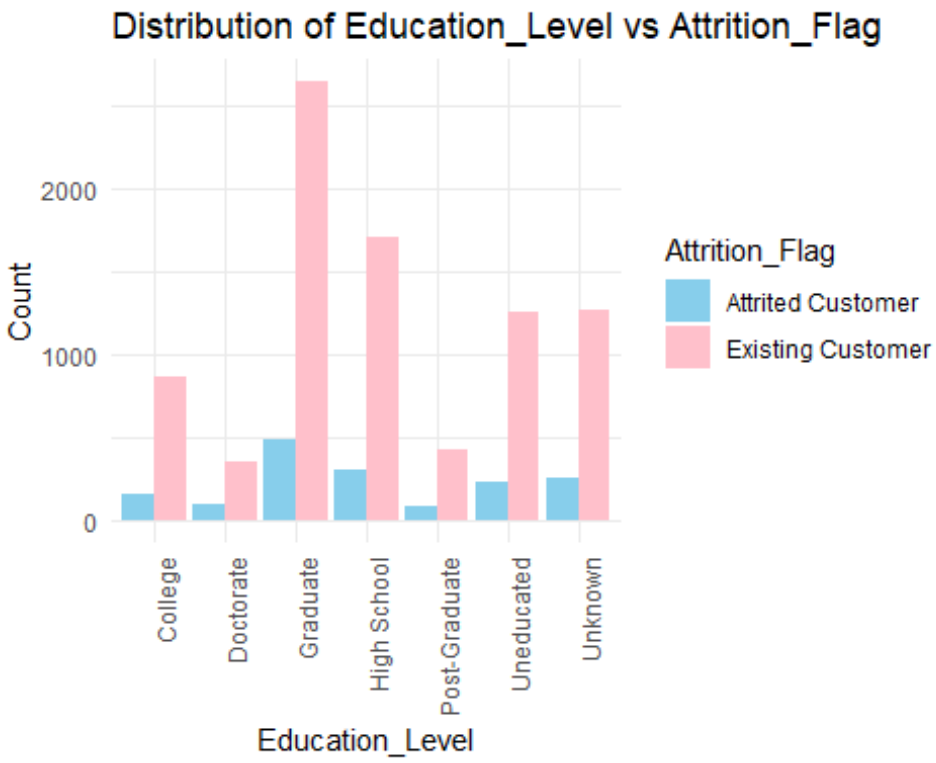

```
cat_cols <- names(BankChurners)[sapply(df, is.factor) | sapply(BankChurne
rs, is.character)]

custom_colors <- c("sky blue", "pink")
# Generate histograms for each categorical column:
for (col in cat_cols) {

  h <- ggplot(BankChurners, aes_string(x = col, fill = "Attrition_Flag"))
+
    geom_bar(position = "dodge") +
    labs(title = paste("Distribution of", col, "vs Attrition_Flag"),
         x = col,
         y = "Count") +
    scale_fill_manual(values = custom_colors) +
    theme_minimal() +
    theme(axis.text.x = element_text(angle = 90, hjust = 1))

  print(h)

  cat("\n")
}
```

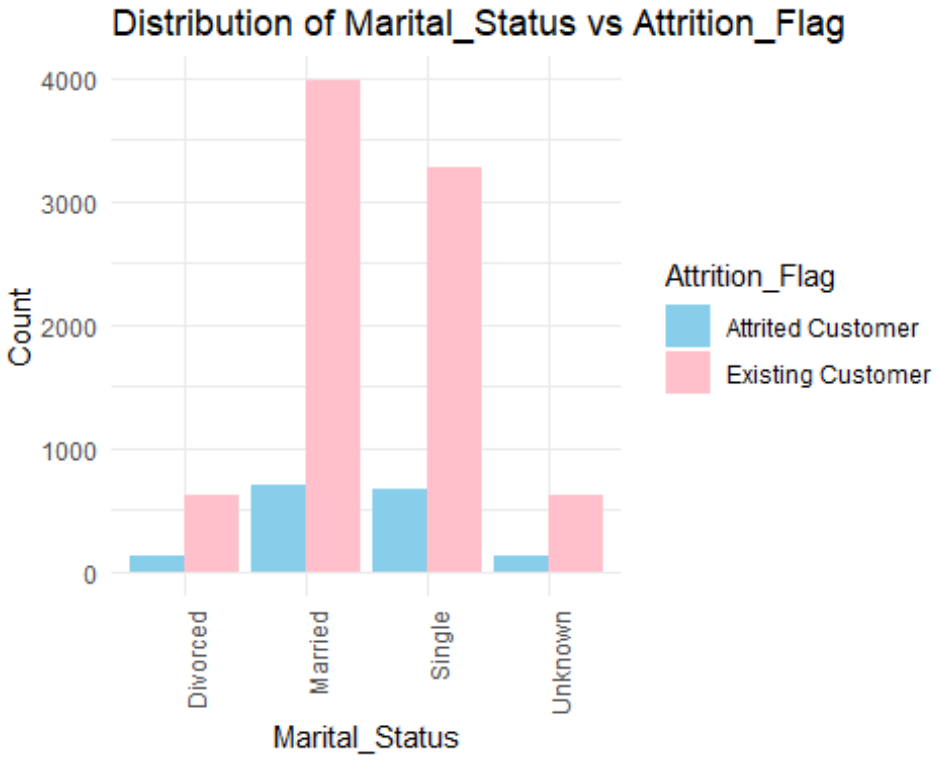
```
## Warning: `aes_string()` was deprecated in ggplot2 3.0.0.
## ℹ Please use tidy evaluation idioms with `aes()`.
## ℹ See also `vignette("ggplot2-in-packages")` for more information.
## This warning is displayed once every 8 hours.
```

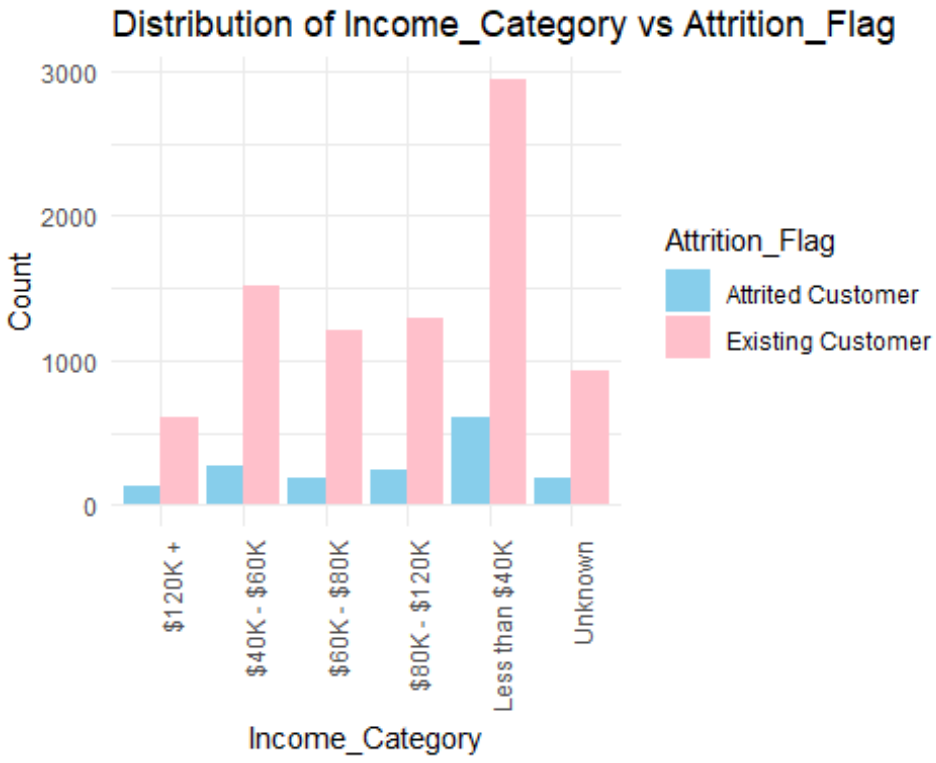
```
## Call `lifecycle::last_lifecycle_warnings()` to see where this warning
was
## generated.
```

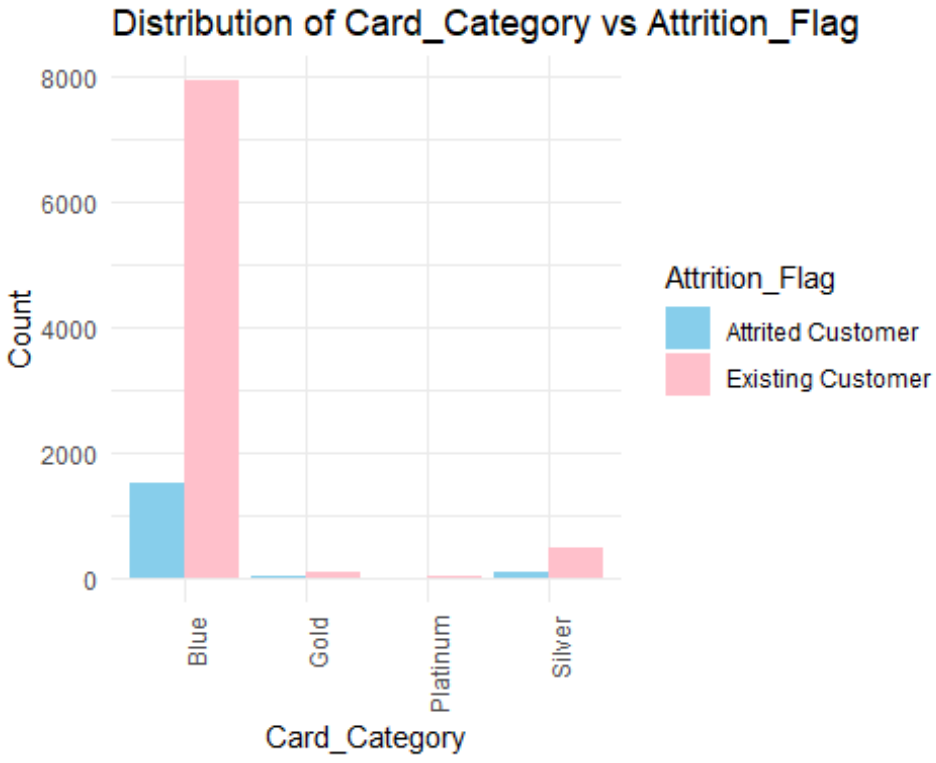




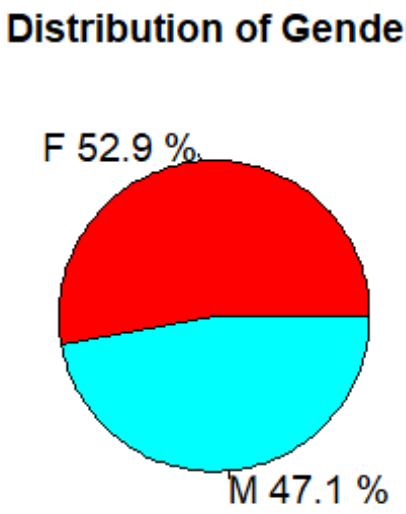

Distribution of Education_Level vs Attrition_Flag
Count
2000
1000
0
College
Doctorate
Graduate
High School
Post-Graduate
Uneducated
Unknown
Education_Level
Attrition_Flag
Attrited Customer
Existing Customer


Distribution of Marital_Status vs Attrition_Flag
Count
4000
3000
2000
1000
0
Divorced
Married
Single
Unknown
Marital_Status
Attrition_Flag
Attrited Customer
Existing Customer

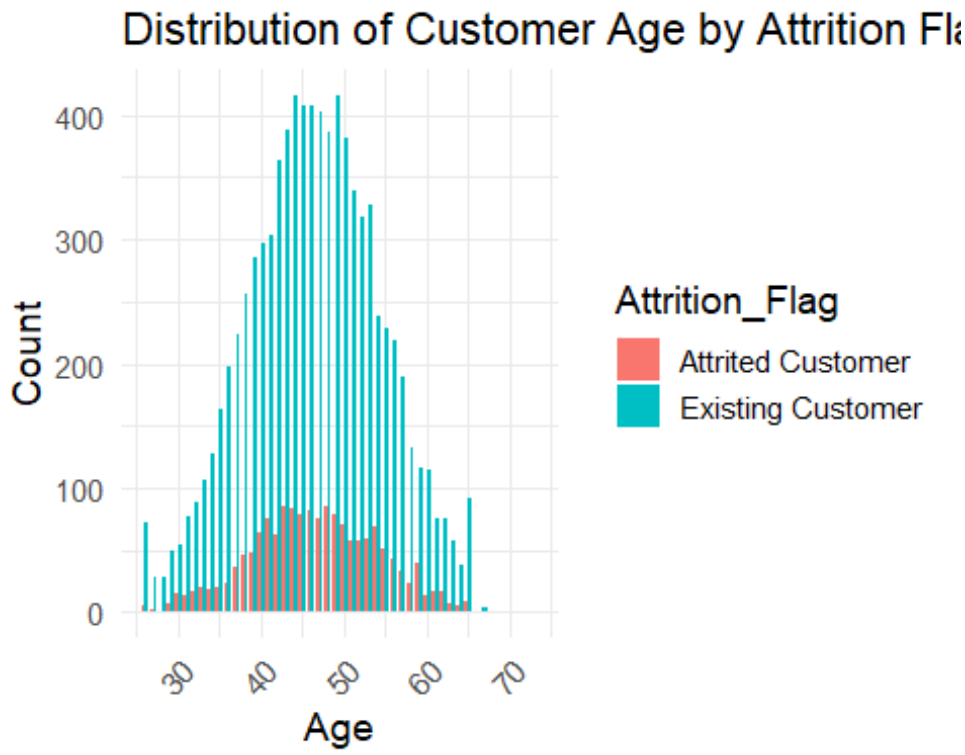

Distribution of Income_Category vs Attrition_Flag
Count
3000
2000
1000
0
$120K +
$40K - $60K
$60K - $80K
$80K - $120K
Less than $40K
Unknown
Income_Category
Attrition_Flag
Attrited Customer
Existing Customer


Distribution of Card_Category vs Attrition_Flag
Count
8000
6000
4000
2000
0
Blue
Gold
Platinum
Silver
Card_Category
Attrition_Flag
Attrited Customer
Existing Customer

```r
plot_pie_single <- function(column) {
  target_column <- table(BankChurners[["Gender"]])
  pie_percent <- round(100 * target_column / sum(target_column), 1)

  pie(target_column,
      labels = paste(names(target_column), pie_percent, "%"),
      main = paste("Distribution of", "Gender"),
      col = rainbow(length(target_column)),
      cex = 1.2)
}


plot_pie_single("Gender")
```




```r
ggplot(BankChurners, aes(x = Customer_Age, fill = Attrition_Flag)) +
  geom_bar(position = "dodge") +
  labs(x = "Age",
       y = "Count",
       title = "Distribution of Customer Age by Attrition Flag") +
  theme_minimal(base_size = 14) +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



Step 4: Classification of Customers by Usage Levels

A new variable is created that classifies customers into two groups: High and Low usage, based on the total number of daytime call minutes.

How is it defined? If a customer has been more than 2 months inactive, they are classified as "Low". If they have fewer, they are classified as "High".

Why is this done? This classification helps segment customers and better understand which type of user is more likely to churn. For example, if we find that high-usage customers have a higher churn rate, the bank might consider offering special plans or incentives to retain this group.

```
umbral <- 2 ##It has been chosen 2 months of inactivity
consumption_level_grouping <- ifelse(BankChurners$Months_Inactive_12_mon
>= umbral, "Low", "High")

print(consumption_level_grouping)
```

```
##     [1] "High" "High" "High" "Low"  "High" "High" "High" "Low"  "Low"
"Low"
##    [11] "Low"  "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"  "Low"
"High"
##    [21] "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"
"High"
##    [31] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
```

```
##    [41] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##    [51] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##    [61] "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"
"Low"
##    [71] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##    [81] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##    [91] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
##   [101] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "High"
"Low"
##   [111] "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"  "High" "Low"
"Low"
##   [121] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "High" "Low"  "High"
"Low"
##   [131] "High" "High" "Low"  "High" "High" "High" "Low"  "High" "Low"
"Low"
##   [141] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"High"
##   [151] "High" "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"
"Low"
##   [161] "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"
"Low"
##   [171] "Low"  "Low"  "Low"  "High" "High" "Low"  "High" "Low"  "Low"
"Low"
##   [181] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "High" "High" "High"
"High"
##   [191] "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"
"High"
##   [201] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##   [211] "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High"
"High"
##   [221] "High" "High" "Low"  "Low"  "Low"  "Low"  "High" "Low"  "High"
"Low"
##   [231] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##   [241] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"High"
##   [251] "High" "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"
"Low"
##   [261] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
##   [271] "High" "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"
"High"
##   [281] "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"
"Low"
```

```
##   [291] "Low"  "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"  "Low"
"Low"
##   [301] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"
"High"
##   [311] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [321] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [331] "Low"  "High" "High" "High" "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [341] "High" "Low"  "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"
"High"
##   [351] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##   [361] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [371] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [381] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##   [391] "Low"  "High" "High" "High" "Low"  "High" "High" "Low"  "Low"
"Low"
##   [401] "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [411] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##   [421] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High"
"Low"
##   [431] "Low"  "High" "Low"  "Low"  "High" "High" "High" "High" "Low"
"High"
##   [441] "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"
"Low"
##   [451] "Low"  "Low"  "High" "High" "High" "Low"  "Low"  "High" "High"
"Low"
##   [461] "High" "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [471] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"High"
##   [481] "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"
"High"
##   [491] "High" "High" "High" "High" "Low"  "High" "Low"  "Low"  "Low"
"Low"
##   [501] "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"  "High" "Low"
"Low"
##   [511] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "High"
"Low"
##   [521] "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"
"Low"
##   [531] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
```

```
##   [541] "High" "Low"  "Low"  "High" "Low"  "Low"  "High" "Low"  "Low"
"Low"
##   [551] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [561] "High" "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [571] "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"  "High" "Low"
"Low"
##   [581] "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"  "High" "Low"
"High"
##   [591] "High" "High" "Low"  "Low"  "High" "Low"  "Low"  "Low"  "High"
"Low"
##   [601] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"
"Low"
##   [611] "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##   [621] "Low"  "High" "High" "Low"  "High" "Low"  "High" "Low"  "Low"
"High"
##   [631] "High" "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [641] "Low"  "Low"  "High" "High" "Low"  "High" "Low"  "Low"  "Low"
"High"
##   [651] "High" "High" "Low"  "Low"  "High" "High" "Low"  "High" "High"
"Low"
##   [661] "Low"  "Low"  "High" "High" "Low"  "Low"  "High" "Low"  "Low"
"Low"
##   [671] "Low"  "Low"  "Low"  "High" "High" "High" "High" "High" "Low"
"High"
##   [681] "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
##   [691] "Low"  "Low"  "High" "Low"  "Low"  "High" "High" "Low"  "Low"
"Low"
##   [701] "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"
"Low"
##   [711] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [721] "High" "Low"  "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"
"Low"
##   [731] "Low"  "Low"  "High" "Low"  "Low"  "High" "Low"  "Low"  "Low"
"High"
##   [741] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##   [751] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [761] "Low"  "Low"  "High" "High" "Low"  "High" "Low"  "High" "Low"
"High"
##   [771] "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "High"
"Low"
##   [781] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High"
"Low"
```

```
##   [791] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "High" "Low"  "Low"
"Low"
##   [801] "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "High" "Low"
"Low"
##   [811] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
##   [821] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##   [831] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [841] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High"
"High"
##   [851] "Low"  "High" "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##   [861] "High" "Low"  "Low"  "Low"  "Low"  "High" "Low"  "High" "Low"
"Low"
##   [871] "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "High" "Low"
"Low"
##   [881] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"
"Low"
##   [891] "High" "High" "High" "High" "Low"  "High" "High" "Low"  "Low"
"Low"
##   [901] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [911] "High" "Low"  "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"
"Low"
##   [921] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##   [931] "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"  "Low"
"Low"
##   [941] "High" "High" "Low"  "Low"  "Low"  "High" "Low"  "High" "High"
"Low"
##   [951] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "High"
"High"
##   [961] "Low"  "Low"  "Low"  "High" "Low"  "Low"  "High" "Low"  "Low"
"Low"
##   [971] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [981] "Low"  "High" "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##   [991] "Low"  "Low"  "Low"  "High" "Low"  "Low"  "High" "Low"  "High"
"High"
##  [1001] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
##  [1011] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"
"Low"
##  [1021] "High" "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"
"High"
##  [1031] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "High"
"High"
```

```
##  [1041] "Low"  "High" "High" "Low"  "High" "Low"  "Low"  "Low"  "High"
"Low"
##  [1051] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "High"
"Low"
##  [1061] "Low"  "Low"  "High" "Low"  "High" "High" "Low"  "Low"  "Low"
"Low"
##  [1071] "Low"  "High" "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##  [1081] "Low"  "High" "High" "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
##  [1091] "Low"  "Low"  "High" "Low"  "High" "High" "High" "Low"  "Low"
"Low"
##  [1101] "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"  "High" "Low"
"High"
##  [1111] "High" "Low"  "Low"  "Low"  "High" "High" "High" "Low"  "High"
"Low"
##  [1121] "High" "Low"  "Low"  "Low"  "Low"  "High" "High" "High" "High"
"Low"
##  [1131] "Low"  "High" "Low"  "Low"  "High" "High" "High" "Low"  "High"
"Low"
##  [1141] "Low"  "High" "Low"  "High" "High" "Low"  "Low"  "High" "High"
"Low"
##  [1151] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High" "High"
"Low"
##  [1161] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##  [1171] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##  [1181] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"
"Low"
##  [1191] "Low"  "High" "High" "High" "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##  [1201] "High" "High" "Low"  "High" "Low"  "Low"  "Low"  "Low"  "High"
"Low"
##  [1211] "Low"  "Low"  "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"
"High"
##  [1221] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"
"Low"
##  [1231] "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"High"
##  [1241] "High" "High" "Low"  "Low"  "High" "High" "Low"  "High" "High"
"Low"
##  [1251] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "High"
"High"
##  [1261] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"
"Low"
##  [1271] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
##  [1281] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
```

```
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## [10041] "Low"  "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"  "Low"
"Low"
## [10051] "Low"  "Low"  "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
## [10061] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"  "Low"
"Low"
## [10071] "Low"  "Low"  "High" "Low"  "Low"  "Low"  "Low"  "High" "High"
"Low"
## [10081] "High" "Low"  "High" "High" "High" "Low"  "High" "Low"  "Low"
"Low"
## [10091] "Low"  "High" "Low"  "Low"  "High" "High" "Low"  "Low"  "Low"
"Low"
## [10101] "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "Low"  "High" "Low"
"Low"
## [10111] "Low"  "Low"  "High" "Low"  "High" "Low"  "Low"  "Low"  "Low"
"Low"
## [10121] "Low"  "High" "Low"  "Low"  "Low"  "Low"  "Low"
```

Step 5: Statistical analysis

Now let's delve deeper into the statistical analysis of the data:

```
head(BankChurners)
```

```
## # A tibble: 6 × 22
##   CLIENTNUM Attrition_Flag   Customer_Age Gender Dependent_count Educa
tion_Level
##       <dbl> <chr>                   <dbl> <chr>            <dbl> <chr>
## 1 768805383 Existing Custom…           45 M                    3 High
School
## 2 818770008 Existing Custom…           49 F                    5 Gradu
ate
## 3 713982108 Existing Custom…           51 M                    3 Gradu
ate
## 4 769911858 Existing Custom…           40 F                    4 High
School
## 5 709106358 Existing Custom…           40 M                    3 Unedu
cated
## 6 713061558 Existing Custom…           44 M                    2 Gradu
ate
## # ⓘ 16 more variables: Marital_Status <chr>, Income_Category <chr>,
## #   Card_Category <chr>, Months_on_book <dbl>, Total_Relationship_Coun
t <dbl>,
## #   Months_Inactive_12_mon <dbl>, Contacts_Count_12_mon <dbl>,
## #   Credit_Limit <dbl>, Total_Revolving_Bal <dbl>, Avg_Open_To_Buy <db
l>,
## #   Total_Amt_Chng_Q4_Q1 <dbl>, Total_Trans_Amt <dbl>, Total_Trans_Ct
<dbl>,
## #   Total_Ct_Chng_Q4_Q1 <dbl>, Avg_Utilization_Ratio <dbl>, Churners <
lgl>
```

```
str(BankChurners)

## tibble [10,127 × 22] (S3: tbl_df/tbl/data.frame)
##  $ CLIENTNUM               : num [1:10127] 768805383 818770008 7139821
08 769911858 709106358 ...
##  $ Attrition_Flag          : chr [1:10127] "Existing Customer" "Existi
ng Customer" "Existing Customer" "Existing Customer" ...
##  $ Customer_Age            : num [1:10127] 45 49 51 40 40 44 51 32 37
48 ...
##  $ Gender                  : chr [1:10127] "M" "F" "M" "F" ...
##  $ Dependent_count         : num [1:10127] 3 5 3 4 3 2 4 0 3 2 ...
##  $ Education_Level         : chr [1:10127] "High School" "Graduate" "G
raduate" "High School" ...
##  $ Marital_Status          : chr [1:10127] "Married" "Single" "Married
" "Unknown" ...
##  $ Income_Category         : chr [1:10127] "$60K - $80K" "Less than $4
0K" "$80K - $120K" "Less than $40K" ...
##  $ Card_Category           : chr [1:10127] "Blue" "Blue" "Blue" "Blue"
...
##  $ Months_on_book          : num [1:10127] 39 44 36 34 21 36 46 27 36
36 ...
##  $ Total_Relationship_Count: num [1:10127] 5 6 4 3 5 3 6 2 5 6 ...
##  $ Months_Inactive_12_mon  : num [1:10127] 1 1 1 4 1 1 1 2 2 3 ...
##  $ Contacts_Count_12_mon   : num [1:10127] 3 2 0 1 0 2 3 2 0 3 ...
##  $ Credit_Limit            : num [1:10127] 12691 8256 3418 3313 4716 .
..
##  $ Total_Revolving_Bal     : num [1:10127] 777 864 0 2517 0 ...
##  $ Avg_Open_To_Buy         : num [1:10127] 11914 7392 3418 796 4716 ..
.
##  $ Total_Amt_Chng_Q4_Q1    : num [1:10127] 1.33 1.54 2.59 1.4 2.17 ...
##  $ Total_Trans_Amt         : num [1:10127] 1144 1291 1887 1171 816 ...
##  $ Total_Trans_Ct          : num [1:10127] 42 33 20 20 28 24 31 36 24
32 ...
##  $ Total_Ct_Chng_Q4_Q1     : num [1:10127] 1.62 3.71 2.33 2.33 2.5 ...
##  $ Avg_Utilization_Ratio   : num [1:10127] 0.061 0.105 0 0.76 0 0.311
0.066 0.048 0.113 0.144 ...
##  $ Churners                : logi [1:10127] FALSE FALSE FALSE FALSE FA
LSE FALSE ...

summary(BankChurners)

##    CLIENTNUM         Attrition_Flag      Customer_Age      Gender
##  Min.   :708082083   Length:10127       Min.   :26.00   Length:10127
##  1st Qu.:713036770   Class :character   1st Qu.:41.00   Class :charact
er
##  Median :717926358   Mode  :character   Median :46.00   Mode  :charact
er
##  Mean   :739177606                      Mean   :46.33
##  3rd Qu.:773143533                      3rd Qu.:52.00
##  Max.   :828343083                      Max.   :73.00
##  Dependent_count Education_Level    Marital_Status     Income_Category
```

```
##  Min.   :0.000   Length:10127       Length:10127       Length:10127
##  1st Qu.:1.000   Class :character   Class :character   Class :characte
r
##  Median :2.000   Mode  :character   Mode  :character   Mode  :characte
r
##  Mean   :2.346
##  3rd Qu.:3.000
##  Max.   :5.000
##  Card_Category      Months_on_book  Total_Relationship_Count
##  Length:10127       Min.   :13.00   Min.   :1.000
##  Class :character   1st Qu.:31.00   1st Qu.:3.000
##  Mode  :character   Median :36.00   Median :4.000
##                     Mean   :35.93   Mean   :3.813
##                     3rd Qu.:40.00   3rd Qu.:5.000
##                     Max.   :56.00   Max.   :6.000
##  Months_Inactive_12_mon Contacts_Count_12_mon  Credit_Limit
##  Min.   :0.000          Min.   :0.000         Min.   : 1438
##  1st Qu.:2.000          1st Qu.:2.000         1st Qu.: 2555
##  Median :2.000          Median :2.000         Median : 4549
##  Mean   :2.341          Mean   :2.455         Mean   : 8632
##  3rd Qu.:3.000          3rd Qu.:3.000         3rd Qu.:11068
##  Max.   :6.000          Max.   :6.000         Max.   :34516
##  Total_Revolving_Bal Avg_Open_To_Buy Total_Amt_Chng_Q4_Q1 Total_Trans_
Amt
##  Min.   :   0        Min.   :    3   Min.   :0.0000       Min.   :  51
0
##  1st Qu.: 359        1st Qu.: 1324   1st Qu.:0.6310       1st Qu.: 215
6
##  Median :1276        Median : 3474   Median :0.7360       Median : 389
9
##  Mean   :1163        Mean   : 7469   Mean   :0.7599       Mean   : 440
4
##  3rd Qu.:1784        3rd Qu.: 9859   3rd Qu.:0.8590       3rd Qu.: 474
1
##  Max.   :2517        Max.   :34516   Max.   :3.3970       Max.   :1848
4
##  Total_Trans_Ct   Total_Ct_Chng_Q4_Q1 Avg_Utilization_Ratio  Churners
##  Min.   : 10.00   Min.   :0.0000      Min.   :0.0000        Mode :logi
cal
##  1st Qu.: 45.00   1st Qu.:0.5820      1st Qu.:0.0230        FALSE:8500
##  Median : 67.00   Median :0.7020      Median :0.1760        TRUE :1627
##  Mean   : 64.86   Mean   :0.7122      Mean   :0.2749
##  3rd Qu.: 81.00   3rd Qu.:0.8180      3rd Qu.:0.5030
##  Max.   :139.00   Max.   :3.7140      Max.   :0.9990
```

All the variables are transformed into factor to avoid future codyfing problems.

```
Bank_table <- mutate_if(BankChurners, is.character, as.factor)

Bank_table <- mutate_if(BankChurners, is.double, as.factor)
```

```
Bank_table <- mutate_if(BankChurners, is.logical, as.factor)

str(Bank_table)
```

```
## tibble [10,127 × 22] (S3: tbl_df/tbl/data.frame)
##  $ CLIENTNUM               : num [1:10127] 768805383 818770008 7139821
08 769911858 709106358 ...
##  $ Attrition_Flag          : chr [1:10127] "Existing Customer" "Existi
ng Customer" "Existing Customer" "Existing Customer" ...
##  $ Customer_Age            : num [1:10127] 45 49 51 40 40 44 51 32 37
48 ...
##  $ Gender                  : chr [1:10127] "M" "F" "M" "F" ...
##  $ Dependent_count         : num [1:10127] 3 5 3 4 3 2 4 0 3 2 ...
##  $ Education_Level         : chr [1:10127] "High School" "Graduate" "G
raduate" "High School" ...
##  $ Marital_Status          : chr [1:10127] "Married" "Single" "Married
" "Unknown" ...
##  $ Income_Category         : chr [1:10127] "$60K - $80K" "Less than $4
0K" "$80K - $120K" "Less than $40K" ...
##  $ Card_Category           : chr [1:10127] "Blue" "Blue" "Blue" "Blue"
...
##  $ Months_on_book          : num [1:10127] 39 44 36 34 21 36 46 27 36
36 ...
##  $ Total_Relationship_Count: num [1:10127] 5 6 4 3 5 3 6 2 5 6 ...
##  $ Months_Inactive_12_mon  : num [1:10127] 1 1 1 4 1 1 1 2 2 3 ...
##  $ Contacts_Count_12_mon   : num [1:10127] 3 2 0 1 0 2 3 2 0 3 ...
##  $ Credit_Limit            : num [1:10127] 12691 8256 3418 3313 4716 .
..
##  $ Total_Revolving_Bal     : num [1:10127] 777 864 0 2517 0 ...
##  $ Avg_Open_To_Buy         : num [1:10127] 11914 7392 3418 796 4716 ..
.
##  $ Total_Amt_Chng_Q4_Q1    : num [1:10127] 1.33 1.54 2.59 1.4 2.17 ...
##  $ Total_Trans_Amt         : num [1:10127] 1144 1291 1887 1171 816 ...
##  $ Total_Trans_Ct          : num [1:10127] 42 33 20 20 28 24 31 36 24
32 ...
##  $ Total_Ct_Chng_Q4_Q1     : num [1:10127] 1.62 3.71 2.33 2.33 2.5 ...
##  $ Avg_Utilization_Ratio   : num [1:10127] 0.061 0.105 0 0.76 0 0.311
0.066 0.048 0.113 0.144 ...
##  $ Churners                : Factor w/ 2 levels "FALSE","TRUE": 1 1 1
1 1 1 1 1 1 1 ...
```

· Classification model construction

In this point of the study, it is important to consider a method that includes only the variables that are significantly related to the churn. As we previously saw in correlation analysis, these variables are “Contact_counts_12_mon” and “Months_Inactive_12_mon”. It is better to discard the rest of the variables if we want to achieve a more accurate result.

```
set.seed(123)  #For more reproducibility
trainIndex <- createDataPartition(Bank_table$Churners, p = 0.7, list = FA
LSE)
trainData <- Bank_table[trainIndex, ]
testData <- Bank_table[-trainIndex, ]

Bank_table$random<-sample(0:1,size = nrow(Bank_table),replace = T,prob =
c(0.3,0.7))

rl<- glm(Churners ~ Contacts_Count_12_mon + Months_Inactive_12_mon, train
Data, family=binomial(link='logit'))

summary(rl)

##
## Call:
## glm(formula = Churners ~ Contacts_Count_12_mon + Months_Inactive_12_mo
n,
##     family = binomial(link = "logit"), data = trainData)
##
## Coefficients:
##                         Estimate Std. Error z value            Pr(>|z|)
## (Intercept)             -3.95010    0.12862  -30.71 <0.0000000000000002
***
## Contacts_Count_12_mon    0.48691    0.03158   15.42 <0.0000000000000002
***
## Months_Inactive_12_mon  0.40498    0.03174   12.76 <0.0000000000000002
***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 6249.4  on 7088  degrees of freedom
## Residual deviance: 5828.6  on 7086  degrees of freedom
## AIC: 5834.6
##
## Number of Fisher Scoring iterations: 5
```

Interpretation of the coefficients:

Intercept (Constant): -3.95010

The intercept value indicates that when both the number of contacts and inactive months are 0, the log-odds of churn is -3.95010. This value is difficult to interpret directly, but it indicates a low probability of churn in that baseline case (no contacts and no inactivity).

Contacts_Count_12_mon (0.48691):

Each additional contact in the past 12 months increases the log-odds of a customer churning by 0.48691. In terms of probability, this means that a higher number of contacts leads to a higher likelihood of the customer churning. A positive coefficient indicates that customer contacts are correlated with a higher risk of churn.

Probability: To better interpret this number, it could be converted it to an odds ratio: e^0.48691 ≈ 1.627. This means that for every additional contact, the likelihood of churn increases by approximately 62.7%.

Months_Inactive_12_mon (0.40498):

Related to the months inactive, each additional month of inactivity in the past 12 months increases the log-odds of churn by 0.40498. Talking about probability, a customer who has been inactive for a longer time is more likely to churn. The positive coefficient indicates that more months of inactivity are associated with a higher risk of churn.

Probability: We convert this coefficient to an odds ratio: e^0.40498 ≈ 1.499 This means that for every additional month of inactivity, the likelihood of churn increases by approximately 49.9%.

Significance of the coefficients: The p-values (Pr(>|z|)) are extremely small for both predictor variables (Contacts_Count_12_mon and Months_Inactive_12_mon), meaning they are statistically significant. This implies that we can conclude with a high level of confidence that both the number of contacts and months of inactivity significantly influence the probability of a customer churning.

#Conclusions of this model:

· *Contacts_Count_12_mon:* The more contacts a customer has had with the company in the past 12 months, the higher the likelihood of churn. This suggests that more interactions (perhaps related to problems or complaints) could be a sign of dissatisfaction.

· *Months_Inactive_12_mon:* The more months a customer has been inactive in the past 12 months, the higher the likelihood of churn. Prolonged inactivity is a strong indicator that the customer may leave the company.

All in all, both factors have a significant impact on the likelihood of churn. These findings could help the company focus its efforts on customers with high contact frequency or long periods of inactivity to try to retain them.

Now let's delve into another model: RandomForest

```
model <- randomForest(Churners ~ Contacts_Count_12_mon + Months_Inactive_
12_mon, data = trainData)
print(model)

##
## Call:
```

```
##  randomForest(formula = Churners ~ Contacts_Count_12_mon + Months_Inac
tive_12_mon,      data = trainData)
##                Type of random forest: classification
##                      Number of trees: 500
## No. of variables tried at each split: 1
##
##         OOB estimate of  error rate: 15.49%
## Confusion matrix:
##       FALSE TRUE  class.error
## FALSE  5945    5 0.0008403361
## TRUE   1093   46 0.9596136962

summary(model)

##                 Length Class  Mode
## call               3  -none- call
## type               1  -none- character
## predicted        7089  factor numeric
## err.rate         1500  -none- numeric
## confusion           6  -none- numeric
## votes           14178  matrix numeric
## oob.times        7089  -none- numeric
## classes             2  -none- character
## importance          2  -none- numeric
## importanceSD        0  -none- NULL
## localImportance     0  -none- NULL
## proximity           0  -none- NULL
## ntree               1  -none- numeric
## mtry                1  -none- numeric
## forest             14  -none- list
## y                7089  factor numeric
## test                0  -none- NULL
## inbag               0  -none- NULL
## terms               3  terms  call

# Trying to increase the number of trees to 1000 to improve the model
random_forest_model <- randomForest(
  formula = Churners ~ Contacts_Count_12_mon + Months_Inactive_12_mon,
  data = trainData,
  ntree = 1000
)

print(random_forest_model)

##
## Call:
##  randomForest(formula = Churners ~ Contacts_Count_12_mon + Months_Inac
tive_12_mon,      data = trainData, ntree = 1000)
##                Type of random forest: classification
##                      Number of trees: 1000
## No. of variables tried at each split: 1
```

```
##
##         OOB estimate of  error rate: 15.5%
## Confusion matrix:
##       FALSE TRUE  class.error
## FALSE  5945    5 0.0008403361
## TRUE   1094   45 0.9604916594
```

Key results:

OOB (Out-of-Bag) error estimate: The 15.5% OOB error means the model misclassifies 15.5% of the observations when they are not used in training. This is a measure of the model's accuracy, and a 15.5% error is relatively high.

Confusion matrix:

#FALSE class (non-churners): The model correctly predicted 5945 observations. It incorrectly classified 5 observations as churners (TRUE). The class error for non-churners is very low, at 0.084%, indicating the model is very good at identifying customers who do not churn.

#TRUE class (churners): Only 45 churners were correctly classified. 1094 churners were incorrectly classified as non-churners. The class error is very high, at 96%, meaning the model struggles significantly to identify churners.

General interpretation:

The model has a low error rate for correctly predicting customers who do not churn, but it performs very poorly when predicting those who do churn, suggesting it is highly imbalanced or that the selected variables are not sufficient to adequately capture churn behavior. It could be improved by tuning the model parameters, adding more predictive variables, or addressing the class imbalance.

```
confusion<-function(real,scoring,umbral){
  conf<-table(real,scoring>=umbral)
  if(ncol(conf)==2) return(conf) else return(NULL)
}

metrics<-function(matrix_conf){
  success <- (matrix_conf[1,1] + matrix_conf[2,2]) / sum(matrix_conf) *10
0
  precision <- matrix_conf[2,2] / (matrix_conf[2,2] + matrix_conf[1,2]) *
100
  recall <- matrix_conf[2,2] / (matrix_conf[2,2] + matrix_conf[2,1]) *100
  F1 <- 2*precision*recall/(precision+recall)
  output<-c(success,precision,recall,F1)
  return(output)
}


thresholds<-function(real,scoring){
```

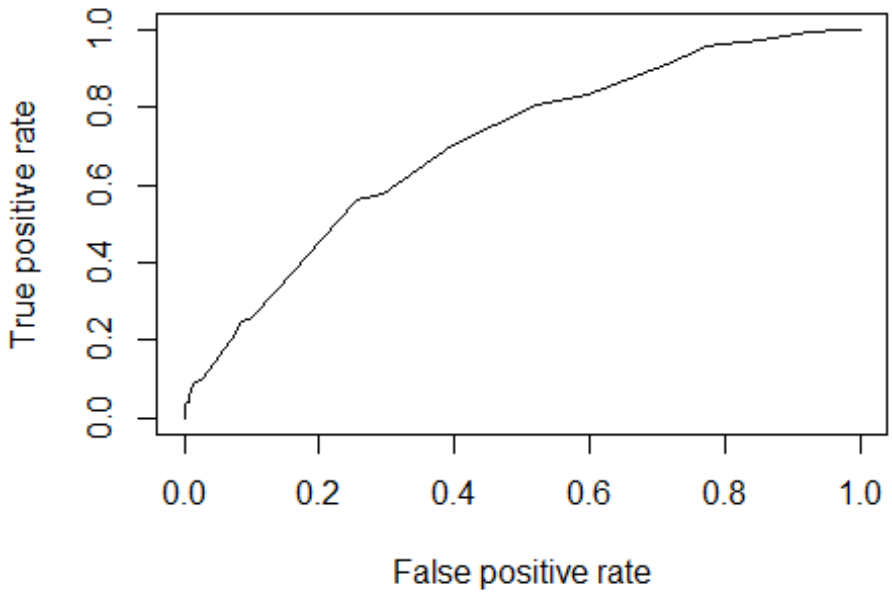
```
  thresholds<-data.frame(
threshold=rep(0,times=19),success=rep(0,times=19),precision=rep(0,times=1
9),recall=rep(0,times=19),F1=rep(0,times=19))
  cont <- 1
  for (cada in seq(0.05,0.95,by = 0.05)){
    data<-metrics(confusion(real,scoring,cada))
    register<-c(cada,data)
    thresholds[cont,]<-register
    cont <- cont + 1
  }
  return(thresholds)
}

roc<-function(prediction){
  r<-performance(prediction,'tpr','fpr')
  plot(r)
}

auc<-function(prediction){
  a<-performance(prediction,'auc')
  return(a@y.values[[1]])
}

rl_predict<-predict(rl,testData,type = 'response')
head(rl_predict)
```

```
##          1          2          3          4          5          6
## 0.02805514 0.13666357 0.11062343 0.10281561 0.21849916 0.14662174
```

```
thr_rl<-thresholds(testData$Churners,rl_predict)
thr_rl
```

```
##    threshold  success precision     recall        F1
## 1       0.05 22.25148  17.03026 99.1803279 29.069069
## 2       0.10 38.77551  19.64602 90.9836066 32.314410
## 3       0.15 62.01448  25.36982 70.2868852 37.282609
## 4       0.20 70.96774  29.21941 56.7622951 38.579387
## 5       0.25 79.92100  33.60215 25.6147541 29.069767
## 6       0.30 80.97433  35.19737 21.9262295 27.020202
## 7       0.35 83.47597  43.63636  9.8360656 16.053512
## 8       0.40 84.16722  54.43038  8.8114754 15.167549
## 9       0.45 84.03555  54.28571  3.8934426  7.265774
## 10      0.50 84.29888  73.91304  3.4836066  6.653620
## 11      0.55 83.96972  66.66667  0.4098361  0.814664
## 12      0.60 83.96972  66.66667  0.4098361  0.814664
## 13      0.65 83.96972 100.00000  0.2049180  0.408998
## 14      0.70 83.96972 100.00000  0.2049180  0.408998
## 15      0.75  0.75000   0.75000  0.7500000  0.750000
## 16      0.80  0.80000   0.80000  0.8000000  0.800000
## 17      0.85  0.85000   0.85000  0.8500000  0.850000
```

```
## 18      0.90  0.90000   0.90000  0.9000000  0.900000
## 19      0.95  0.95000   0.95000  0.9500000  0.950000

thr_final_rl<-thr_rl[which.max(thr_rl$F1),1]
thr_final_rl

## [1] 0.2

confusion(testData$Churners,rl_predict,thr_final_rl)

##
## real    FALSE TRUE
##   FALSE  1879  671
##   TRUE    211  277

rl_metrics<-filter(thr_rl,threshold==thr_final_rl)
rl_metrics

##   threshold  success precision  recall       F1
## 1       0.2 70.96774  29.21941 56.7623 38.57939

#Creation of prediction object
rl_prediction<-prediction(rl_predict,testData$Churners)
#ROC
roc_curve <-roc(rl_prediction)
```



```r
auc<-function(rl_prediction){
  a<-performance(rl_prediction,'auc')
  return(a@y.values[[1]])
}

rl_metrics<-cbind(rl_metrics,AUC=round(auc(rl_prediction),2)*100)
print(t(rl_metrics))
```

```
##                [,1]
## threshold  0.20000
## success   70.96774
## precision 29.21941
## recall    56.76230
## F1        38.57939
## AUC       70.00000
```

Summary and Interpretation:

Success Rate: The model has a success rate of 70.97% for correctly identifying customers who churn with this threshold.

Precision and Recall: Precision is relatively low (29.22%), suggesting many false positives (customers classified as churners who are not). Recall is moderate (56.76%), indicating that the model is reasonably good at identifying most churners, but not perfect.

F1 Score: The F1 score of 38.58 reflects a balance between precision and recall, but the value is low, suggesting there is room for improvement in both aspects.

AUC: The AUC value of 70.00% is decent but also indicates that the model has room for improvement in its ability to discriminate between the two classes.

##4. Expected Results and Next Steps

At the end of the analysis, the goal is to have a list of factors that are highly related to the churn rate. This will allow the company three key takeaways:

· *Identify pain points:* If it is found that a high number of inactivity months is associated with churn, the company could improve its customer service to resolve issues more efficiently and reduce churn.

· *Personalize offers:* With the segmentation into “High” and “Low” usage, specific offers can be designed for each group, improving satisfaction and reducing the likelihood of churn.

· *Improve predictive models:* Using the data and analysis, models can be created to more accurately predict which customers are at higher risk of leaving, allowing the company to take preventive measures.

These insights can take us further; let’s consider a few questions: How can we reduce the churn rate more effectively? How would you select these clients in order to

maximize the success and benefit of these actions? We should focus on applying this analysis to a specific target audience.

```
BankChurners$churn_prob <- predict(rl, BankChurners, type = "response")
top_500_customers <- BankChurners %>% arrange(desc(churn_prob)) %>% head(
500)
head(top_500_customers)

## # A tibble: 6 × 23
##   CLIENTNUM Attrition_Flag   Customer_Age Gender Dependent_count Educa
tion_Level
##       <dbl> <chr>                   <dbl> <chr>            <dbl> <chr>
## 1 804829533 Attrited Custom…           59 M                    0 High
School
## 2 709649958 Attrited Custom…           62 M                    0 Post-
Graduate
## 3 713110908 Existing Custom…           30 M                    1 Unkno
wn
## 4 807587433 Attrited Custom…           56 F                    2 Docto
rate
## 5 712378983 Attrited Custom…           54 M                    1 Unkno
wn
## 6 768632958 Attrited Custom…           59 F                    1 Gradu
ate
## # ⓘ 17 more variables: Marital_Status <chr>, Income_Category <chr>,
## #   Card_Category <chr>, Months_on_book <dbl>, Total_Relationship_Coun
t <dbl>,
## #   Months_Inactive_12_mon <dbl>, Contacts_Count_12_mon <dbl>,
## #   Credit_Limit <dbl>, Total_Revolving_Bal <dbl>, Avg_Open_To_Buy <db
l>,
## #   Total_Amt_Chng_Q4_Q1 <dbl>, Total_Trans_Amt <dbl>, Total_Trans_Ct
<dbl>,
## #   Total_Ct_Chng_Q4_Q1 <dbl>, Avg_Utilization_Ratio <dbl>, Churners <
lgl>,
## #   churn_prob <dbl>
```

##5. Conclusions

· Months of inactivity have a significant impact on churn.

· The more contacts a customer has had with the company in the past 12 months, the higher the likelihood of churn. This suggests that more interactions could be a sign of dissatisfaction.

· The logistic regression model has acceptable accuracy, suggesting it is suitable for predicting churn.

· Marketing campaigns can be more effective if they target a cluster of customers identified as having a higher likelihood of churn.