

Homework 04

CUNY MSDS DATA 621

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1 HOMEWORK

1.1 Overview

In this homework assignment, you will explore, analyze and model a data set containing approximately 8000 records representing a customer at an auto insurance company. Each record has two response variables. The first response variable, **TARGET_FLAG**, is a 1 or a 0. A “1” means that the person was in a car crash. A zero means that the person was not in a car crash. The second response variable is **TARGET_AMT**. This value is zero if the person did not crash their car. But if they did crash their car, this number will be a value greater than zero.

1.2 Objective

Your objective is to build multiple linear regression and binary logistic regression models on the training data to predict the probability that a person will crash their car and also the amount of money it will cost if the person does crash their car. You can only use the variables given to you (or variables that you derive from the variables provided).

1.3 Dataset description

1.3.1 Variable definitions

The below list represent the definitions for each given variable.

VARIABLE_NAME	DEFINITION
INDEX	Identification Variable (do not use)
TARGET_FLAG	Was Car in a crash? 1=YES 0=NO
TARGET_AMT	If car was in a crash, what was the cost
AGE	Age of Driver
BLUEBOOK	Value of Vehicle
CAR_AGE	Vehicle Age
CAR_TYPE	Type of Car
CAR_USE	Vehicle Use
CLM_FREQ	# Claims (Past 5 Years)
EDUCATION	Max Education Level
HOMEKIDS	# Children at Home
HOME_VAL	Home Value
INCOME	Income
JOB	Job Category
KIDSDRIV	# Driving Children
MSTATUS	Marital Status
MVR_PTS	Motor Vehicle Record Points
OLDCLAIM	Total Claims (Past 5 Years)
PARENT1	Single Parent
RED_CAR	A Red Car
REVOKED	License Revoked (Past 7 Years)
SEX	Gender
TIF	Time in Force
TRAVTIME	Distance to Work
URBANICITY	Home/Work Area
YOJ	Years on Job

1.3.2 Theoretical effect of variables

The below list represent the theoretical effects for each given variable.

VARIABLE_NAME	THEORETICAL_EFFECT
INDEX	None
TARGET_FLAG	None
TARGET_AMT	None
AGE	Very young people tend to be risky. Maybe very old people also.
BLUEBOOK	Unknown effect on probability of collision, but probably effect the payout if there is a crash
CAR_AGE	Unknown effect on probability of collision, but probably effect the payout if there is a crash
CAR_TYPE	Unknown effect on probability of collision, but probably effect the payout if there is a crash
CAR_USE	Commercial vehicles are driven more, so might increase probability of collision
CLM_FREQ	The more claims you filed in the past, the more you are likely to file in the future
EDUCATION	Unknown effect, but in theory more educated people tend to drive more safely
HOMEKIDS	Unknown effect
HOME_VAL	In theory, home owners tend to drive more responsibly
INCOME	In theory, rich people tend to get into fewer crashes
JOB	In theory, white collar jobs tend to be safer
KIDSDRV	When teenagers drive your car, you are more likely to get into crashes
MSTATUS	In theory, married people drive more safely
MVR PTS	If you get lots of traffic tickets, you tend to get into more crashes
OLDCLAIM	If your total payout over the past five years was high, this suggests future payouts will be high
PARENT1	Unknown effect
RED_CAR	Urban legend says that red cars (especially red sports cars) are more risky. Is that true?
REVOKED	If your license was revoked in the past 7 years, you probably are a more risky driver.
SEX	Urban legend says that women have less crashes than men. Is that true?
TIF	People who have been customers for a long time are usually more safe.
TRAVTIME	Long drives to work usually suggest greater risk
URBANICITY	Unknown
YOJ	People who stay at a job for a long time are usually more safe

1.4 Deliverables

- A write-up submitted in PDF format. Your write-up should have four sections. Each one is described below. You may assume you are addressing me as a fellow data scientist, so do not need to shy away from technical details.
- Assigned predictions (probabilities, classifications, cost) for the evaluation data set. Use 0.5 threshold.
- Include your R statistical programming code in an Appendix.

2 DATA EXPLORATION

2.1 Data acquisition

For reproducibility purposes, I have included the original data sets in my Git Hub account, I will read it as a data frame from that location.

```
data.train <- get_data(git_user, git_dir, 'insurance_training_data.csv')
data.eval <- get_data(git_user, git_dir, 'insurance-evaluation-data.csv')
```

2.2 General exploration

The below process will help us obtain insights from our given data.

2.2.1 Dimensions

Let's see the dimensions of our training data set.

Records	Variables
8161	26

From the above table, we can see how the training data set has a total of 8161 different records and 26 variables including **INDEX**, **TARGET_FLAG** and **TARGET_AMT**. These variables do not represent much of the initial insights since they correspond to our response variables.

For simplicity reasons, I will discard the **INDEX** column.

```
remove_cols <- names(data.train) %in% c('INDEX')
data.train <- data.train[!remove_cols]
```

2.2.2 Structure

The below structure is currently present in the data, for simplicity reasons, I have previously loaded and treated this data set as a data frame in which all the variables with decimals are numeric.

variable	class	levels
TARGET_FLAG	integer	NA
TARGET_AMT	numeric	NA
KIDSDRV	integer	NA
AGE	integer	NA
HOMEKIDS	integer	NA
YOJ	integer	NA
INCOME	Factor w/ 6613 levels	"", "\$0", "\$1,007", "\$1,022", ...
PARENT1	Factor w/ 2 levels	"No", "Yes"
HOME_VAL	Factor w/ 5107 levels	"", "\$0", "\$100,093", "\$100,123", ...
MSTATUS	Factor w/ 2 levels	"Yes", "z_No"
SEX	Factor w/ 2 levels	"M", "z_F"
EDUCATION	Factor w/ 5 levels	"<High School", "Bachelors", "Masters", "PhD", ...
JOB	Factor w/ 9 levels	"", "Clerical", "Doctor", "Home Maker", ...
TRAVTIME	integer	NA

variable	class	levels
CAR_USE	Factor w/ 2 levels	“Commercial”, “Private”
BLUEBOOK	Factor w/ 2789 levels	“\$1,500”, “\$1,520”, “\$1,530”, “\$1,540”, ...
TIF	integer	NA
CAR_TYPE	Factor w/ 6 levels	“Minivan”, “Panel Truck”, “Pickup”, “Sports Car”, ...
RED_CAR	Factor w/ 2 levels	“no”, “yes”
OLDCLAIM	Factor w/ 2857 levels	“\$0”, “\$1,000”, “\$1,008”, “\$1,011”, ...
CLM_FREQ	integer	NA
REVOKE	Factor w/ 2 levels	“No”, “Yes”
MVR_PTS	integer	NA
CAR_AGE	integer	NA
URBANICITY	Factor w/ 2 levels	“Highly Urban/ Urban”, “z_Highly Rural/ Rural”

From the above table, we can notice how we need to take care of certain strings that are seeing as factors but in reality they are representing numbers and should not be seeing as factors. This will be addressed in more detail as we advance.

2.3 Summaries

Let's find some summary statistics about our given data, for that; I will get a little bit more insights for all the columns including the **TARGET_FLAG** and **TARGET_AMT** variables.

2.3.1 Combined Summary

In this section, we will explore the combined results as introductory insights.

```
data.train.summary <- get_df_summary(data.train)
data.train.summary
```

	Min	1st Qu	Median	Mean	3rd Qu	Max	Other
TARGET_FLAG	0	0	0	0.2638	1	1	
TARGET_AMT	0	0	0	1504	1036	107586	
KIDSDRV	0	0	0	0.1711	0	4	
AGE	16	39	45	44.79	51	81	NA's :6
HOMEKIDS	0	0	0	0.7212	1	5	
YOJ	0	9	11	10.5	13	23	NA's :454 (Other) :7086
INCOME							
PARENT1							
HOME_VAL							(Other) :5391
MSTATUS							
SEX							
EDUCATION							
JOB							(Other) :1413
TRAVTIME	5	22	33	33.49	44	142	
CAR_USE							
BLUEBOOK							(Other):7843
TIF	1	1	4	5.351	7	25	
CAR_TYPE							
RED_CAR							
OLDCLAIM							(Other):3134
CLM_FREQ	0	0	0	0.7986	2	5	

	Min	1st Qu	Median	Mean	3rd Qu	Max	Other
REVOKED							
MVR PTS	0	0	1	1.696	3	13	
CAR AGE	-3	1	8	8.328	12	28	NA's :510
URBANICITY							

Please note that this is for introductory insights and should not be considered as complete results.

2.3.2 TARGET_FLAG Summaries

In the mean time I will split the data into two data-sets depending on the **TARGET_FLAG**. Let's see some summaries for each group.

```
TARGET_FLAG_0 <- data.train[data.train$TARGET_FLAG == 0,]
TARGET_FLAG_1 <- data.train[data.train$TARGET_FLAG == 1,]
```

2.3.2.1 Number of records by group

The below table shows how many records each group has.

	Records	Percentage
TARGET_FLAG_0	6008	73.62
TARGET_FLAG_1	2153	26.38
TOTAL	8161	100.00

2.3.2.2 TARGET_FLAG = 0

Let's have a better look at the individualized summaries by having TARGET_FLAG = 0.

```
data.train.summary_0 <- get_df_summary(TARGET_FLAG_0)
data.train.summary_0
```

	Min	1st Qu	Median	Mean	3rd Qu	Max	Other
TARGET_FLAG	0	0	0	0	0	0	
TARGET_AMT	0	0	0	0	0	0	
KIDSDRV	0	0	0	0.1393	0	4	
AGE	16	40	46	45.32	51	81	NA's :1
HOMEKIDS	0	0	0	0.644	1	5	
YOJ	0	9	12	10.67	13	23	NA's :331 (Other) :5294
INCOME							
PARENT1							
HOME_VAL							(Other) :4205
MSTATUS							
SEX							
EDUCATION							
JOB							(Other) :1053
TRAVTIME	5	22	32	33.03	43	142	
CAR_USE							
BLUEBOOK							(Other):5789
TIF	1	1	6	5.556	8	25	
CAR_TYPE							

	Min	1st Qu	Median	Mean	3rd Qu	Max	Other
RED_CAR							
OLDCLAIM							(Other):1885
CLM_FREQ	0	0	0	0.6486	1	5	
REVOKE							
MVR_PTS	0	0	1	1.414	2	11	
CAR_AGE	0	4	9	8.671	13	28	NA's :368
URBANICITY							

2.3.2.3 TARGET_FLAG = 1

Let's have a better look at the individualized summaries by having TARGET_FLAG = 1.

```
data.train.summary_1 <- get_df_summary(TARGET_FLAG_1)
data.train.summary_1
```

	Min	1st Qu	Median	Mean	3rd Qu	Max	Other
TARGET_FLAG	1	1	1	1	1	1	
TARGET_AMT	30.28	2609.78	4104	5702.18	5787	107586.14	
KIDSDRV	0	0	0	0.2596	0	4	
AGE	16	37	43	43.3	50	76	NA's :5
HOMEKIDS	0	0	0	0.9368	2	5	
YOJ	0	9	11	10.02	13	19	NA's :123
INCOME							(Other) :1781
PARENT1							
HOME_VAL							(Other) :1178
MSTATUS							
SEX							
EDUCATION							
JOB							(Other) :302
TRAVTIME	5	24	34	34.77	45	97	
CAR_USE							
BLUEBOOK							(Other):2040
TIF	1	1	4	4.781	7	21	
CAR_TYPE							
RED_CAR							
OLDCLAIM							(Other):1244
CLM_FREQ	0	0	1	1.217	2	5	
REVOKE							
MVR_PTS	0	0	2	2.482	4	13	
CAR_AGE	-3	1	7	7.367	11	25	NA's :142
URBANICITY							

From the above reports, we can notice how we need to “transform” our data in order to make it more workable.

In order to do so, I will start to prep the data. Graphical visualizations and correlations will be provided later on since we need to address a few things in order to make our data more workable.

2.4 Findings

From the above table, is interesting to note as follows:

- The training data-set shows the presence of missing values or **NAs** in some columns; that can be seen in the **Other** column. This will be addressed as we prepare our data down the road.
- “**(Other)**” means that there are factor values that could not be grouped accordingly.
- Interesting to see that **CAR_AGE** shows a minimum value of -3. This needs to be investigated since it seems that it’s not accurate.
- The Maximum value for **TARGET_AMT** seems to be very far away from the mean and the median value. This needs to be evaluated and find out if this is accurate.

3 DATA PREPARATION

In this section, I will prepare our given data-set. For that I will need to address a few things, like factors and missing data.

3.1 Data conversion

In this section, I will describe the conversion of the data that is required in order to have a more manageable understanding of it.

3.1.1 FACTOR to NUMERIC

This section explains the conversions of currency values in which the system interpreted as factors when in reality these should have been treated as numeric type.

The variables that need to be converted are: **INCOME**, **HOME_VAL**, **BLUEBOOK** and **OLDCLAIM**.

3.1.2 FACTOR to “Dummy”

In this section, I will transform the remaining factor variables into various binary “Dummy” variables with values 1 for “Yes” and 0 for “No”.

The variables that need to be converted are: **PARENT1**, **MSTATUS**, **SEX**, **EDUCATION**, **JOB**, **CAR_USE**, **CAR_TYPE**, **RED_CAR**, **REVOKED** and **URBANICITY**.

Please note that there will be a new set of variables summarizing the above data as follows:

- **IS_SINGLE_PARENT** will represent if **PARENT1** = “Yes” with a value of 1; 0 otherwise.
- **IS_MARRIED** will represent if **MSTATUS** = “Yes” with a value of 1; 0 otherwise.
- **IS_FEMALE** will represent if **SEX** = “z_F” with a value of 1; 0 otherwise.
- **EDUCATION** will represent diverse **EDUCATION** levels, “<High School” is the default and this column was not included.
- **JOB** will represent diverse **JOB** levels, “Blank” is the default and this column was not included.
- **IS_CAR_PRIVATE_USE** will represent if **CAR_USE** = “Private” with a value of 1; 0 otherwise.
- **CAR_TYPE** will represent diverse **CAR_TYPE** levels, “Minivan” is the default and this column was not included.
- **IS_CAR_RED** will represent if **RED_CAR** = “Yes” with a value of 1; 0 otherwise.
- **IS_LIC_REVOKED** will represent if **REVOKED** = “Yes” with a value of 1; 0 otherwise.
- **IS_URBAN** will represent if **URBANICITY** = “Highly Urban/ Urban” with a value of 1; 0 otherwise.

Let's see our resulting table.

Column_Names
TARGET_FLAG
TARGET_AMT
KIDSDRV
AGE
HOMEKIDS

Column_Names
YOJ
INCOME
HOME_VAL
TRAVTIME
BLUEBOOK
TIF
OLDCLAIM
CLM_FREQ
MVR_PTS
CAR_AGE
IS_SINGLE_PARENT
IS_MARRIED
IS_FEMALE
EDUCATIONBachelors
EDUCATIONMasters
EDUCATIONPhD
EDUCATIONz_High.School
JOBClerical
JOBDoctor
JOBHome.Maker
JOBLawyer
JOBManager
JOBProfessional
JOBStudent
JOBz_Blue.Collar
IS_CAR_PRIVATE_USE
CAR_TYPEPanel.Truck
CAR_TYPEPickup
CAR_TYPESports.Car
CAR_TYPEVan
CAR_TYPEz_SUV
IS_CAR_RED
IS_LIC_REVOKED
IS_URBAN

3.2 NAs prep

First, let's see how our values are represented after the above transformations.

	Min	1st Qu	Median	Mean	3rd Qu	Max	Other
TARGET_FLAG	0	0	0	2.63800e-01	1	1	
TARGET_AMT	0	0	0	1.50400e+03	1036	107586	
KIDSDRV	0	0	0	1.71100e-01	0	4	
AGE	16	39	45	4.47900e+01	51	81	NA's :6
HOMEKIDS	0	0	0	7.21200e-01	1	5	
YOJ	0	9	11	1.05000e+01	13	23	NA's :454
INCOME	0	28097	54028	6.18980e+04	85986	367030	NA's :445
HOME_VAL	0	0	161160	1.54867e+05	238724	885282	NA's :464
TRAVTIME	5	22	33	3.34900e+01	44	142	
BLUEBOOK	1500	9280	14440	1.57100e+04	20850	69740	
TIF	1	1	4	5.35100e+00	7	25	

	Min	1st Qu	Median	Mean	3rd Qu	Max	Other
OLDCLAIM	0	0	0	4.03700e+03	4636	57037	
CLM_FREQ	0	0	0	7.98600e-01	2	5	
MVR PTS	0	0	1	1.69600e+00	3	13	
CAR AGE	-3	1	8	8.32800e+00	12	28	NA's :510
IS SINGLE PARENT	0	0	0	1.32000e-01	0	1	
IS MARRIED	0	0	1	5.99700e-01	1	1	
IS FEMALE	0	0	1	5.36100e-01	1	1	
EDUCATIONBachelors	0	0	0	2.74700e-01	1	1	
EDUCATIONMasters	0	0	0	2.03200e-01	0	1	
EDUCATIONPhD	0	0	0	8.92000e-02	0	1	
EDUCATIONz_High.School	0	0	0	2.85500e-01	1	1	
JOBClerical	0	0	0	1.55700e-01	0	1	
JOBDoctor	0	0	0	3.01400e-02	0	1	
JOBHome.Maker	0	0	0	7.85400e-02	0	1	
JOBLawyer	0	0	0	1.02300e-01	0	1	
JOBManager	0	0	0	1.21100e-01	0	1	
JOBProfessional	0	0	0	1.36900e-01	0	1	
JOBStudent	0	0	0	8.72400e-02	0	1	
JOBz_Blue.Collar	0	0	0	2.23600e-01	0	1	
IS CAR PRIVATE USE	0	0	1	6.28800e-01	1	1	
CAR TYPEPanel.Truck	0	0	0	8.28300e-02	0	1	
CAR TYPEPickup	0	0	0	1.70200e-01	0	1	
CAR TYPESports.Car	0	0	0	1.11100e-01	0	1	
CAR TYPEVan	0	0	0	9.19000e-02	0	1	
CAR TYPEz_SUV	0	0	0	2.81100e-01	1	1	
IS CAR RED	0	0	0	2.91400e-01	1	1	
IS LIC REVOKED	0	0	0	1.22500e-01	0	1	
IS URBAN	0	1	1	7.95500e-01	1	1	

In order to work the missing values, I will proceed as follows.

3.2.1 Proportion findings

Let's calculate the proportion of missing values in order to determine the best approach for these variables.

The below list display the combined missing percentage values for each variable.

	% Total missing
AGE	0.07
YOJ	5.56
INCOME	5.45
HOME_VAL	5.69
CAR AGE	6.25

3.2.1.1 NAs by TARGET_FLAG group

For this, let's see how many records each group has.

	% Total missing	% TARGET_FLAG = 0	% TARGET_FLAG = 1
AGE	0.07	0.02	0.23

	% Total missing	% TARGET_FLAG = 0	% TARGET_FLAG = 1
YOJ	5.56	5.51	5.71
INCOME	5.45	5.58	5.11
HOME_VAL	5.69	5.71	5.62
CAR_AGE	6.25	6.13	6.60

Since those values are considered low percentages compared to our data set; I will replace the missing NA values with randomly selected values in between the respective Min and Max value with the exception of CAR_AGE since it shows a negative value, hence I will select 0 to be the minimum value for that particular variable.

3.3 New Structure

In order to visualize our new structure, I will put together the new set of variables with the transformations. Let's see our structure once again, but this time after the transformation of the data.

variable	class	levels
TARGET_FLAG	integer	NA
TARGET_AMT	numeric	NA
KIDSDRV	integer	NA
AGE	integer	NA
HOMEKIDS	integer	NA
YOJ	integer	NA
INCOME	numeric	NA
HOME_VAL	numeric	NA
TRAVTIME	integer	NA
BLUEBOOK	numeric	NA
TIF	integer	NA
OLDCLAIM	numeric	NA
CLM_FREQ	integer	NA
MVR_PTS	integer	NA
CAR_AGE	integer	NA
IS_SINGLE_PARENT	numeric	NA
IS_MARRIED	numeric	NA
IS_FEMALE	numeric	NA
EDUCATIONBachelors	numeric	NA
EDUCATIONMasters	numeric	NA
EDUCATIONPhD	numeric	NA
EDUCATIONz_High.School	numeric	NA
JOBClerical	numeric	NA
JOBDoctor	numeric	NA
JOBHome.Maker	numeric	NA
JOBLawyer	numeric	NA
JOBManager	numeric	NA
JOBProfessional	numeric	NA
JOBStudent	numeric	NA
JOBz_Blue.Collar	numeric	NA
IS_CAR_PRIVATE_USE	numeric	NA
CAR_TYPEPanel.Truck	numeric	NA
CAR_TYPEPickup	numeric	NA
CAR_TYPESports.Car	numeric	NA

variable	class	levels
CAR_TYPEVan	numeric	NA
CAR_TYPEz_SUV	numeric	NA
IS_CAR_RED	numeric	NA
IS_LIC_REVOKED	numeric	NA
IS_URBAN	numeric	NA

3.4 CAR_AGE investigation

Let's find out why CAR_AGE has a minimum value of -3 which seems to be incorrect, for this I will select the records for **CAR_AGE < 0**, with the goal of identifying more possible unrealistic values.

	Values
TARGET_FLAG	1
TARGET_AMT	1469
KIDSDRV	0
AGE	47
HOMEKIDS	0
YOJ	12
INCOME	48696
HOME_VAL	212014
TRAVTIME	46
BLUEBOOK	15390
TIF	4
OLDCLAIM	33521
CLM_FREQ	3
MVR PTS	1
CAR_AGE	-3
IS_SINGLE_PARENT	0
IS_MARRIED	0
IS_FEMALE	1
EDUCATIONBachelors	1
EDUCATIONMasters	0
EDUCATIONPhD	0
EDUCATIONz_High.School	0
JOBClerical	0
JOBDoctor	0
JOBHome.Maker	0
JOBLawyer	0
JOBManager	0
JOBProfessional	1
JOBStudent	0
JOBz_Blue.Collar	0
IS_CAR_PRIVATE_USE	1
CAR_TYPEPanel.Truck	0
CAR_TYPEPickup	1
CAR_TYPESports.Car	0
CAR_TYPEVan	0
CAR_TYPEz_SUV	0
IS_CAR_RED	0
IS_LIC_REVOKED	1

	Values
IS_URBAN	1

From the above results, there seems to be no apparent reason as to why this value was entered. A possible reason could be that the person who typed the record, entered a wrong number; it could be probably 3 or 0 or any other value. In order to keep data integrity, I will remove that record from our data set.

3.5 Visualizations

From previous summary tables, we established that TARGET_FLAG groups have diverse values as means, from which we could start creating some hypothesis such as:

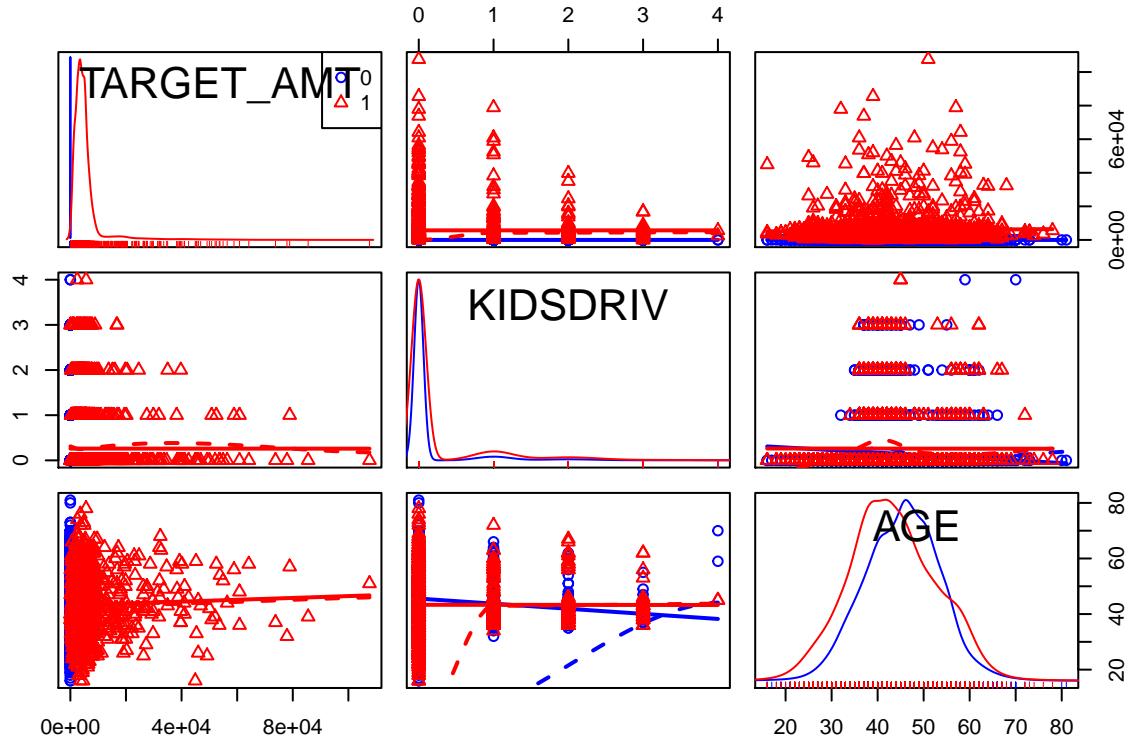
H_0 : The means for the divided data-set in which TARGET_FLAG = 1 and TARGET_FLAG = 0 are the same.

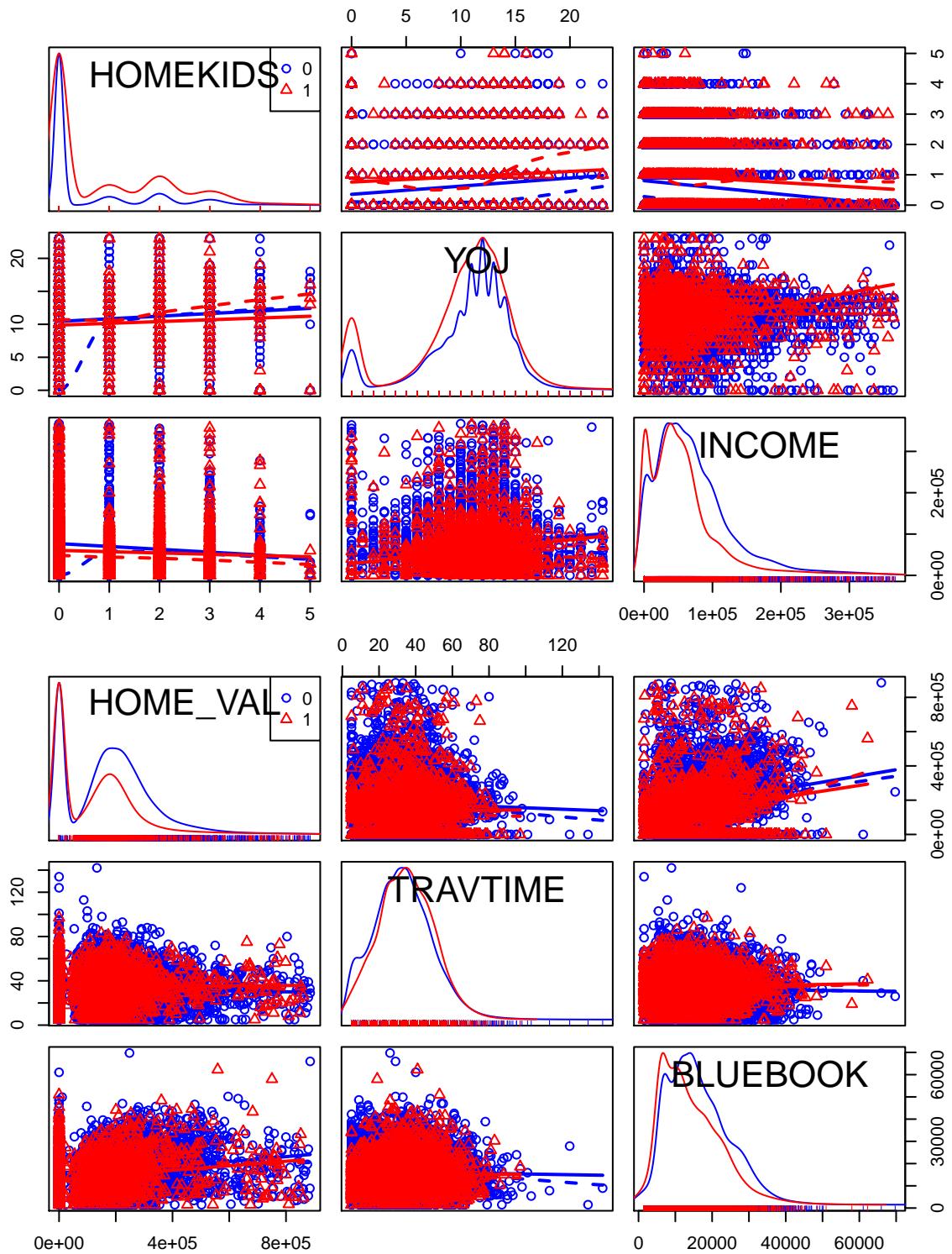
H_1 : The means for the divided data-set in which TARGET_FLAG = 1 and TARGET_FLAG = 0 are not the same.

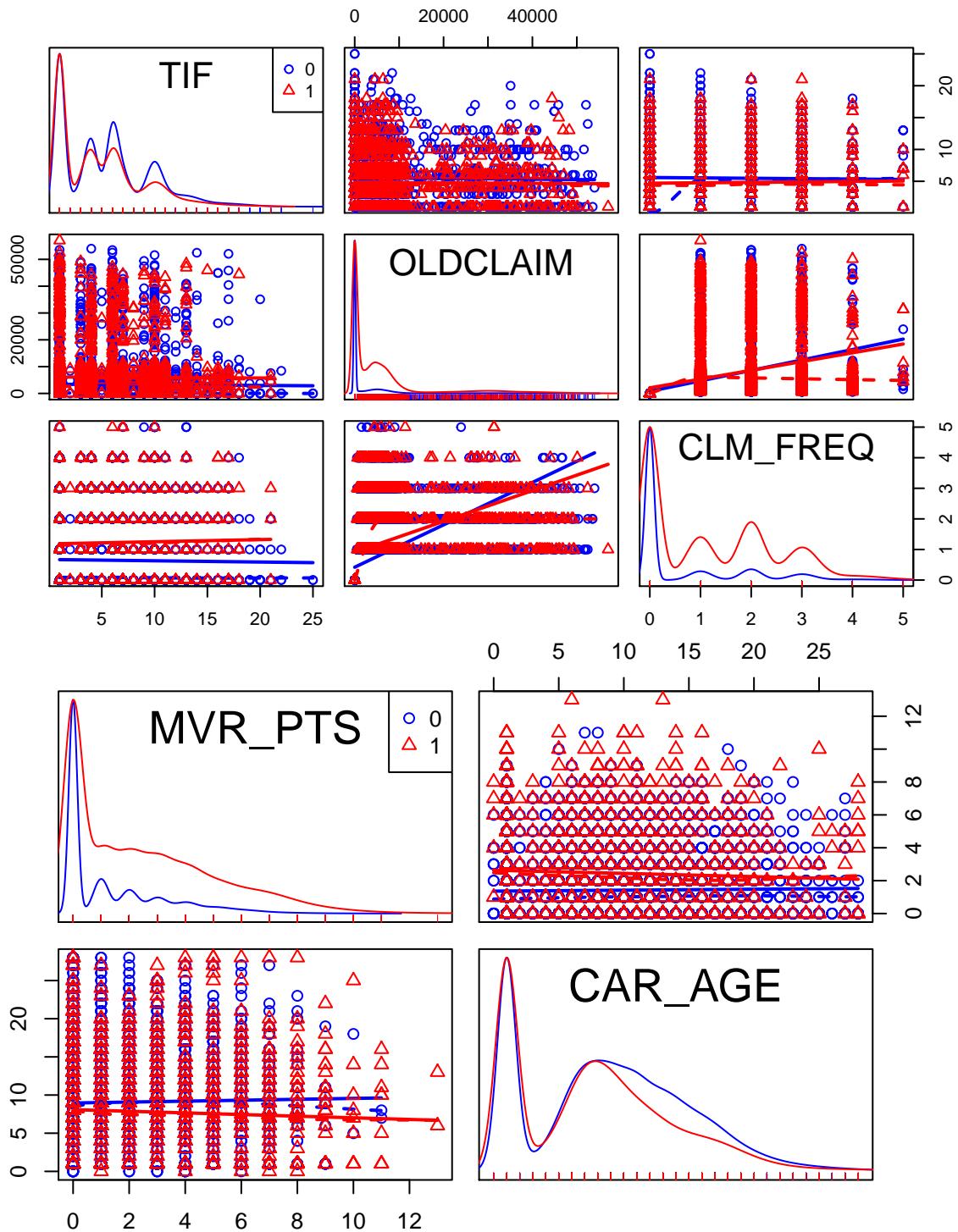
Let's create some visualizations and see how this data behave.

3.5.1 TARGET_FLAG vs other variables.

In this case, I will compare our data by separating our **TARGET_FLAG** values. That is, the light-green color represent “0” and the color red represent “1”, meaning that red was involved in a Car accident while blue or light green was not.

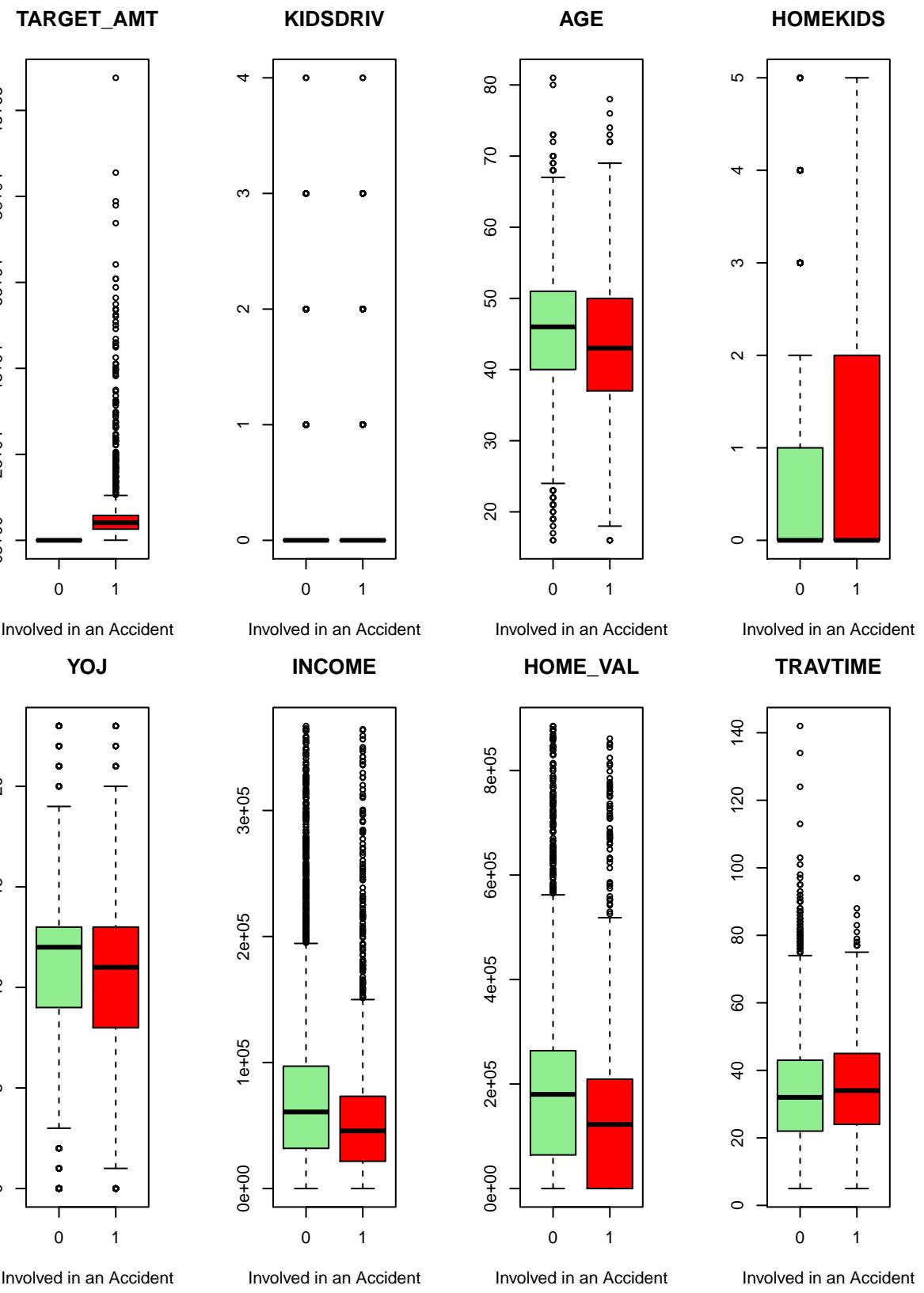


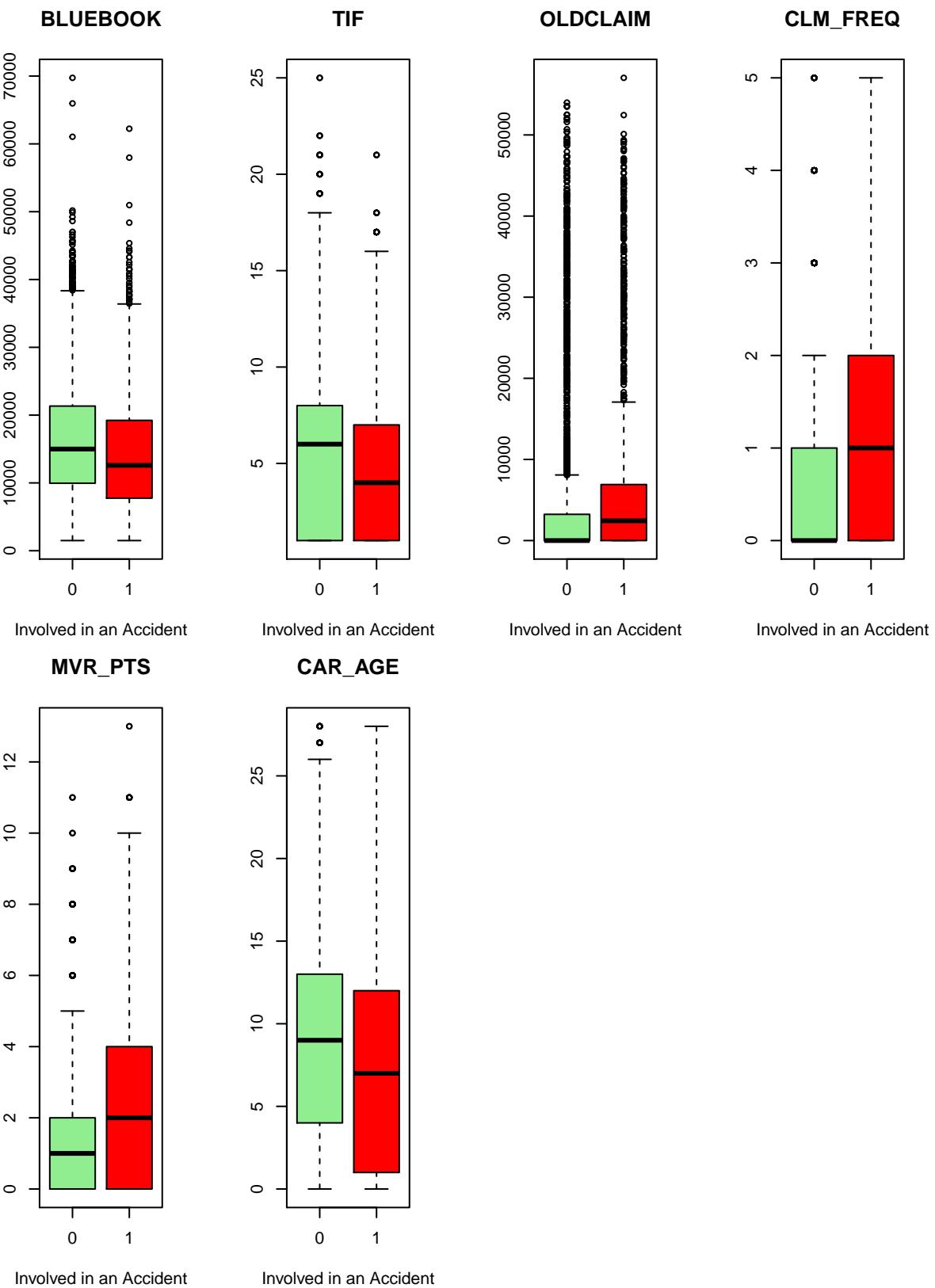




3.5.2 Box plots

From the previous visualizations, we can notice how some sort of relationship exist in between some of the variables. In order to create better understanding, let's visualize their behavior by analyzing individual cases.





Now, If we compare our previous plots and compare them to our given theoretical effect, we can see as follows:

- **AGE:** Definitely AGE seems to be an important factor, we can notice how the mean value on the

data-set that had an accident has a considerable age difference, implying that younger people are more risky.

- **BLUEBOOK:** Definitely, the values are considerably different for the means in terms of records having accidents vs the ones who do not. The BLUEBOOK mean value is lower when there's an accident, thus making sense for the data, since the car should have less value after an accident happens.
- **CAR_AGE:** This is very interesting, it seems that newer cars are more involved in accidents than older cars.
- **INCOME:** The provided data agree with the theoretical effect. That is, the mean income value of the people who are involved in accidents is lower than those who are not. From my perspective, this is something very interesting that could be studied in more detail. Perhaps this is a factor for economic growth, lower income individuals tend to have more accidents, hence limiting their income growth due to repair expenses, fees, fine, loss of time and insurance premiums hikes.
- **MVR PTS:** The data agree with this theoretical effect, it is noted how the mean of MVR PTS is higher when accidents are reported.
- **TIF:** This seems to be true, the data report a higher mean for those who do not have an accident.
- **TRAVTIME:** Not much of a difference but the data seems to agree.

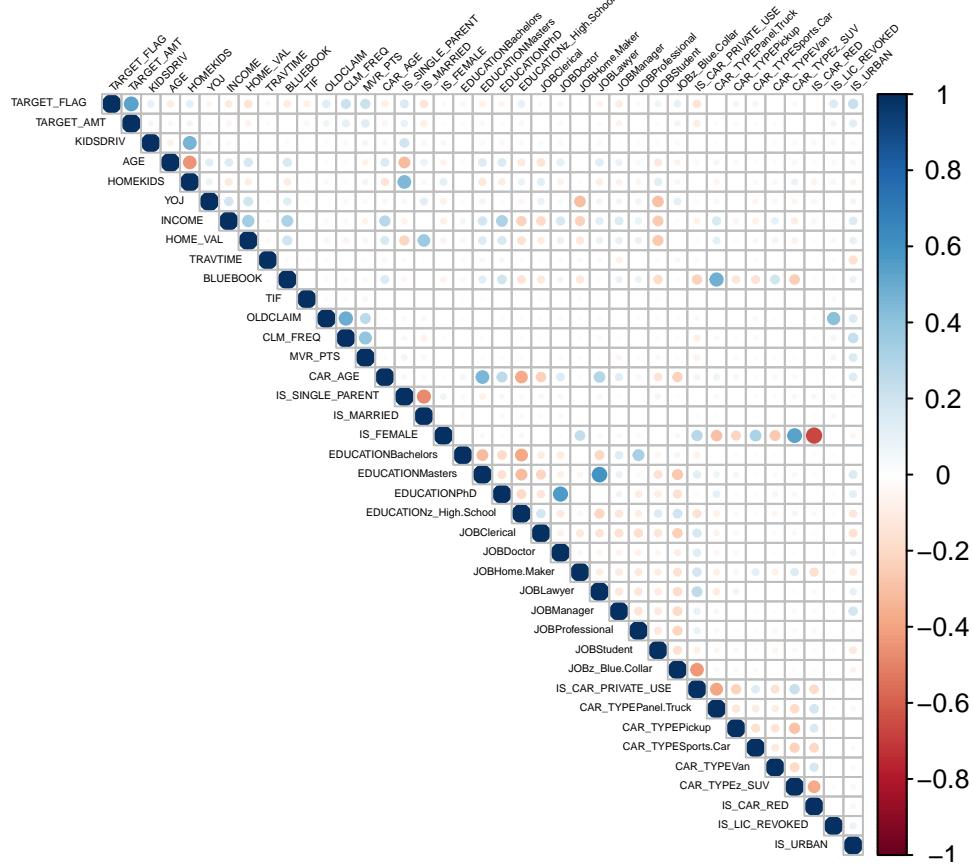
3.6 Correlations

Let's create some visualizations for the correlation matrix.

Let's start with a combined correlation, that is, no difference in between TARGET_FLAG.

3.6.1 Combined Graphical visualization

First, let's create a visual representation of correlations with a heatmap as a guide.



Something interesting to note from the above graph is the existing moderate negative correlation in between **IS_FEMALE** and **IS_RED_CAR**, the value for this correlation is: -0.6666. Now, at this point we should not make any inference from this data since **IS_FEMALE** means either “MALE” or “FEMALE” and **IS_RED_CAR** means either “Yes” or “No”. Further analysis needs to be performed to attain any conclusion related to those two variables.

Also, we can notice some moderate strong correlations from our given data set such as the relation ship in between **EDUCATIONPhD** and **JOBDoctor** with a correlation value of 0.5633. Another moderate correlation noticed in the data set is between **EDUCATIONMasters** and **JOBLawyer** with a correlation value of 0.5993.

3.6.2 Combined Numerical visualization

From the above graph, we can easily identify some sort of correlations in between the response variables **TARGET_FLAG** and **TARGET_AMT** and other variables.

Let's read our correlations table to gain extra insights.

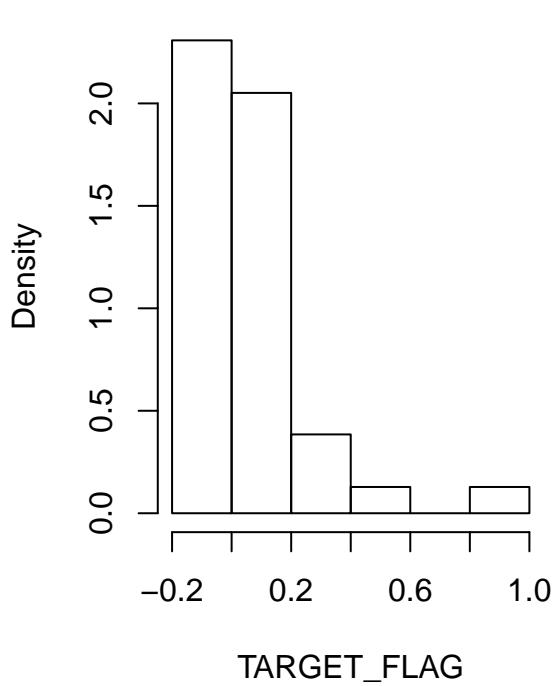
	TARGET_FLAG	TARGET_AMT
TARGET_FLAG	1.0000000	0.5343390
TARGET_AMT	0.5343390	1.0000000
KIDSDRV	0.1037552	0.0553942
AGE	-0.1009939	-0.0410444
HOMEKIDS	0.1157760	0.0619890
YOJ	-0.0583146	-0.0143049
INCOME	-0.1102605	-0.0539195
HOME_VAL	-0.1437383	-0.0633940

	TARGET_FLAG	TARGET_AMT
TRAVTIME	0.0482173	0.0279888
BLUEBOOK	-0.1033931	-0.0046996
TIF	-0.0823179	-0.0464814
OLDCLAIM	0.1375147	0.0710055
CLM_FREQ	0.2158917	0.1164467
MVR_PTS	0.2193023	0.1378661
CAR_AGE	-0.0880951	-0.0541220
IS_SINGLE_PARENT	0.1577305	0.0969660
IS_MARRIED	-0.1349096	-0.0876704
IS_FEMALE	0.0208928	-0.0110533
EDUCATIONBachelors	-0.0429995	-0.0172792
EDUCATIONMasters	-0.0762068	-0.0351720
EDUCATIONPhD	-0.0653596	-0.0244249
EDUCATIONz_High.School	0.1099203	0.0420985
JOBClerical	0.0274597	0.0078049
JOBDoctor	-0.0583510	-0.0347507
JOBHome.Maker	0.0113211	-0.0070821
JOBLawyer	-0.0616731	-0.0291860
JOBManager	-0.1053383	-0.0646074
JOBProfessional	-0.0391082	-0.0045465
JOBStudent	0.0770910	0.0244097
JOBz_Blue.Collar	0.1019157	0.0618307
IS_CAR_PRIVATE_USE	-0.1428605	-0.0986167
CAR_TYPEPanel.Truck	-0.0002809	0.0294682
CAR_TYPEPickup	0.0562177	0.0219152
CAR_TYPESports.Car	0.0573354	0.0232939
CAR_TYPEVan	0.0030861	0.0234793
CAR_TYPEz_SUV	0.0451690	0.0059422
IS_CAR_RED	-0.0068173	0.0080916
IS_LIC_REVOKED	0.1514836	0.0614149
IS_URBAN	0.2241890	0.1209762

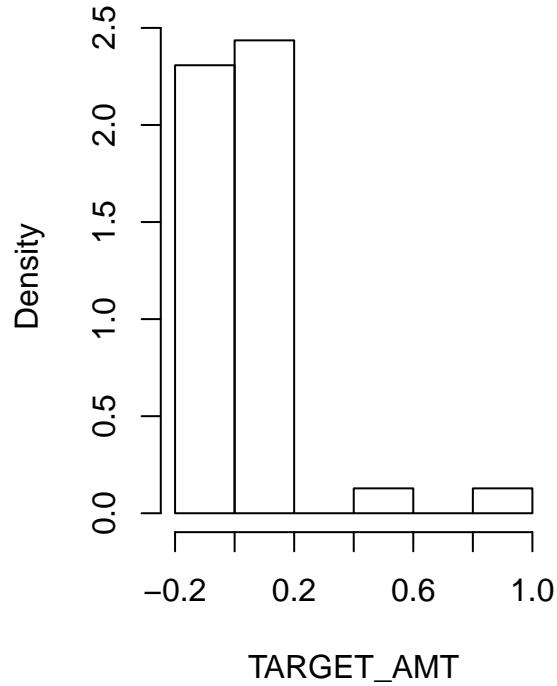
3.6.3 Combined Correlations histogram

Something very interesting to note from the above table, is that the correlations in between the data-sets seems to be very low. We can notice that in the below density distributions for the respective correlations.

Correlations Histogram



Correlations Histogram



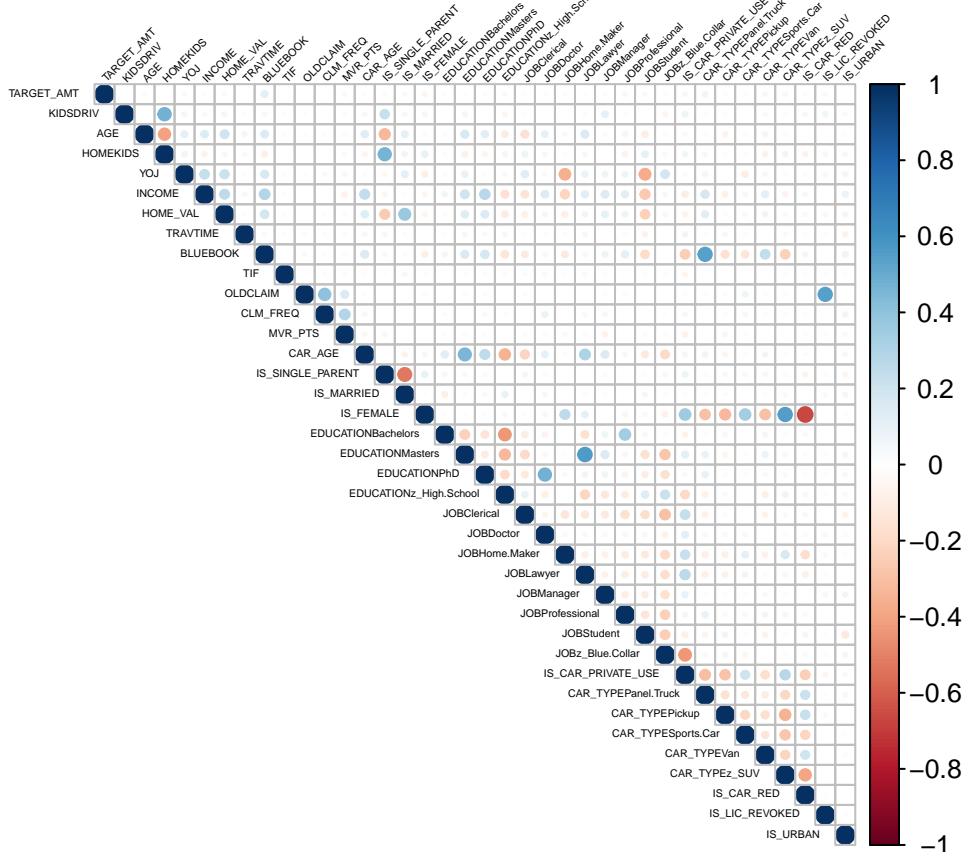
3.7 TARGET_FLAG = Accidents

Let's do a correlation analysis for the data set in which `TARGET_FLAG` = 1 (meaning it had an accident).

3.7.1 Accidents Graphical visualization

Let's create a visual representation of correlations with a heatmap as a guide for all records in which `TARGET_FLAG` = 1.

Please note that the row named `TARGET_FLAG` is not included since all records have `TARGET_FLAG` value of 1, making it redundant.



Same as before, it is interesting to note from the above graph, the existing moderate negative correlation in between `IS_FEMALE` and `IS_RED_CAR`, the value for this correlation is: -0.6678. Now, at this point we should not make any inference from this data since `IS_FEMALE` means either “MALE” or “FEMALE” and `IS_RED_CAR` means either “Yes” or “No”. Further analysis needs to be performed to attain any conclusion related to those two variables.

Also, we can notice how new moderate correlations appeared that were not present before the split; that is:

- `IS_FEMALE` seems to be moderately correlated to `CAR_TYPEz_SUV` with a value of 0.5529.
- `BLUEBOOK` seems to be moderately correlated to `CAR_TYPEPanel.Truck` with a value of 0.5484.
- `OLDCLAIM` seems to be moderately correlated to `IS_LIC_REVOKED` with a value of 0.5427.

Now, if we think about the data and their correlations, some data points seem to make sense. I will not extrapolate too much into this since our main goal is to create a Model in which we could predict the probability that a person will crash their car and also how much money it will cost if the person does crash the car. Hence, I will continue but will keep this correlations in mind.

3.7.2 Accidents Numerical visualization

From the above graph, we can easily identify some sort of correlations in between the response variables `TARGET_AMT` and the other variables.

Let's read our correlations table to gain extra insights.

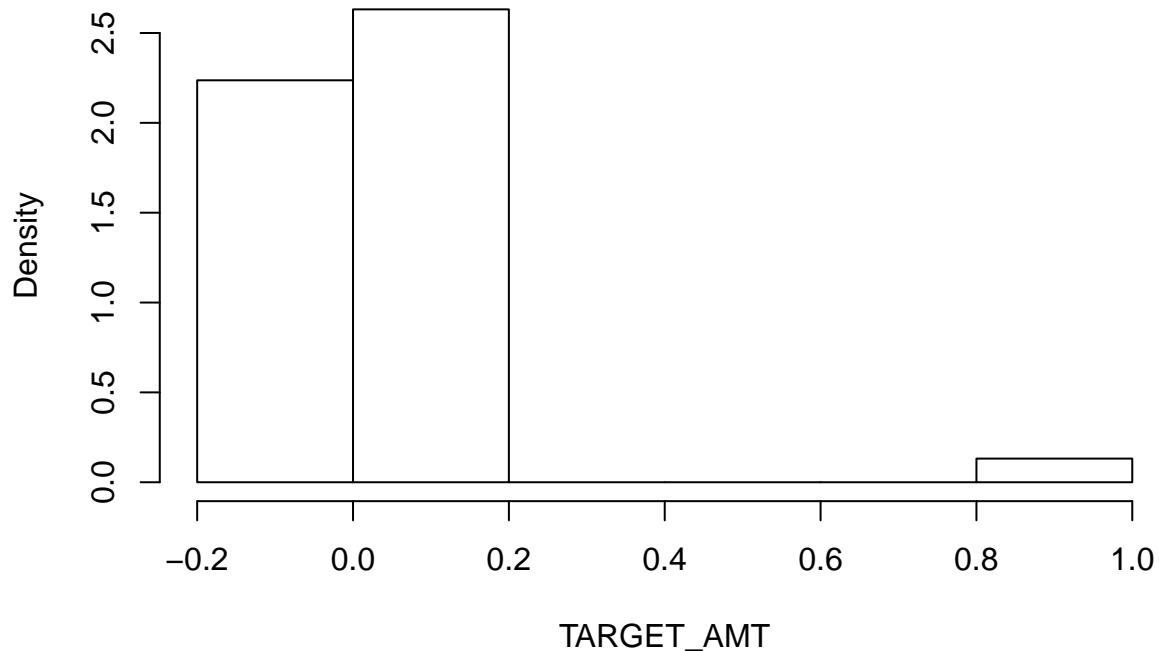
TARGET_AMT	
TARGET_AMT	1.000000

	TARGET_AMT
KIDSDRV	-0.0000869
AGE	0.0267510
HOMEKIDS	0.0002698
YOJ	0.0355627
INCOME	0.0119340
HOME_VAL	0.0313537
TRAVTIME	0.0053657
BLUEBOOK	0.1181297
TIF	-0.0060620
OLDCLAIM	-0.0049723
CLM_FREQ	0.0023251
MVR PTS	0.0396710
CAR AGE	-0.0164264
IS SINGLE PARENT	0.0238302
IS MARRIED	-0.0351848
IS FEMALE	-0.0513430
EDUCATIONBachelors	0.0136662
EDUCATIONMasters	0.0143267
EDUCATIONPhD	0.0294767
EDUCATIONz_High.School	-0.0358840
JOBClerical	-0.0151891
JOBDoctor	-0.0122018
JOBHome.Maker	-0.0293974
JOBLawyer	0.0102382
JOBManager	-0.0256129
JOBProfessional	0.0406747
JOBStudent	-0.0331511
JOBz_Blue.Collar	0.0155259
IS CAR PRIVATE USE	-0.0496142
CAR_TYPEPanel.Truck	0.0682806
CAR_TYPEPickup	-0.0174060
CAR_TYPESports.Car	-0.0152654
CAR_TYPEVan	0.0499290
CAR_TYPEz_SUV	-0.0405600
IS CAR RED	0.0271768
IS LIC REVOKED	-0.0365018
IS URBAN	0.0048888

3.7.3 Accidents Correlations histogram

Something very interesting to note from the above table, is that the correlations in between the data-sets seems to be very low. We can notice that behavior in the below density distribution for the respective correlations.

Correlations Histogram



3.8 Comparing Means

The below table, compare the means for both records indicated in the TARGET_FLAG variable, that is 1 = Accident vs 0 = No Accident.

	No Accident	Accident	Insights	Obs	Level
TARGET_FLAG	0.00	1.00	Inf % higher	-	***
TARGET_AMT	0.00	5704.15	Inf % higher	-	***
KIDSDRV	0.14	0.26	86 % higher	-	**
AGE	45.32	43.34	4 % lower	+	.
HOMEKIDS	0.64	0.94	47 % higher	-	*
YOJ	10.70	10.13	5 % lower	+	.
INCOME	72457.00	57593.00	21 % lower	+	.
HOME_VAL	183495.00	133802.00	27 % lower	+	*
TRAVTIME	33.03	34.77	5 % higher	-	.
BLUEBOOK	16231.00	14255.00	12 % lower	+	.
TIF	5.56	4.78	14 % lower	+	.
OLDCLAIM	3312.00	6049.00	83 % higher	-	**
CLM_FREQ	0.65	1.22	88 % higher	-	**
MVR_PTS	1.41	2.48	76 % higher	-	**
CAR_AGE	9.04	7.82	13 % lower	+	.
IS_SINGLE_PARENT	0.10	0.22	120 % higher	-	***
IS_MARRIED	0.64	0.49	23 % lower	+	.
IS_FEMALE	0.53	0.55	4 % higher	-	.
EDUCATIONBachelors	0.29	0.24	17 % lower	+	.
EDUCATIONMasters	0.22	0.15	32 % lower	+	*
EDUCATIONPhD	0.10	0.06	40 % lower	+	*
EDUCATIONz_High.School	0.26	0.37	42 % higher	-	*

	No Accident	Accident	Insights	Obs	Level
JOBClerical	0.15	0.17	13 % higher	-	.
JOBDoctor	0.04	0.01	75 % lower	+	**
JOBHome.Maker	0.08	0.08	No insights		
JOBLawyer	0.11	0.07	36 % lower	+	*
JOBManager	0.14	0.06	57 % lower	+	*
JOBProfessional	0.14	0.11	21 % lower	+	.
JOBStudent	0.07	0.12	71 % higher	-	*
JOBz_Blue.Collar	0.20	0.29	45 % higher	-	*
IS_CAR_PRIVATE_USE	0.67	0.51	24 % lower	+	.
CAR_TYPEPanel.Truck	0.08	0.08	No insights		
CAR_TYPEPickup	0.16	0.21	31 % higher	-	*
CAR_TYPESports.Car	0.10	0.14	40 % higher	-	*
CAR_TYPEVan	0.09	0.09	No insights		
CAR_TYPEz_SUV	0.27	0.32	19 % higher	-	.
IS_CAR_RED	0.29	0.29	No insights		
IS_LIC_REVOKED	0.09	0.21	133 % higher	-	***
IS_URBAN	0.74	0.95	28 % higher	-	*

It is very important to note how some insights are taken from the two data sets by comparing side by side. In order to identify those results, I have created two extra columns labeled **Obs** in which denotes how some variables could imply positive or negative outcomes related to accidents, the **Level** has four different indicators depending on the percentage increase as follows:

- **Pos:** Two options “+” or “-” meaning, the data shows an increase or decrease in between comparisons.
- **Level:** Has four level as follows:
 - “.”: Percentage of difference is less than 25%.
 - “**”: Percentage of difference is between [25, 75[%.
 - “***”: Percentage of difference is between [75, 100[%.
 - “****”: Percentage of difference is more or equal than 100%.

Also, is important to note that some variables seem to have a beneficial role in avoiding accidents, and that can be seeing in the above table as well.

Something worthy of mentioning is that our theoretical effect mentions: “*urban leyend says that women have less crashes than men*”. By looking at the above table, this legend could be answered as to be false, we could see a slight increase of FEMALES involved in car accidents in about 3% to 4% higher than not having accidents, that is an increase from about 0.53 to about 0.55. Also, we should expect a rate of about 50% since is considered even for insured drivers in America.

4 BUILD MODELS

At this point, we are getting ready to start building models, however I would like to point out that in this case is a little bit difficult to determine what data transformation could be used in order to refine our models.

4.1 Binary Logistic Regression Models

I would like to point that since this work requires **Binary Logistic Regression**, we are going to be using the **logit** function as our Likelihood link function for Logistic Regression by assuming that it follows a binomial

distribution as follows:

$$y_i|x_i \sim Bin(m_i, \theta(x_i))$$

so that,

$$P(Y_i = y_i|x_i) = \binom{m_i}{y_i} \theta(x_i)^{y_i} (1 - \theta(x_i))^{m_i - y_i}$$

Now, in order to solve our problem, we need to build a linear predictor model in which the individual predictors that compose the response Y_i are all subject to the same q predictors (x_{i1}, \dots, x_{iq}) . Please note that the group of predictors, are commonly known as **covariate classes**. In this case, we need a model that describes the relationship of x_1, \dots, x_q to p . In order to solve this problem, we will construct a linear predictor model as follows:

$$\eta_i = \beta_0 + \beta_1 x_{i1} + \dots + \beta_q x_{iq}$$

4.1.1 Logit link function

In this case, since we need to set $\eta_i = p_i$; with $0 \leq p_i \leq 1$, I will use the *link function* g such that $\eta_i = g(p_i)$ with $0 \leq g^{-1}(\eta) \leq 1$ for any η . In order to do so, I will pick the **Logit** link function $\eta = \log(p/(1-p))$.

An alternate way will be by employing the χ^2 Chi square distribution; for the purposes of this project, I will employ the use of the binomial distribution or the χ^2 depending on which one is a better choice, also I will assume that all Y_i are all independent of each other.

4.1.2 Binomial NULL Model

In this section I will build a **Binary Logistic Regression** Null model utilizing all the variables and data, please note that I won't do any transformations. This model will be considered to be valid and will be considered as we advance. In order to build this model, I will not include the **TARGET_AMT** variable since that will be employed in the next model build up.

```
##
## Call:
## glm(formula = TARGET_FLAG ~ 1, family = binomial(link = "logit"),
##      data = data.train.bin)
##
## Deviance Residuals:
##      Min        1Q    Median        3Q       Max
## -0.7825   -0.7825   -0.7825    1.6327    1.6327
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.02669    0.02512 -40.87   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 9415.3  on 8159  degrees of freedom
## Residual deviance: 9415.3  on 8159  degrees of freedom
```

```

## AIC: 9417.3
##
## Number of Fisher Scoring iterations: 4

```

I will assume that this to be a valid model.

4.1.3 Binomial FULL Model

In this section I will build a **Binary Logistic Regression** Full model utilizing all the variables and data, please note that I won't do any transformations. This model will be considered to be valid and will be considered as we advance.

```

##
## Call:
## glm(formula = TARGET_FLAG ~ ., family = binomial(link = "logit"),
##      data = data.train.bin)
##
## Deviance Residuals:
##    Min      1Q  Median      3Q     Max
## -2.5767 -0.7119 -0.4036  0.6227  3.1503
##
## Coefficients:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)              -2.994e+00  3.314e-01 -9.032 < 2e-16 ***
## KIDSDRV                  3.840e-01  6.107e-02   6.287 3.23e-10 ***
## AGE                     -7.555e-04  3.975e-03  -0.190  0.849257
## HOMEKIDS                 4.966e-02  3.692e-02   1.345  0.178586
## YOJ                      -7.653e-03  7.788e-03  -0.983  0.325777
## INCOME                   -1.625e-06  6.267e-07  -2.593  0.009526 **
## HOME_VAL                 -6.858e-07  2.348e-07  -2.921  0.003489 **
## TRAVTIME                  1.441e-02  1.881e-03   7.660  1.85e-14 ***
## BLUEBOOK                 -2.297e-05  5.212e-06  -4.407  1.05e-05 ***
## TIF                      -5.522e-02  7.330e-03  -7.534  4.92e-14 ***
## OLDCLAIM                 -1.422e-05  3.907e-06  -3.639  0.000274 ***
## CLM_FREQ                  1.999e-01  2.849e-02   7.014  2.31e-12 ***
## MVR PTS                  1.153e-01  1.360e-02   8.477 < 2e-16 ***
## CAR AGE                  -7.370e-04  6.266e-03  -0.118  0.906362
## IS SINGLE PARENT          3.825e-01  1.094e-01   3.497  0.000471 ***
## IS MARRIED                -5.582e-01  7.783e-02  -7.172  7.39e-13 ***
## IS FEMALE                 -8.132e-02  1.118e-01  -0.727  0.466943
## EDUCATIONBachelors        -4.376e-01  1.128e-01  -3.881  0.000104 ***
## EDUCATIONMasters           -3.537e-01  1.726e-01  -2.049  0.040433 *
## EDUCATIONPhD               -3.174e-01  2.051e-01  -1.548  0.121597
## EDUCATIONz_High.School    -3.047e-03  9.486e-02  -0.032  0.974379
## JOB Clerical                5.050e-01  1.942e-01   2.601  0.009297 **
## JOB Doctor                 -4.103e-01  2.654e-01  -1.546  0.122087
## JOB Home.Maker              4.230e-01  2.036e-01   2.078  0.037726 *
## JOB Lawyer                  1.266e-01  1.686e-01   0.751  0.452621
## JOB Manager                 -5.246e-01  1.705e-01  -3.077  0.002089 **
## JOB Professional             1.895e-01  1.775e-01   1.068  0.285511
## JOB Student                 4.288e-01  2.087e-01   2.055  0.039873 *
## JOBz Blue.Collar            3.499e-01  1.845e-01   1.896  0.057940 .
## IS CAR PRIVATE USE          -7.639e-01  9.170e-02  -8.330 < 2e-16 ***
## CAR TYPE Panel.Truck        5.505e-01  1.614e-01   3.411  0.000647 ***

```

```

## CAR_TYPEPickup      5.510e-01  1.007e-01   5.472 4.46e-08 ***
## CAR_TYPESports.Car 1.029e+00  1.296e-01   7.941 2.01e-15 ***
## CAR_TYPEVan         6.114e-01  1.261e-01   4.847 1.25e-06 ***
## CAR_TYPEz_SUV       7.703e-01  1.111e-01   6.933 4.12e-12 ***
## IS_CAR_RED          -2.506e-03 8.618e-02  -0.029 0.976805
## IS_LIC_REVOKED     8.894e-01  9.117e-02   9.756 < 2e-16 ***
## IS_URBAN            2.387e+00  1.129e-01  21.147 < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 9415.3  on 8159  degrees of freedom
## Residual deviance: 7316.8  on 8122  degrees of freedom
## AIC: 7392.8
##
## Number of Fisher Scoring iterations: 5

```

In this particular case, we notice how some variables are not statistically significant; for study purposes, I will assume that this is a valid model.

4.1.4 Binomial STEP Model

In this case, I will create multiple models using the STEP function from R.

```
bin_Model_STEP <- step(bin_Model_NULL,
                        scope = list(upper=bin_Model_FULL),
                        direction="both",
                        test="Chisq",
                        data=data.train.bin)
```

For simplicity reasons, I have decided not to include the automatic responses; instead I will present the final model results.

4.1.4.1 ANOVA results

Let's check an ANOVA table based on the above testing results.

Step	Df	Deviance	Resid. Df	Resid. Dev	AIC
	NA	NA	8159	9415.297	9417.297
+ IS_URBAN	-1	501.7552780	8158	8913.542	8917.542
+ MVR PTS	-1	271.5277948	8157	8642.014	8648.014
+ HOME_VAL	-1	219.1676131	8156	8422.846	8430.846
+ IS_CAR_PRIVATE_USE	-1	174.3281407	8155	8248.518	8258.518
+ BLUEBOOK	-1	138.9556413	8154	8109.562	8121.562
+ IS_SINGLE_PARENT	-1	112.1201022	8153	7997.442	8011.442
+ IS_LIC_REVOKED	-1	95.2189847	8152	7902.223	7918.223
+ JOBManager	-1	88.0830361	8151	7814.140	7832.140
+ TRAVTIME	-1	58.2595752	8150	7755.881	7775.881
+ TIF	-1	57.0485376	8149	7698.832	7720.832
+ KIDSDRIV	-1	53.2561495	8148	7645.576	7669.576
+ CLM_FREQ	-1	43.2287532	8147	7602.347	7628.347
+ EDUCATIONz_High.School	-1	33.8405122	8146	7568.507	7596.507
+ CAR_TYPESports.Car	-1	28.2833549	8145	7540.223	7570.223

Step	Df	Deviance	Resid. Df	Resid. Dev	AIC
+ CAR_TYPEz_SUV	-1	35.1767133	8144	7505.047	7537.047
+ IS_MARRIED	-1	30.4554129	8143	7474.591	7508.591
+ INCOME	-1	32.1572427	8142	7442.434	7478.434
+ JOBClerical	-1	17.1378050	8141	7425.296	7463.296
+ OLDCLAIM	-1	13.3590688	8140	7411.937	7451.937
+ CAR_TYPEPickup	-1	11.8937289	8139	7400.043	7442.043
+ CAR_TYPEVan	-1	14.2678147	8138	7385.776	7429.776
+ CAR_TYPEPanel.Truck	-1	16.0797833	8137	7369.696	7415.696
+ JOBDoctor	-1	8.4824840	8136	7361.213	7409.213
+ CAR_AGE	-1	6.6048430	8135	7354.609	7404.609
+ EDUCATIONBachelors	-1	5.3370024	8134	7349.272	7401.272
+ EDUCATIONMasters	-1	11.3304398	8133	7337.941	7391.941
+ EDUCATIONPhD	-1	9.4981966	8132	7328.443	7384.443
- CAR_AGE	1	0.0047192	8133	7328.448	7382.448
- EDUCATIONz_High.School	1	0.0934403	8134	7328.541	7380.541
+ HOMEKIDS	-1	2.2554506	8133	7326.286	7380.286
+ YOJ	-1	2.7828687	8132	7323.503	7379.503

From the above results and calculations, it was concluded that the best model is as follows:

```

## 
## Call:
## glm(formula = TARGET_FLAG ~ IS_URBAN + MVR PTS + HOME_VAL + IS_CAR_PRIVATE_USE +
##     BLUEBOOK + IS_SINGLE_PARENT + IS_LIC_REVOKED + JOBManager +
##     TRAVTIME + TIF + KIDSDRV + CLM_FREQ + CAR_TYPESports.Car +
##     CAR_TYPEz_SUV + IS_MARRIED + INCOME + JOBClerical + OLDCLAIM +
##     CAR_TYPEPickup + CAR_TYPEVan + CAR_TYPEPanel.Truck + JOBDoctor +
##     EDUCATIONBachelors + EDUCATIONMasters + EDUCATIONPhD + HOMEKIDS +
##     YOJ, family = binomial(link = "logit"), data = data.train.bin)
## 
## Deviance Residuals:
##      Min        1Q     Median        3Q       Max
## -2.5863  -0.7155  -0.4047   0.6283   3.1234
## 
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -2.592e+00  1.839e-01 -14.095 < 2e-16 ***
## IS_URBAN     2.372e+00  1.124e-01  21.092 < 2e-16 ***
## MVR PTS     1.141e-01  1.357e-02   8.408 < 2e-16 ***
## HOME_VAL    -7.446e-07  2.309e-07 -3.225 0.001260 **
## IS_CAR_PRIVATE_USE -7.864e-01  7.499e-02 -10.487 < 2e-16 ***
## BLUEBOOK    -2.527e-05  4.647e-06 -5.437 5.41e-08 ***
## IS_SINGLE_PARENT 3.760e-01  1.087e-01   3.458 0.000544 ***
## IS_LIC_REVOKED 8.868e-01  9.105e-02   9.740 < 2e-16 ***
## JOBManager  -7.463e-01  1.072e-01  -6.961 3.39e-12 ***
## TRAVTIME     1.449e-02  1.879e-03   7.714 1.21e-14 ***
## TIF          -5.541e-02  7.323e-03  -7.567 3.82e-14 ***
## KIDSDRV      3.820e-01  5.997e-02   6.369 1.91e-10 ***
## CLM_FREQ     1.997e-01  2.845e-02   7.019 2.23e-12 ***
## CAR_TYPESports.Car 9.832e-01  1.065e-01   9.232 < 2e-16 ***
## CAR_TYPEz_SUV    7.235e-01  8.523e-02   8.489 < 2e-16 ***
## IS_MARRIED    -5.487e-01  7.748e-02  -7.081 1.43e-12 ***

```

```

## INCOME          -1.924e-06  6.116e-07 -3.146  0.001653 ** 
## JOBCLerical    1.720e-01  8.898e-02  1.934  0.053174 .  
## OLDCLAIM        -1.413e-05  3.902e-06 -3.622  0.000293 *** 
## CAR_TYPEPickup  5.293e-01  9.852e-02  5.373  7.76e-08 *** 
## CAR_TYPEVan     6.065e-01  1.196e-01  5.069  3.99e-07 *** 
## CAR_TYPEPanel.Truck 5.395e-01  1.431e-01  3.769  0.000164 *** 
## JOBDoctor       -5.278e-01  2.494e-01 -2.117  0.034268 *  
## EDUCATIONBachelors -4.805e-01  7.559e-02 -6.356  2.07e-10 *** 
## EDUCATIONMasters -5.420e-01  9.198e-02 -5.892  3.80e-09 *** 
## EDUCATIONPhD    -5.061e-01  1.458e-01 -3.472  0.000517 *** 
## HOMEKIDS         5.740e-02  3.391e-02  1.693  0.090442 .  
## YOJ              -1.185e-02  7.098e-03 -1.669  0.095071 . 
## --- 
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 
## 
## (Dispersion parameter for binomial family taken to be 1) 
## 
## Null deviance: 9415.3 on 8159 degrees of freedom 
## Residual deviance: 7323.5 on 8132 degrees of freedom 
## AIC: 7379.5 
## 
## Number of Fisher Scoring iterations: 5

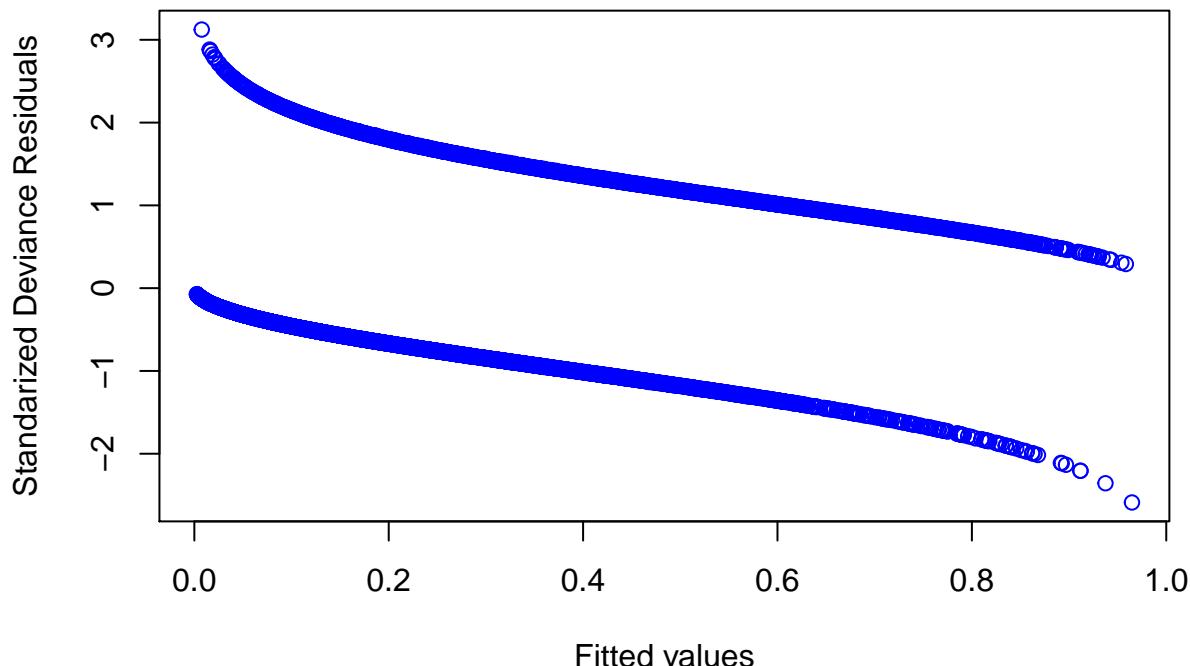
```

From the above results, we noticed how all the predictors are statistical significant, also, we notice how from the above model, the HOME_VAL and the INCOME are not as statistical significant compared to other variables.

4.1.4.2 Plot of standardized residuals

The below plot shows our fitted models vs the deviance standardized residuals.

Standarize residuals for binary data



4.1.5 Confusion Matrix

Let's start by building a confusion matrix in order to obtain valuable insights.

```
## Confusion Matrix and Statistics
##
##             Reference
## Prediction    0     1
##           0 5550 1257
##           1  458  895
##
##                 Accuracy : 0.7898
##                 95% CI : (0.7808, 0.7986)
##   No Information Rate : 0.7363
##   P-Value [Acc > NIR] : < 2.2e-16
##
##                 Kappa : 0.3856
## Mcnemar's Test P-Value : < 2.2e-16
##
##                 Sensitivity : 0.4159
##                 Specificity : 0.9238
##   Pos Pred Value : 0.6615
##   Neg Pred Value : 0.8153
##   Prevalence : 0.2637
##   Detection Rate : 0.1097
## Detection Prevalence : 0.1658
##   Balanced Accuracy : 0.6698
##
##   'Positive' Class : 1
##
```

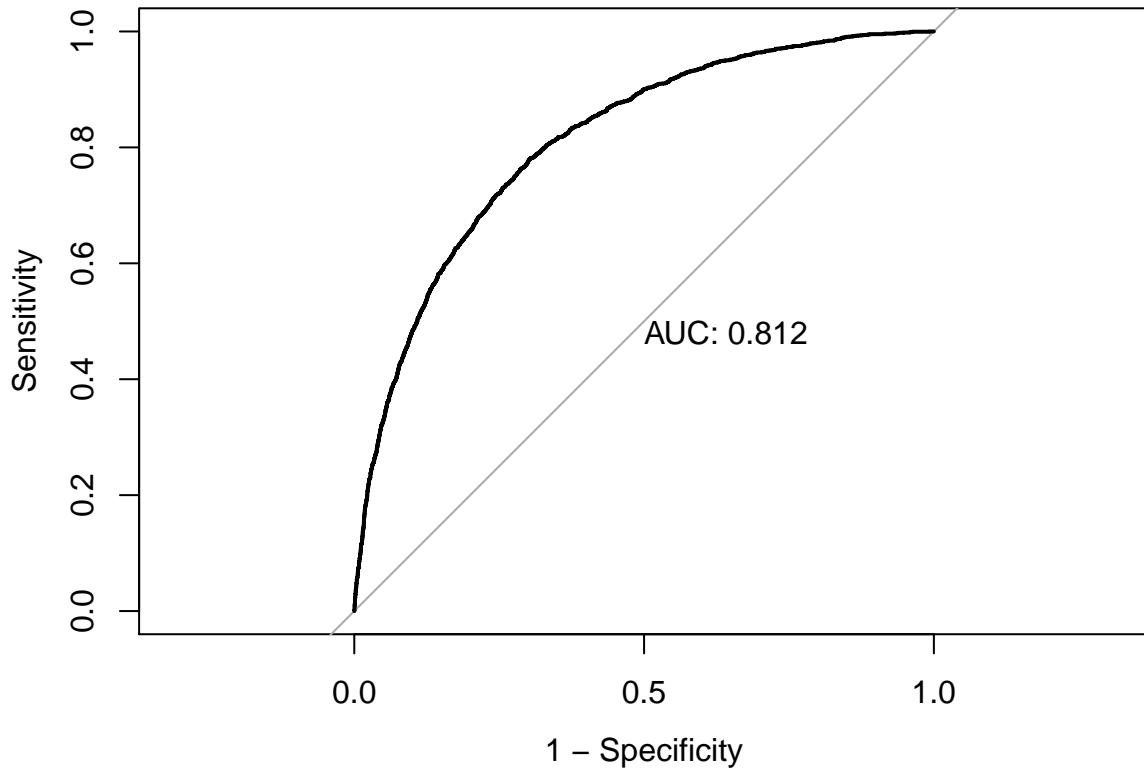
It is interesting to note that the reported Accuracy is 0.7898284.

From the above results, we obtain as follows:

	Value
Sensitivity	0.4158922
Specificity	0.9237683
Pos Pred Value	0.6614930
Neg Pred Value	0.8153372
Precision	0.6614930
Recall	0.4158922
F1	0.5106990
Prevalence	0.2637255
Detection Rate	0.1096814
Detection Prevalence	0.1658088
Balanced Accuracy	0.6698303

4.1.6 ROC and AUC

As we know, the **Receiver Operating Characteristic Curves** (ROC) is a great quantitative assessment tool of the model. In order to quantify our model, I will employ as follows:



Let's see our confidence intervals for the area under the curve.

	AUC
Lower bound	0.8015396
Estimated value	0.8118504
Higher bound	0.8221612

4.1.7 Binary STEP MODIFIED Model

In this case, I will add 1 to the following variables and then I will calculate the log, thus to avoid errors since some entries reported 0 and $\log(0)$ will produce errors, also I will remove the variable HOMEKIDS; let's take a look as follows:

- $\log(1 + \text{INCOME})$
- $\log(1 + \text{HOME_VAL})$
- $\log(1 + \text{BLUEBOOK})$
- $\log(1 + \text{OLDCLAIM})$
- $\text{HOMEKIDS} <- \text{Remove}$

Let's see the results:

```
## 
## Call:
## glm(formula = TARGET_FLAG ~ IS_URBAN + MVR_PTS + log(1 + HOME_VAL) +
##       IS_CAR_PRIVATE_USE + log(1 + BLUEBOOK) + IS_SINGLE_PARENT +
##       IS_LIC_REVOKED + JOBManager + TRAVTIME + TIF + KIDSDRIV +
##       CLM_FREQ + CAR_TYPESports.Car + CAR_TYPEz_SUV + IS_MARRIED +
##       log(1 + INCOME) + JOBClerical + log(1 + OLDCLAIM) + CAR_TYPEPickup +
##       CAR_TYPEVan + CAR_TYPEPanel.Truck + JOBDoctor + EDUCATIONBachelors +
```

```

##      EDUCATIONMasters + EDUCATIONPhD + YOJ, family = binomial(link = "logit"),
##      data = data.train.bin)
##
## Deviance Residuals:
##      Min       1Q   Median       3Q      Max
## -2.6106 -0.7169 -0.4012  0.6251  3.1464
##
## Coefficients:
##                               Estimate Std. Error z value Pr(>|z|)
## (Intercept)          0.449796  0.525004  0.857  0.39158
## IS_URBAN            2.408764  0.113906 21.147 < 2e-16 ***
## MVR PTS             0.103476  0.013992  7.395 1.41e-13 ***
## log(1 + HOME_VAL) -0.023995  0.006356 -3.775  0.00016 ***
## IS_CAR_PRIVATE_USE -0.807898  0.075476 -10.704 < 2e-16 ***
## log(1 + BLUEBOOK) -0.328587  0.054484 -6.031 1.63e-09 ***
## IS_SINGLE_PARENT    0.432665  0.094510  4.578 4.69e-06 ***
## IS_LIC_REVOKED     0.700961  0.081276  8.624 < 2e-16 ***
## JOBManager         -0.722699  0.107335 -6.733 1.66e-11 ***
## TRAVTIME            0.014845  0.001883  7.885 3.14e-15 ***
## TIF                 -0.054347  0.007329 -7.415 1.21e-13 ***
## KIDSDRV             0.423039  0.054971  7.696 1.41e-14 ***
## CLM_FREQ            0.091849  0.043361  2.118  0.03416 *
## CAR_TYPESports.Car  0.945197  0.107131  8.823 < 2e-16 ***
## CAR_TYPEz_SUV       0.732312  0.085011  8.614 < 2e-16 ***
## IS_MARRIED          -0.491494  0.081374 -6.040 1.54e-09 ***
## log(1 + INCOME)    -0.072339  0.013133 -5.508 3.63e-08 ***
## JOBClerical         0.275260  0.090260  3.050  0.00229 **
## log(1 + OLDCLAIM)  0.022103  0.012436  1.777  0.07552 .
## CAR_TYPEPickup      0.535625  0.098545  5.435 5.47e-08 ***
## CAR_TYPEVan          0.595850  0.119427  4.989 6.06e-07 ***
## CAR_TYPEPanel.Truck 0.418935  0.135944  3.082  0.00206 **
## JOBDoctor           -0.484072  0.248086 -1.951  0.05103 .
## EDUCATIONBachelors -0.469375  0.075173 -6.244 4.27e-10 ***
## EDUCATIONMasters    -0.548683  0.090087 -6.091 1.13e-09 ***
## EDUCATIONPhD        -0.628394  0.139306 -4.511 6.46e-06 ***
## YOJ                  0.017980  0.008905  2.019  0.04348 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 9415.3 on 8159 degrees of freedom
## Residual deviance: 7301.2 on 8133 degrees of freedom
## AIC: 7355.2
##
## Number of Fisher Scoring iterations: 5

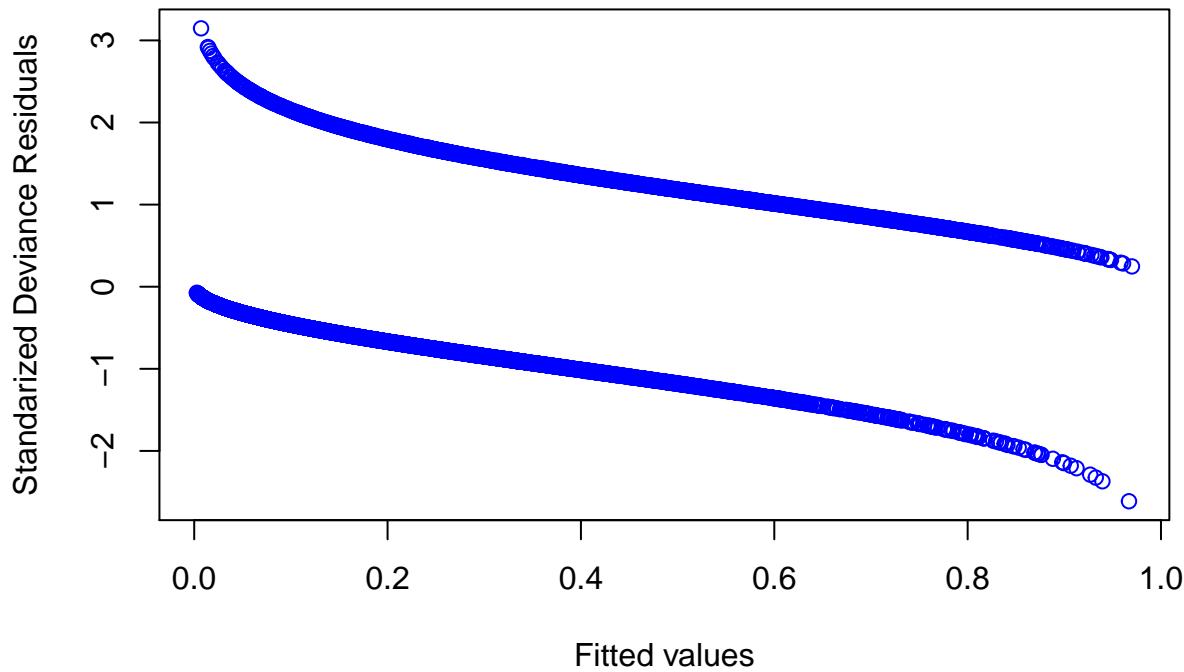
```

As we can see, this transformation produced similar entries compared to our automatically selected model but it seems to be slightly better since the AIC is lower than the automatically selected model by the STEP procedure.

4.1.7.1 Plot of standardized residuals

The below plot shows our fitted models vs the deviance standardized residuals.

Standarize residuals for binary data



4.1.8 Confusion Matrix

Let's start by building a confusion matrix in order to obtain valuable insights.

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   0     1
##           0 5561 1268
##           1  447  884
##
##           Accuracy : 0.7898
##             95% CI : (0.7808, 0.7986)
##   No Information Rate : 0.7363
##   P-Value [Acc > NIR] : < 2.2e-16
##
##           Kappa : 0.3833
##   Mcnemar's Test P-Value : < 2.2e-16
##
##           Sensitivity : 0.4108
##           Specificity  : 0.9256
##   Pos Pred Value : 0.6642
##   Neg Pred Value : 0.8143
##           Prevalence : 0.2637
##   Detection Rate  : 0.1083
## Detection Prevalence : 0.1631
##   Balanced Accuracy : 0.6682
##
##   'Positive' Class : 1
```

##

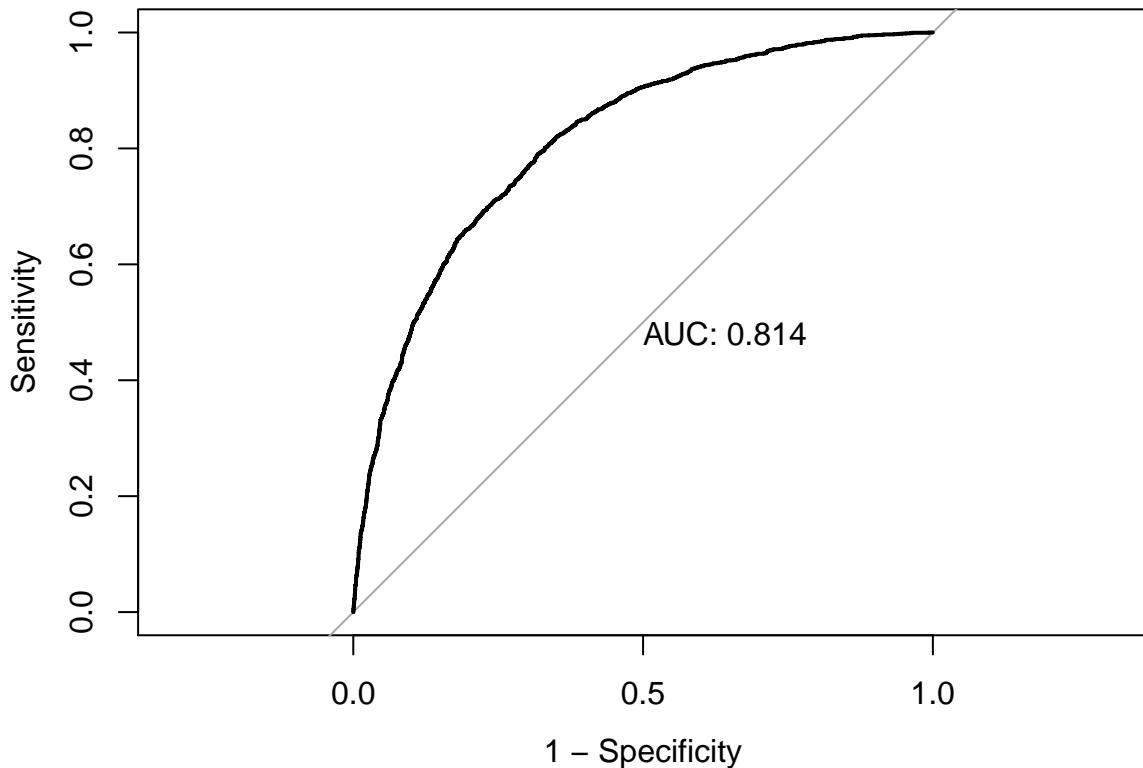
Is interesting to note that the reported Accuracy is 0.7898284.

From the above results, we obtain as follows:

	Value
Sensitivity	0.4107807
Specificity	0.9255992
Pos Pred Value	0.6641623
Neg Pred Value	0.8143213
Precision	0.6641623
Recall	0.4107807
F1	0.5076084
Prevalence	0.2637255
Detection Rate	0.1083333
Detection Prevalence	0.1631127
Balanced Accuracy	0.6681899

4.1.9 ROC and AUC

As we know, the **Receiver Operating Characteristic Curves** (ROC) is a great quantitative assessment tool of the model. In order to quantify our model, I will employ as follows:



Let's see our confidence intervals for the area under the curve.

	AUC
Lower bound	0.8033390
Estimated value	0.8135629

	AUC
Higher bound	0.8237867

IMPORTANT

If we check our theory, the **AIC** defines as follows: *the smaller the value for AIC the better the model*; in this case, we can easily observe how by adding certain variables, our AIC values decrease making it a better model.

4.1.10 Binary MODEL SELECTION

In this case, I will select the model returned in the STEP procedure, that is:

```
bin_Model_FINAL <- bin_Model_STEP
```

The reasons are explained below:

- This model returned the second lowest **Akaike's Information Criterion AIC**.
- This model returned the second nearest to zero median value.
- This model displayed the smallest standard errors for the considered predictor variables.
- This model present the smallest rate of change for all predictor variables.
- This model returned the second lowest residual deviance.
- From the below table we can see how the probability of being higher than the χ^2 are very low.

	Df	Chisq	Pr(>Chisq)
IS_URBAN	1	444.877135	0.0000000
MVR PTS	1	70.699251	0.0000000
HOME_VAL	1	10.400387	0.0012599
IS_CAR_PRIVATE_USE	1	109.982078	0.0000000
BLUEBOOK	1	29.562730	0.0000001
IS_SINGLE_PARENT	1	11.959901	0.0005436
IS_LIC_REVOKED	1	94.871581	0.0000000
JOBManager	1	48.451199	0.0000000
TRAVTIME	1	59.513042	0.0000000
TIF	1	57.257133	0.0000000
KIDSDRV	1	40.559335	0.0000000
CLM_FREQ	1	49.266736	0.0000000
CAR_TYPESports.Car	1	85.227207	0.0000000
CAR_TYPEz_SUV	1	72.061019	0.0000000
IS_MARRIED	1	50.145391	0.0000000
INCOME	1	9.899663	0.0016531
JOBClerical	1	3.738453	0.0531737
OLDCLAIM	1	13.115512	0.0002929
CAR_TYPEPickup	1	28.866084	0.0000001
CAR_TYPEVan	1	25.698922	0.0000004
CAR_TYPEPanel.Truck	1	14.206252	0.0001638
JOBDoctor	1	4.481264	0.0342684
EDUCATIONBachelors	1	40.398578	0.0000000
EDUCATIONMasters	1	34.721076	0.0000000
EDUCATIONPhD	1	12.053972	0.0005168
HOMEKIDS	1	2.866491	0.0904419

	Df	Chisq	Pr(>Chisq)
YOJ	1	2.786344	0.0950709

4.1.11 Test Binary model

From the above chosen model, I will create a reduced data frame containing only the variables needed in order to run our model. The selected variables are:

vars
TARGET_FLAG
IS_URBAN
MVR_PTS
HOME_VAL
IS_CAR_PRIVATE_USE
BLUEBOOK
IS_SINGLE_PARENT
IS_LIC_REVOKED
JOBManager
TRAVTIME
TIF
KIDSDRV
CLM_FREQ
CAR_TYPESports.Car
CAR_TYPEz_SUV
IS_MARRIED
INCOME
JOBClerical
OLDCLAIM
CAR_TYPEPickup
CAR_TYPEVan
CAR_TYPEPanel.Truck
JOBDoctor
EDUCATIONBachelors
EDUCATIONMasters
EDUCATIONPhD
HOMEKIDS
YOJ

4.1.11.1 Final Model Comparisons

From here, I will define a NULL model with the chosen variables in order to compare results with the FINAL model.

```
##  
## Call:  
## glm(formula = TARGET_FLAG ~ 1, family = binomial(link = "logit"),  
##       data = data.train.final)  
##  
## Deviance Residuals:  
##      Min        1Q    Median        3Q       Max  
## -0.7825 -0.7825 -0.7825  1.6327  1.6327  
##
```

```

## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.02669   0.02512  -40.87  <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
## Null deviance: 9415.3 on 8159 degrees of freedom
## Residual deviance: 9415.3 on 8159 degrees of freedom
## AIC: 9417.3
##
## Number of Fisher Scoring iterations: 4

```

4.1.11.2 Analysis of Deviance Table

The below table, will display a Deviance analysis by employing the χ^2 test.

Resid. Df	Resid. Dev	Df	Deviance	Pr(>Chi)
8132	7323.503	NA	NA	NA
8159	9415.297	-27	-2091.794	0

In the above results, we can easily compare our Residual Deviance in which our model has better results compared to the null model since the null model's deviance will change in -2091.7941687 units compared to our final model.

4.2 Multiple Linear Regression Model

Now, that we have build our Binary Model, I will proceed to build a Multiple Linear Regression Model in order to predict the TARGET_AMT for the records indicating that an accident happened.

4.2.1 Summaries

In order to have a better understanding of our current data, I will present a summary table for all the records that have accidents only.

	Min	1st Qu	Median	Mean	3rd Qu	Max
TARGET_FLAG	1.00	1.00	1.00	1.00000e+00	1	1.0
TARGET_AMT	30.28	2610.69	4108.07	5.70415e+03	5788	107586.1
KIDSDRV	0.00	0.00	0.00	2.59800e-01	0	4.0
AGE	16.00	37.00	43.00	4.33400e+01	50	78.0
HOMEKIDS	0.00	0.00	0.00	9.37300e-01	2	5.0
YOJ	0.00	8.00	11.00	1.01300e+01	13	23.0
INCOME	0.00	21636.00	45776.00	5.75930e+04	73151	364441.0
HOME_VAL	0.00	0.00	122628.00	1.33802e+05	209151	861206.0
TRAVTIME	5.00	24.00	34.00	3.47700e+01	45	97.0
BLUEBOOK	1500.00	7758.00	12590.00	1.42550e+04	19218	62240.0
TIF	1.00	1.00	4.00	4.78100e+00	7	21.0
OLDCLAIM	0.00	0.00	2432.00	6.04900e+03	6905	57037.0
CLM_FREQ	0.00	0.00	1.00	1.21600e+00	2	5.0

	Min	1st Qu	Median	Mean	3rd Qu	Max
MVR_PTS	0.00	0.00	2.00	2.48200e+00	4	13.0
CAR_AGE	0.00	1.00	7.00	7.82200e+00	12	28.0
IS_SINGLE_PARENT	0.00	0.00	0.00	2.21200e-01	0	1.0
IS_MARRIED	0.00	0.00	0.00	4.89300e-01	1	1.0
IS_FEMALE	0.00	0.00	1.00	5.53400e-01	1	1.0
EDUCATIONBachelors	0.00	0.00	0.00	2.42600e-01	0	1.0
EDUCATIONMasters	0.00	0.00	0.00	1.52000e-01	0	1.0
EDUCATIONPhD	0.00	0.00	0.00	5.80900e-02	0	1.0
EDUCATIONz_High.School	0.00	0.00	0.00	3.68500e-01	1	1.0
JOBClerical	0.00	0.00	0.00	1.72400e-01	0	1.0
JOBDoctor	0.00	0.00	0.00	1.34800e-02	0	1.0
JOBHome.Maker	0.00	0.00	0.00	8.36400e-02	0	1.0
JOBLawyer	0.00	0.00	0.00	7.11000e-02	0	1.0
JOBManager	0.00	0.00	0.00	6.36600e-02	0	1.0
JOBProfessional	0.00	0.00	0.00	1.14300e-01	0	1.0
JOBStudent	0.00	0.00	0.00	1.23600e-01	0	1.0
JOBz_Blue.Collar	0.00	0.00	0.00	2.94600e-01	1	1.0
IS_CAR_PRIVATE_USE	0.00	0.00	1.00	5.13500e-01	1	1.0
CAR_TYPEPanel.Truck	0.00	0.00	0.00	8.27100e-02	0	1.0
CAR_TYPEPickup	0.00	0.00	0.00	2.05400e-01	0	1.0
CAR_TYPESports.Car	0.00	0.00	0.00	1.41300e-01	0	1.0
CAR_TYPEVan	0.00	0.00	0.00	9.34000e-02	0	1.0
CAR_TYPEz_SUV	0.00	0.00	0.00	3.15100e-01	1	1.0
IS_CAR_RED	0.00	0.00	0.00	2.86200e-01	1	1.0
IS_LIC_REVOKED	0.00	0.00	0.00	2.05400e-01	0	1.0
IS_URBAN	0.00	1.00	1.00	9.46600e-01	1	1.0

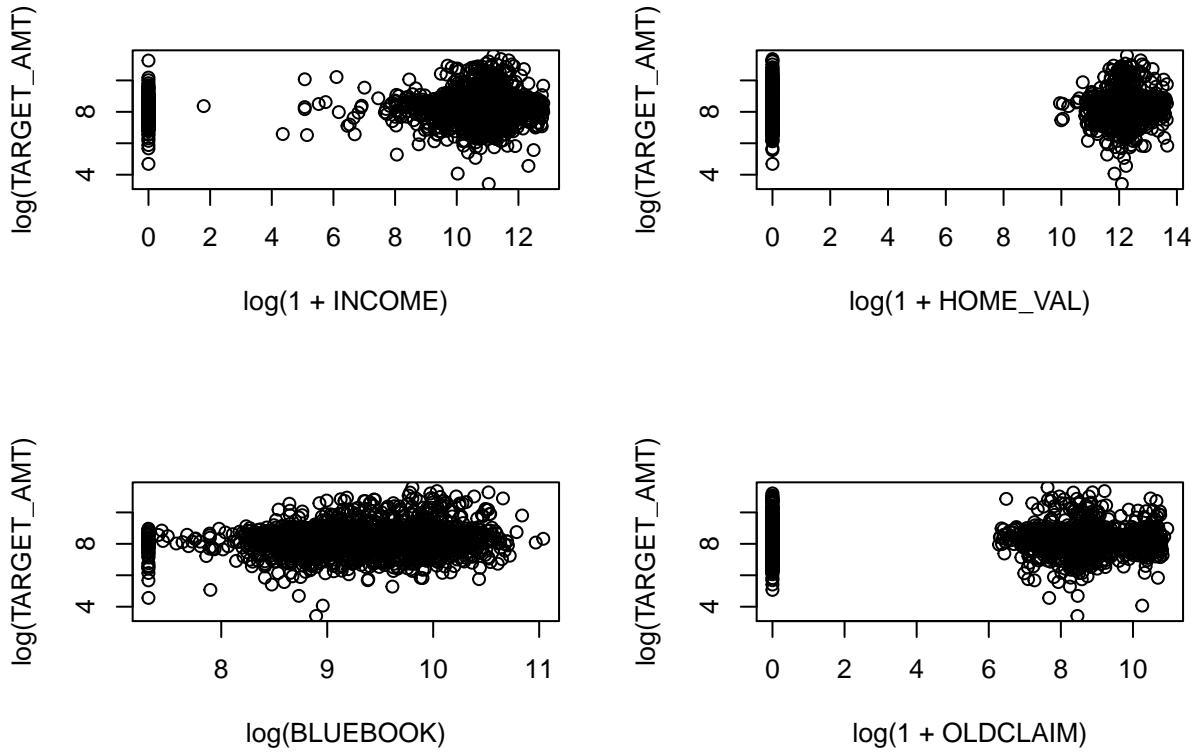
4.2.2 Transformations

Notice how some variables present 0 as minimum input; that is **INCOME**, **HOME_VAL** and **OLDCLAIM**. This is very important since I will perform some transformations as follows:

- **TARGET_AMT**: will be transformed to $\log(\text{TARGET_AMT})$.
- **INCOME**: will be transformed to $\log(1 + \text{INCOME})$ <- To avoid $\log(0)$ problem.
- **HOME_VAL**: will be transformed to $\log(1 + \text{HOME_VAL})$ <- To avoid $\log(0)$ problem.
- **BLUEBOOK**: will be transformed to $\log(\text{BLUEBOOK})$.
- **OLDCLAIM**: will be transformed to $\log(1 + \text{OLDCLAIM})$ <- To avoid $\log(0)$ problem.

4.2.3 Visualizations

Let's see if could find some linear relationships in terms of linearity among **TARGET_AMT** vs other variables.



From the above graphs, we could seem to identify some sort of linearity in the given data set, also, we notice how the $\log(1 + \text{VARIABLE})$ has some effect in the plots.

4.2.4 Leverage and Outliers

In this section, I will try to identify and build a list of Leverage points alongside outliers.

4.2.5 Multiple Regression NULL Model

Let's start with a null model in order to start having a better understanding. This model will be considered to be valid and will be considered as we advance.

```
## 
## Call:
## lm(formula = log_TARGET_AMT ~ 1, data = TARGET_FLAG_1)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -4.8660 -0.4091  0.0443  0.3871  3.3096 
## 
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)    
## (Intercept) 8.27644    0.01751   472.6   <2e-16 ***
## ---      
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 0.8125 on 2151 degrees of freedom
```

4.2.6 Multiple Regression FULL Model

In this section, I will build a FULL model, thus in order to keep having a better understanding of the model. This model will be considered to be valid and will be considered as we advance.

```
##
## Call:
## lm(formula = log_TARGET_AMT ~ ., data = TARGET_FLAG_1)
##
## Residuals:
##    Min     1Q Median     3Q    Max 
## -5.0505 -0.3791  0.0624  0.4248  2.9125 
##
## Coefficients: (1 not defined because of singularities)
##                               Estimate Std. Error t value Pr(>|t|)    
## (Intercept)             6.6219045  0.3637622 18.204 < 2e-16 ***
## TARGET_FLAG                NA        NA        NA        NA      
## KIDSDRIV            -0.0301002  0.0329426 -0.914 0.360970  
## AGE                  0.0008240  0.0021749  0.379 0.704840  
## HOMEKIDS              0.0136086  0.0215630  0.631 0.528037  
## YOJ                 -0.0001170  0.0053961 -0.022 0.982707  
## TRAVTIME              -0.0003177  0.0011534 -0.275 0.783026  
## TIF                  -0.0011951  0.0044208 -0.270 0.786927  
## CLM_FREQ              -0.0530680  0.0242192 -2.191 0.028549 *  
## MVR PTS               0.0139056  0.0072827  1.909 0.056345 .  
## CAR AGE              -0.0007791  0.0037051 -0.210 0.833478  
## IS SINGLE PARENT      0.0232964  0.0611578  0.381 0.703299  
## IS MARRIED             -0.1201347  0.0526775 -2.281 0.022673 *  
## IS FEMALE              -0.0859461  0.0658086 -1.306 0.191694  
## EDUCATIONBachelors    -0.0649046  0.0647233 -1.003 0.316072  
## EDUCATIONMasters       0.1029520  0.1090695  0.944 0.345323  
## EDUCATIONPhD            0.1537568  0.1269872  1.211 0.226106  
## EDUCATIONz_High.School  0.0059409  0.0535503  0.111 0.911673  
## JOB Clerical            0.0743435  0.1231961  0.603 0.546270  
## JOB Doctor              -0.0131399  0.1839070 -0.071 0.943047  
## JOB Home.Maker           0.0303227  0.1325648  0.229 0.819094  
## JOB Lawyer              -0.0354852  0.1069424 -0.332 0.740061  
## JOB Manager              0.0208008  0.1108565  0.188 0.851179  
## JOB Professional          0.1130966  0.1170222  0.966 0.333928  
## JOB Student              0.1260001  0.1361558  0.925 0.354858  
## JOBz Blue.Collar         0.0564755  0.1186269  0.476 0.634069  
## IS CAR PRIVATE USE       0.0136397  0.0543605  0.251 0.801907  
## CAR TYPEPanel.Truck      0.0368181  0.0916320  0.402 0.687869  
## CAR TYPEPickup            0.0376195  0.0620571  0.606 0.544441  
## CAR TYPESports.Car        0.0718072  0.0765241  0.938 0.348167  
## CAR TYPEVan               -0.0187183  0.0791974 -0.236 0.813184  
## CAR TYPEz SUV              0.0954950  0.0669215  1.427 0.153736  
## IS CAR RED                0.0359232  0.0516642  0.695 0.486931  
## IS LIC REVOKED             -0.0337374  0.0440626 -0.766 0.443958  
## IS URBAN                  0.0473326  0.0785668  0.602 0.546939  
## log INCOME                -0.0011698  0.0090670 -0.129 0.897352  
## log HOME VAL               0.0056977  0.0039472  1.443 0.149033  
## log BLUEBOOK               0.1578179  0.0342402  4.609 4.28e-06 ***  
## log OLDCLAIM                0.0114251  0.0070581  1.619 0.105657
```

```

## INCOME_Outlier      -1.2126046  0.4517518  -2.684 0.007327 **
## HOME_VAL_Outlier    0.7621985  0.6101766   1.249 0.211751
## BLUEBOOK_Outlier    0.7088887  0.1902301   3.726 0.000199 ***
## OLDCLAIM_Outlier    0.1474221  0.6087918   0.242 0.808683
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7996 on 2110 degrees of freedom
## Multiple R-squared:  0.0499, Adjusted R-squared:  0.03144
## F-statistic: 2.703 on 41 and 2110 DF,  p-value: 4.402e-08

```

Interesting to see only a few statistically significant variables while the R^2 shows to be low. The p-value is very low and the median is considered to be near zero.

4.2.7 Multiple Regression STEP Model

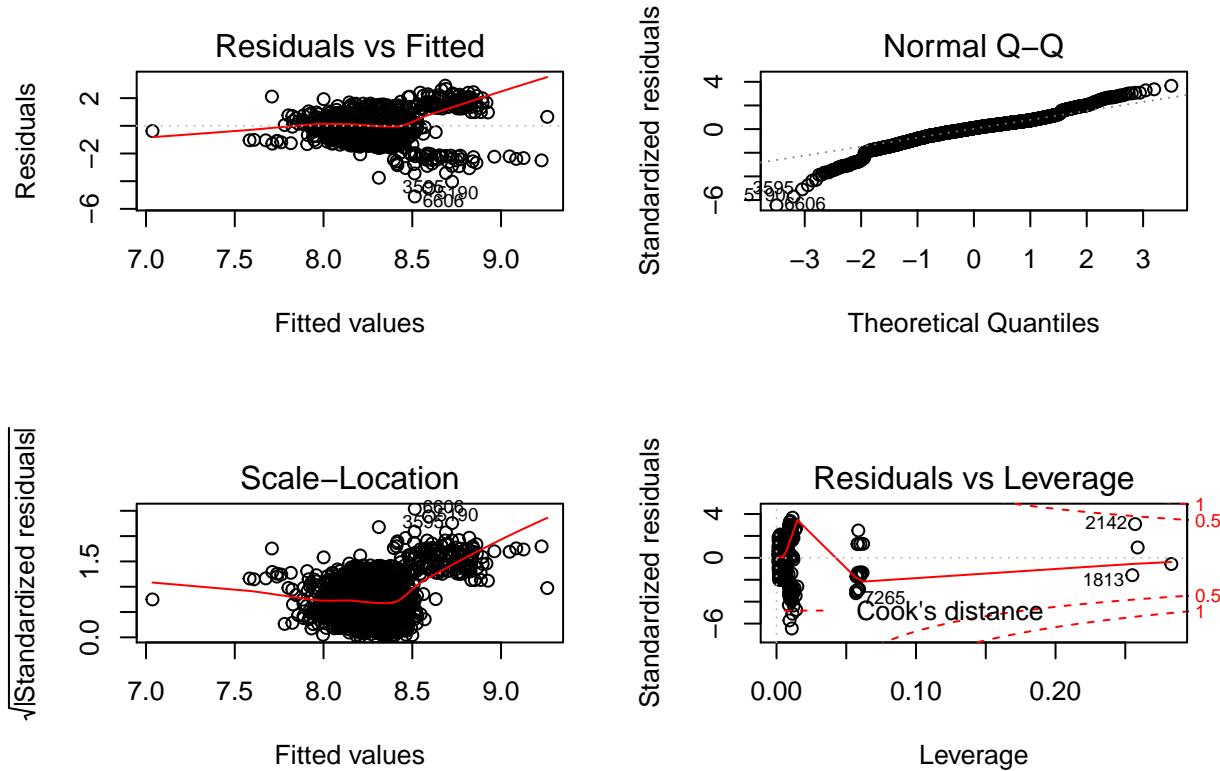
In this section, I will build a model by employing the STEP function from R, thus in order to keep having a better understanding of the model. This model will be considered to be valid and will be considered as we advance.

```

##
## Call:
## lm(formula = log_TARGET_AMT ~ BLUEBOOK_Outlier + log_BLUEBOOK +
##     IS_MARRIED + INCOME_Outlier + HOME_VAL_Outlier + MVR PTS +
##     EDUCATIONBachelors + IS_FEMALE + CLM_FREQ, data = TARGET_FLAG_1)
##
## Residuals:
##    Min      1Q  Median      3Q      Max
## -5.1036 -0.3798  0.0669  0.4300  2.9004
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)    
## (Intercept)             6.955403  0.250897  27.722 < 2e-16 ***
## BLUEBOOK_Outlier        0.712254  0.188213   3.784 0.000158 ***
## log_BLUEBOOK            0.145953  0.026226   5.565 2.95e-08 ***
## IS_MARRIED              -0.081364  0.034463  -2.361 0.018319 *  
## INCOME_Outlier          -1.182167  0.422567  -2.798 0.005195 ** 
## HOME_VAL_Outlier        0.874650  0.403540   2.167 0.030311 *  
## MVR PTS                 0.016472  0.006979   2.360 0.018352 *  
## EDUCATIONBachelors     -0.076328  0.040307  -1.894 0.058403 .  
## IS_FEMALE               -0.053820  0.034684  -1.552 0.120874  
## CLM_FREQ                -0.021031  0.014426  -1.458 0.145046  
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7961 on 2142 degrees of freedom
## Multiple R-squared:  0.04399, Adjusted R-squared:  0.03997
## F-statistic: 10.95 on 9 and 2142 DF,  p-value: < 2.2e-16

```

Something interesting from the above results is that it shows non statistical significant values as part of the model. That is IS_FEMALE and CLM_FREQ are not statistically significant.



From the above graphs, we can quickly identify the **lobster shape** figure, which indicates that this model seems to be some how appropriate due to being some how homoscedastic, plus the Normal Q-Q line seems to differ on the lower end but not by much on the upper end which will be more problematic due to the nature of paying out insurance money.

4.2.7.1 ANOVA results

Let's check an ANOVA table based on the above testing results.

Step	Df	Deviance	Resid. Df	Resid. Dev	AIC
	NA	NA	2151	1419.904	-892.8199
+ BLUEBOOK_Outlier	-1	24.241941	2150	1395.662	-927.8781
+ log_BLUEBOOK	-1	21.713173	2149	1373.949	-959.6212
+ IS_MARRIED	-1	2.955640	2148	1370.993	-962.2556
+ INCOME_Outlier	-1	2.577242	2147	1368.416	-964.3048
+ HOME_VAL_Outlier	-1	3.299849	2146	1365.116	-967.5005
+ MVR PTS	-1	2.493846	2145	1362.622	-969.4355
+ EDUCATIONBachelors	-1	2.281735	2144	1360.340	-971.0420
+ IS_FEMALE	-1	1.546264	2143	1358.794	-971.4896
+ CLM_FREQ	-1	1.346765	2142	1357.447	-971.6236

4.2.8 Multiple Regression STEP MODIFIED Model

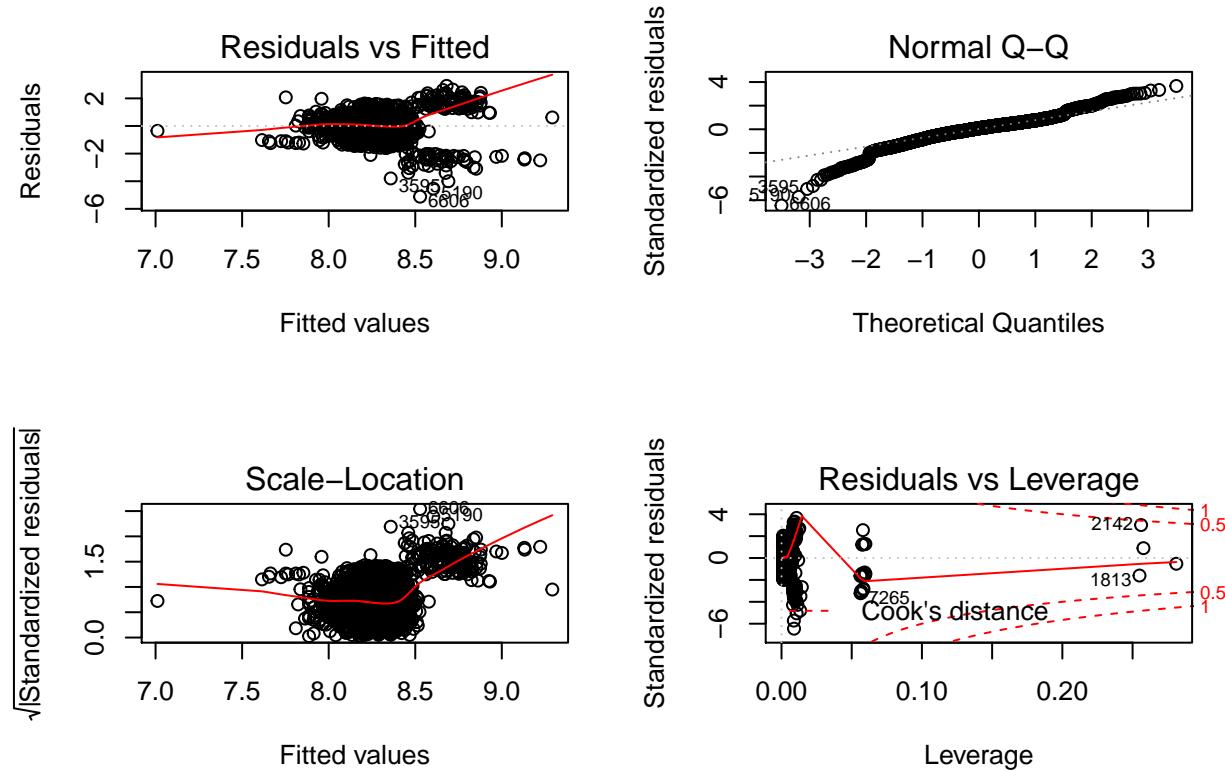
In this section, I will create a manual model in order to try to overcome the previous identify problems. In this case, I will add an iteration AGE:IS_FEMALE and I will keep the statistically significant values provided above.

```
##
```

```

## Call:
## lm(formula = log_TARGET_AMT ~ BLUEBOOK_Outlier + log_BLUEBOOK +
##     IS_MARRIED + INCOME_Outlier + HOME_VAL_Outlier + MVR PTS +
##     EDUCATIONBachelors, data = TARGET_FLAG_1)
##
## Residuals:
##    Min      1Q  Median      3Q      Max 
## -5.1177 -0.3756  0.0705  0.4232  2.9049 
## 
## Coefficients:
##             Estimate Std. Error t value Pr(>|t|)    
## (Intercept) 6.873667  0.247386 27.785 < 2e-16 ***
## BLUEBOOK_Outlier 0.707848  0.188193  3.761 0.000174 *** 
## log_BLUEBOOK   0.149567  0.026142  5.721 1.21e-08 *** 
## IS_MARRIED    -0.080899  0.034480 -2.346 0.019052 *  
## INCOME_Outlier -1.206908  0.422566 -2.856 0.004330 ** 
## HOME_VAL_Outlier 0.903923  0.403548  2.240 0.025197 *  
## MVR PTS       0.013377  0.006664  2.008 0.044817 *  
## EDUCATIONBachelors -0.076464  0.040322 -1.896 0.058047 .  
## --- 
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 
## 
## Residual standard error: 0.7965 on 2144 degrees of freedom
## Multiple R-squared:  0.04195, Adjusted R-squared:  0.03882 
## F-statistic: 13.41 on 7 and 2144 DF, p-value: < 2.2e-16

```



Something interesting to note is that in this case, all predictors are statistically significant, the Normal Q-Q plot seems to follow a line for almost all the values with only a slight overpricing on the top but with an under prediction on the bottom left. The Residuals vs the Fitted lobster shape figure seems to be homoscedastic, my only concern will be the Multiple R^2 which is very low but I will consider this to be OK due to previous

correlations showed that the correlations are very low as well.

4.2.9 Multiple Linear Regression MODEL SELECTION

Below, I will describe why I have chosen the **Multiple Regression STEP MODIFIED Model** to be my selected model for the multiple linear regression model.

```
lm_Model_FINAL <- lm_Model_Step_Modified
```

- The generated ANOVA table shows this combination of variables to be have lowest AIC.
- The coefficients make sense.
- The Median is near Zero.
- The coefficients are considered low, alongside the standard errors as well.
- The Residuals vs the Fitted values seems to be homoscedastic.
- The residuals and the normal Q-Q plot also make sense and follow “good” standards for data analysis.
- My only concerns will be the R^2 to be too low but it was noted the low correlation among variables.

5 Predictions

In this section, I will proceed to predict values from the evaluation data set.

5.1 Evaluation data transformations

In this section I will transform our evaluation data same as our original data has.

5.2 Predict TARGET_FLAG

In this section, I will predict the probability of having an accident or no accident and categorize it in the TARGET_FLAG variable.

5.2.1 Accident Predictions Table

In this section, I will predict the values on the **evaluation** data set employing the **training** data set.

Let's see a table for the first 20 records.

INDEX	TARGET_FLAG
3	0
9	0
10	0
18	0
21	0
30	0
31	0
37	0
39	0
47	0

INDEX	TARGET_FLAG
60	0
62	1
63	1
64	0
68	0
75	1
76	1
83	0
87	1
92	0

5.3 Predict TARGET_AMT

In this section, I will predict the amount based on the final linear model selected. In order to accomplish this goal, I need to do as follows:

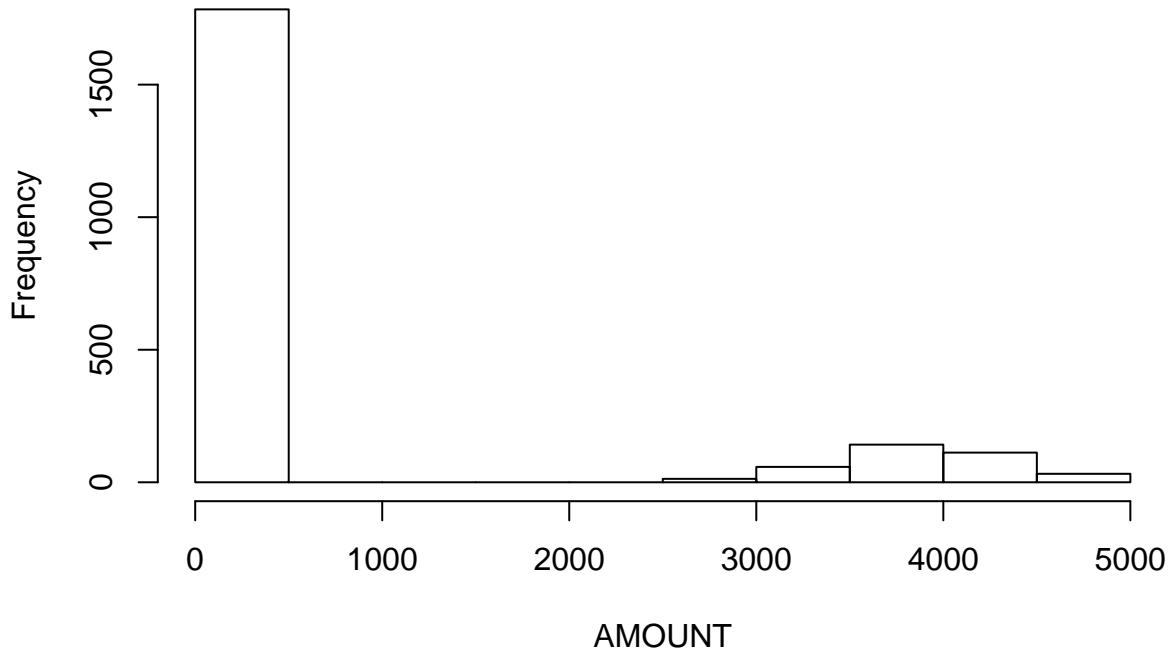
Since there's no way to indicate if the new values are considered outliers or not, I will assign a zero instead; then I will re-evaluate with the given values.

- data.eval\$BLUEBOOK_Outlier <- 0
- data.eval\$INCOME_Outlier <- 0
- data.eval\$HOME_VAL_Outlier <- 0

Let's see the first 20 records of the first run for the predicted data set.

INDEX	TARGET_FLAG	TARGET_AMT
3	0	0.00
9	0	0.00
10	0	0.00
18	0	0.00
21	0	0.00
30	0	0.00
31	0	0.00
37	0	0.00
39	0	0.00
47	0	0.00
60	0	0.00
62	1	4160.33
63	1	3794.61
64	0	0.00
68	0	0.00
75	1	4026.46
76	1	2961.95
83	0	0.00
87	1	3583.60
92	0	0.00

Predicted Amount: First Run

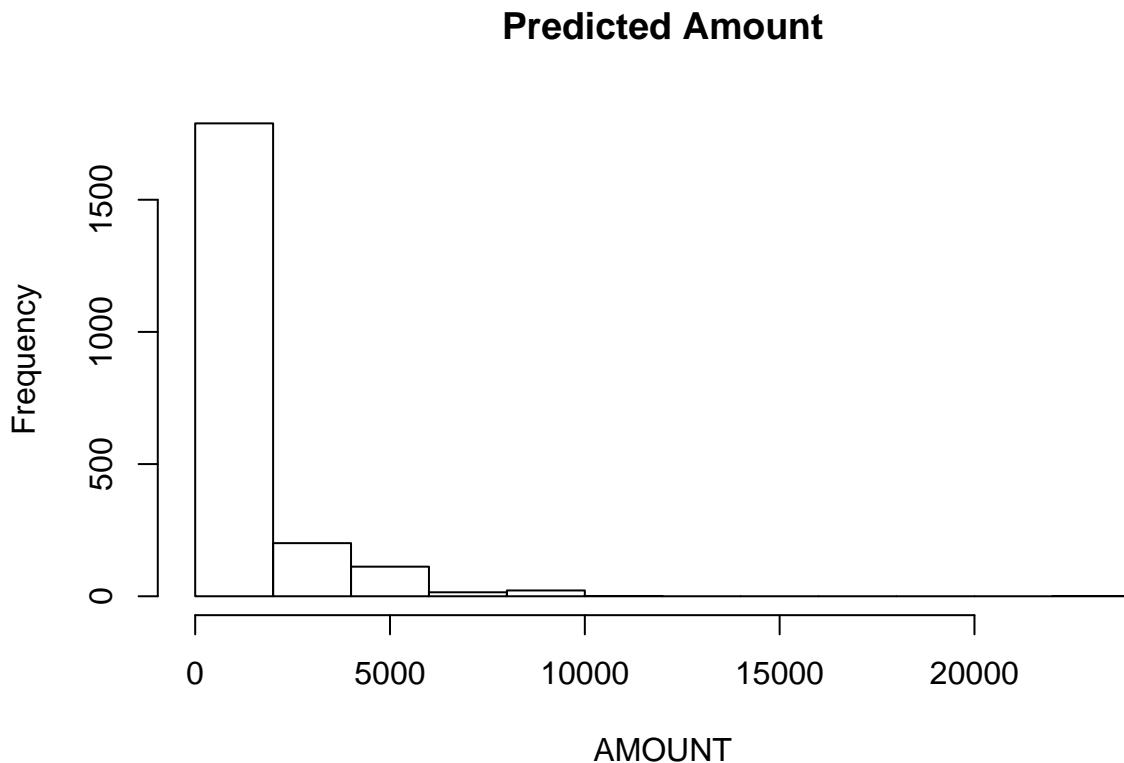


Now, the above values were calculated assuming that all outliers were ZERO. Let's recalculate and see if new Outliers can be found in order to refine our values.

```
##      Min. 1st Qu. Median     Mean 3rd Qu.    Max.  
##      0.0    0.0    0.0   646.2    0.0 4932.3
```

Let's see the first 20 records of the final predicted data set.

INDEX	TARGET_FLAG	TARGET_AMT
3	0	0.00
9	0	0.00
10	0	0.00
18	0	0.00
21	0	0.00
30	0	0.00
31	0	0.00
37	0	0.00
39	0	0.00
47	0	0.00
60	0	0.00
62	1	4160.33
63	1	3794.61
64	0	0.00
68	0	0.00
75	1	4026.46
76	1	2187.72
83	0	0.00
87	1	3583.60
92	0	0.00



```
##      Min. 1st Qu. Median     Mean 3rd Qu.    Max.
##      0.0    0.0    0.0   719.6    0.0 23918.2
```

5.4 Export file

In order to provide a csv output for the predictions table.

```
write.csv(data.eval_ORIGINAL, file = "insurance-my-evaluated-data.csv", row.names=FALSE)
```