

Marketing A Term Deposit

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Summary

This article explores factors affecting people's purchase decision of a term deposit during a bank's marketing campaign. Using a hierarchical logistic model, I found that consumers who have purchased a term deposit in previous marketing campaigns are more likely to purchase again, but the effect of previous campaign outcomes diminishes when consumers are more confident about future economy.

1. Introduction

A term deposit offered at banks is a type of investment associated with relatively low risks. Consumers' deposits are locked up for a period of time. At the end of the investment period, consumers withdraw their deposits and gain some interests in return. Compared to traditional saving accounts, term deposits offer a slightly higher interest rate. With consumers' term deposits, banks could make a profit by lending these money to other individuals or companies in need and charging an even higher interest rate. Therefore, banks always try to run marketing campaigns and attract more term deposits.

With a Portuguese bank marketing dataset, my primary research goal is to identify crucial features of a successful telephone marketing campaign for term deposits. Specifically, I wonder how consumers' decisions in previous marketing campaigns affect the current campaign outcome. Moro, Cortez, and Rita (2014) ¹ explored a similar data set with four different data mining models. Focusing on model comparisons, they found neural network is the best model to predict the success of banks' telephone marketing, compared to logistic regression, decision trees, and support vector machine. Different from their approach, in addition to my primary research goal, I also examined if the odds of purchasing a term deposit differ across contacted month with a hierarchical logistic model.

2. Data

The dataset is based on marketing campaigns of a Portuguese bank from May 2008 to November 2010. This dataset is available in the UCI machine learning repository. Due to data limitation, the current data set only includes a part of the dataset used by Moro, Cortez and Rita (2014). Overall, 41,188 observations of 18 variables are included in the dataset.

The binary response variable represents whether consumers purchased a term deposit at the end of a marketing campaign. All potential predictors are grouped from four aspects and listed in Table 1. Indicated by recent contact type, consumers are contacted via telephone or cellular. Three potential outcomes are recorded for previous campaigns. Success indicates

¹S. Moro, P. Cortez and P. Rita. A Data-Driven Approach to Predict the Success of Bank Telemarketing. Decision Support Systems (2014).

Table 1: Variables

| Group | Variables |
|--------------------------|--|
| Consumer Characteristics | age (num), job (factor), marital status (factor), education (factor), housing loan history (factor), personal loan history (factor) |
| Recent Contact | type (factor), month (factor), day (factor) |
| Contact History | number of contacts performed with this consumer for this campaign (num), number of days since approached by previous marketing campaigns (num), number of previous campaigns the consumer was approached (num), previous campaign outcome (factor) |
| Social & Economic | quarterly employment variation rate (num), daily Euribor 3 month rate (num), monthly consumer price index (num), monthly consumer confidence index (num) |

that a consumer has purchased a term deposit in previous marketing campaigns, while failure indicates that a consumer has been approached before, but has never purchased a term deposit. Nonexistent indicates a new consumer who has never been contacted for a marketing campaign.

Four social and economic attributes are listed. The quarterly employment variation rate describes the economy from the aspect of employment. The consumer price index suggests the price variation of goods and services. The consumer confidence index shows consumer optimism of the current and future household spending and saving activities. The Euribor 3 month rate provides the average interest rate that European banks charge each other for loans with three-month maturity, indicating banks' expectation of future economic conditions. A low consumer price index, a high consumer confidence index, and a low Euribor 3 month rate indicate that people are optimistic about future economy.

Missing data is a potential problem in this data set. Less than 10 percent of data for education, housing loan history, personal loan history, and consumers' job title is missing. I used MICE in R to create imputations and take care of this problem. Five imputed datasets were generated and these imputed datasets follow a similar distribution as the observed dataset. The following analysis is based on the first randomly imputed dataset.

3. Exploratory Analysis

Plotting potential predictors and the response variable, I observed a nonlinear relationship of age. Specifically, consumers are less likely to purchase the product during their mid-ages (30s-50s), compared to their 20s and 60s (Figure 1). For further analysis, I regrouped consumers' age into three categories: young ($\text{age} \leq 30$), middle ($30 < \text{age} < 60$), and old ($\text{age} \geq 60$). Marital status, housing loan, personal loan, and contacted day are similar across consumers who purchased a term deposit and those who did not. Consumers are more likely to purchase a term deposit if they have high school degrees, and are contacted by cellular in March, September, October, and December (Table 8, 11, and 12). Since the likelihood of purchasing a term deposit varies across contacted month, a varying-intercept model needs to be considered. Additionally, the number of contacts made before this campaign is

positively related with the outcome of this campaign, while the number of contacts made for this campaign is negatively related with the likelihood of purchasing a term deposit (Figure 4 and 2). Furthermore, consumers who have previously purchased a term deposits are more likely to purchase again than those who have never been approached before or those who have been approached but have not purchased a term deposit in previous marketing campaigns (Table 2).

Table 2: Previous Campaign Outcome and Term Deposits

| | failure | nonexistent | success |
|-----|---------|-------------|---------|
| no | 0.86 | 0.91 | 0.35 |
| yes | 0.14 | 0.09 | 0.65 |

Next, I examined how social and economics attributes affect consumers' decision of purchasing a term deposit during a marketing campaign. Since the Euribor 3 month rate is clustered around 1.3 and 4.9, I regrouped the variable into two categories: low ($\text{euribor} \leq 3$) and high ($\text{euribor} > 3$). Plotting social and economics attributes against the response variable, a negative relationship is observed for consumer price index and Euribor 3 month rate, while a positive relationship is observed for consumer confidence index. The pattern is consistent with their definitions. Additionally, I found that the relationship between consumer confidence index and consumers' probability of purchasing a term deposit varies across previous campaign outcome (Figure 10). The significance of this interactions will be analyzed in the model below.

4. Modeling

In this section, logistic models and multi-level models are used to explore features leading to a successful marketing campaign for term deposits. Most numeric variables, including age, quarterly employment variation rate, monthly consumer price index, and monthly consumer confidence index are mean-centered for precise interpretation. The model selection process is summarized in Table 4.

M1: Baseline Model

Based on results from exploratory analysis and the main research question, all potential predictors are included in the baseline model. As indicated in the exploratory analysis section, I included new categorical variables of age and Euribor 3 month rate instead of the numerical ones to avoid violations of the linearity assumption. Additionally, I dropped employment variation rate due to multicollinearity.

M2: Interactions

Since I am also interested in if the effect of previous campaign outcome on the probability of consumers purchasing a term deposit varies by expected economy, the interaction term between previous campaign outcome and consumer confidence index is added to the advanced model.

M3: Stepwise Model

According to stepwise model selection results, AIC drops variables including housing loan and personal loan. Since the anova test shows that the new model is not significantly different from the interaction model, I continued with the stepwise model for simplicity.

M4: Hierarchical Logistic model

To examine if the odds of purchasing a term deposit differ across contacted month, a varying intercept by contacted month is added to the stepwise model. The following multi-level logistic model is my final model:

$$\begin{aligned} \log\left(\frac{\pi_{ij}}{1 - \pi_{ij}}\right) = & \beta_0 + \gamma_{0j} + \beta_1 \text{newage}_{ij} + \beta_2 \text{job}_{ij} + \beta_3 \text{marital}_{ij} + \beta_4 \text{education}_{ij} \\ & + \beta_5 \text{contact}_{ij} + \beta_6 \text{day}_{ij} + \beta_7 \text{campaign}_{ij} + \beta_8 \text{previous}_{ij} + \beta_9 \text{poutcome}_{ij} \\ & + \beta_{10} \text{confc}_{ij} + \beta_{11} \text{price}_{ij} + \beta_{12} \text{loweuri}_{ij} + \beta_{13} \text{poutcome}_{ij} * \text{confc}_{ij}, \\ \epsilon_{ij} \sim & N(0, \sigma^2), \gamma_{0j} \sim N(0, \gamma_0^2) \end{aligned}$$

Model assumptions are checked with binned residual plots. Most data points are randomly distributed within the 95 percent band (Figure 11). The pattern in the plot between binned residual against numerical variables also looks random, indicating no violation for the linearity assumption (Figure 13). In the logistic model (M3), all VIF values are below 10, indicating no serious multicollinearity problem in the final model.

Visualizing the random effect, March and May are potential outliers (Figure 14). Their 95 percent confidence intervals are far away from zero. The odds of purchasing a term deposit is extremely high in March, but low in May. After eliminating outliers, the model is computed again again. Although 14,315 observations are removed from the data set, the binned residual plot does not change much (Figure 15). Therefore, I report results including these potential outliers (Table 5 for full results). Fixed effects of the hierarchical model are consistent with logistic model results. The model accuracy is 0.81, and the AUC is 0.79 (Figure 12). Due to page limitation, only variables of interests are reported and interpreted here (Table 3).

Table 3: Simple Hierarchical Model Results - Variables of Interests

| Random effects: | | | | |
|---|-------------|------------|----------|--------------|
| Groups | Name | Variance | Std.Dev. | |
| month | (Intercept) | 0.1541 | 0.3925 | |
| Number of obs: 41188, groups: month, 10 | | | | |
| Fixed effects: | Estimate | Std. Error | z value | Pr(> z) |
| (Intercept) | -3.1118102 | 0.1934678 | -16.084 | < 2e-16 *** |
| poutcomenonexistent | 0.5002969 | 0.0865843 | 5.778 | 7.55e-09 *** |
| poutcomesuccess | 1.7893375 | 0.0809860 | 22.094 | < 2e-16 *** |
| confc | 0.0842785 | 0.0076907 | 10.959 | < 2e-16 *** |
| poutcomenonexistent:confc | -0.0290122 | 0.0079351 | -3.656 | 0.000256 *** |
| poutcomesuccess:confc | -0.0342754 | 0.0114872 | -2.984 | 0.002847 ** |

intercept: For a fixed month, the expected odds ratio of purchasing a term deposit is 0.04 ($e^{-3.112}$) if the consumer is below 30, divorced, working as an admin, with a basic 4-year education, and who has not been contacted right before this campaign and is approached on a Friday by cell phone for the first time for this campaign. This consumer has been approached for previous campaigns but has not bought any product. The daily Euribor 3 moth rate is high, but the consumer price index and consumer confidence index are on the average level.

poutcome: For a fixed month, keeping all other variables constant, compared to a consumer who did not agree to purchase a term deposit for previous campaigns, the odds ratio of purchasing a term deposit for this campaign increases by 5.98 ($e^{1.789}$) if the consumer has successfully purchased the product in previous campaigns, while the odds ratio only increases by 1.65 ($e^{0.500}$) if the consumer has not been approached in previous campaigns.

confc: For a fixed month, keeping all other variables constant, an additional unit increase in consumer confidence index increases the odds ratio of purchasing a term deposit for this campaign by 1.09 ($e^{0.084}$).

poutcome*confc: For a fixed month, keeping all other variables constant, when consumer confidence index increases by 1 unit, compared to a consumer who did not agree to purchase a term deposit in previous campaigns, the odds ratio of purchasing a term deposit for this campaign only increases by 1.05 ($e^{(0.084-0.034)}$) if the consumer has successfully purchased the product in previous campaign, and the odds ratio increases by 1.06 ($e^{(0.084-0.029)}$) if the consumer has never been approached before.

Random Effect - month: Taking April as an example: for any consumer contacted in April, the baseline odds of purchasing is 0.04 ($e^{(-3.112-0.167)}$), which is lower than the overall month wide average. The across-county variation attributed to the random intercept is 0.3925.

To answer the main research question, the odds ratio of consumers purchasing a term deposit for the current marketing campaign increases if they have successful experience in previous campaigns. However, the effect of previous campaign outcome diminishes if people are optimistic about future economy. Additionally, consumers are more likely to purchase a term deposit in a marketing campaign if they are contacted by cell phone on Monday and with successful outcomes in previous campaigns.

5. Conclusion

This analysis provides insights for banks to conduct successful marketing campaigns, especially for attracting term deposits. When people are pessimistic about future economy, banks should focus on loyal consumers and convince them to purchase term deposits again. When people are confident about future economy, banks could approach the general public for term deposits. Additionally, banks need to remember that consumers are less likely to purchase if they are contacted multiple times for the same marketing campaign.

One limitation of this analysis is that far more consumers in the dataset chose not to purchase a term deposit at the end of the marketing campaign, which may lead to potential bias in the analysis. Additionally, this dataset is solely based on one Portuguese bank. Future studies could explore the same research question with data from other countries and analyze if the impact of telephone marketing campaigns would be different.

Reference

S. Moro, P. Cortez and P. Rita. A Data-Driven Approach to Predict the Success of Bank Telemarketing. Decision Support Systems (2014), doi:10.1016/j.dss.2014.03.001.

Appendix

Table 4: Model Selection Process

| Model | Predictors |
|------------------|--|
| M1(Baseline) | newage, job, marital, education, housing, loan, contact, month, day, campaign, previous, poutcome, loweuri, confc, pricec |
| M2(Interactions) | M1 + poutcome * confc |
| M3(Stepwise) | newage, job, marital, education, contact, month, day, campaign, previous, poutcome, loweuri, confc, pricec, poutcome * confc |
| M4(Hierarchical) | (1 month), newage, job, marital, education, contact, day, campaign, previous, poutcome, loweuri, confc, pricec, poutcome * confc |

* $\log(\frac{\pi_{ij}}{1-\pi_{ij}})$ as response variable

*M4 is the final model

Table 5: Hierarchical Model Results

| | | | | |
|---|-------------|------------|----------|--------------|
| Random effects: | | | | |
| Groups | Name | Variance | Std.Dev. | |
| month | (Intercept) | 0.1541 | 0.3925 | |
| Number of obs: 41188, groups: month, 10 | | | | |
| Fixed effects: | Estimate | Std. Error | z value | Pr(> z) |
| (Intercept) | -3.1118102 | 0.1934678 | -16.084 | < 2e-16 *** |
| poutcomenonexistent | 0.5002969 | 0.0865843 | 5.778 | 7.55e-09 *** |
| poutcomesuccess | 1.7893375 | 0.0809860 | 22.094 | < 2e-16 *** |
| contacttelephone | -0.5109690 | 0.0600645 | -8.507 | < 2e-16 *** |
| newage1 | -0.1256645 | 0.0493806 | -2.545 | 0.010933 * |
| newage2 | 0.1726695 | 0.1088135 | 1.587 | 0.112549 |
| confc | 0.0842785 | 0.0076907 | 10.959 | < 2e-16 *** |
| pricec | 0.5763663 | 0.0448670 | 12.846 | < 2e-16 *** |
| loweuril | 2.1634644 | 0.0623028 | 34.725 | < 2e-16 *** |
| previous | 0.0442995 | 0.0531416 | 0.834 | 0.404500 |
| jobblue-collar | -0.1766379 | 0.0688682 | -2.565 | 0.010321 * |
| jobentrepreneur | -0.0624599 | 0.1066762 | -0.586 | 0.558206 |
| jobhousemaid | -0.1028875 | 0.1278346 | -0.805 | 0.420907 |
| jobmanagement | -0.0619316 | 0.0745173 | -0.831 | 0.405915 |
| jobretired | 0.1285898 | 0.1007873 | 1.276 | 0.202008 |
| jobself-employed | -0.0767367 | 0.1011959 | -0.758 | 0.448272 |
| jobservices | -0.1452526 | 0.0746407 | -1.946 | 0.051652 . |
| jobstudent | 0.1940960 | 0.0982516 | 1.976 | 0.048211 * |
| jobtechnician | -0.0124446 | 0.0615256 | -0.202 | 0.839708 |
| jobunemployed | -0.0009718 | 0.1100673 | -0.009 | 0.992956 |
| campaign | -0.0507620 | 0.0092471 | -5.490 | 4.03e-08 *** |
| daymon | -0.2280943 | 0.0575171 | -3.966 | 7.32e-05 *** |
| daythu | 0.0475612 | 0.0553337 | 0.860 | 0.390045 |
| daytue | 0.0472444 | 0.0569329 | 0.830 | 0.406638 |
| daywed | 0.1349873 | 0.0565416 | 2.387 | 0.016968 * |
| educationbasic.6y | 0.1416537 | 0.1006498 | 1.407 | 0.159311 |
| educationbasic.9y | 0.0108800 | 0.0799808 | 0.136 | 0.891796 |
| educationhigh.school | 0.1004085 | 0.0778517 | 1.290 | 0.197141 |
| educationilliterate | 0.6194988 | 0.5382881 | 1.151 | 0.249786 |
| educationprofessional.course | 0.0708652 | 0.0862707 | 0.821 | 0.411402 |
| educationuniversity.degree | 0.1918115 | 0.0779836 | 2.460 | 0.013908 * |
| maritalmarried | 0.0351581 | 0.0596401 | 0.590 | 0.555523 |
| maritalsingle | 0.0521449 | 0.0670333 | 0.778 | 0.436630 |
| poutcomenonexistent:confc | -0.0290122 | 0.0079351 | -3.656 | 0.000256 *** |
| poutcomesuccess:confc | -0.0342754 | 0.0114872 | -2.984 | 0.002847 ** |

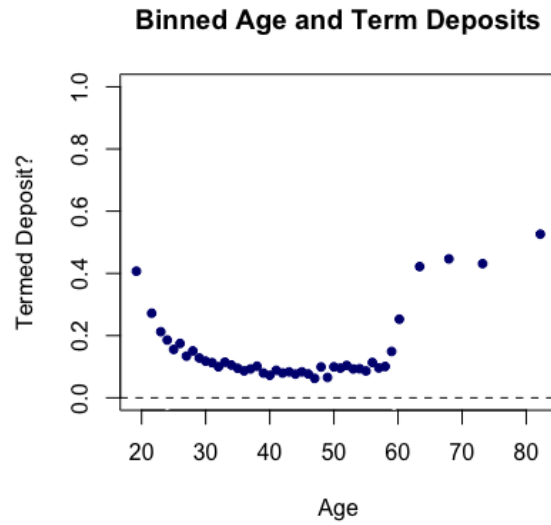


Figure 1: Binned Age and Term Deposits

Table 6: Job and Term Deposits

| | admin. | blue-collar | entrepreneur | housemaid | management | retired |
|-----|---------------|-------------|--------------|------------|------------|---------|
| no | 0.87 | 0.93 | 0.91 | 0.90 | 0.89 | 0.75 |
| yes | 0.13 | 0.07 | 0.09 | 0.10 | 0.11 | 0.25 |
| | self-employed | services | student | technician | unemployed | unknown |
| no | 0.90 | 0.92 | 0.69 | 0.89 | 0.86 | |
| yes | 0.10 | 0.08 | 0.31 | 0.11 | 0.14 | |

Table 7: Marriage and Term Deposits

| | divorced | married | single | unknown |
|-----|----------|---------|--------|---------|
| no | 0.90 | 0.90 | 0.86 | |
| yes | 0.10 | 0.10 | 0.14 | |

Table 8: Education and Term Deposits

| | basic.4y | basic.6y | basic.9y | high.school | illiterate |
|-----|---------------------|-------------------|----------|-------------|------------|
| no | 0.90 | 0.92 | 0.92 | 0.89 | 0.78 |
| yes | 0.10 | 0.08 | 0.08 | 0.11 | 0.22 |
| | professional.course | university.degree | unknown | | |
| no | 0.89 | 0.86 | | | |
| yes | 0.11 | 0.14 | | | |

Table 9: Housing Loan and Term Deposits

| | no | unknown | yes |
|-----|------|---------|------|
| no | 0.89 | | 0.88 |
| yes | 0.11 | | 0.12 |

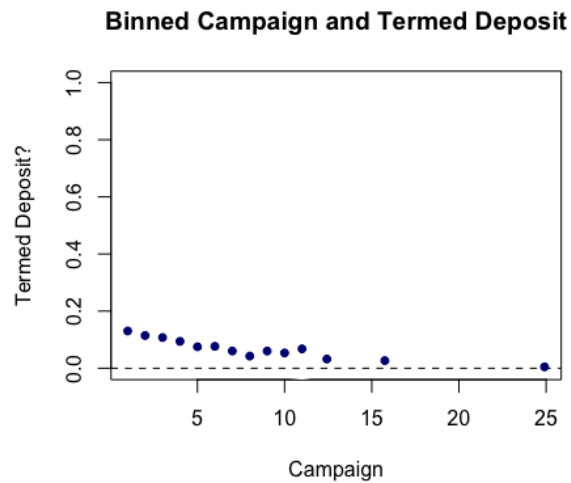


Figure 2: Binned Contacts for This Campaign and Term Deposits

Table 10: Personal Loan and Term Deposits

| | no | unknown | yes |
|-----|------|---------|------|
| no | 0.89 | | 0.89 |
| yes | 0.11 | | 0.11 |

Table 11: Contacted Type and Term Deposits

| | cellular | telephone |
|-----|----------|-----------|
| no | 0.85 | 0.95 |
| yes | 0.15 | 0.05 |

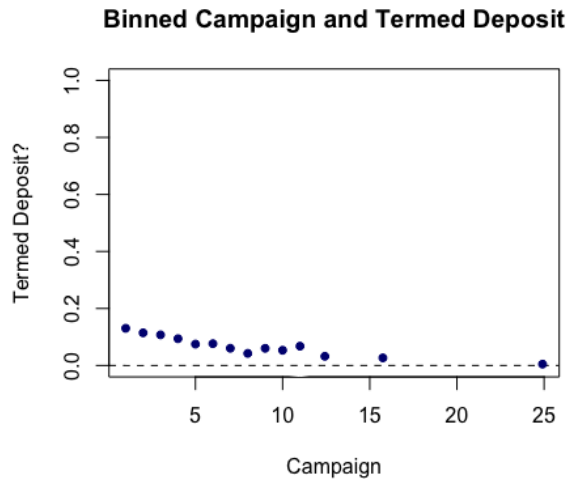


Figure 3: Binned Days since Last Contact and Term Deposits

Table 12: Contacted Month and Term Deposits

| | apr | aug | dec | jul | jun | mar | may | nov | oct | sep |
|-----|------|------|------|------|------|------|------|------|------|------|
| no | 0.80 | 0.89 | 0.51 | 0.91 | 0.89 | 0.49 | 0.94 | 0.90 | 0.56 | 0.55 |
| yes | 0.20 | 0.11 | 0.49 | 0.09 | 0.11 | 0.51 | 0.06 | 0.10 | 0.44 | 0.45 |

Table 13: Contacted Day and Term Deposits

| | fri | mon | thu | tue | wed |
|-----|------|------|------|------|------|
| no | 0.89 | 0.90 | 0.88 | 0.88 | 0.88 |
| yes | 0.11 | 0.10 | 0.12 | 0.12 | 0.12 |

Binned Contacts before this Campaign and Term Deposits

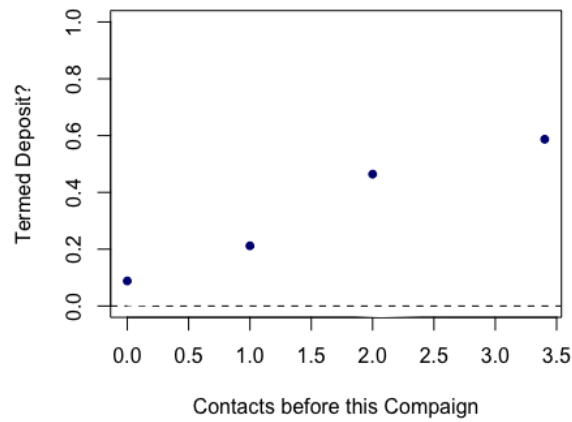


Figure 4: Binned Contacts before this Campaign and Term Deposits

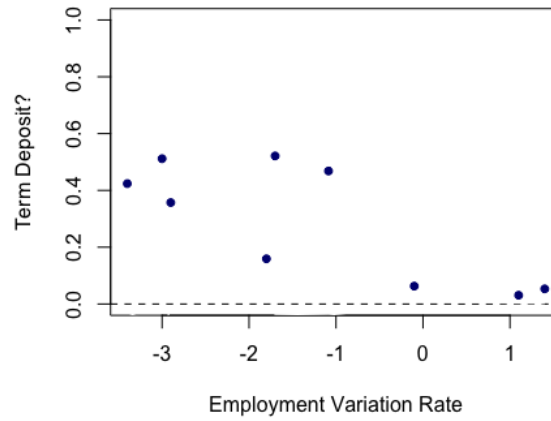
Binned Employment Variation Rate and Term Depo

Figure 5: Binned Employment Variation Rate and Term Deposits



Figure 6: Binned Consumer Price Index and Term Deposits

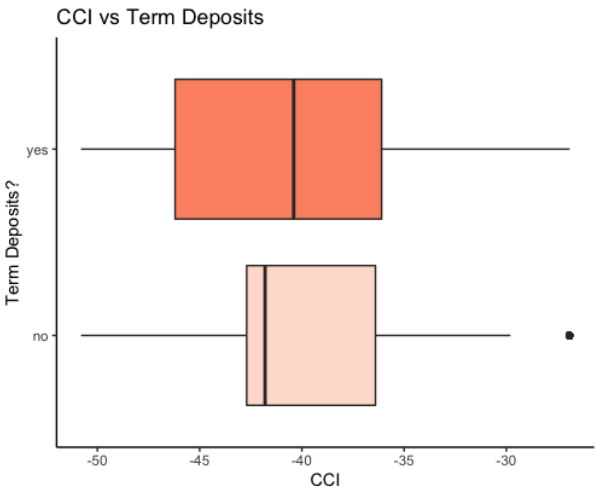


Figure 7: Binned Consumer Confidence Index and Term Deposits

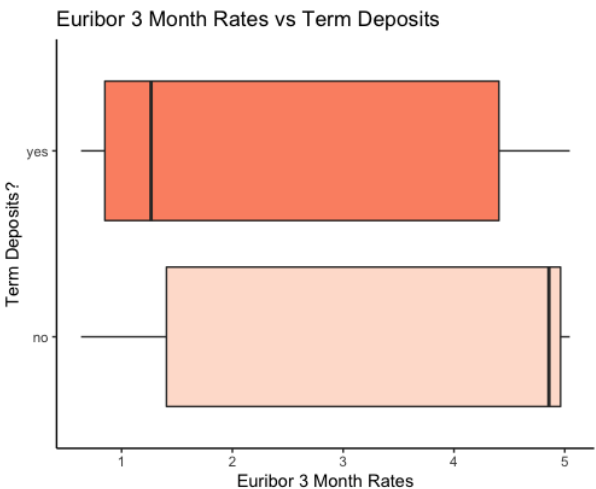


Figure 8: Binned Euribor 3 Month Rates and Term Deposits

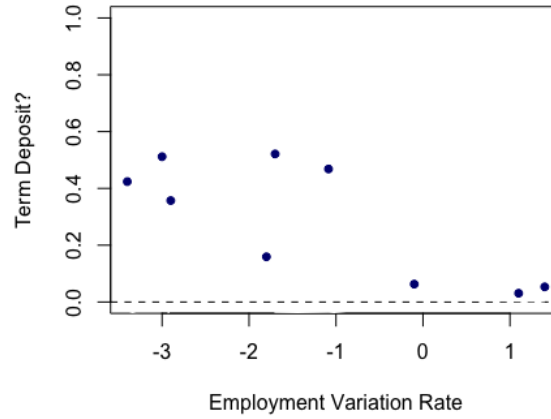
Binned Employment Variation Rate and Term Depo

Figure 9: Binned Employment Variation Rate and Term Deposits

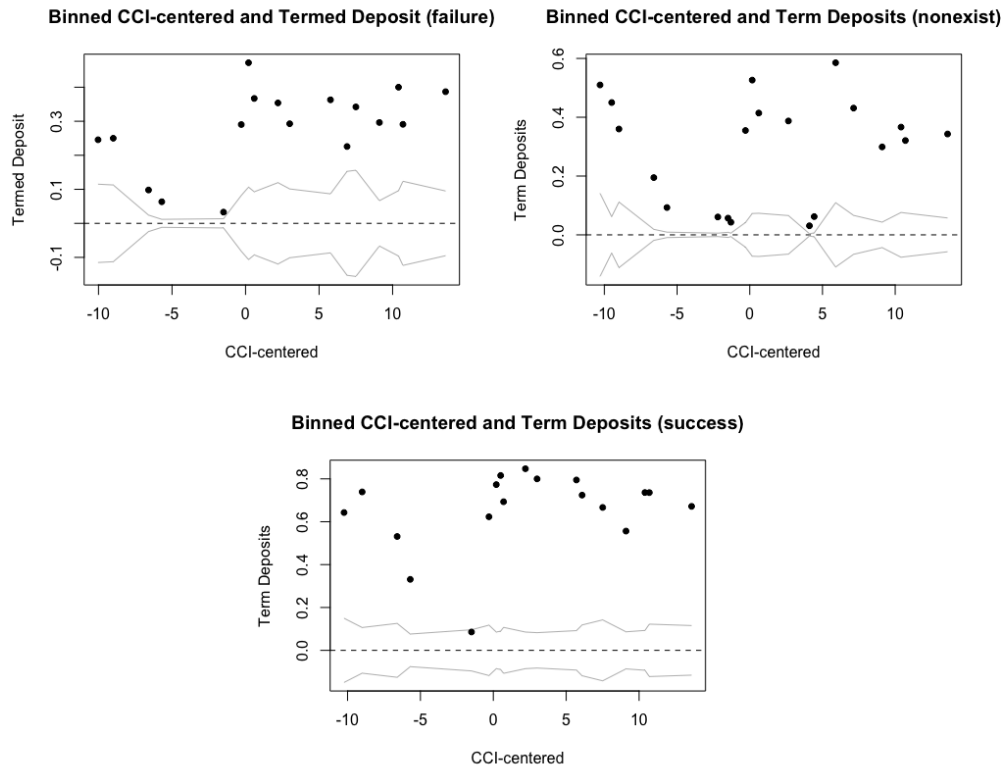


Figure 10: Interaction: CCI and Previous Campaign Outcome

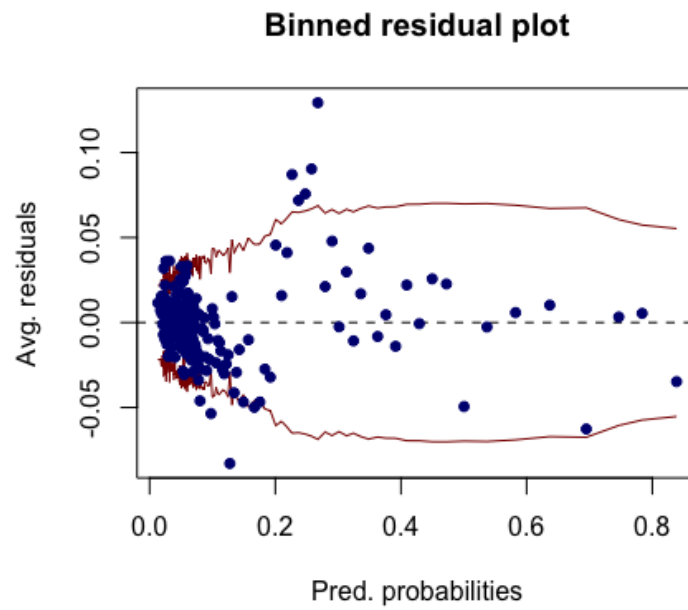


Figure 11: Binned Residual Plot

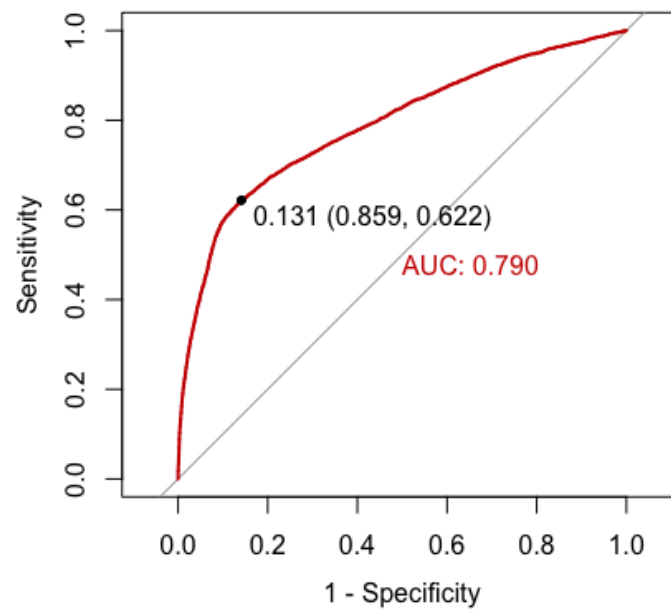


Figure 12: AUC

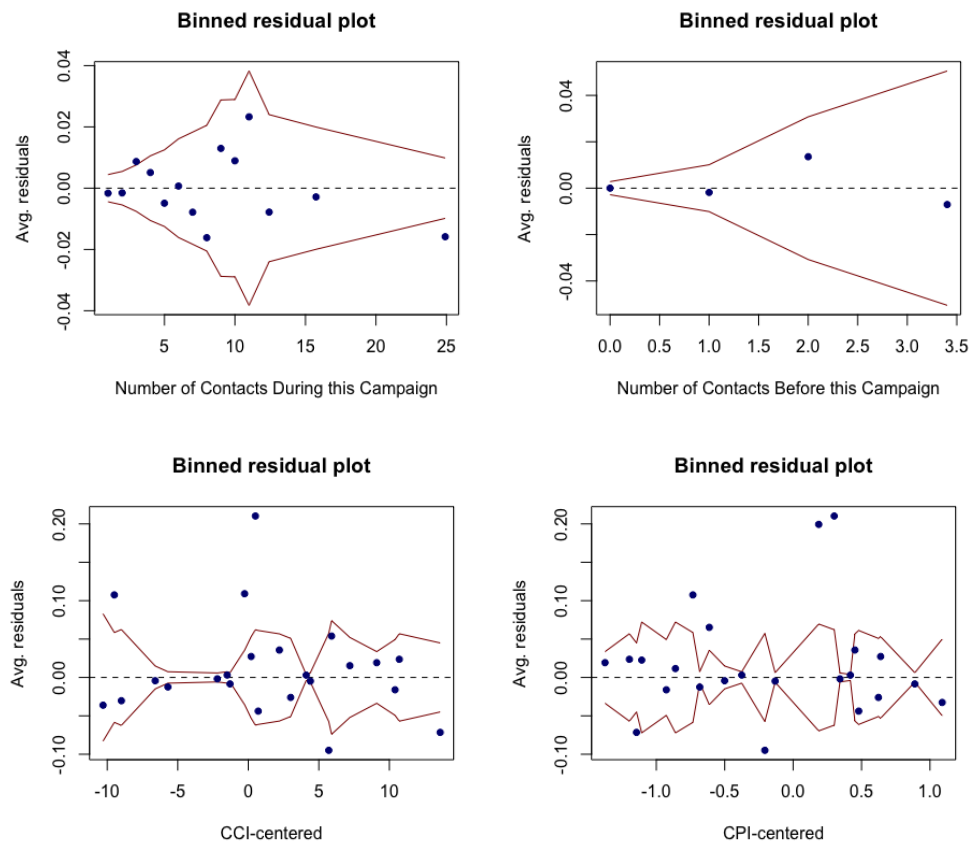


Figure 13: Linearity Check

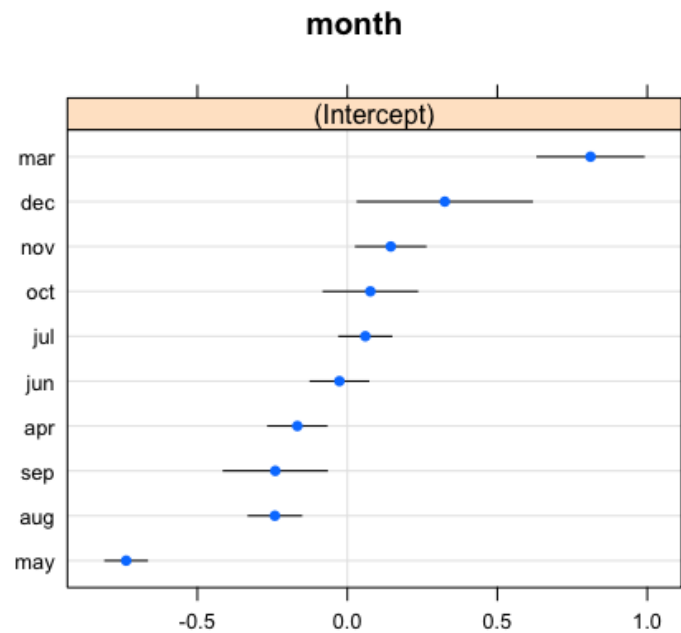


Figure 14: Outlier Check

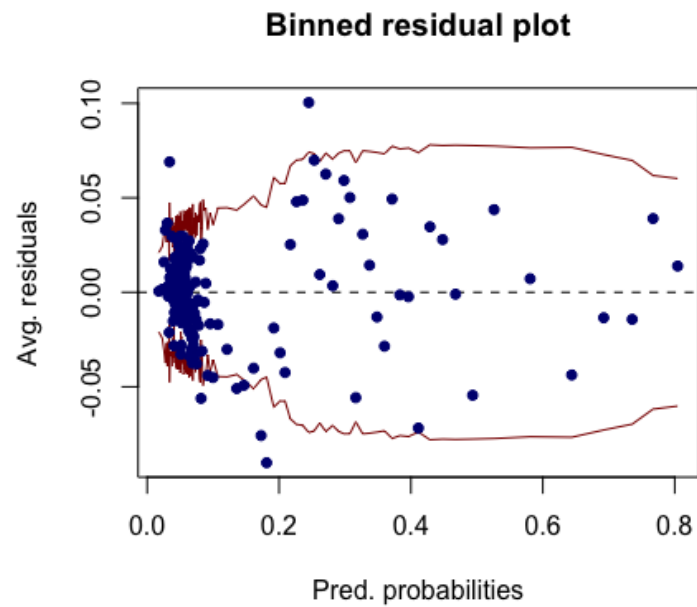


Figure 15: Binned Residual Plot without Potential Outliers

Main Code

Data Prepare

```
1 # Data Loading
2 bank <- read.csv(/Users/Chenyu/Downloads/bank-additional-full.csv, header=TRUE,
  stringsAsFactors=FALSE)
3
4 bank$job <- as.factor(bank$job)
5 bank$marital <- as.factor(bank$marital)
6 bank$education <- as.factor(bank$education)
7 bank$housing <- as.factor(bank$housing)
8 bank$loan <- as.factor(bank$loan)
9 bank$contact <- as.factor(bank$contact)
10 bank$month <- as.factor(bank$month)
11 bank$day_of_week <- as.factor(bank$day_of_week)
12 bank$poutcome <- as.factor(bank$poutcome)
13 bank$y <- as.factor(bank$y)
14 bank$ynum <- as.numeric(bank$y) - 1
15
16 # install.packages(naniar)
17 library(naniar)
18 bankna <- replace_with_na(bank, replace = list(job = unknown, marital = unknown,
  education = unknown,
19 housing = unknown, loan = unknown,
  poutcome = unknown))
20 na_count <- sapply(bankna, function(y) sum(length(which(is.na(y)))))
21 na_count <- data.frame(na_count)
22 bank = subset(bankna, select = -c(default,duration))
23 summary(bank)
24
25 library(mice)
26 # Visualize Missing Data
27 md.pattern(bank)
28 # install.packages(VIM)
29 library(VIM);library(lattice)
30 agr(bank,col=c(lightblue3,darkred),numbers=TRUE,sortVars=TRUE,labels=names(bank),
  cex.axis=.7,gap=3,ylab=c(Proportion missing,Missingness
  pattern))
31 marginplot(bank[,c(diameter.,age)],col=c(lightblue3,darkred),cex.numbers = 1.2,pch
  =19)
32 # Imputation
33 bank_imp <- mice(bank,m=5,print=F)
34
35 library(ggplot2)
```

```
36 d1 <- complete(bank_imp,1);d1
37 apply(table(d1[,c(y,education)])/sum(table(d1[,c(y,education)])),2,function(x) x/
    sum(x))
38 apply(table(d1[,c(y,housing)])/sum(table(d1[,c(y,housing)])),2,function(x) x/sum(x
    ))
39 apply(table(d1[,c(y,loan)])/sum(table(d1[,c(y,loan)])),2,function(x) x/sum(x))
40 d1$oldconsumer[d1$pdays == 999] <- 0
41 d1$oldconsumer[d1$pdays < 999] <- 1
42 table(d1$oldconsumer)
43 d1$newage[d1$age <=30] <- 0
44 d1$newage[d1$age >30 & d1$age < 60] <- 1
45 d1$newage[d1$age >=60] <- 2
46 d1$newage <- as.factor(d1$newage)
47 table(d1$newage)
48
49 d2 <- complete(bank_imp,2);d2
50 apply(table(d2[,c(y,education)])/sum(table(d2[,c(y,education)])),2,function(x) x/
    sum(x))
51 apply(table(d2[,c(y,housing)])/sum(table(d2[,c(y,housing)])),2,function(x) x/sum(x
    ))
52 apply(table(d2[,c(y,loan)])/sum(table(d2[,c(y,loan)])),2,function(x) x/sum(x))
53
54 bank_obs <- na.omit(bank)
55 apply(table(bank_obs[,c(y,education)])/sum(table(bank_obs[,c(y,education)])),2,
    function(x) x/sum(x))
56 apply(table(bank_obs[,c(y,housing)])/sum(table(bank_obs[,c(y,housing)])),2,
    function(x) x/sum(x))
57 apply(table(bank_obs[,c(y,loan)])/sum(table(bank_obs[,c(y,loan)])),2,function(x) x
    /sum(x))
58
59 library(MatchIt) #for propensity score matching
60 library(cobalt)
61 library(tidyverse)
62 library(knitr)
63 library(GGally)
64 library(xtable)
65 library(arm)
66 library(pROC)
67 library(e1071)
68 library(caret)
69 library(rms)
70 require(gridExtra)
71
72 # EDA
```

```
73
74 # age (none / people are less likely to purchase the product during their mid-ages
    (30s–50s), compared to their 20s and 60s)
75 table(bank$age)
76 ggplot(bank,aes(x=y, y=age, fill=y)) +
77   geom_boxplot() + coord_flip() +
78   scale_fill_brewer(palette=Reds) +
79   labs(title=Age vs Termed Deposit,
80        x=Termed Deposit?,y=Age) +
81   theme_classic() + theme(legend.position=none)
82 binnedplot(y=bank$ynum, bank$age, xlab=Age, ylim=c(0,1), col.pts=navy,
83            ylab =Termed Deposit?, main=Binned Age and Term Deposits,
84            col.int=white)
85
86
87 # job (retired — highest)
88 table(bank$job)
89 tjob <- apply(table(bank[,c(y,job)])/sum(table(bank[,c(y,job)])),2,function(x) x/
    sum(x))
90 xtable(tjob)
91 plot(0:11,tapply(bank$ynum, bank$job, mean),col='blue4',pch=10)
92
93 # marital (similar)
94 table(bank$marital)
95 tmarital <- apply(table(bank[,c(y,marital)])/sum(table(bank[,c(y,marital)])),2,
    function(x) x/sum(x))
96 xtable(tmarital)
97 plot(0:3,tapply(bank$ynum, bank$marital, mean),col='blue4',pch=10)
98
99 # education (high school — highest)
100 table(bank$education)
101 teducation <- apply(table(bank[,c(y,education)])/sum(table(bank[,c(y,education)])),
    2,function(x) x/sum(x))
102 xtable(teducation)
103 plot(0:7,tapply(bank$ynum, bank$education, mean),col='blue4',pch=10)
104
105 # housing (similar)
106 table(bank$housing)
107 thousing <- apply(table(bank[,c(y,housing)])/sum(table(bank[,c(y,housing)])),2,
    function(x) x/sum(x))
108 xtable(thousing)
109 plot(0:2,tapply(bank$ynum, bank$housing, mean),col='blue4',pch=10)
110
111 # loan (similar)
```

```
112 table(bank$loan)
113 tloan <- apply(table(bank[,c(y,loan)])/sum(table(bank[,c(y,loan)])),2,function(x)
      x/sum(x))
114 xtable(tloan)
115 plot(0:2,tapply(bank$ynum, bank$loan, mean),col='blue4',pch=10)
116
117 # contact (cellular slightly higher)
118 tcontact <- apply(table(bank[,c(y,contact)])/sum(table(bank[,c(y,contact)])),2,
      function(x) x/sum(x))
119 xtable(tcontact)
120 plot(0:1,tapply(bank$ynum, bank$contact, mean),col='blue4',pch=10)
121
122 # month (apr, aug, jul, jun, may, nov)
123 tmonth <- apply(table(bank[,c(y,month)])/sum(table(bank[,c(y,month)])),2,function(
      x) x/sum(x))
124 xtable(tmonth)
125 plot(0:9,tapply(bank$ynum, bank$month, mean),col='blue4',pch=10)
126
127 # day (similar)
128 plot(0:4,tapply(bank$ynum, bank$day_of_week, mean),col='blue4',pch=10)
129
130 # duration (positive) ? don't include
131 ggplot(bank,aes(x=y, y=duration, fill=y)) +
132   geom_boxplot() + coord_flip() +
133   scale_fill_brewer(palette=Reds) +
134   labs(title=Duration vs Termed Deposit,
135        x=Termed Deposit?,y=Duration) +
136   theme_classic() + theme(legend.position=none)
137 binnedplot(y=bank$ynum,bank$duration,xlab=Duration,ylim=c(0,1),col.pts=navy,
138            ylab =Termed Deposit?,main=Binned Duration and Termed Deposit,
139            col.int=white)
140 cor(bank$ynum,bank$duration)
141 regduration <- glm(y~duration, data=bank, family = binomial)
142 summary(regduration)
143
144 # campaign (none / decreasing over the number of contacts)
145 ggplot(bank,aes(x=y, y=campaign, fill=y)) +
146   geom_boxplot() + coord_flip() +
147   scale_fill_brewer(palette=Reds) +
148   labs(title=Campaign vs Termed Deposit,
149        x=Termed Deposit?,y=Campaign) +
150   theme_classic() + theme(legend.position=none)
151 binnedplot(y=bank$ynum,bank$campaign,xlab=Campaign,ylim=c(0,1),col.pts=navy,
152            ylab =Term Deposits?,main=Binned Number of Contacts During this
      Campaign and Term Deposits,
```

```
153         col.int=white)
154
155 # previous
156 ggplot(bank,aes(x=y, y=previous, fill=y)) +
157   geom_boxplot() + coord_flip() +
158   scale_fill_brewer(palette=Reds) +
159   labs(title=Contacts for this Campaign vs Termed Deposit,
160        x=Termed Deposit?,y=Contacts for this Campaign) +
161   theme_classic() + theme(legend.position=none)
162 bank$yescontact[bank$previous == 0] <- 0
163 bank$yescontact[bank$previous != 0] <- 1
164 tyescontact <- apply(table(bank[,c(y, yescontact)])/sum(table(bank[,c(y, yescontact)
165   ])),2,function(x) x/sum(x))
166 xtable(tyescontact)
167 binnedplot(y=bank$ynum, bank$previous, xlab=Contacts before this
168   Campaign, ylim=c(0,1), col.pts=navy,
169   ylab =Term Deposit?, main=Binned Contacts before this Campaign and Term
170   Deposits,
171   col.int=white)
172 # plot(0:1,tapply(bank$ynum, bank$yescontact, mean), col='blue4', pch=10)
173
174 # poutcome: consumers who have previously bought termed deposits are more likely
175   to purchase again
176 table(bank$poutcome)
177 tpoutcome <- apply(table(bank[,c(y, poutcome)])/sum(table(bank[,c(y, poutcome)])),2,
178   function(x) x/sum(x))
179 xtable(tpoutcome)
180 plot(0:2,tapply(bank$ynum, bank$poutcome, mean), col='blue4', pch=10)
181
182 # employment variation rate (negative) [drop — high correlation with CPI and
183   Euribor]
184 ggplot(bank,aes(x=y, y=emp.var.rate, fill=y)) +
185   geom_boxplot() + coord_flip() +
186   scale_fill_brewer(palette=Reds) +
187   labs(title=Employment Variation Rate vs Termed Deposit,
188        x=Termed Deposit?,y=Employment Variation Rate) +
189   theme_classic() + theme(legend.position=none)
190 binnedplot(y=bank$ynum, bank$emp.var.rate, xlab=Employment Variation
191   Rate, ylim=c(0,1), col.pts=navy,
192   ylab =Term Deposit?, main=Binned Employment Variation Rate and Term
193   Deposits,
194   col.int=white)
195
196 # consumer price index (negative)
197 ggplot(bank,aes(x=y, y=cons.price.idx, fill=y)) +
198   geom_boxplot() + coord_flip() +
```

```
191 scale_fill_brewer(palette=Reds) +
192 labs(title=Consumer Price Index vs Term Deposits,
193       x=Term Deposits?,y=Consumer Price Index) +
194 theme_classic() + theme(legend.position=none)
195 binnedplot(y=bank$ynum, bank$cons.price.idx, xlab=Consumer Price
196            Index, ylim=c(0,1), col.pts=navy,
197            ylab =Term Deposits?, main=Binned Consumer Price Index and Term
198            Deposits,
199            col.int=white)
200 # CCI (positive)
201 ggplot(bank, aes(x=y, y=cons.conf.idx, fill=y)) +
202   geom_boxplot() + coord_flip() +
203   scale_fill_brewer(palette=Reds) +
204   labs(title=CCI vs Term Deposits,
205        x=Term Deposits?, y=CCI) +
206   theme_classic() + theme(legend.position=none)
207 binnedplot(y=bank$ynum, bank$cons.conf.idx, xlab=CCI, ylim=c(0,1), col.pts=navy,
208            ylab =Term Deposits?, main=Binned CCI and Term Deposits,
209            col.int=white)
210 # Euribor (negative)
211 ggplot(bank, aes(x=y, y=euribor3m, fill=y)) +
212   geom_boxplot() + coord_flip() +
213   scale_fill_brewer(palette=Reds) +
214   labs(title=Euribor 3 Month Rates vs Term Deposits,
215        x=Term Deposits?, y=Euribor 3 Month Rates) +
216   theme_classic() + theme(legend.position=none)
217 binnedplot(y=bank$ynum, bank$euribor3m, xlab=Euribor 3 Month
218            Rates, ylim=c(0,1), col.pts=navy,
219            ylab =Term Deposits?, main=Binned Euribor 3 Month Rates and Term
220            Deposits,
221            col.int=white)
222 summary(d1$euribor3m)
223 d1$loweuri[d1$euribor3m<=3]<-1
224 d1$loweuri[d1$euribor3m>3]<-0
225 d1$loweuri<-as.factor(d1$loweuri)
226 # correlation: employment variation rate, consumer price index, CCI, Euribor
227 cor(bank$emp.var.rate, bank$cons.conf.idx)
228 cor(bank$cons.price.idx, bank$emp.var.rate)
229 cor(bank$emp.var.rate, bank$euribor3m)
230 cor(bank$cons.price.idx, bank$cons.conf.idx)
231 cor(bank$cons.price.idx, bank$euribor3m)
232 cor(bank$cons.conf.idx, bank$euribor3m)
```

```

233 # interaction
234 # age * poutcome
235 binnedplot(d1$agec[d1$poutcome==failure],
236             y=d1$ynum[d1$poutcome==failure],
237             xlab = Age-centered, ylab = Termed Deposit, main = Binned Age-centered
                and Termed Deposit (failure))
238 binnedplot(d1$agec[d1$poutcome==nonexistent],
239             y=d1$ynum[d1$poutcome==nonexistent],
240             xlab = Age-centered, ylab = Termed Deposit, main = Binned Age-centered
                and Termed Deposit (nonexist))
241 binnedplot(d1$agec[d1$poutcome==success],
242             y=d1$ynum[d1$poutcome==success],
243             xlab = Age-centered, ylab = Termed Deposit, main = Binned Age-centered
                and Termed Deposit (success))
244
245 # newage:poutcome
246 plot(0:2, tapply(d1$ynum[d1$poutcome==failure], d1$newage[d1$poutcome==failure],
247                 mean), col='blue4', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
248 par(new=TRUE)
249 plot(0:2, tapply(d1$ynum[d1$poutcome==nonexistent], d1$newage[d1$poutcome==
250                 nonexistent], mean), col='red4', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
251 par(new=TRUE)
252 plot(0:2, tapply(d1$ynum[d1$poutcome==success], d1$newage[d1$poutcome==success],
253                 mean), col='black', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
254 title(xlab = Age, ylab = 'Prob of Purchasing a Term Deposit')
255 legend(topright, pch=c(10,10), legend=c(failure,nonexistent,success), col=c(blue4,
256                 red4,black), bty=n)
257
258 # poutcome:confc
259 binnedplot(d1$confc[d1$poutcome==failure],
260             y=d1$ynum[d1$poutcome==failure],
261             xlab = CCI-centered, ylab = Term Deposits, main = Binned CCI-centered
                and Term Deposits (failure))
262 binnedplot(d1$confc[d1$poutcome==nonexistent],
263             y=d1$ynum[d1$poutcome==nonexistent],
264             xlab = CCI-centered, ylab = Term Deposits, main = Binned CCI-centered
                and Term Deposits (nonexist))
265 binnedplot(d1$confc[d1$poutcome==success],
266             y=d1$ynum[d1$poutcome==success],
267             xlab = CCI-centered, ylab = Term Deposits, main = Binned CCI-centered
                and Term Deposits (success))
268
269 # poutcome:loweuri
270 plot(0:1, tapply(d1$ynum[d1$poutcome==failure], d1$loweuri[d1$poutcome==failure],
271                 mean), col='blue4', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
272 par(new=TRUE)

```



```

268 plot(0:1,tapply(d1$ynum[d1$poutcome==nonexistent], d1$loweuri[d1$poutcome==
      nonexistent], mean),col='red4',pch=10,ann=FALSE,ylim=c(0,1),cex=1.5)
269 par(new=TRUE)
270 plot(0:1,tapply(d1$ynum[d1$poutcome==success], d1$loweuri[d1$poutcome==success],
      mean),col='black',pch=10,ann=FALSE,ylim=c(0,1),cex=1.5)
271 title(xlab = Euribor,ylab = 'Prob of Purchasing a Term Deposit')
272 legend(topright,pch=c(10,10),legend=c(failure,nonexistent,success),col=c(blue4,
      red4,black),bty=n)

```

Model

```

1  # centering
2  bank$agec <- bank$age - mean(bank$age)
3  bank$varc <- bank$emp.var.rate + mean(bank$emp.var.rate)
4  bank$pricec <- bank$cons.price.idx - mean(bank$cons.price.idx)
5  bank$confc <- bank$cons.conf.idx - mean(bank$cons.conf.idx)
6  bank$euric <- bank$euribor3m - mean(bank$euribor3m)
7
8  d1$agec <- d1$age - mean(d1$age)
9  d1$varc <- d1$emp.var.rate + mean(d1$emp.var.rate)
10 d1$pricec <- d1$cons.price.idx - mean(d1$cons.price.idx)
11 d1$confc <- d1$cons.conf.idx - mean(d1$cons.conf.idx)
12 d1$euric <- d1$euribor3m - mean(d1$euribor3m)
13
14 # model 1
15 modell <- glm(ynum~ newage + job + marital + education + housing + loan + contact
16             + month + day_of_week + campaign + previous + poutcome
17             + varc + pricec + confc + loweuri, data = d1, family = binomial)
18 summary(modell)
19
20 rawresid1 <- residuals(modell,resp)
21 binnedplot(x=fitted(modell),y=rawresid1,xlab=Pred. probabilities,
22            col.int=red4,ylab=Avg. residuals,main=Binned residual
23            plot,col.pts=navy)
24 binnedplot(x=d1$campaign,y=rawresid1,xlab=Number of Contacts During this Campaign,
25            col.int=red4,ylab=Avg. residuals,main=Binned residual
26            plot,col.pts=navy)
27 binnedplot(x=d1$previous,y=rawresid1,xlab=Contacts for this Campaign,
28            col.int=red4,ylab=Avg. residuals,main=Binned residual
29            plot,col.pts=navy)
30 binnedplot(x=d1$varc,y=rawresid1,xlab=employment variation rate centered,
31            col.int=red4,ylab=Avg. residuals,main=Binned residual
32            plot,col.pts=navy)
33 binnedplot(x=d1$pricec,y=rawresid1,xlab=CPI centered,
34            col.int=red4,ylab=Avg. residuals,main=Binned residual
35            plot,col.pts=navy)

```

```
30 |         col.int=red4,ylab=Avg.  residuals,main=Binned residual
      plot,col.pts=navy)
31 | binnedplot(x=d1$confc,y=rawresid1,xlab=CCI centered,
32 |         col.int=red4,ylab=Avg.  residuals,main=Binned residual
      plot,col.pts=navy)
33 |
34 | # Model validation
35 | # multicollinearity
36 | vif(model1)
37 | #let's do the confusion matrix with .5 threshold
38 | Conf_mat <- confusionMatrix(as.factor(ifelse(fitted(model1) >= mean(d1$ynum), 1,
      0)),
39 |                             as.factor(d1$ynum),positive = 1)
40 | Conf_mat$table
41 | Conf_mat$overall[Accuracy];
42 | Conf_mat$byClass[c(Sensitivity,Specificity)] #True positive rate and True negative
      rate
43 | #Maybe we can try to increase that accuracy.
44 | roc(bank$ynum,fitted(model1),plot=T,print.thres=best,legacy.axes=T,
45 |     print.auc =T,col=red3)
46 |
47 | model2 <- glm(ynum~ newage + job + marital + education + housing + loan + previous
48 |             + contact + month + day_of_week + campaign + poutcome + confc +
      loweuri,
49 |             data = d1, family = binomial)
50 | summary(model2)
51 | vif(model2)
52 |
53 | # interaction
54 | model3 <- glm(ynum~ newage + job + marital + education + housing + loan + previous
55 |             + contact + month + day_of_week + campaign + poutcome
56 |             + confc + pricec + loweuri + poutcome:confc, data = d1, family =
      binomial)
57 | summary(model3)
58 | vif(model3)
59 |
60 | # Stepwise
61 | model0 <- glm(ynum~ 1, data = d1, family = binomial)
62 | model_stepwiseaic <- step(model0,scope=formula(model3),direction=both, trace=0)
63 | model_stepwiseaic$call
64 | Model_aic <- glm(ynum~ loweuri + month + poutcome + confc + pricec +
65 |                 contact + day_of_week + job + campaign + newage + education +
66 |                 poutcome:confc,
67 |                 data = d1, family = binomial)
68 | summary(Model_aic)
```

```

69 anova(model3, Model_aic, test= Chisq)
70 # no difference: pick Model_aic
71
72 vif(Model_aic)
73 rawresid2 <- residuals(Model_aic, resp)
74 binnedplot(x=fitted(Model_aic), y=rawresid2, xlab=Pred. probabilities,
75            col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
76 binnedplot(x=d1$previous, y=rawresid2, xlab=Contacts for this Campaign,
77            col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
78 binnedplot(x=d1$confc, y=rawresid2, xlab=CCI centered,
79            col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
80 binnedplot(x=d1$priced, y=rawresid2, xlab=CPI centered,
81            col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
82 binnedplot(x=d1$campaign, y=rawresid2, xlab=Number of Contacts During this Campaign,
83            col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
84
85 Conf_mat <- confusionMatrix(as.factor(ifelse(fitted(Model_aic) >= mean(d1$ynum),
86            1, 0)),
87                             as.factor(d1$ynum), positive = 1)
88 Conf_mat$table
89 Conf_mat$overall[Accuracy];
90 Conf_mat$byClass[c(Sensitivity, Specificity)] #True positive rate and True negative
      rate
91 #Maybe we can try to increase that accuracy.
92 roc(d1$ynum, fitted(Model_aic), plot=T, print.thres=best, legacy.axes=T,
93     print.auc =T, col=red3)
94
95 # CPI
96 model4 <- glm(ynum~ poutcome + month + contact + newage + priced +
97              job + campaign + day_of_week + education + marital+poutcome:priced
98              ,
99              data = d1, family = binomial)
100 vif(model4)
101 rawresid4 <- residuals(model4, resp)
102 binnedplot(x=fitted(model4), y=rawresid4, xlab=Pred. probabilities,
103            col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
104 binnedplot(x=d1$priced, y=rawresid4, xlab=CPI centered,
105            col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)

```

```

105 model5 <- glm(ynum~ poutcome + month + contact + newage + confc + pricec + loweuri
    + previous +
106             job + campaign + day_of_week + education + marital+ poutcome:confc
    ,
107             data = d1, family = binomial)
108 summary(model5)
109 vif(model5)
110 rawresid5 <- residuals(model5,resp)
111 binnedplot(x=fitted(model5),y=rawresid5,xlab=Pred. probabilities,
112            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
113 binnedplot(x=d1$confc,y=rawresid5,xlab=CCI centered,
114            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
115 binnedplot(x=d1$pricec,y=rawresid5,xlab=CPI centered,
116            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
117 binnedplot(x=d1$campaign,y=rawresid5,xlab=Number of Contacts During this Campaign,
118            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
119
120
121 # Hierarchical Model
122 multimodel5 <- glmer(formula = ynum~poutcome + (1|month) + contact + newage +
    confc + pricec + loweuri + previous +
123                    job + campaign + day_of_week + education + marital +
    poutcome:confc, family = binomial(link=logit),
124                    data = d1)
125 summary(multimodel5)
126 library(sjPlot)
127 tab_model(multimodel5)
128 dotplot(ranef(multimodel5, condVar=TRUE))
129
130 rawresid5 <- residuals(multimodel5,resp)
131 binnedplot(x=fitted(multimodel5),y=rawresid5,xlab=Pred. probabilities,
132            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
133 binnedplot(x=d1$previous,y=rawresid5,xlab=Number of Contacts Before this Campaign,
134            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
135 binnedplot(x=d1$confc,y=rawresid5,xlab=CCI-centered,
136            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
137 binnedplot(x=d1$pricec,y=rawresid5,xlab=CPI-centered,
138            col.int=red4,ylab=Avg. residuals,main=Binned residual
    plot,col.pts=navy)
139 binnedplot(x=d1$campaign,y=rawresid5,xlab=Number of Contacts During this Campaign,

```

```
140 |         col.int=red4,ylab=Avg.  residuals,main=Binned residual
141 |         plot,col.pts=navy)
142 | (ranef(multimodel5)$month)[apr,]
143 |
144 | Conf_mat <- confusionMatrix(as.factor(ifelse(fitted(multimodel5) >= mean(d1$ynum)
145 |         , 1,0)),
146 |                             as.factor(d1$ynum),positive = 1)
147 | Conf_mat$table
148 | Conf_mat$overall[Accuracy];
149 | Conf_mat$byClass[c(Sensitivity,Specificity)] #True positive rate and True negative
150 |         rate
151 | #Maybe we can try to increase that accuracy.
152 | roc(d1$ynum,fitted(multimodel5),plot=T,print.thres=best,legacy.axes=T,
153 |     print.auc =T,col=red3)
154 |
155 | # Eliminate Outlier: May & March
156 | newd1 <- d1[!(d1$month==may),]
157 | newd1 <- newd1[!(newd1$month==mar),]
158 | newmodel <- glmer(formula = ynum~poutcome + (1|month) + contact + newage + confc +
159 |     pricec + loweuri + previous +
160 |     job + campaign + day_of_week + education + marital + poutcome:
161 |     confc, family = binomial(link=logit),
162 |     data = newd1)
163 | summary(newmodel)
164 | newrawresid <- residuals(newmodel,resp)
165 | binnedplot(x=fitted(newmodel),y=newrawresid,xlab=Pred.  probabilities,
166 |     col.int=red4,ylab=Avg.  residuals,main=Binned residual
167 |     plot,col.pts=navy)
```