

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-month 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 successfully purchased a term deposit 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 **

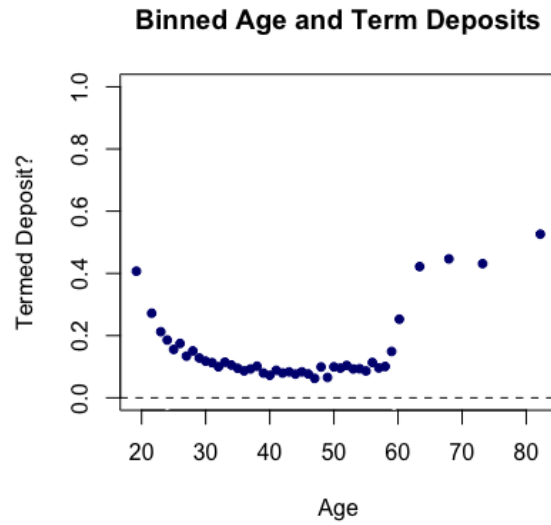


Figure 1: Binned Age and Term Deposits

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

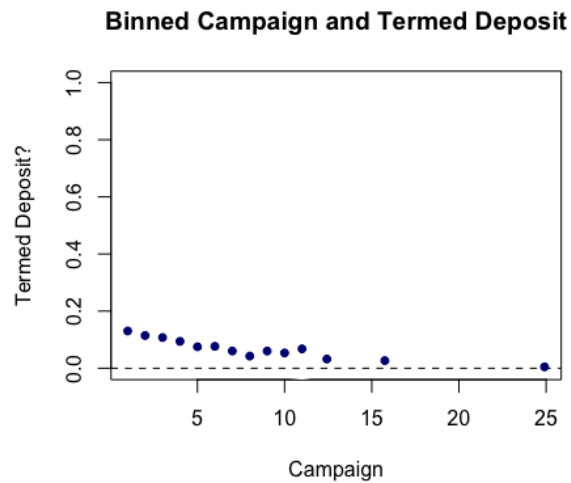


Figure 2: Binned Contacts for This Campaign and Term Deposits

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

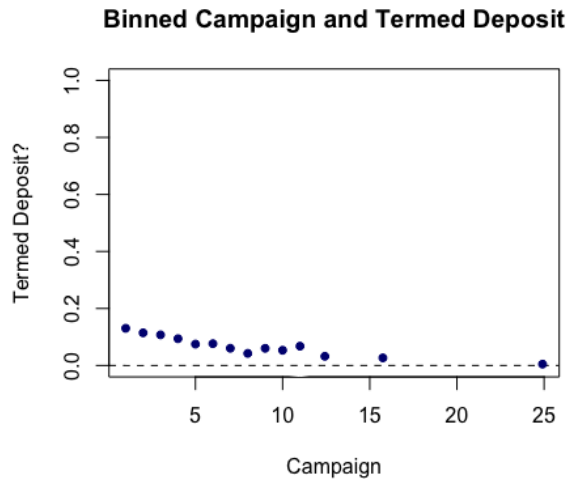


Figure 3: Binned Days since Last Contact and Term Deposits

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

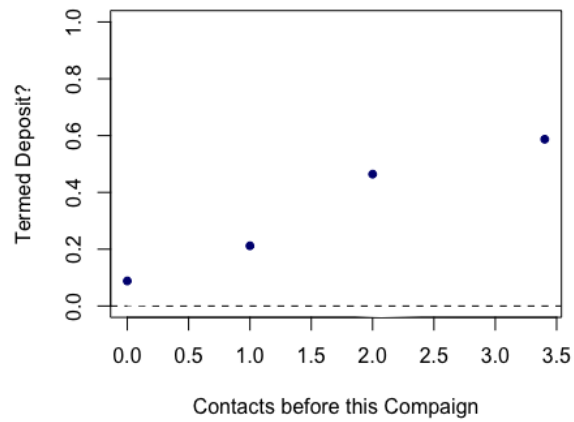


Figure 4: Binned Contacts before this Campaign and Term Deposits

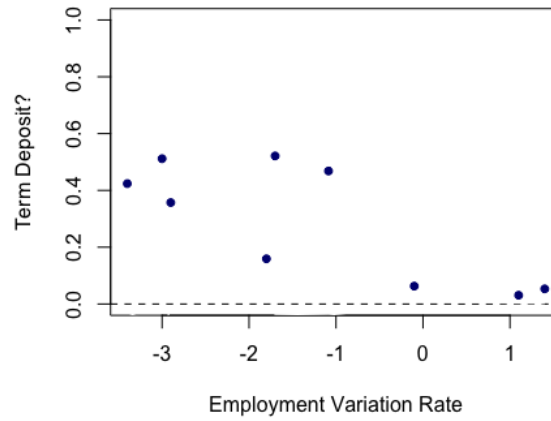
Binned Employment Variation Rate and Term Depo

Figure 5: Binned Employment Variation Rate and Term Deposits



Figure 6: Binned Consumer Price Index and Term Deposits

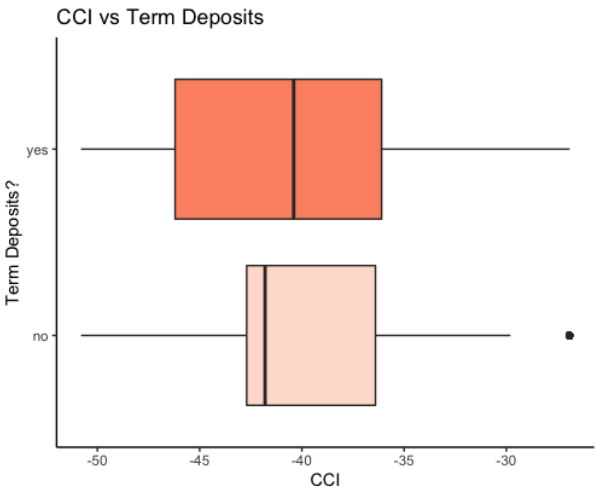


Figure 7: Binned Consumer Confidence Index and Term Deposits

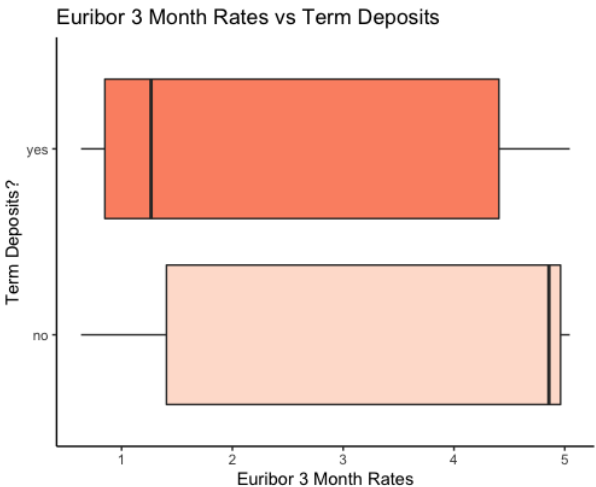


Figure 8: Binned Euribor 3 Month Rates and Term Deposits

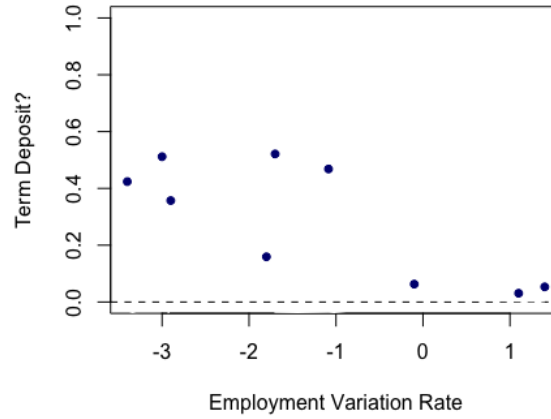
Binned Employment Variation Rate and Term Depo

Figure 9: Binned Employment Variation Rate and Term Deposits

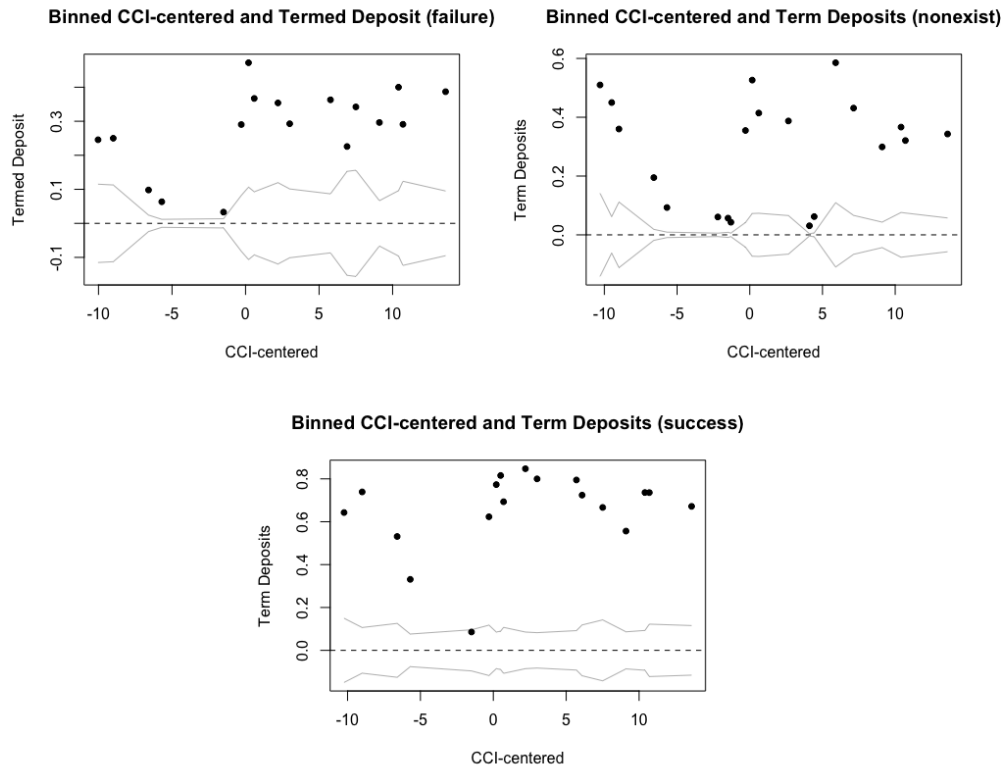


Figure 10: Interaction: CCI and Previous Campaign Outcome

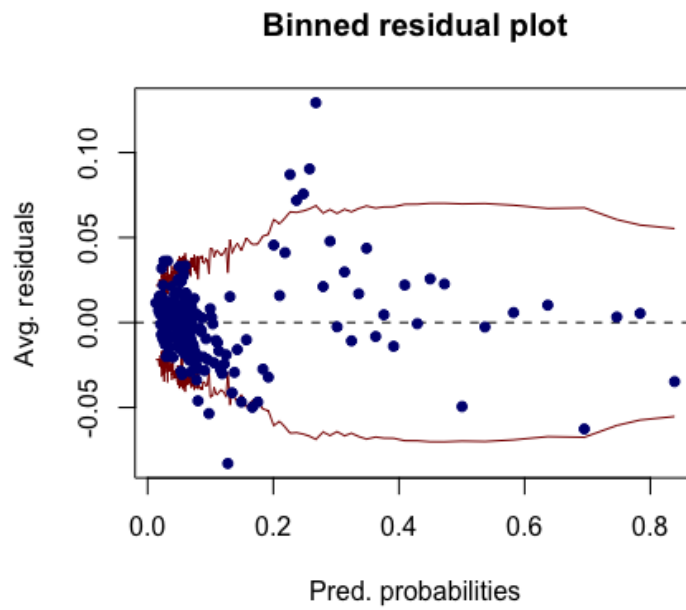


Figure 11: Binned Residual Plot

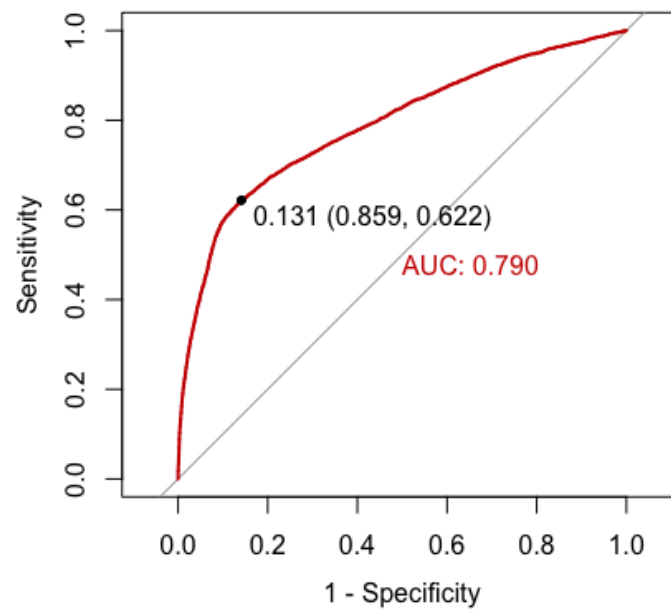


Figure 12: AUC

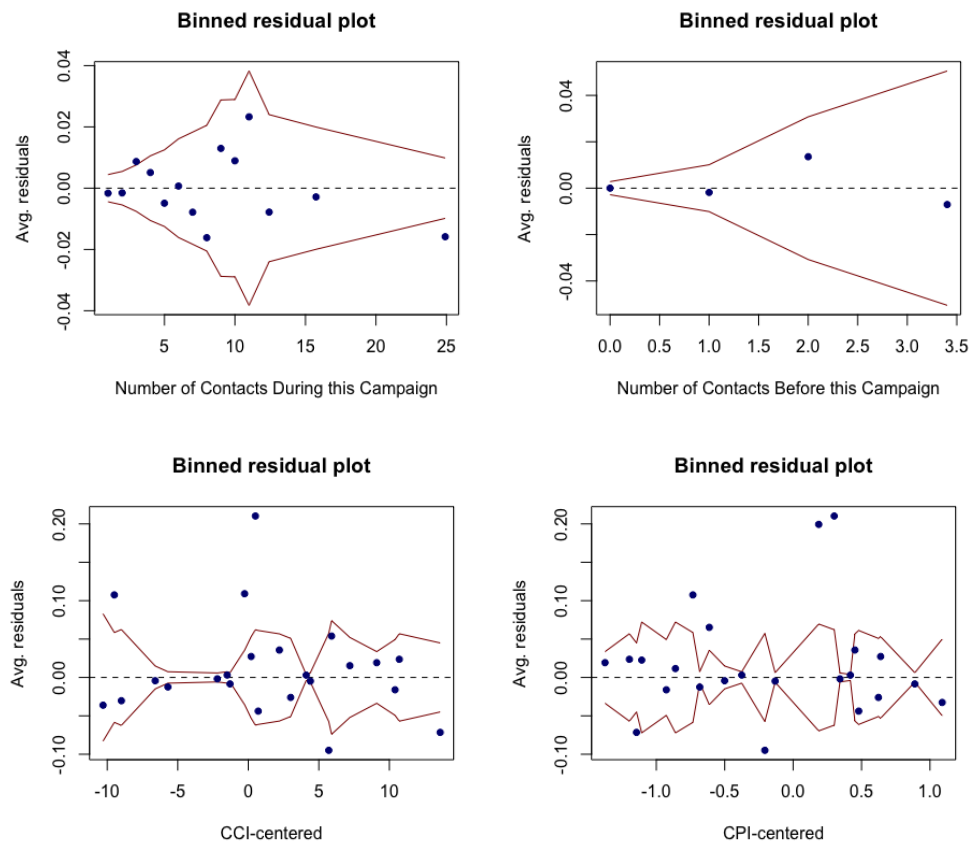


Figure 13: Linearity Check

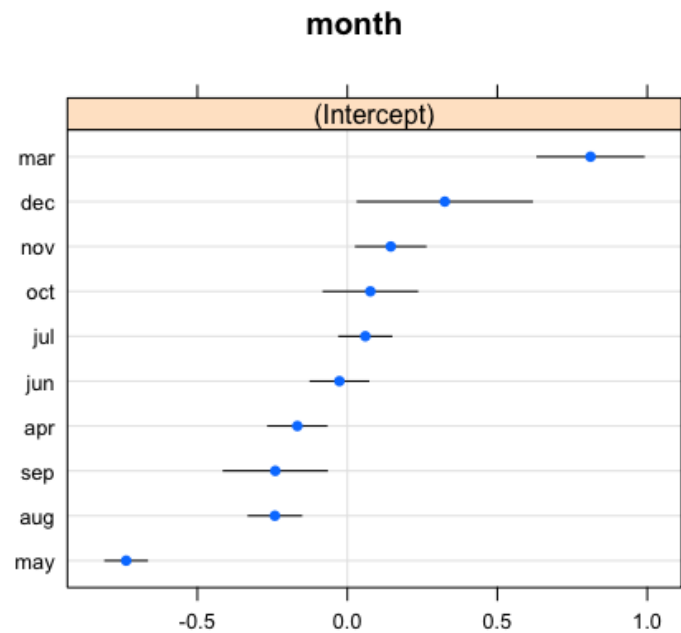


Figure 14: Outlier Check

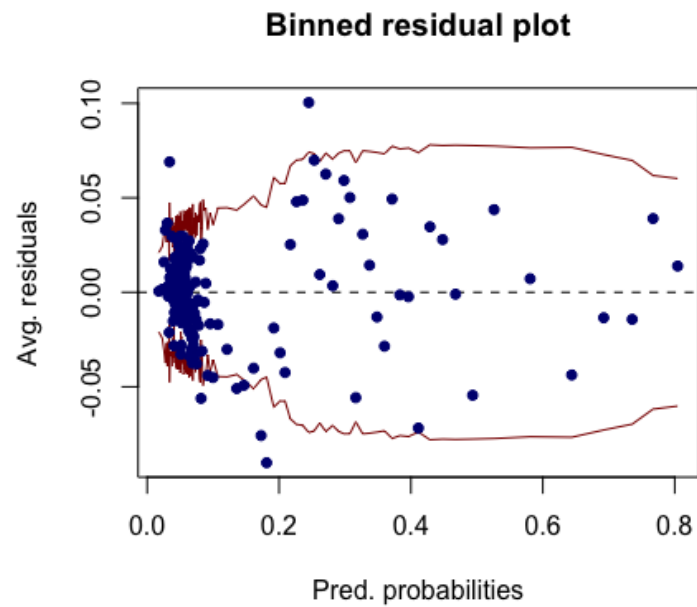


Figure 15: Binned Residual Plot without Potential Outliers

Main Code

Data Prepare

```
1 # Data Loading
2 bank <- read.csv(/Users/Chenyu/Desktop/2020 Fall/IDS 702/Final
   Project/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 <- apply(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 aggr(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
153            Campaign and Term Deposits,
154            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)]),2,function(x) x/sum(x))
165 xtable(tyescontact)
166 binnedplot(y=bank$ynum, bank$previous, xlab=Contacts before this
167           Campaign, ylim=c(0,1), col.pts=navy,
168           ylab =Term Deposit?, main=Binned Contacts before this Campaign and Term
169           Deposits,
170           col.int=white)
171 # plot(0:1,tapply(bank$ynum, bank$yescontact, mean), col='blue4', pch=10)
172
173 # poutcome: consumers who have previously bought termed deposits are more likely
174 # to purchase again
175 table(bank$poutcome)
176 tpoutcome <- apply(table(bank[,c(y, poutcome)]),2,function(x) x/sum(x))
177 xtable(tpoutcome)
178 plot(0:2,tapply(bank$ynum, bank$poutcome, mean), col='blue4', pch=10)
179
180 # employment variation rate (negative) [drop – high correlation with CPI and
181 # Euribor]
182 ggplot(bank,aes(x=y, y=emp.var.rate, fill=y)) +
183   geom_boxplot() + coord_flip() +
184   scale_fill_brewer(palette=Reds) +
185   labs(title=Employment Variation Rate vs Termed Deposit,
186        x=Termed Deposit?,y=Employment Variation Rate) +
187   theme_classic() + theme(legend.position=none)
188 binnedplot(y=bank$ynum, bank$emp.var.rate, xlab=Employment Variation
189           Rate, ylim=c(0,1), col.pts=navy,
190           ylab =Term Deposit?, main=Binned Employment Variation Rate and Term
191           Deposits,
192           col.int=white)
193
194 # consumer price index (negative)
195 ggplot(bank,aes(x=y, y=cons.price.idx, fill=y)) +
196   geom_boxplot() + coord_flip() +
197   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
201 # CCI (positive)
202 ggplot(bank, aes(x=y, y=cons.conf.idx, fill=y)) +
203   geom_boxplot() + coord_flip() +
204   scale_fill_brewer(palette=Reds) +
205   labs(title=CCI vs Term Deposits,
206        x=Term Deposits?, y=CCI) +
207   theme_classic() + theme(legend.position=none)
208 binnedplot(y=bank$ynum, bank$cons.conf.idx, xlab=CCI, ylim=c(0,1), col.pts=navy,
209            ylab =Term Deposits?, main=Binned CCI and Term Deposits,
210            col.int=white)
211
212 # Euribor (negative)
213 ggplot(bank, aes(x=y, y=euribor3m, fill=y)) +
214   geom_boxplot() + coord_flip() +
215   scale_fill_brewer(palette=Reds) +
216   labs(title=Euribor 3 Month Rates vs Term Deposits,
217        x=Term Deposits?, y=Euribor 3 Month Rates) +
218   theme_classic() + theme(legend.position=none)
219 binnedplot(y=bank$ynum, bank$euribor3m, xlab=Euribor 3 Month
220            Rates, ylim=c(0,1), col.pts=navy,
221            ylab =Term Deposits?, main=Binned Euribor 3 Month Rates and Term
222            Deposits,
223            col.int=white)
224
225 summary(d1$euribor3m)
226 d1$loweuri[d1$euribor3m<=3]<-1
227 d1$loweuri[d1$euribor3m>3]<-0
228 d1$loweuri<-as.factor(d1$loweuri)
229
230 # correlation: employment variation rate, consumer price index, CCI, Euribor
231 cor(bank$emp.var.rate, bank$cons.conf.idx)
232 cor(bank$cons.price.idx, bank$emp.var.rate)
233 cor(bank$emp.var.rate, bank$euribor3m)
234 cor(bank$cons.price.idx, bank$cons.conf.idx)
235 cor(bank$cons.price.idx, bank$euribor3m)
236 cor(bank$cons.conf.idx, bank$euribor3m)
237
238 # 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],
                mean), col='blue4', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
247 par(new=TRUE)
248 plot(0:2, tapply(d1$ynum[d1$poutcome==nonexistent], d1$newage[d1$poutcome==
                nonexistent], mean), col='red4', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
249 par(new=TRUE)
250 plot(0:2, tapply(d1$ynum[d1$poutcome==success], d1$newage[d1$poutcome==success],
                mean), col='black', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
251 title(xlab = Age, ylab = 'Prob of Purchasing a Term Deposit')
252 legend(topright, pch=c(10,10), legend=c(failure,nonexistent,success), col=c(blue4,
                red4,black), bty=n)
253
254 # poutcome:confc
255 binnedplot(d1$confc[d1$poutcome==failure],
256           y=d1$ynum[d1$poutcome==failure],
257           xlab = CCI-centered, ylab = Term Deposits, main = Binned CCI-centered
                and Term Deposits (failure))
258 binnedplot(d1$confc[d1$poutcome==nonexistent],
259           y=d1$ynum[d1$poutcome==nonexistent],
260           xlab = CCI-centered, ylab = Term Deposits, main = Binned CCI-centered
                and Term Deposits (nonexist))
261 binnedplot(d1$confc[d1$poutcome==success],
262           y=d1$ynum[d1$poutcome==success],
263           xlab = CCI-centered, ylab = Term Deposits, main = Binned CCI-centered
                and Term Deposits (success))
264
265 # poutcome:loweuri
266 plot(0:1, tapply(d1$ynum[d1$poutcome==failure], d1$loweuri[d1$poutcome==failure],
                mean), col='blue4', pch=10, ann=FALSE, ylim=c(0,1), cex=1.5)
267 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(topleft,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)
36 binnedplot(x=d1$confc,y=rawresid1,xlab=CCI centered,
37            col.int=red4,ylab=Avg. residuals,main=Binned residual
38            plot,col.pts=navy)

```

```
32 |         col.int=red4,ylab=Avg.  residuals,main=Binned residual
33 |         plot,col.pts=navy)
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$ynum), 1,
39 |         0)),
40 |         as.factor(d1$ynum),positive = 1)
41 | Conf_mat$table
42 | Conf_mat$overall[Accuracy];
43 | Conf_mat$byClass[c(Sensitivity,Specificity)] #True positive rate and True negative
44 | rate
45 | #Maybe we can try to increase that accuracy.
46 | roc(bank$ynum,fitted(model1),plot=T,print.thres=best,legacy.axes=T,
47 |     print.auc =T,col=red3)
48 |
49 | model2 <- glm(ynum~ newage + job + marital + education + housing + loan + previous
50 |             + contact + month + day_of_week + campaign + poutcome + confc +
51 |             loweuri,
52 |             data = d1, family = binomial)
53 | summary(model2)
54 | vif(model2)
55 |
56 | # interaction
57 | model3 <- glm(ynum~ newage + job + marital + education + housing + loan + previous
58 |             + contact + month + day_of_week + campaign + poutcome
59 |             + confc + pricec + loweuri + poutcome:confc, data = d1, family =
60 |             binomial)
61 | summary(model3)
62 | vif(model3)
63 |
64 | # Stepwise
65 | model0 <- glm(ynum~ 1, data = d1, family = binomial)
66 | model_stepwiseaic <- step(model0,scope=formula(model3),direction=both, trace=0)
67 | model_stepwiseaic$call
68 | Model_aic <- glm(ynum~ loweuri + month + poutcome + confc + pricec +
69 |             contact + day_of_week + job + campaign + newage + education +
70 |             poutcome:confc,
71 |             data = d1, family = binomial)
72 | summary(Model_aic)
73 | anova(model3, Model_aic, test= Chisq)
74 | # no difference: pick Model_aic
```

```

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$pricec, y=rawresid2, xlab=CPI centered,
81           col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
82 binnedplot(x=d1$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$ynum),
1,0)),
86                             as.factor(d1$ynum), positive = 1)
87 Conf_mat$table
88 Conf_mat$overall[Accuracy];
89 Conf_mat$byClass[c(Sensitivity, Specificity)] #True positive rate and True negative
        rate
90 #Maybe we can try to increase that accuracy.
91 roc(d1$ynum, fitted(Model_aic), plot=T, print.thres=best, legacy.axes=T,
92     print.auc =T, col=red3)
93
94 # CPI
95 model4 <- glm(ynum~ poutcome + month + contact + newage + pricec +
96             job + campaign + day_of_week + education + marital+poutcome:pricec
              ,
97             data = d1, family = binomial)
98 vif(model4)
99 rawresid4 <- residuals(model4, resp)
100 binnedplot(x=fitted(model4), y=rawresid4, xlab=Pred. probabilities,
101           col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
102 binnedplot(x=d1$pricec, y=rawresid4, xlab=CPI centered,
103           col.int=red4, ylab=Avg. residuals, main=Binned residual
              plot, col.pts=navy)
104
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
113           plot,col.pts=navy)
114 binnedplot(x=d1$confc,y=rawresid5,xlab=CCI centered,
115           col.int=red4,ylab=Avg. residuals,main=Binned residual
116           plot,col.pts=navy)
117 binnedplot(x=d1$pricec,y=rawresid5,xlab=CPI centered,
118           col.int=red4,ylab=Avg. residuals,main=Binned residual
119           plot,col.pts=navy)
120
121 # Hierarchical Model
122 multimodel5 <- glmer(formula = ynum~poutcome + (1|month) + contact + newage +
123                   confc + pricec + loweuri + previous +
124                   job + campaign + day_of_week + education + marital +
125                   poutcome:confc, family = binomial(link=logit),
126                   data = d1)
127 summary(multimodel5)
128 library(sjPlot)
129 tab_model(multimodel5)
130 dotplot(ranef(multimodel5, condVar=TRUE))
131
132 rawresid5 <- residuals(multimodel5,resp)
133 binnedplot(x=fitted(multimodel5),y=rawresid5,xlab=Pred. probabilities,
134           col.int=red4,ylab=Avg. residuals,main=Binned residual
135           plot,col.pts=navy)
136 binnedplot(x=d1$previous,y=rawresid5,xlab=Number of Contacts Before this Campaign,
137           col.int=red4,ylab=Avg. residuals,main=Binned residual
138           plot,col.pts=navy)
139 binnedplot(x=d1$confc,y=rawresid5,xlab=CCI-centered,
140           col.int=red4,ylab=Avg. residuals,main=Binned residual
141           plot,col.pts=navy)
142 binnedplot(x=d1$pricec,y=rawresid5,xlab=CPI-centered,
143           col.int=red4,ylab=Avg. residuals,main=Binned residual
144           plot,col.pts=navy)
145 binnedplot(x=d1$campaign,y=rawresid5,xlab=Number of Contacts During this Campaign,
146           col.int=red4,ylab=Avg. residuals,main=Binned residual
147           plot,col.pts=navy)
148
149 (ranef(multimodel5)$month)[apr,]

```

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