P3 Jan-Feb 2019

Data Science for Business
Assignment 2: Credit Card Default

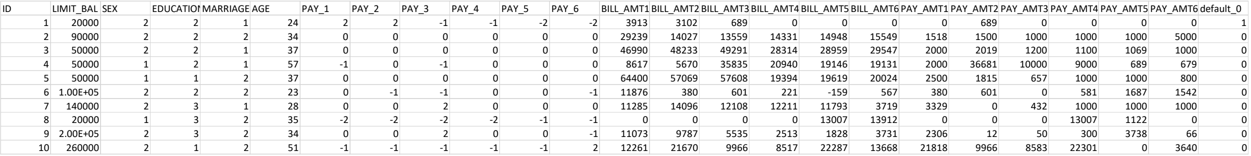
The Business Context

A major eastern-European bank wants to better predict the likelihood of default for its customers, as well as identify the key drivers that determine this likelihood. They hope that this would inform the bank's decisions on who to give a credit to and what credit limit to provide, as well as also help the bank have a better understanding of their current and potential customers, which would inform their future strategy, including their planning of offering targeted credit products to their customers.

The Data

The bank collected data on 25 000 of their existing clients. Of those, 1 000 were randomly selected to participate in a pilot described below. Data about the remaining 24 000 is in the file "DSB A2 – credit data.xls". The dataset contains various information, including demographic factors, credit data, history of payment, and bill statements of credit card customers from April to September, as well as information on the outcome: did the customer default or not in October.

The screenshot below depicts the first 10 rows of the data:



ID	LIMIT_BAL	SEX	EDUCATION	MARRIAGE	AGE	PAY_1	PAY_2	PAY_3	PAY_4	PAY_5	PAY_6	BILL_AMT1	BILL_AMT2	BILL_AMT3	BILL_AMT4	BILL_AMT5	BILL_AMT6	PAY_AMT1	PAY_AMT2	PAY_AMT3	PAY_AMT4	PAY_AMT5	PAY_AMT6	default_0
1	20000	2	2	1	24	2	2	-1	-1	-2	-2	3913	3102	689	0	0	0	0	689	0	0	0	0	1
2	90000	2	2	2	34	0	0	0	0	0	0	29239	14027	13559	14331	14948	15549	1518	1500	1000	1000	1000	5000	0
3	50000	2	2	1	37	0	0	0	0	0	0	46990	48233	49291	28314	28959	29547	2000	2019	1200	1100	1069	1000	0
4	50000	1	2	1	57	-1	0	-1	0	0	0	8617	5670	35835	20940	19146	19131	2000	36681	10000	9000	689	679	0
5	50000	1	1	2	37	0	0	0	0	0	0	64400	57069	57608	19394	19619	20024	2500	1815	657	1000	1000	800	0
6	1.00E+05	2	2	2	23	0	-1	-1	0	0	-1	11876	380	601	221	-159	567	380	601	0	581	1687	1542	0
7	140000	2	3	1	28	0	0	2	0	0	0	11285	14096	12108	12211	11793	3719	3329	0	432	1000	1000	1000	0
8	20000	1	3	2	35	-2	-2	-2	-2	-1	-1	0	0	0	0	13007	13912	0	0	0	13007	1122	0	0
9	2.00E+05	2	3	2	34	0	0	2	0	0	-1	11073	9787	5535	2513	1828	3731	2306	12	50	300	3738	66	0
10	260000	2	1	2	51	-1	-1	-1	-1	-1	2	12261	21670	9966	8517	22287	13668	21818	9966	8583	22301	0	3640	0

Data Dictionary

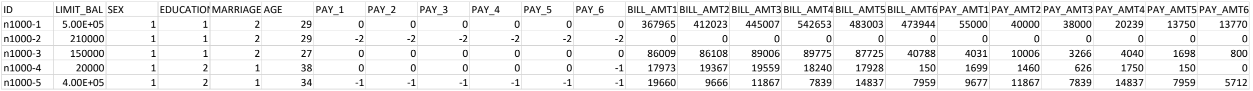
- **ID**: ID of each client
- **LIMIT_BAL**: Total amount of credit line with the bank (including all individual and family/supplementary credit)
- **SEX**: Gender (1=male, 2=female)
- **EDUCATION**: Education (1=graduate, 2=undergraduate, 3=high-school, 4=other, 5,6=unknown)
- **MARRIAGE**: Marital status (1=married, 2=single, 3=other)
- **AGE**: Age in years
- **PAY_1**: Repayment status 1 month ago, – in September: (-2=no need to pay, zero balance, "payment holiday", etc., -1=paid in full, 0=revolving credit (meaning client paid more than the minimum payment, but less than the total balance), 1= delay for one month, ... 8=delay for 8 months, 9=delay for 9 months or more)
- **PAY_2**: Repayment status 2 months ago, – in August (scale as above for PAY_1)
- **PAY_3**: Repayment status 3 months ago (scale as above for PAY_1)
- **PAY_4**: Repayment status 4 months ago (scale as above for PAY_1)
- **PAY_5**: Repayment status 5 months ago (scale as above for PAY_1)
- **PAY_6**: Repayment status 6 months ago (scale as above for PAY_1)
- **BILL_AMT1**: Amount of bill statement 1 month ago, – in September
- **BILL_AMT2**: Amount of bill statement 2 months ago

- **BILL_AMT3**: Amount of bill statement 3 months ago
- **BILL_AMT4**: Amount of bill statement 4 months ago
- **BILL_AMT5**: Amount of bill statement 5 months ago
- **BILL_AMT6**: Amount of bill statement 6 months ago
- **PAY_AMT1**: Amount of payment 1 month ago, – in September
- **PAY_AMT2**: Amount of payment 2 months ago
- **PAY_AMT3**: Amount of payment 3 months ago
- **PAY_AMT4**: Amount of payment 4 months ago
- **PAY_AMT5**: Amount of payment 5 months ago
- **PAY_AMT6**: Amount of payment 6 months ago
- **Default_0**: Default in October (1=yes, 0=no)

Your Pilot Project

Your department wants to pilot a new product, a short-term credit line with the limit of 25,000, and for the purposes of this assignment assume that the line is for 1 month at 2% per month. More so, assume that the client who was issued credit and repaid it will more likely use your bank for similar short-term financing needs in the future, which has an additional lifetime value (CLV) of 1,000. However, if the client will default, then you will be able to recover only 20,000 out of 25,000 credit granted.

The data about 1 000 clients that were randomly selected for this pilot is in the file "DSB A2 - new applications.xlsx». The screenshot below depicts the first 5 rows of the data:



ID	LIMIT_BAL	SEX	EDUCATIOI	MARRIAGE	AGE	PAY_1	PAY_2	PAY_3	PAY_4	PAY_5	PAY_6	BILL_AMT1	BILL_AMT2	BILL_AMT3	BILL_AMT4	BILL_AMT5	BILL_AMT6	PAY_AMT1	PAY_AMT2	PAY_AMT3	PAY_AMT4	PAY_AMT5	PAY_AMT6
n1000-1	5.00E+05	1	1	2	29	0	0	0	0	0	0	367965	412023	445007	542653	483003	473944	55000	40000	38000	20239	13750	13770
n1000-2	210000	1	1	2	29	-2	-2	-2	-2	-2	-2	0	0	0	0	0	0	0	0	0	0	0	0
n1000-3	150000	1	1	2	27	0	0	0	0	0	0	86009	86108	89006	89775	87725	40788	4031	10006	3266	4040	1698	800
n1000-4	20000	1	2	1	38	0	0	0	0	0	-1	17973	19367	19559	18240	17928	150	1699	1460	626	1750	150	0
n1000-5	4.00E+05	1	2	1	34	-1	-1	-1	-1	-1	-1	19660	9666	11867	7839	14837	7959	9677	11867	7839	14837	7959	5712

The ultimate question: which of the 1 000 "new applicants" in the pilot should be issued credit?

In your analyses, please make the following simplifying assumptions:

(i) Defaults on the previously issued credit is not your problem
(ii) All the clients who will be offered the credit line will use it in full
(iii) Your cost of capital = 0

In other words, for each client in the pilot, if the credit is issued and repaid, then the bank earns a profit of 25,000*2% + 1,000 = 1,500; if the credit is granted but the client defaults, then the bank loses 25,000 - 20,000 = 5,000? And if the credit is not issued, then the profit=loss=0.

The Assignment [100pts]

Please reply to all the following questions via the Qualtrics survey (link provided on the course website).

1) Determine which of the 1 000 clients in the pilot should be issued credit. Once done, create a spreadsheet with only one column, A1:A1000, of 0s and 1s, representing your recommendation for issuing credit to each of 1 000 pilot customers in the order of their IDs as per the data (1 issue, 0 do not issue).

Copy-paste this column in the Qualtrics survey link. [Please paste 1000 digits, 1 or 0, with spaces between them and no other symbols (no commas, or dashes, or anything else). Example: 1 0 0 1 …]

2) We will calculate the profit that the bank would have actually received following your recommendation. [we can calculate this because we have the data about which of these 1 000 clients will actually default and which will not; you do not have this data]

   Your score for this part of the assignment will be:
   a. Profit <=0, 0 points
   b. Profit >0 but <=100,000, 20 points
   c. Profit >100,000 but <=300,000, 30 points
   d. Profit >300,000 but <=500,000, 40 points
   e. Profit >500,000, 50 points

3) Which three of 1 000 pilot clients are most likely to repay the loan if it were granted to them?
4) Which three of 1 000 pilot clients are least likely to repay the loan if it were granted to them?

   [Please paste 3 IDs with spaces between them (no commas, or anything else). Example: n1000-1 n1000-88 n1000-69]

   You will get 10 points for each of Q2 and Q3 if two or more of your selected clients actually repay/default.

Lastly, please answer three theory-based multiple-choice questions [10 points each]:

5) A colleague came by to discuss two clients: A and B. The colleague says that a model predicts that A will repay and B will default. What should the bank do?
   a. Issue credit to A and do not issue credit to B
   b. Issue credit to A, but do some more work on B
   c. Do not issue to B, but do some more work on A
   d. The statement above does not provide enough information to determine the best course of action.

   If you select responses b-d, you will be prompted to describe what exactly you suggest needs to be done to make a decision.

As we discussed in class, models predict probabilities, which are then compared to some threshold, T, and the prediction is classified as positive ("yes") if Prob>T, and it is classified as negative ("no") otherwise.

6) As T increases, what will happen to the confusion matrix and its metrics:
   a. To total number of correct "yes" predictions will increase
   b. Sensitivity (i.e., the percentage of correct "yes" predictions) will increase
   c. The total number of "yes" predictions will increase
   d. Specificity (i.e., the percentage of correct "no" predictions) will increase

7) As T increases, what will happen to the ROC curve
   a. It will be shifting toward the lower-left
   b. It will be shifting toward the upper-right
   c. It will not be shifting
   d. It will be shifting, but it is impossible to predict in which direction (depends on the data and/or the model)

Hints:

- Do not over-think – start with an MVP (“minimum viable product”). Use the data “as is,” apply minimal data cleaning and pre-processing, build a simple predictive model, and use its results to go “all the way” to arrive to the final issue/no issue decision for each new pilot applicant
- Think about how you can use the existing 24 000 clients data to determine (and evaluate) a strategy for deciding which of the new 1 000 should be issued credit once you have the model predictions for them.
- Once you have a working MVP model on the “as is” data, consider feature engineering. Think about what information is contained in your data, but is not currently captured by your variables. Brainstorm new variables that you can “engineer” from your data, create them and add to your data, rerun your models and comment on the improvements in the model’s predictions. Creative feature engineering will improve your model accuracy and will allow you to obtain a higher profit for Q1.

In addition to filling the Qualtrics survey, for the assignment, please also prepare a report summarizing what you have done, and upload this report PDF, as well as your R code on the INSEAD course portal. We will primarily grade your Qualtrics survey submission, but in case we have questions, we will consult the report/code.