PREDICTING VARIABLE ANNUITY PLAN PURCHASES

MODEL ASSESSMENT AND PREDICTION

BLUE TEAM 18 - SENCE CONSULTING

Sanket Sahasrabudhe
Ethan Scheper
Noah Johnson
Charis Williams
Elizabeth Surratt

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Table of Contents

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Overview

Commercial Banking Corporation (the Bank) is seeking to target a customer base likely to purchase a variable rate annuity product and has hired SENCE Consulting to identify these customers and assist with predictive modeling. Previously, we built a binary logistic regression model that had 14 main effects and one interaction effect. In order to assess our model's predictions, we began by calculating two probability-based metrics: the discrimination slope (0.2430) and the percentage concordance (79.73%) and discordance (20.27%). Furthermore, SENCE Consulting employed classification metrics to gauge our model's ability to distinguish who did and did not buy the annuity. First, we calculated the optimal classification cutoff (0.2976) based on the K-S statistic (0.4641). Using this cutoff as the basis for classification, we computed the model's confusion matrix, accuracy, and lift. After assessing these metrics, SENCE Consulting recommends using this model for future data and accordingly adjusting the cutoff for binary classification based on performance or future cost analysis. Additionally, we suggest expanding the Bank's analysis to unsupervised learning to investigate clusters within the customer base.

Methodology and Analysis

Our final model from the previous report contained 14 main effects and one interaction term. The selected variables and their associated p-values are reported in Table 2 in the Appendix. To evaluate the performance of this model, we first assessed its ability to rank order the predicted probability of purchasing the variable rate annuity product. Next, we analyzed its ability to classify customers and predict the binary indicator based on a calculated threshold. Lastly, the designated cutoff from the classification metrics was used to determine the accuracy and lift of the model.

Discrimination Slope

To measure how well the model performed based on predicted probabilities, we calculated the discrimination slope, which was found to be 0.2430. In context, this means there was approximately a 24% difference between the predicted probabilities of purchasing and not purchasing the variable annuity product. Figure 1 shows a visual demonstration of this via a density plot of predicted probabilities.

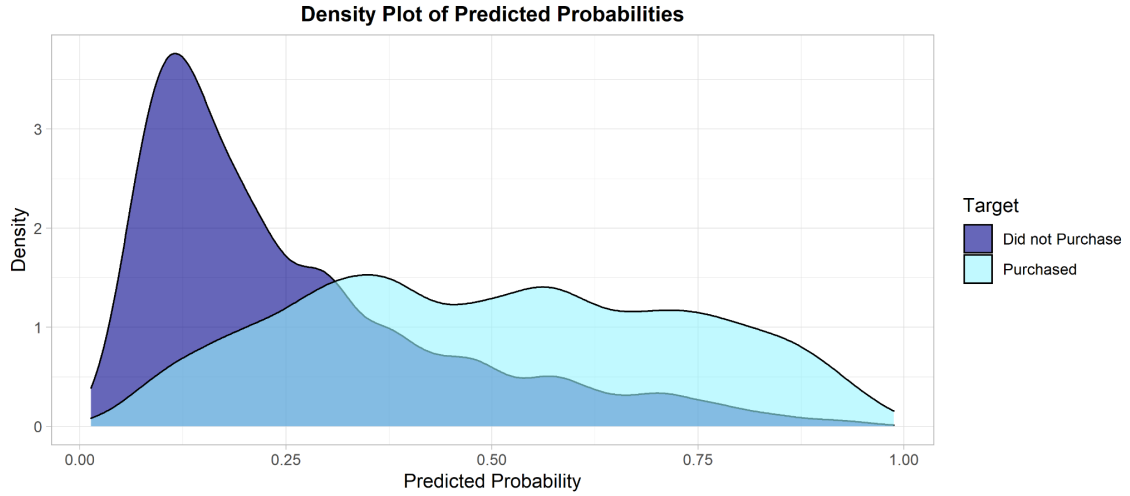

Figure 1: Density plot of the predicted probabilities, demonstrating the discrimination slope

The distribution of customers who did not purchase the product displayed a large peak at low predicted probabilities, meaning the model effectively discriminated non-events. In contrast, the distribution of customers who did purchase the product had a wider spread and a smaller peak. This was indicative that our model did not rank-order events as well as non-events.

Concordance, Discordance, and Tied Pairs

Next, we continued exploring rank-order statistics. The concordance of the model is 79.73%, meaning that nearly 80% of pairwise comparisons accurately assigned a higher predicted probability to customers who actually purchased the product. Given there were no tied pairs, the discordance is the complement of concordance at 20.27%, indicating the customer with the lower probability purchased the annuity.

Classification Metrics and Computing Optimal Cutoff

The next step for evaluating the model was to take a closer look at the classification metrics. To determine the cutoff that will be used for distinguishing events and non-events, we calculated a K-S statistic of 0.4641. This gave us an optimal classification cutoff of 0.2976 that was used for all our remaining classification methods. A visual representation of the K-S statistic is in Figure 4 in the Appendix. Therefore, customers with a predicted probability of 0.2976 or greater were predicted to buy the variable rate annuity product while all others were not. Figure 2 visualizes a ROC Curve to show how this cutoff compares to others in terms of sensitivity and specificity.

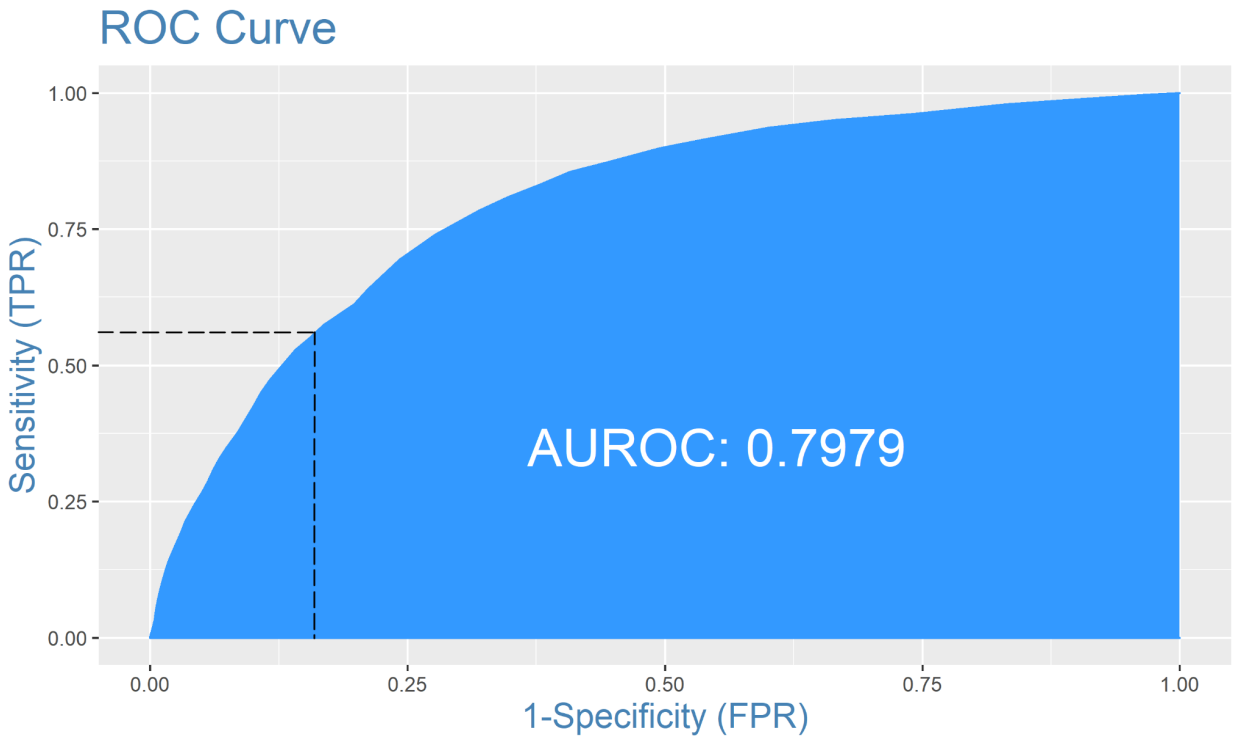

Figure 2: ROC curve with lines for True Positive Rate and False Positive Rate at our chosen cutoff (.2976)

This area under the ROC curve was consistent with the concordance reported above. With probability-based metrics reported and a cutoff determined, we then explored how the model performed on the validation set.

Results

Accuracy and Lift

We wanted to test the ability of our regression model to detect an event and a non-event correctly. At a cutoff of 0.2976, the model had an accuracy of 70.24%. This signifies that 1492 of the 2124 customers in the validation set were classified correctly based on the established cutoff.

The last classification metric that we calculated was the model's lift. At the selected cutoff of 0.2976, the lift value is 1.78, as shown in Figure 3.

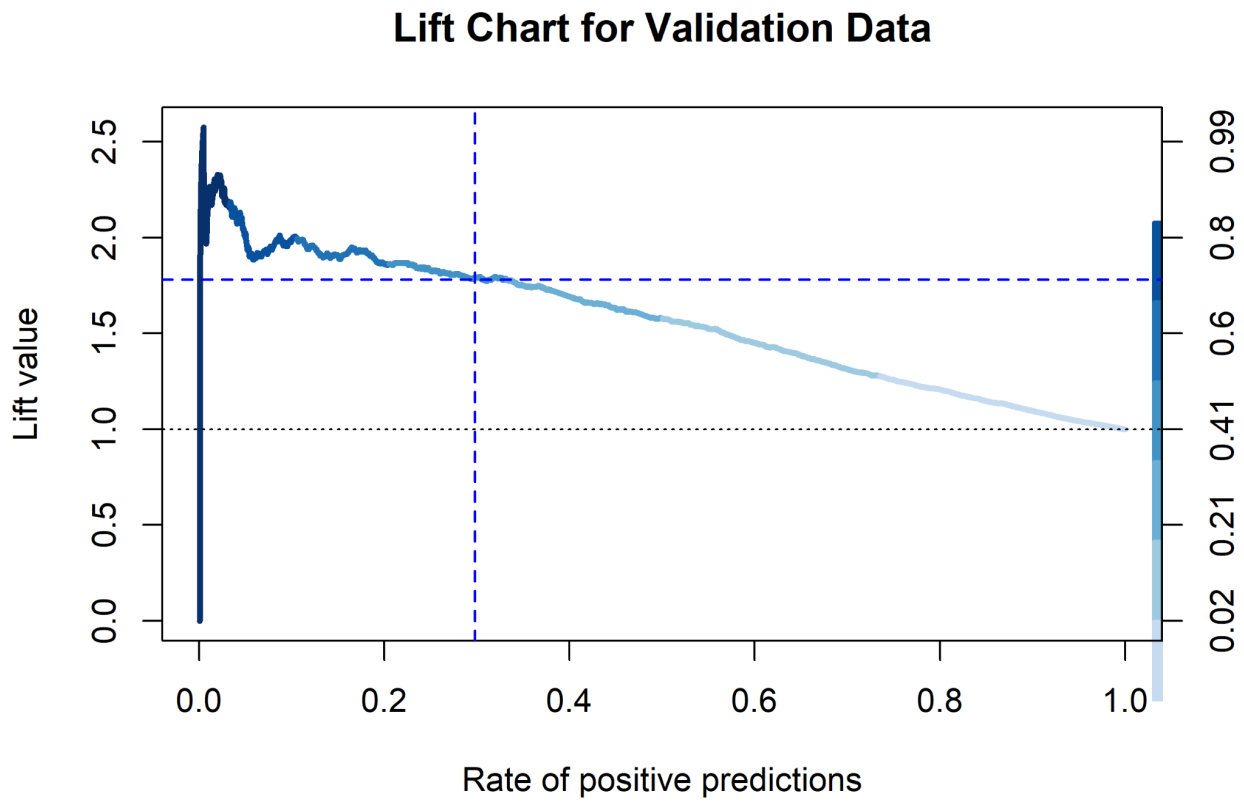

Figure 3: Lift chart with lines indicating lift value at our chosen cutoff (.2976)

This indicates that in the top 29.76% of customers, based on predicted probability, there will be approximately 1.78 times as many purchases of the variable annuity than in a random sample of 29.76% of all the Bank's customers.

Confusion Matrix

The final confusion matrix shown in Table 1 displays how the customers were categorized based on their predicted and actual purchases of the product.

Table 1: Final confusion matrix at the cutoff of 0.2976

	Predicted to not purchase product	Predicted to purchase product
Did not purchase product	909	159
Did purchase product	473	583

Using the cutoff from the K-S statistic, the model had a sensitivity, or true positive rate, of 55.21%; a specificity, or true negative rate of 85.11%; and a precision of 78.67%.

Recommendations

To further the Bank's goal of targeting customers who are likely to purchase the variable rate annuity product, SENCE Consulting recommends the following:

- Continue marketing the variable rate annuity product to customers with high account balances, specifically in long-term accounts, and a propensity to invest with the Bank.
- Monitor the performance of the model on new data and adjust the cutoff accordingly.
- Consider the trade-offs of false positives and false negatives to select a business-focused cutoff and maximize profit.
- Perform an unsupervised learning technique such as k-means clustering on the customers to identify distinct customer groups to target.

Conclusion

SENCE Consulting calculated probability and classification-based metrics to evaluate the performance of the final logistic regression model. A discrimination slope of 0.2430 indicated the model's ability to discriminate between customers who are likely or unlikely to purchase the variable rate annuity product. The percentage concordance of 79.73% displayed the model's ability to correctly rank-order potential events. After this, classification metrics were computed using the cutoff from the K-S statistic, which was 0.2976. We calculated the accuracy of the model to be 70.24%. Upon plotting the lift of the model, we found a value of 1.78 at our desired cutoff. This indicated that in the top 30% of customers predicted to buy the product, there would be about 1.78 times more purchases of the annuity than in a random sample of 30% of all the Bank's customers. Finally, the confusion matrix calculated the sensitivity to be 55% and specificity to be 85%. SENCE Consulting recommends continued implementation of our current model and considering the costs of false positives and negatives when choosing a classification cutoff. We also recommend supplementing our findings with unsupervised learning to identify customer base segments.

Appendix

Table 2: Final regression model variables ordered by descending significance (ascending p-value)

Variable Description	p-Value
Binned savings account balance (SAVBAL_Bin)	$1.5882 * 10^{-126}$
Binned checking account balance (DDABAL_Bin)	$4.8841 * 10^{-59}$
Binned certificate of deposit account balance (CDBAL_Bin)	$2.0279 * 10^{-39}$
Indicator for money market account (MM)	$3.0722 * 10^{-23}$
Binned number of checks written (CHECKS_Bin)	$6.6320 * 10^{-20}$
Binned total ATM withdrawal amount (ATMAMT_Bin)	$2.6162 * 10^{-9}$
Binned number of teller visit interactions (TELLER_Bin)	$1.1731 * 10^{-8}$
Indicator for credit card (CC)	$1.2884 * 10^{-7}$
Indicator for checking account (DDA)	$3.5133 * 10^{-6}$
Indicator for installment loan (ILS)	$8.1925 * 10^{-5}$
Indicator for investment account (INV)	$8.2438 * 10^{-5}$
Indicator for checking account (DDA), indicator for retirement account (IRA)	$2.5171 * 10^{-4}$
Indicator for mortgage (MTG)	$8.0252 * 10^{-4}$
Number of insufficient fund issues (NSF)	$1.3239 * 10^{-3}$
Indicator for retirement account (IRA)	$8.6667 * 10^{-1}$

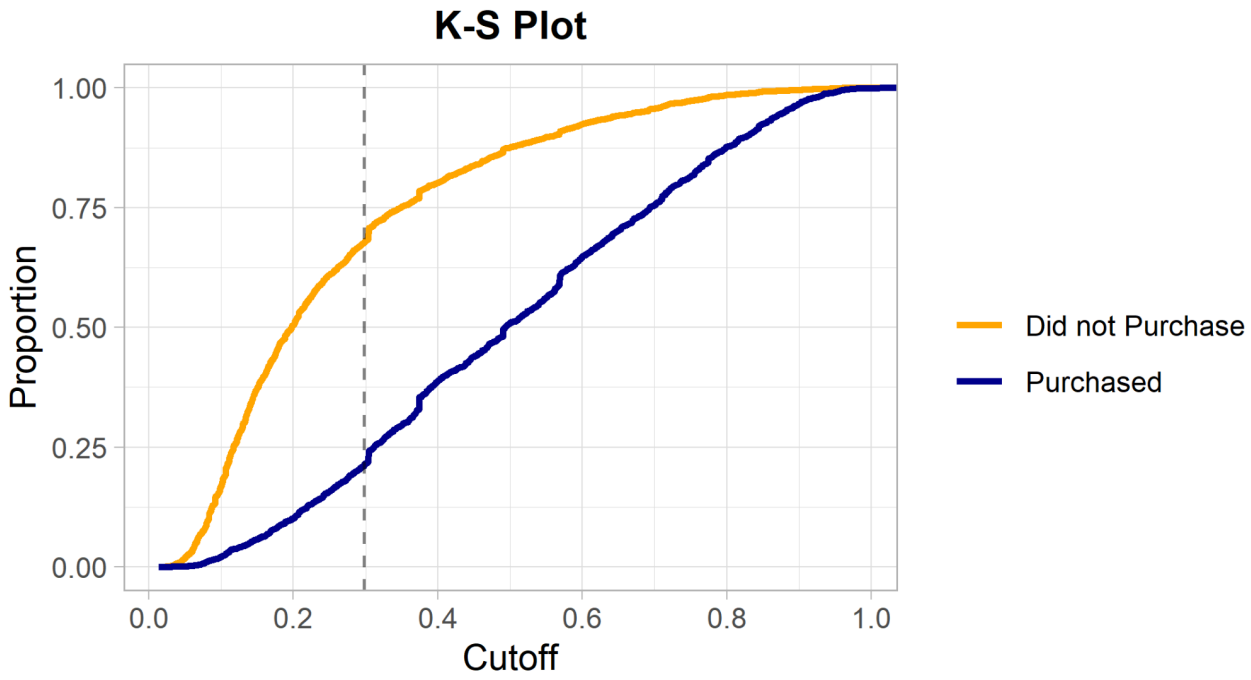

Figure 4: K-S Plot with a line indicating our chosen cutoff (.2976)

Homework Report Checklist

The team member(s) responsible for checking each item should enter their initials in the field next to each question. All items should be addressed before submitting the assignment with the initialed checklist attached.

Sections & Structure

Overview

CW	Is the overview concise?
CW	Does it provide context about the business problem? <Content>
CW	Does it briefly address your team's work, quantifiable results, and recommendations? <Action>
CW	Does it offer audience-centered reasons for recommendations? <Context>

Body Sections

EMS	Does the report body include information on methods, analysis, quantifiable results, and recommendations?
CW	Is content grouped into appropriate sections (*methodology*, *analysis*, *results*, *recommendations*)?

Conclusion

EMS	Does the report have a conclusion?
EMS	Does the conclusion sum up the report and emphasize relevant takeaways?

Structure

EMS	Does each major section have a heading?
CW	Are sections, subsections, and paragraphs organized logically for easy navigation?

Visuals

Introduction, Discussion, and Captions

SS	Is each visual introduced in the text before it appears?
SS	Is each visual close to where it is introduced?
SS	Does each visual include a title with the following information: type (*table* or *figure*), number, and a descriptive caption?
SS	Is each visual discussed and interpreted in the text?
SS	Are figures and tables numbered separately?
SS	Are table captions above the table? Are figure captions below the figure?

Visual Design

EAS	Do figures/tables use audience-friendly labels rather than variable names?
SS	Are the visuals easy to interpret?
ss	Are the visuals appropriately sized?
SS	Do tables appear on one page (*not split between 2 pages*)?
EAS	Are legends and axis labels included for figures?
EMS	Are numbers in tables right aligned?
SS	Are the visuals designed well (*ex*: *re-created in Word or Excel*, *not blurry or stretched*,…)?

Document Design

Title Page Design

EMS	Does it include a descriptive title?
EMS	Does it state the team name, team members' names, and the submission date?

Table of Contents Design

EAS	Does it list all the major sections of the report with corresponding page numbers?
EAS	Do the page numbers and sections in the Table of Contents match the report?

Document Design for Entire Report

NJ	Is a standard typeface (*Calibri*, *Arial*, *etc.*) used?
NJ	Is the size of the body text between 10-12 pt.?
CW	Are headings and subheadings used to organize information?
NJ	Are distinctive text styles (*bold*, *italic*, *etc.*) used to distinguish between heading levels?
NJ	Are text styles for headings used consistently (*ex*: *all level-one headings are bold*)?
NJ	Are all paragraphs an appropriate length (*fewer than 12 lines*)?
NJ	Is white space used to indicate paragraph breaks?
NJ	Are bullet lists used for a series of items and numbered lists to show a hierarchy?

Writing Style and Mechanics

Spelling and Capitalization

EMS	Are spelling errors located and corrected?
NJ	Is spelling consistent throughout (*no switching between acceptable spellings*)?
EMS	Is capitalization used appropriately (*proper nouns*, *etc*.)?
EMS	Is capitalization of words consistent throughout the report?

Grammar and Punctuation

CW	Are verb tenses used appropriately?
CW	Are marks of punctuation used appropriately?
EAS	Is subject-verb agreement used in every sentence?
EMS	Is the grammar checker updated and are underlined grammar issues addressed?

Writing Style

EMS	Are all sentences in the report easy for your audience to understand quickly?
EMS	Are most sentences written in active voice?
EMS	Are idioms and vague words eliminated from the report?
CW	Are acronyms introduced before being used?
EMS	Are well-written topic sentences included at the beginning of each paragraph?
EAS	Are lists parallel?
EMS	Is the appropriate point of view used when addressing your audience or describing team actions?