

The background of the slide is a collage of financial and business-related items. In the top left, a portion of a black calculator is visible, showing keys for '3', '6', '+', and '='. Below the calculator, there are several charts: a bar chart at the top with months from May to December on the x-axis, a pie chart in the center, and a line graph at the bottom left with data points connected by lines. To the right of the pie chart, there is a fan of US dollar bills. In the bottom right corner, a silver compass is shown. A black pen lies diagonally across the bottom left of the slide. The overall theme is finance and business analysis.

# Bank Telemarketing Success

## Classification problem

### Rui Yuan

# Clients and Problem

- Bank wants to implement a telemarketing campaign.
- And they want to know about the campaign performance: success rate; what their target clients are (that are likely to subscribe bank term deposit or other financial products).

# Data

- The data is download from UCI ML Repository, related with direct marketing campaigns of a Portuguese banking institution dated from May 2008 to November 2010.
- The marketing campaigns were based on phone calls.
- 45,211 rows and 16 columns.
- Target: Whether client subscribe bank term deposit (1 = yes, 0 = no )

## 15 Features

### bank clients' data:

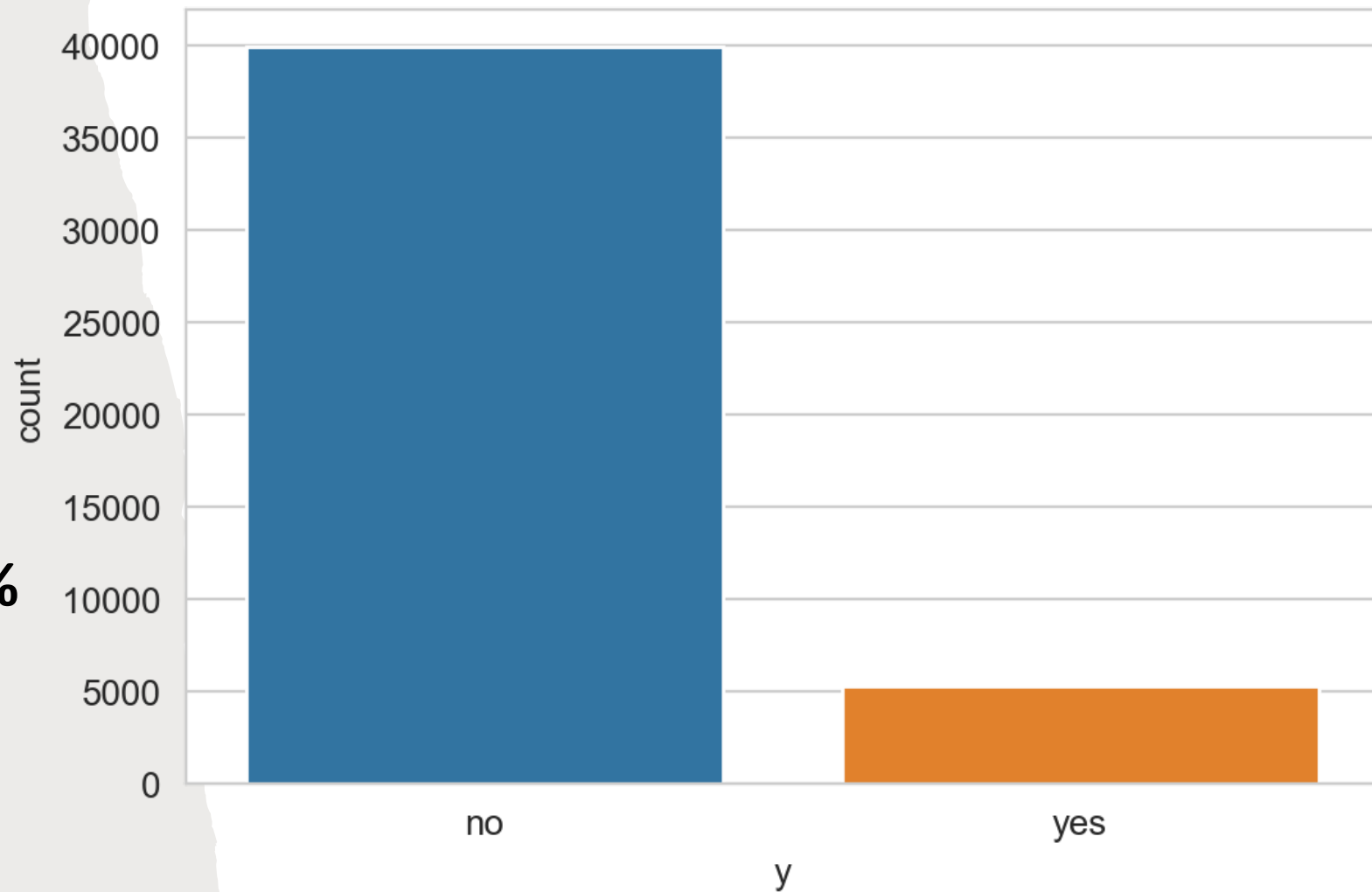
- 1 - **age**: numeric, 18 to 95.
- 2 - **job** : type of job (categorical: "admin.", "unknown", "unemployed", "management", "housemaid", "entrepreneur", "student", "blue-collar", "self-employed", "retired", "technician", "services")
- 3 - **marital status** (categorical: "married", "divorced", "single"; note: "divorced" means divorced or widowed)
- 4 - **education** (categorical: "unknown", "secondary", "primary", "tertiary")
- 5 - **default**: has credit in default? (binary: "yes", "no")
- 6 - **balance**: average yearly balance, in euros (numeric)
- 7 - **housing**: has housing loan? (binary: "yes", "no")
- 8 - **loan**: has personal loan? (binary: "yes", "no")

### campaign data and other attributes:


- 9 - **contact**: contact communication type (categorical: "cellular", "telephone", "unknown")
- 10 - **day**: last contact day of the month
- 11 - **month**: last contact month of year (categorical: "jan", "feb", "mar", ..., "nov", "dec")
- 12 - **campaign**: number of contacts performed during this campaign and for this client (numeric, includes last contact)
- 13 - **pdays**: number of days that passed by after the client was last contacted from a previous campaign (numeric; 999 means client was not previously contacted)
- 14 - **previous**: number of contacts performed before this campaign and for this client (numeric)
- 15 - **poutcome**: outcome of the previous marketing campaign (categorical: "failure", "nonexistent", "success")

# Class Distribution

Success rate=  $\text{yes/all} = 12\%$



# Classification Modeling Goal


- Goal:  precision score on positive class & number of true positives (subscribe)
- In Business Sense: Model being able to target clients upon changing needs.
  - Business capability can vary depending on the amount of sources, such as number of employees, phone plan fees, etc.
  - So how many clients bank can reach to or how many phone calls bank can do in a given period (week/month/year) may vary, and we want the model being able to target potential clients upon business changing capability.

# Modeling & Performance Metric Report

## Phase 1: Model Testing

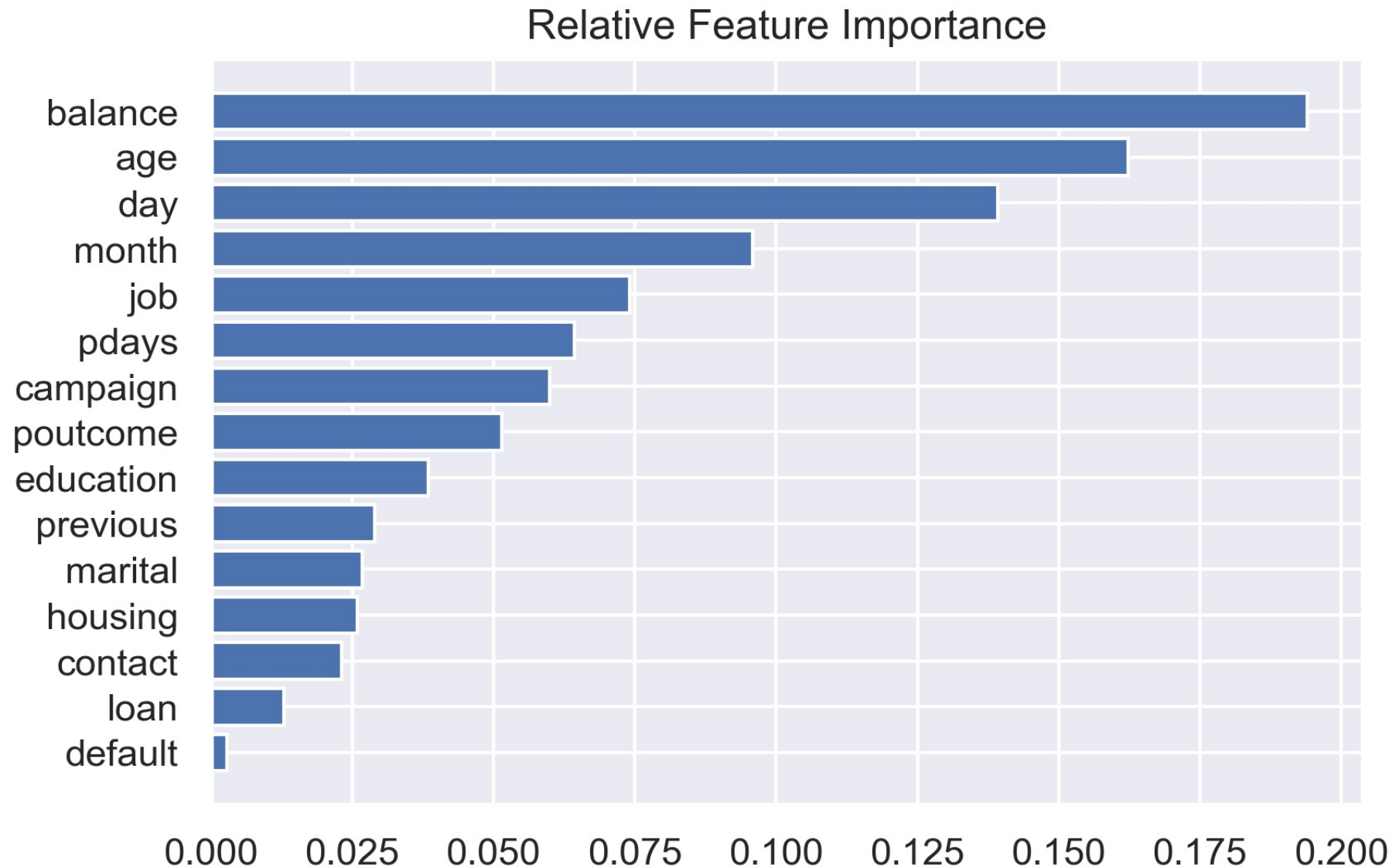
Model	Precision	Recall	F-1	Accuracy
1. K-Nearest Neighbor Baseline	0.43	0.12	0.18	0.88
2. K-Nearest Neighbor Optimized with Grid Search	0.48	0.04	0.07	0.88
3. Logistic Regression Baseline	0.50	0.00	0.00	0.88
4. Logistic Regression Regularized	0.48	0.04	0.07	0.88
5. Random Forest Baseline	0.69	0.21	0.32	0.89
6. Random Forest Optimized with Random Search	<b>0.71</b>	0.19	0.30	0.89

## Phase 2: Handle Class Imbalance

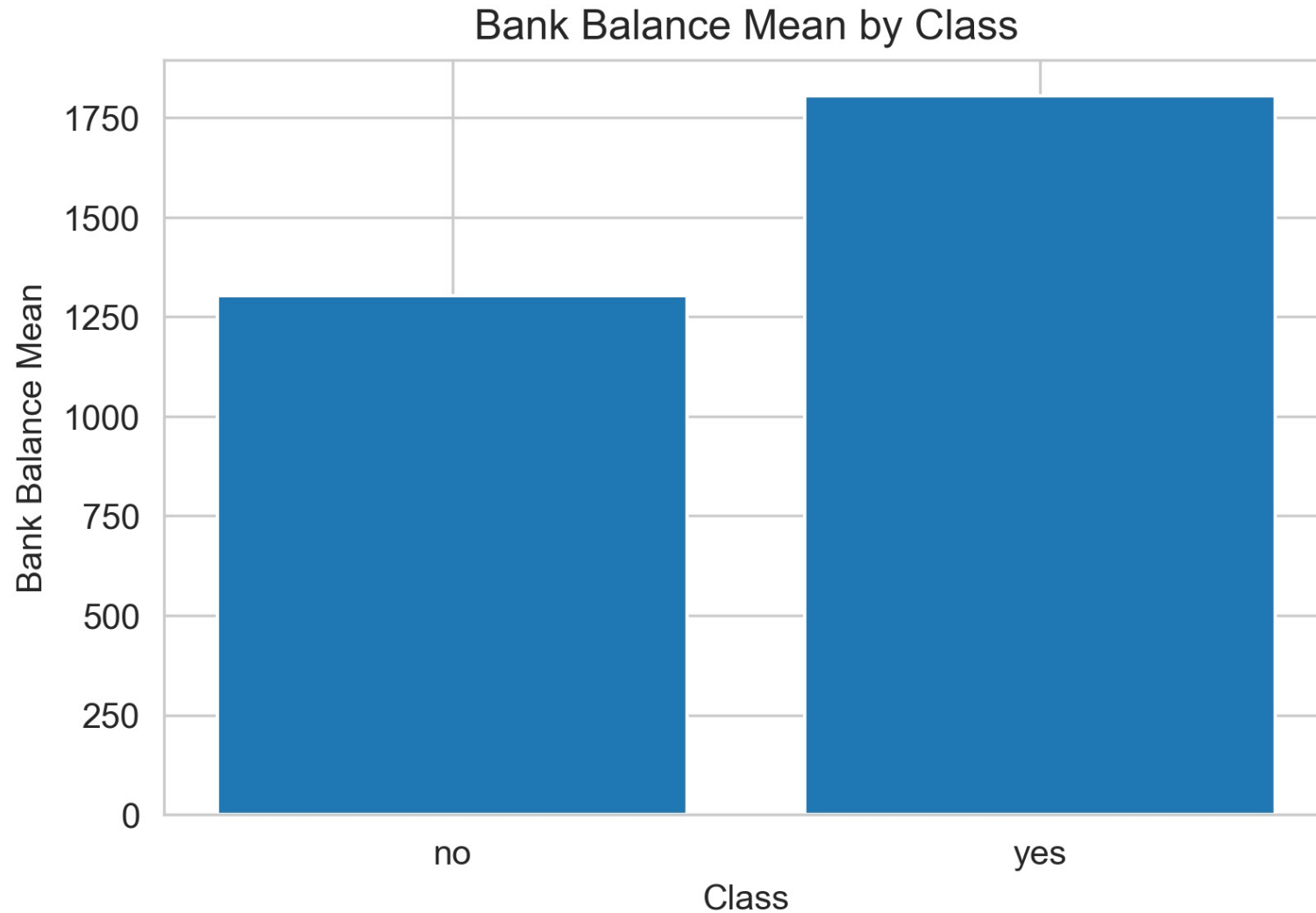
Model	Precision	Recall	F-1	Accuracy
7. Random Forest with Sampling method	0.55	0.29	0.38	0.89
8. Random Forest with Adjusted Class Weight	0.69	0.19	0.30	0.89
9. Random Forest with Probability Threshold Adjustment 	Adjustable	Adjustable	Adjustable	Adjustable



# Feature Importance from RF model



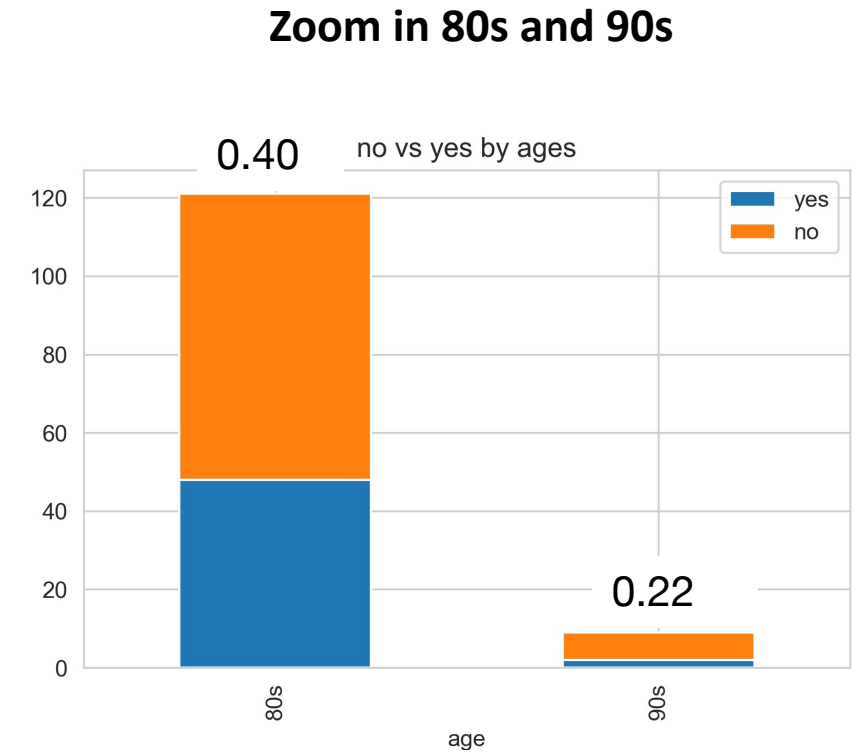
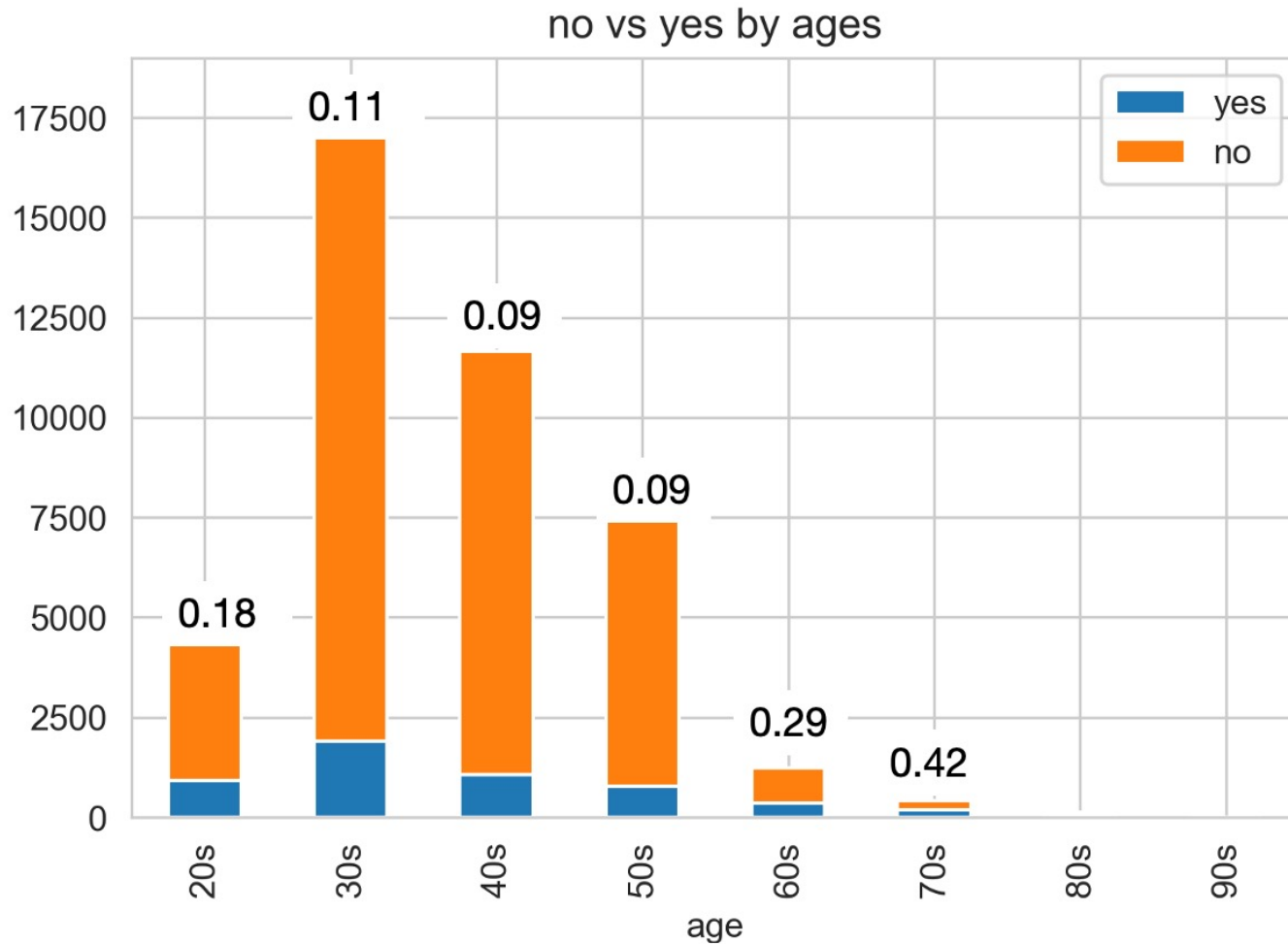
# Closer look at important features: balance



**Positive class has higher average bank balance**

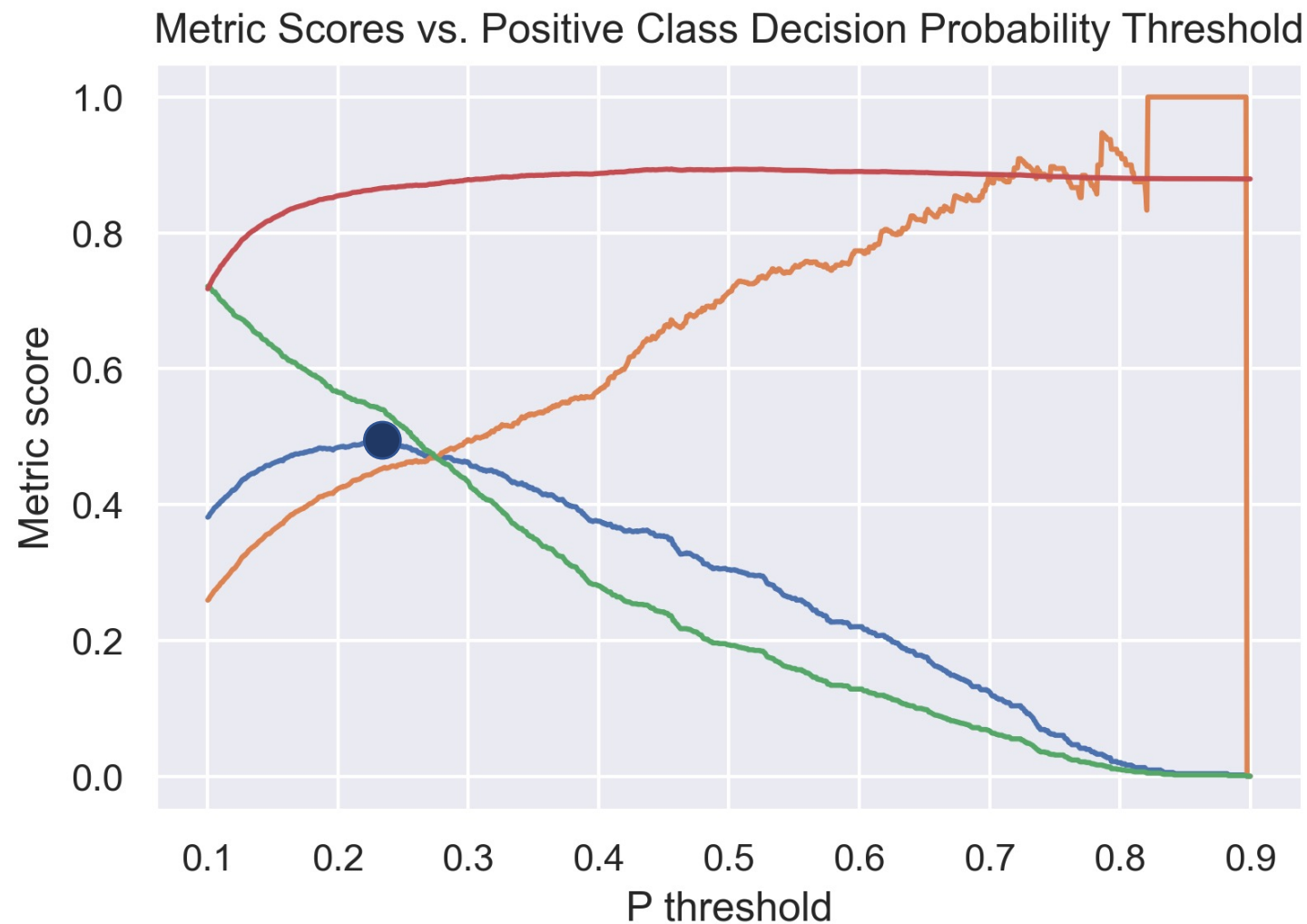


# Closer look at important features: age

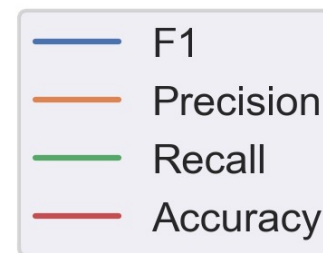


**Elderly groups have higher success rate but lower number of success**

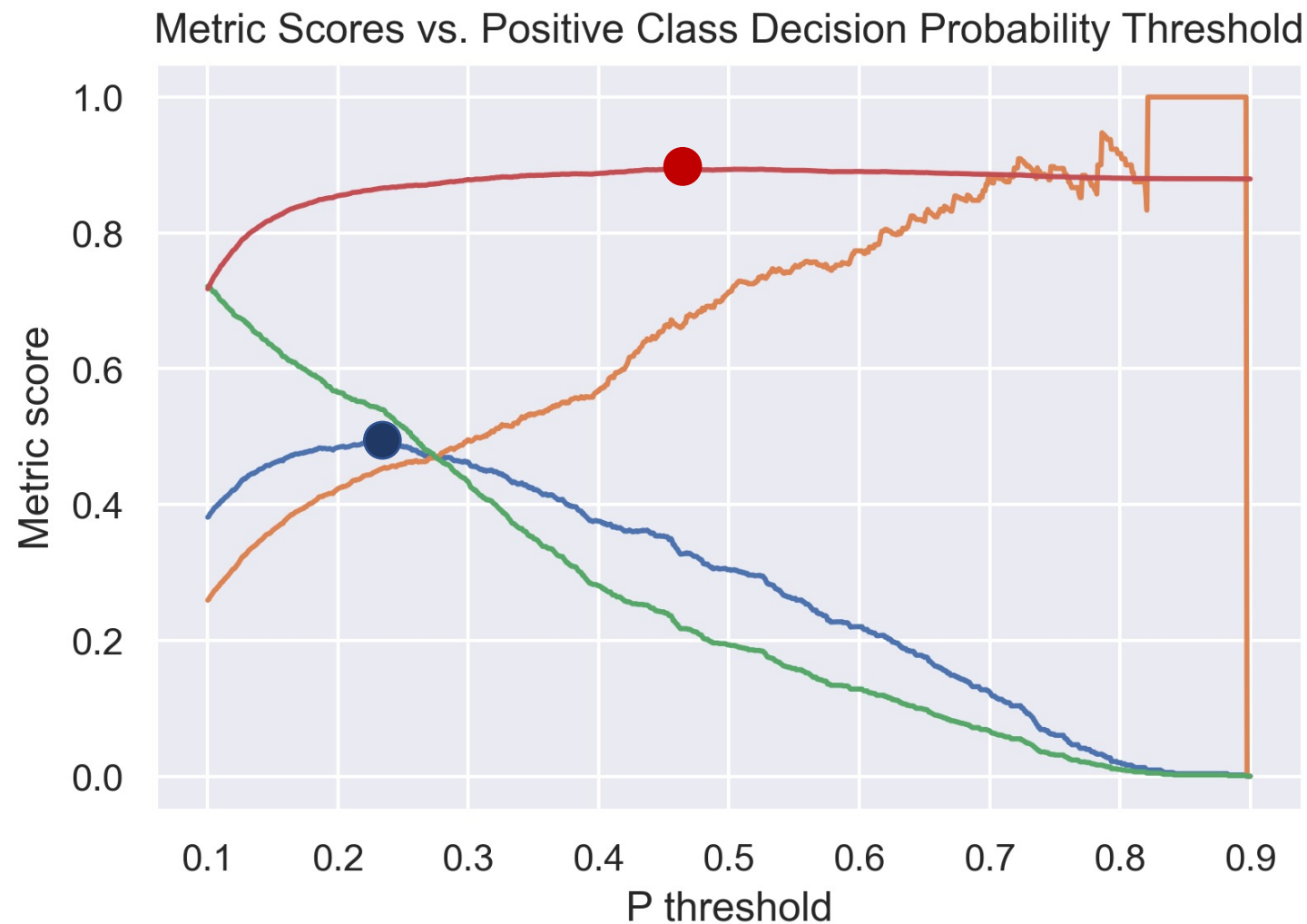
# Solution: RF model w/ Probability Threshold Controlling



Metric	Best Score	Probability
F1	0.47	0.24



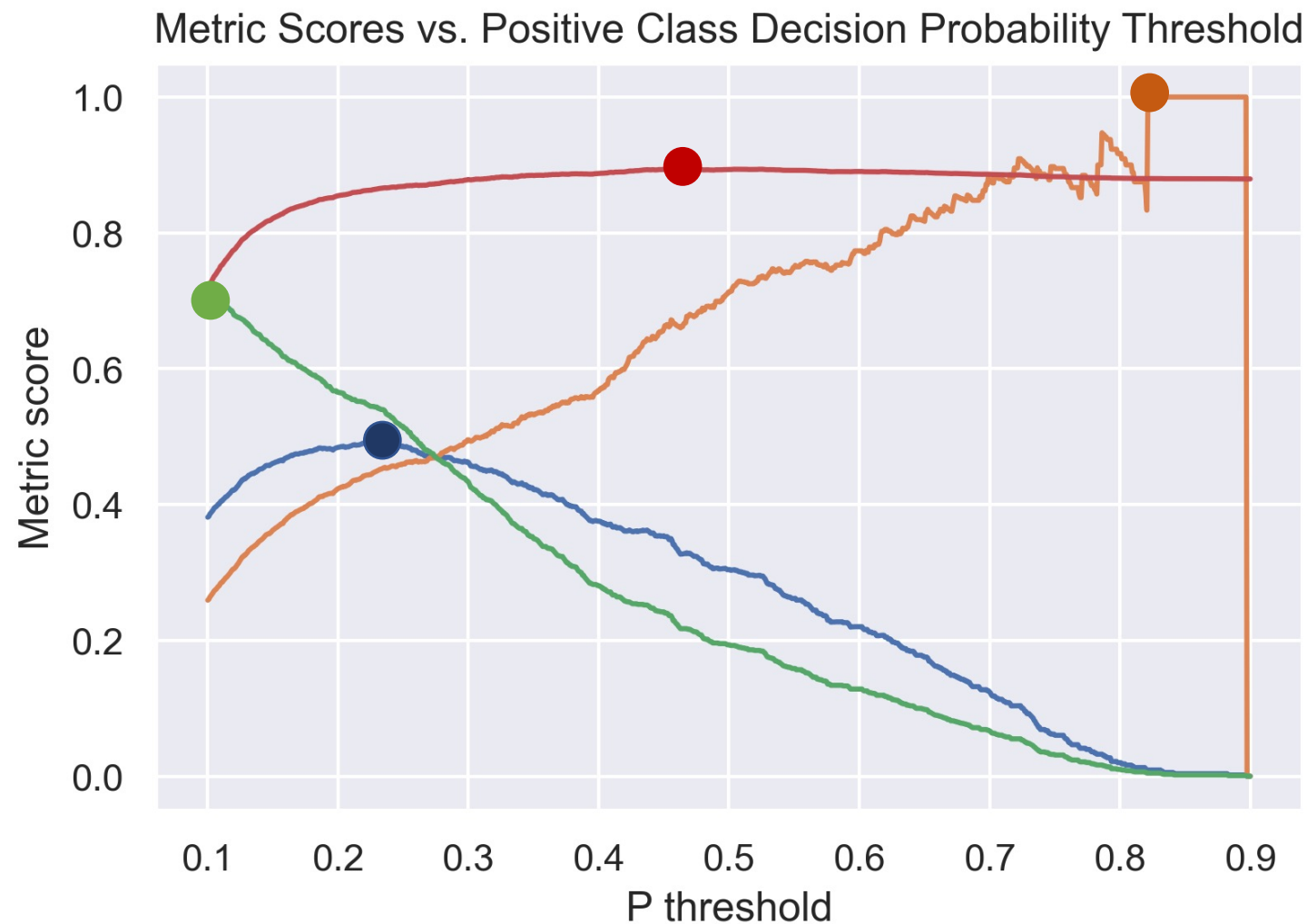
# Solution: RF model w/ Probability Threshold Controlling



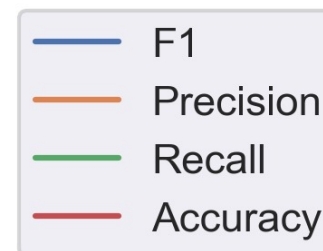
Metric	Best Score	Probability
F1	0.47	0.24
Accuracy	0.89	0.46



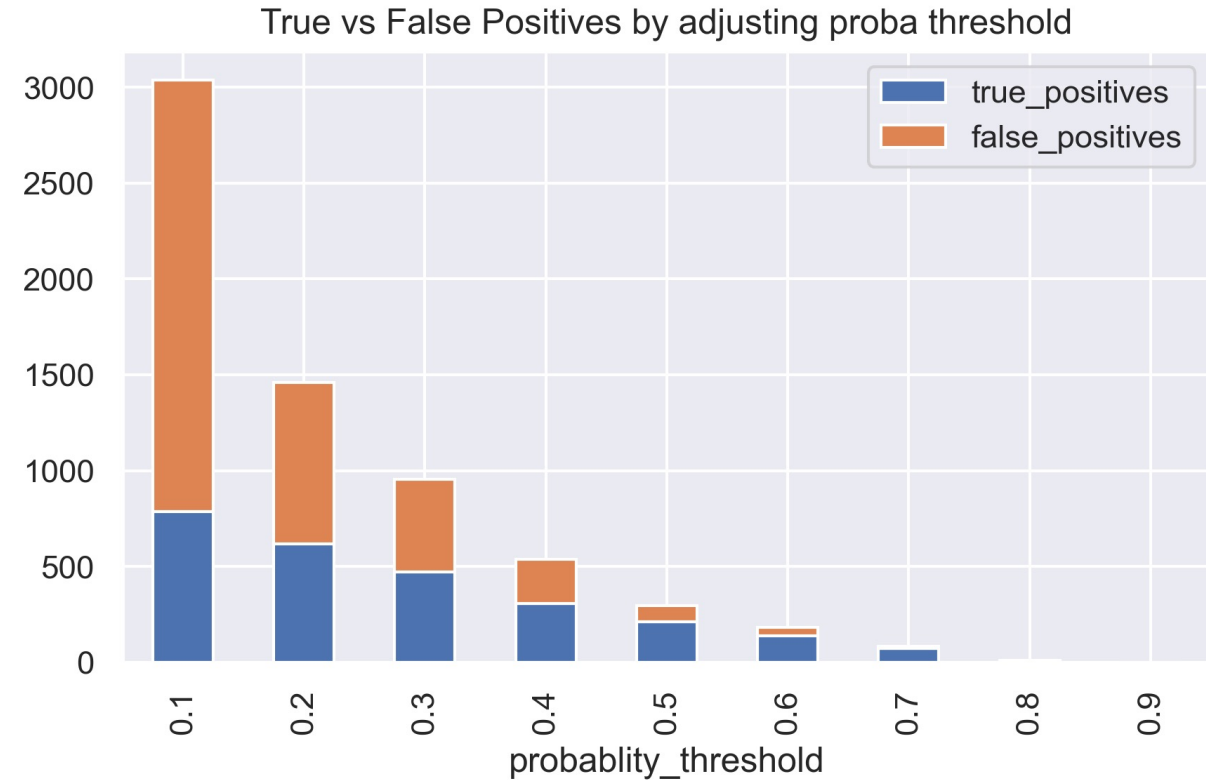
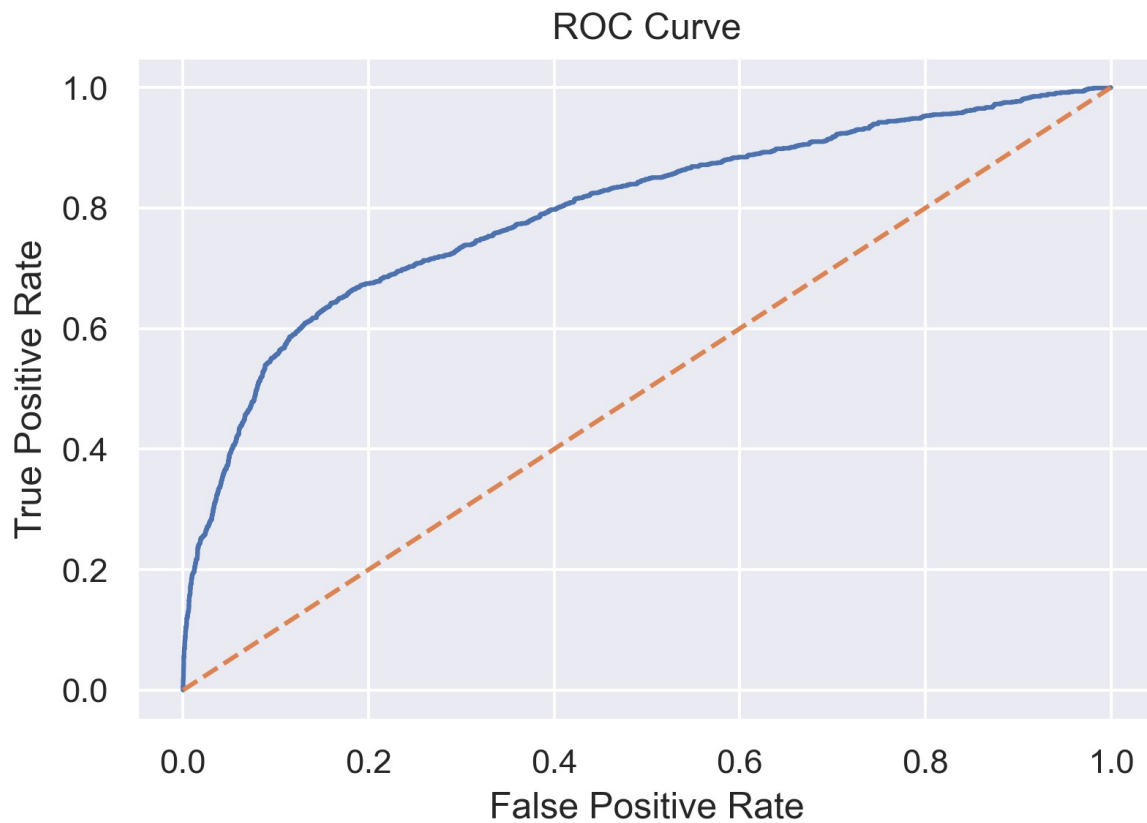
# Solution: RF model w/ Probability Threshold Controlling



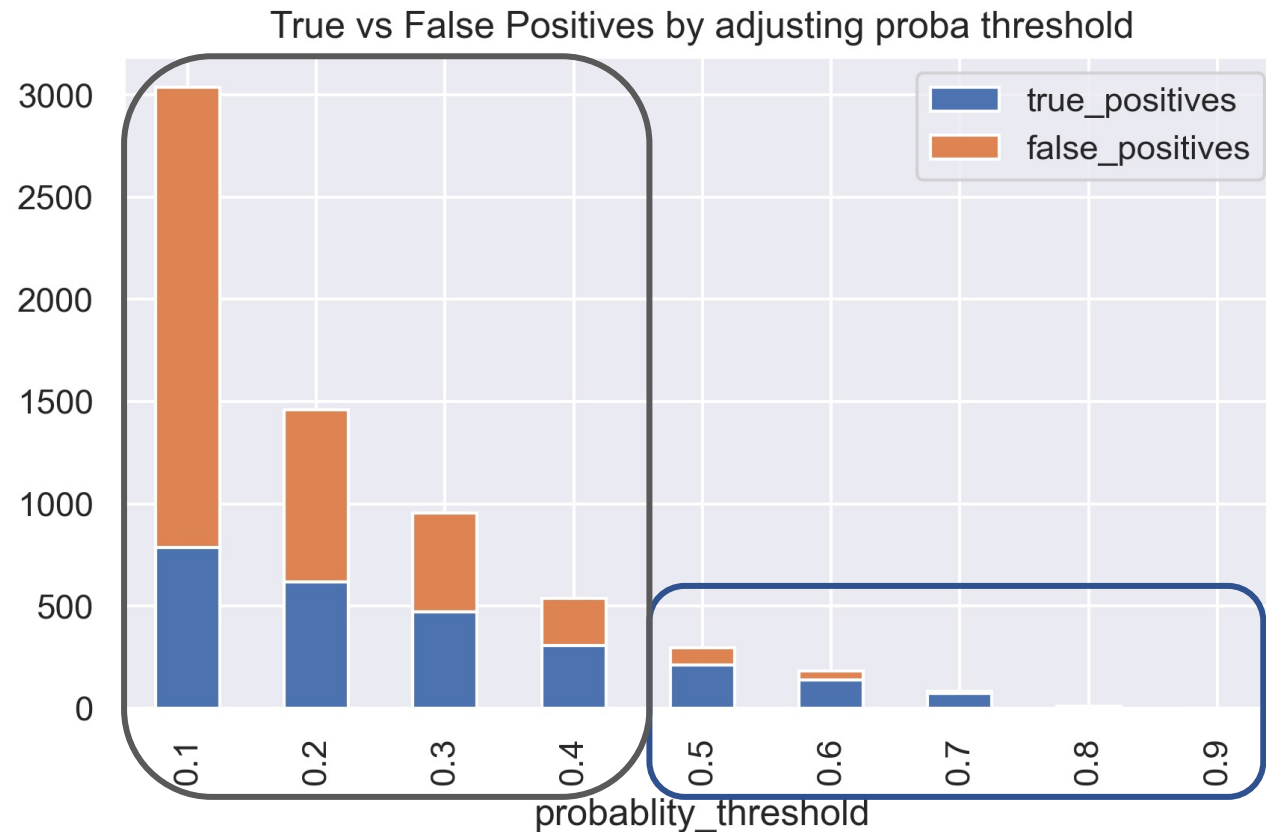
Metric	Best Score	Probability
F1	0.47	0.24
Accuracy	0.89	0.46
Precision	1.00	0.82



# Solution: RF model w/ Probability Threshold Controlling



# Solution: RF model w/ Probability Threshold Controlling

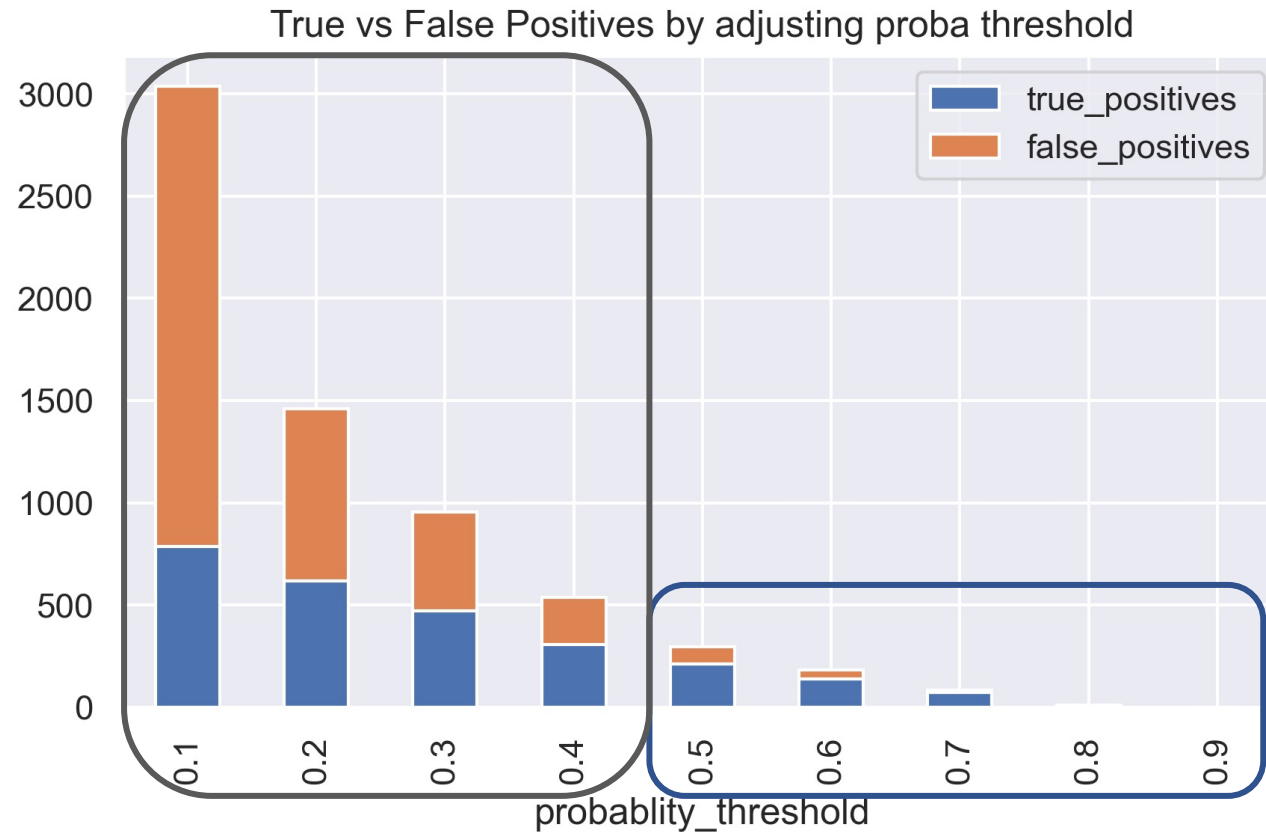


Proba Threshold	True Positives	False Positives	Predicted Positives	Precision Score
0.1	787	2250	3037	0.26
0.2	617	841	1458	0.46
0.3	472	481	953	0.49
0.4	306	233	539	0.56
0.5	211	85	296	0.71
0.6	140	41	181	0.77
0.7	72	10	82	0.88
0.8	11	1	12	0.92
0.9	0	0	0	

**Prob threshold 0.5 to 0.9, precision score ranges from around 0.7 to 0.9.**

**Prob threshold 0.1 to 0.4, precision score ranges from 0.26 to 0.56.**

# Solution: RF model w/ Probability Threshold Controlling

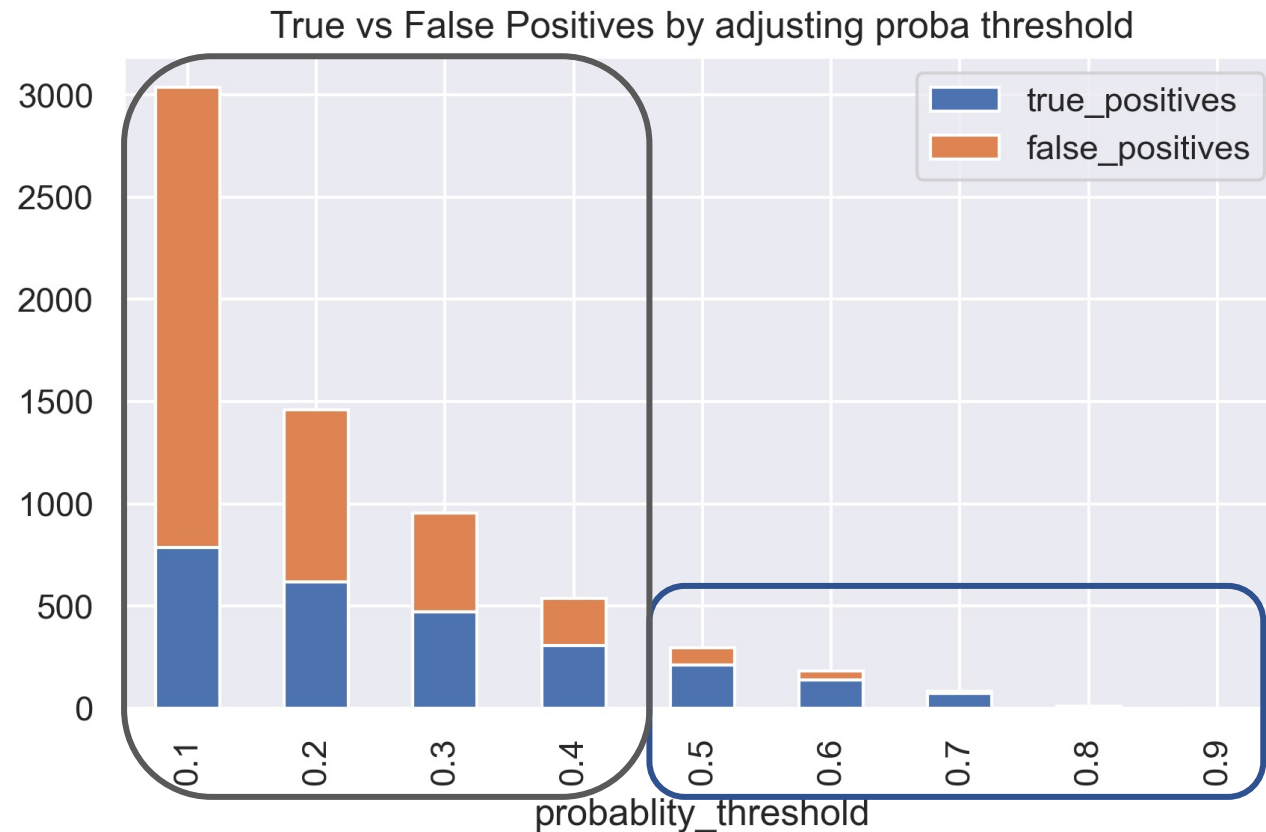


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0.9	0	0	0	

**Prob 0.1 to 0.4 have greater true positives than prob 0.5 to 0.9**



# Solution: RF model w/ Probability Threshold Controlling

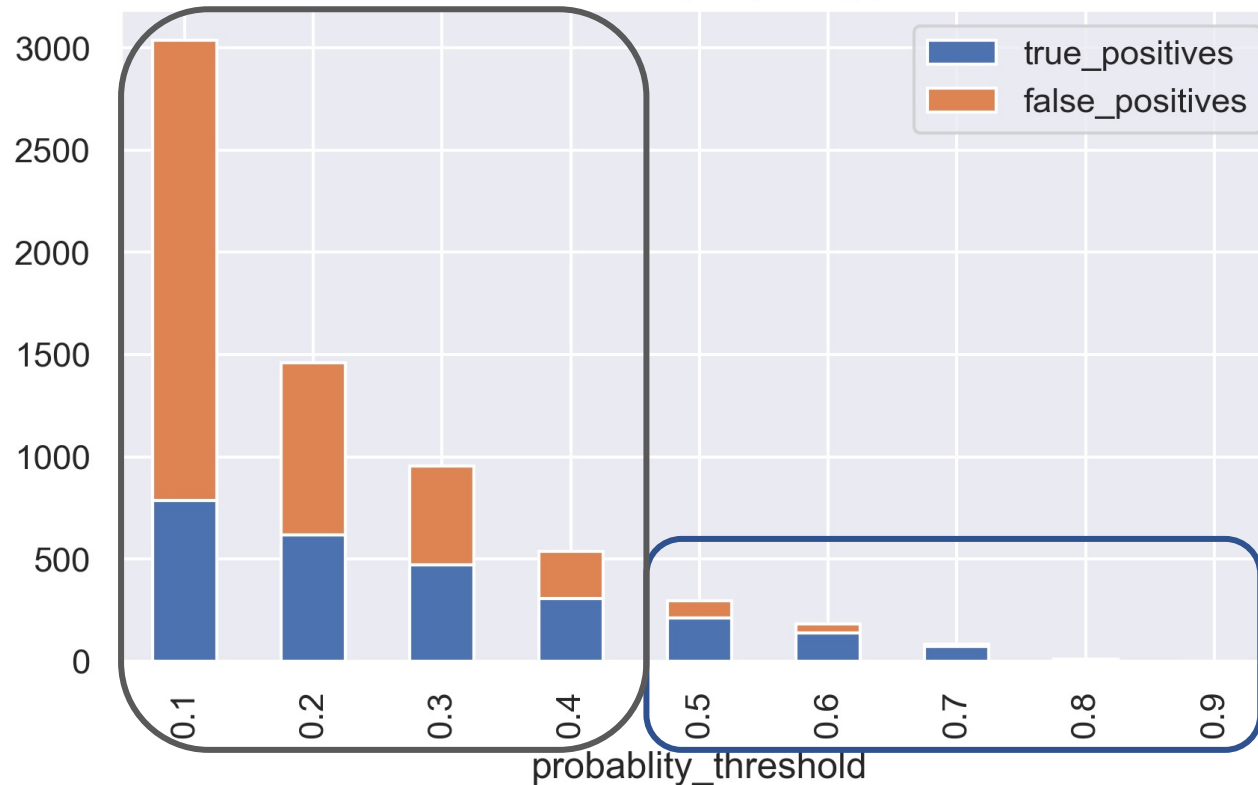


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0.8	11	1	12	0.92
0.9	0	0	0	

**At prob threshold 0.8, precision 0.92 with only 11 positives.  
At prob threshold 0.9, no positives being captured.  
Best Precision  $\neq$  Best Result**

# Solution: RF model w/ Probability Threshold Controlling

True vs False Positives by adjusting proba threshold



Proba Threshold	True Positives	False Positives	Predicted Positives	Precision Score
0.1	787	2250	3037	0.26
0.2	617	841	1458	0.46
0.3	472	481	953	0.49
0.4	306	233	539	0.56
0.5	211	85	296	0.71
0.6	140	41	181	0.77
0.7	72	10	82	0.88
0.8	11	1	12	0.92
0.9	0	0	0	

**Compare Proba threshold 0.1 and 0.2:**

**With slightly greater number of true positives, Prob 0.1 has more than twice predicted positives as much as of prob 0.2**

A collage of business-related items. In the top left is a black calculator with white buttons. In the top right is a silver compass. In the bottom left is a black pen. The background features several charts and graphs: a bar chart at the top, a pie chart in the center, a line graph on the left, and a table of numbers at the bottom. A semi-transparent white box with the text "Thank you!" is centered over the pie chart.

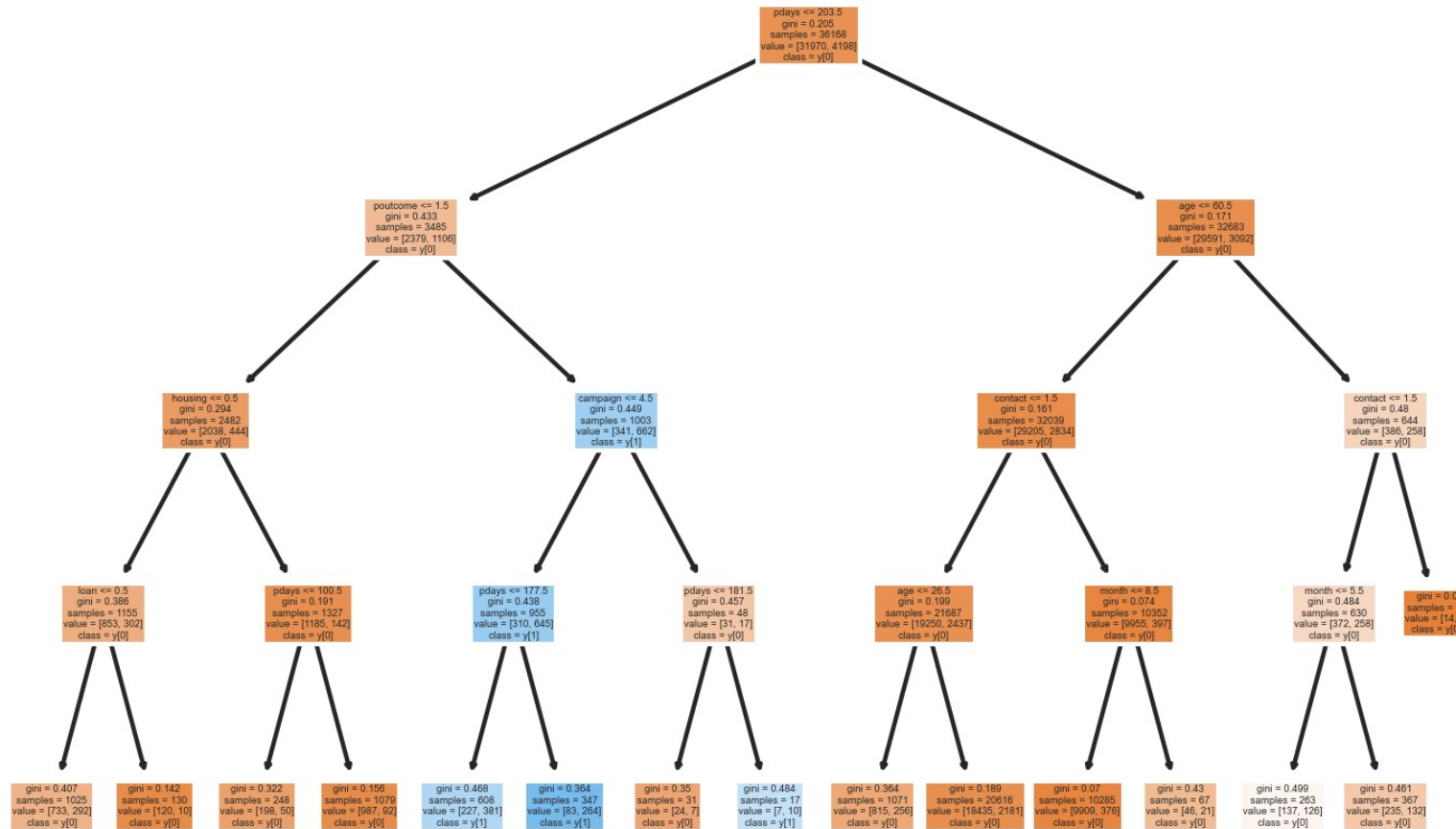
Thank you!



# Futher Work

- Boosting with Ada Boost, XG boost
- More Models: SVM, Naive Bayes, etc.

# Appendix (1): Visualize the Tree (max\_depth=4)





# Appendix (2): Visualize the Tree (Greedy Approach)

