

Nebraska Mortgage Segments & Market Entry Strategy

A Quantitative study of FRM Market in Nebraska

Oct 13, 2021



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Case Challenge: Analyzing the Nebraska Mortgage Loan Market

CASE CHALLENGE

Great Lakes Midwest Bank (GLMB), a regional bank is planning expanding its operations in Nebraska.

Before expanding their operations, they are surveying the health and opportunity of the Nebraska mortgage market.

A dataset from Fannie Mae was made available for analysis. About a quarter of all entries are “in-progress” mortgages and need to be predicted to obtain full picture.

The task is to analyze the dataset and determine which segments of the Nebraska mortgage market GLMB should focus on.

The primary consideration of the analysis is to maximize the dollar value of mortgages issued while limiting the number of mortgage delinquencies.

METHOD

A random forest classification model was built to predict outcomes of “in-progress” mortgages to arrive at full dataset.

The team built a Linear Regression model with knowable^[1] variables to slice the dataset into appropriate segments.

Team studied other sellers for better understanding of market dynamics, and for establishing a reference point to our market entry strategy.

KEY RESULTS

1. Created a 4-stage market entry plan with timelines and milestones.
2. Defined appropriate segments for different stages of the strategy.
3. In the end, the team projects Great Lakes Midwest Bank capture between \$80M to \$102M in mortgage issuance, which accounts for approximately 3.3% of the Nebraska Conforming FRM market.

The Prediction Model

After trying a few modeling methods, Random Forest Classifier performed the best

Cleaning & Parsing ▶

The team started off with cleaning the dataset and filling the missing data in preparation for data analysis.

The data was first converted to be parsed by the model. For classification methods such as Random Forest, factorial variables are converted to numerical values while the team kept a data legend.

Linear Regression ▶

Generalized Linear Regression was the first modeling attempted.

The model yielded poor results. The accuracy wasn't high, and false negatives were especially high.

This model was later refined and used to assess the effects of variables on outcome (mature or delinquent).

Classification - SGD ▶

The next classification model was Stochastic Gradient Descent.

But, as the data was too skewed towards successful mortgages, the model overfitted to the dataset, which resulted in many false negatives.

Random Forest ▶

Then a Random Forest model was created from the decision trees and used on the dataset.

This time it outperformed all previous models and yielded the most consistent results.

Random Forest Model has:

- 100% accuracy in predicting the mortgages that are “in-progress” but will be prepaid or matured during the term.
- 95% accuracy in predicting the mortgages that will result in a delinquent status during their term.
- 88% accuracy in predicting the mortgages that will result in a Deed-in-Lieu or REO disposition status [Appendix A].

This model gave us a high degree of confidence in predicting the outcomes of the currently “in-progress” mortgages.

Market Analysis of Full Dataset

Analysis of dataset suggests NE's market is competitive and allows space for newcomers.

Key Statistics

2.55%

Delinquency Rate

0.131%

Above Fed Rate

751.92

Average Credit Score

Open Market

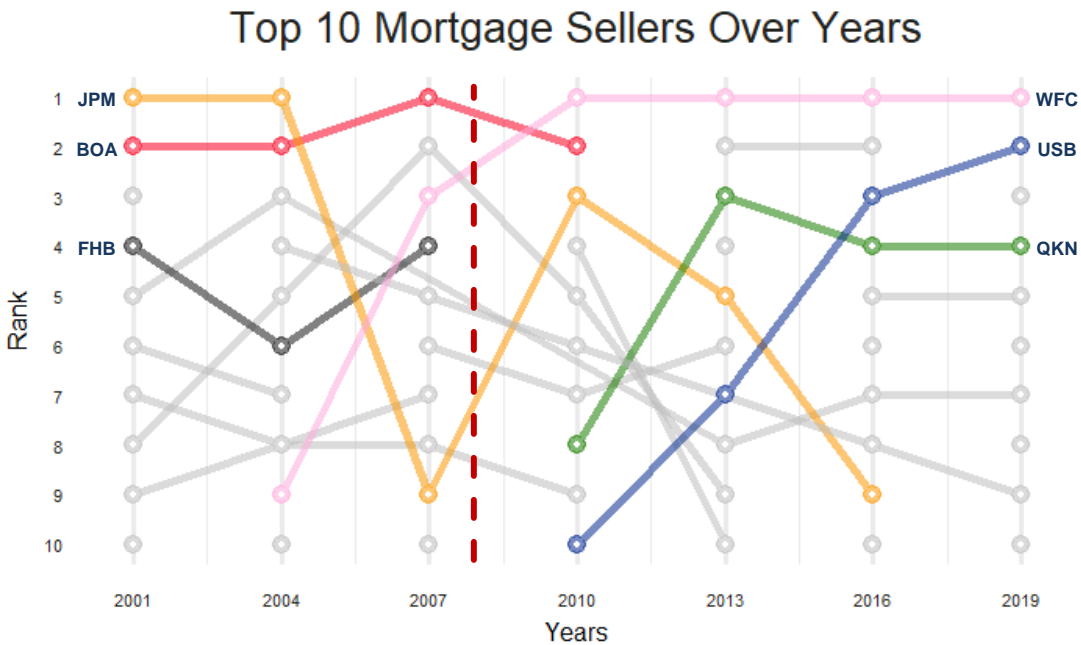
The share of "Other" sellers has steadily increased over the past two decades, suggesting that while top sellers dominate, other players including new entrants to the market have a decent chance to succeed



Fierce Competition



Nebraska's Fixed-Rate-Mortgage (FRM) market has seen major reshuffle set on by 08's financial crisis.

Top sellers from early 2000s (JPM, BOA) rarely stayed at top ten after 10+ years. Wells Fargo and U.S. Bank now dominates the market, along with non-bank entities such like Quicken Loan.



Competitor Analysis of 4 Banks of Different Market Cap

Historic data from midsized regional banks provides reference point for GLMB's target market share

	WELLS FARGO	usbank.	TRUIST 	Flagstar® Bank 
Market Share (appx. range, recent)	15% ~ 18%	4% ~ 10%	<u>0.8% ~ 4%</u>	<u>0.6% ~ 3%</u>
Default rate (since 2009, q1~q2~q3)	1.34% ~ 3.39% ~ 4.95%	0.29% ~ 4.23% ~ 7.67%	1.14% ~ 2.06% ~ 3.80%	3.37% ~ 5.23% ~ 6.40%
Mean loan amount (q1~q2~q3)(\$)	147.5K ~ 162.7K ~ 172.0K	125.0K ~ 139.3K ~ 152.5K	131.0K ~ 160.8K ~ 194K	144.5K ~ 156.6K ~ 158.3K
Mean rate deviation ^[1] (q1~q2~q3)	0.184% ~ 0.1946% ~ 0.231%	-0.045% ~ 0.061% ~ 0.153%	0.135% ~ 0.173% ~ 0.227%	0.246% ~ 0.295% ~ 0.348%
Mean credit score (q1~q2~q3)	771.0 ~ 773.5 ~ 776.2	745.2 ~ 759.0 ~ 775	773.8 ~ 778.5 ~ 785.0	765.0 ~ 768.1 ~ 771.2
Market Cap (2019)	\$222.43B	\$90.96B	<u>\$33.06B</u>	<u>\$2.16B</u>
Branch Locations (appx.)	5200	3067	<u>1218</u>	<u>150</u>
Operating States	50 + DC	26	<u>11, Southern + DC</u>	<u>5, Midwest + California</u>
Ranking (2019)	1	2	<u>9</u>	<u>7</u>

Conclusions:

Although both large banks dominate the market, mortgages by Wells Fargo have very different profile from U.S. Bank.

While Wells Fargo consistently targets those requesting higher than average loan amounts, borrowers of U.S. Bank consistently have lower credit score, and request less in loan. Borrowers of U.S. Bank also have higher default rate.

Truist and Flagstar both have similar market share in NE FRM market: less than top players, but noteworthy given its resources. As a regional bank, GLMB should realistically aim to capture a similarly-sized market share.

Numbers from Flagstar and Truist bank serves as our references.

Future Market Conditions

Future market conditions remain uncertain amid rising inflation, high CPI, hot housing market, & imminent rise in interest rates in FY22

Currently, there is rising inflation in all sectors of the economy due to supply chain bottlenecks, labor shortage, and changing workplace requirements.

The new housing inventory is running low driving the prices higher due to labor shortage and supply constraints.

Due to COVID-19, the people who could work remotely, shifted to a remote only working environment. This drove up the demand for single family houses and increased demand in higher-end housing market.

Due to the easy monetary policy maintained by the Federal Reserve to support the market recovery from COVID-19, the interest rates are at record lows right now. This is expected to change once the Fed increases the interest rates in FY22.

With supply chain issues still plaguing the markets and workers starting to return to office the demand for housing is easing compared to its highs in March 2020 - April 2021. But the future remains uncertain due to the new COVID variants and the pace of reopening of the economy.

The rate of home price appreciation is slowing

Year-over-year change in median home list price

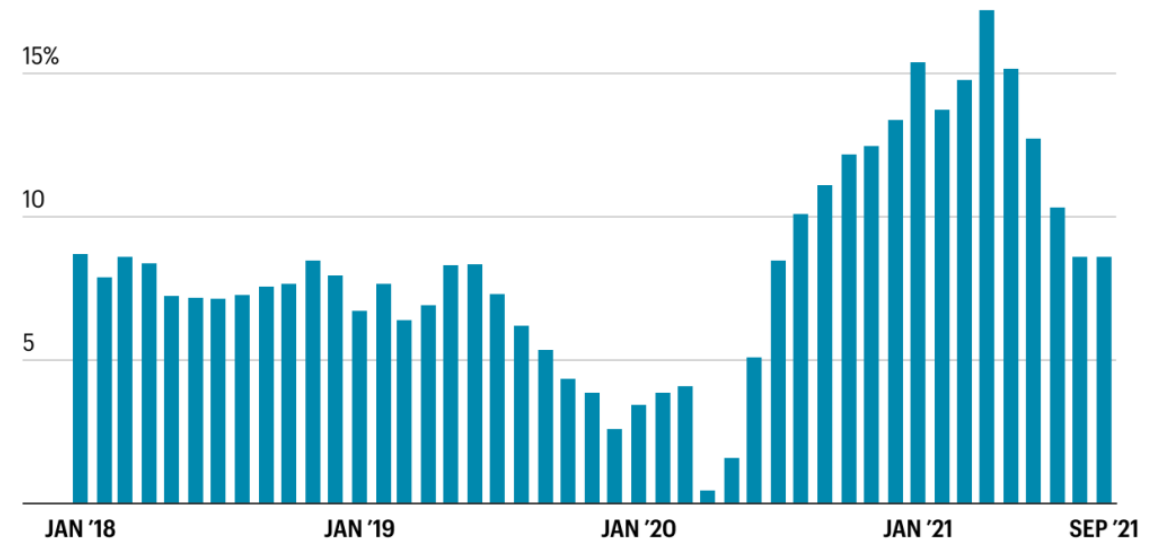


CHART: LANCE LAMBERT • SOURCE: REALTOR.COM

FORTUNE

Figure 1

Variables to Define Segments

Identified key variables and their effects to define segment with low delinquency rates

Variables with Significant Impact

A Linear Regression Model^[1] was created with only variables knowable at time of mortgage issuance, to check effects of each.

All variables listed above have strong statistical significance.

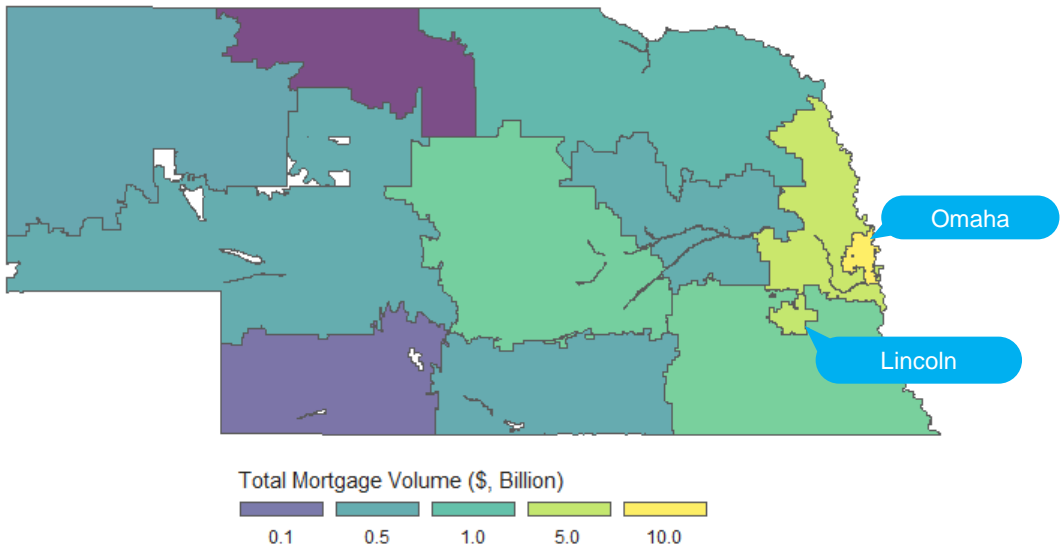
Variables	Effects	
Principal Residence	0.753	<div>Mature</div> <div>Delinquent</div>
Purpose: Purchase	0.643	
Purpose: Refinance	0.366	
Original Interest Rate	0.164	
Credit Score Average	0.016	
Debt-To-Income ratio	-0.015	
Rate Deviation	-0.477	
Grand Islands NE, MSA ^[2]	-0.563	
Property Type: Mfd. Home	-1.081	

These variables are the most important variables in defining segments to reduce likelihood of delinquency.

Geographic Distribution

Nebraska's economy leans heavily to the east, centered in and around Omaha. Most mortgage lending takes place in Omaha, its suburbs, and Lincoln. (3-digit ZIP of 681, 680, & 685)

Mortgages issued since 2010 by 3-digit ZIP



GLMB should open its first branch in Omaha, and gradually expand westward.

[1] Full model approach and results can be found in appendix B

[2] Grand Island MSA is a strong predictor of mortgage delinquency. Our market entry will prioritize other areas in Nebraska.

Proposed Market Entry Strategy Overview

A 10-Year plan to firmly establish market presence in Nebraska with timeline and milestones

Y1 Segment

- ❖ Omaha only
 - ❖ Single Family or Condo
 - ❖ Primary residence
 - ❖ No cash-out refinance
 - ❖ Low DTI, interest rate
 - ❖ Low loan amount
 - ❖ High credit score
- ▶
- ❖ **\$1.7~1.2M** loan amount
 - ❖ **0.05%** market share

Y3 Segment

- ❖ Greater Omaha + Lincoln
 - ❖ Primary or secondary
 - ❖ All property type except Manufactured House
 - ❖ No cash-out refinance
 - ❖ Higher loan amount and DTI
- ▶
- ❖ **\$9.2~7.2M** loan amount
 - ❖ **0.30%** market share

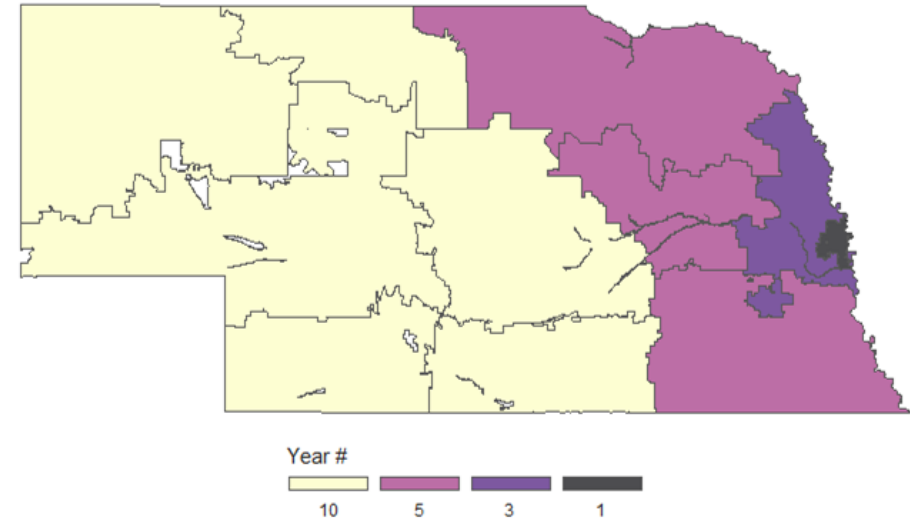
Y5 Segment

- ❖ East Nebraska
 - ❖ Primary, secondary, investment
 - ❖ Add cash-out refinance
 - ❖ Broader interest rate and credit score range
- ▶
- ❖ **\$38.7~26.4M** loan amount
 - ❖ **1.08%** market share

Y10+ Segment

- ❖ All Nebraska
 - ❖ Further broadened interest rate range
 - ❖ Further broadened credit score range
- ▶
- ❖ **\$101.6~80.1M** loan amount
 - ❖ **3.34%** market share

Market Entry Plan by Year



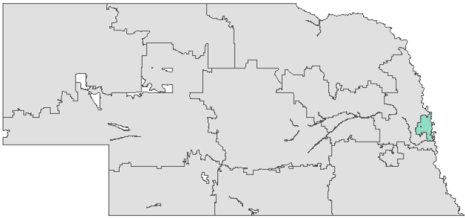
Westward Expansion

The market entry strategy has two significant characteristics.

1. Strategy is to start from the east, where higher economic activities, and expand to the west.
2. The segment begins narrowly defined, selecting for factors that lower delinquency rate, and gradually widens segment range.

Year 1 Segment and Milestones - Omaha

Risk-averse strategy with narrow focus to establish presence in Omaha



Segment A

Variables	Range
3-digit ZIP code:	681 (Omaha)
Property Type	Single family & condo
Loan Purpose	Exclude cash-out refinance
Occupancy	Primary residence only
Rate Deviation	Below 3 rd quantile
Credit Score Average	Above 1 st quantile
Original Loan Amount	Below 3 rd quantile
Debt-to-income	Below 3 rd quantile

Range Analysis

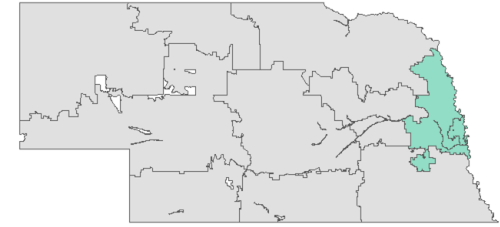
- Location:**
The first branch in Nebraska should be in Omaha, the economic center with the most mortgage activities. High marginal gain.
- Property Type:**
Single family & condo are positively related to mortgage success, lowering default rate.
- Loan Purpose:**
Compared to other purposes, cash-out refinance positively correlates to default.
- Rate Deviation, Credit Score, Original Amount, Debt-to-income:**
Selected ¾ of full dataset that has lower default rate, based on model.

Expected Results

Segment	Segment Share of Total Market	Bank's Target Share of Segment	Bank's Expected Mortgage Volume	Target Share of Total NE Market
Segment A	Around 5%	Around 1%	Between \$1.2 and \$1.7 Million	0.05%

Year 3 Segments and Milestones – Omaha + Lincoln

Broaden physical presence & risk appetite to ensure high marginal return



Segment B, C, & D



Variables

Range

3-digit ZIP code:	681 (B : Omaha) & 685 (C : Lincoln) & 680 (D : Omaha suburbs)
Property Type	Exclude Manufactured Home
Loan Purpose	Exclude cash-out refinance
Occupancy	Principal & Second
Rate Deviation	Below 3 rd quantile
Credit Score Average	Above 1 st quantile
Original Loan Amount	Below Fannie Mae Max ^[1]
Debt-to-income	Below Fannie Mae Limit of 50%

Range Analysis – Changes



Location:

Expand to include Lincoln and suburbs between Lincoln and Omaha

Property Type:

Expanded to all property types except Manufactured Homes, which positively correlates to default.

Occupancy:

Expanded the occupancy status to also include secondary.

Original Amount, Debt-to-income:

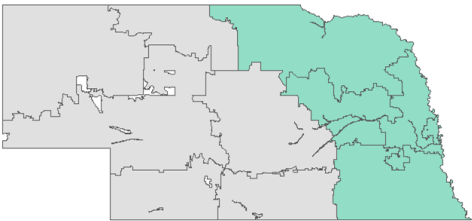
Extended from ¾ of full dataset to under Fannie Mae limits.

Expected Results

Segment	Segment Share of Total Market	Bank's Target Share of Segment	Default Rate	Bank's Expected Mortgage Volume	Target Share of Total NE Market
Segment B	Around 20%	Around 1%	~2.0%	Between \$4.5 and \$6M	0.200%
Segment C	Around 9%	Around 0.5%	~1.5%	Between \$1.3 and \$1.5M	0.045%
Segment D	Around 11%	Around 0.5%	~1.5%	Between \$1.4 and \$1.7M	0.055%
Aggregate:				Between \$7.2 and \$9.2M	0.300%

Year 5 Segments and Milestones – East Nebraska

Grow GLMB’s presence and widen segment definition to capture higher market share



Segment E & F

Variables	Range
3-digit ZIP code:	680, 681, 685 (E) & 683 ^[1] , 686, 687 (F)
Property Type	Exclude Manufactured Home
Loan Purpose	Purchase, Cash-out, Refinance
Occupancy	Principal & Second & Investor
Rate Deviation	Below 85 th percentile
Credit Score Average	Above 15 th percentile
Original Loan Amount	Below Fannie Mae Max
Debt-to-income	50% of Fannie Mae Limit

Range Analysis - Changes

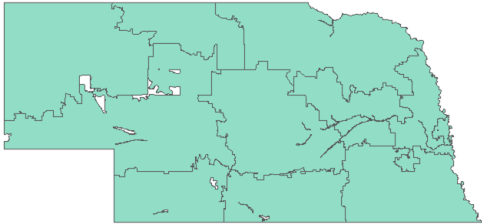
- Location:**
Expand to include all east Nebraska (3-digit ZIP of 683, 686, 687)
- Loan Purpose:**
Expand to include Purchase, Cash-out, and Refinance.
- Occupancy:**
Expanded the occupancy status to also include investment.
- Rate Deviation, Credit Score, Original Amount, Debt-to-income:**
Lifted rate deviation threshold to 85th percentile, lowered credit score threshold to 15th percentile, so that a wider segment may qualify.

Expected Results

Segment	Segment Share of Total Market	Bank’s Target Share of Segment	Default Rate	Bank’s Expected Mortgage Volume	Target Share of Total NE Market
Segment E	Around 50%	Around 2%	~2.5%	Between \$24 and \$36M	1.000%
Segment F	Around 5%	Around 1.5%	~2.5%	Between \$2.4 and \$2.7M	0.075%
Aggregate				Between \$26.4 and \$38.7M	1.075%

Year 10+ Segments and Milestones – Entire Nebraska

Become an established institution in NE with significant and stable market share



Segment G & H

Variables	Range
3-digit ZIP code:	East NE (G) & West NE (H)
Property Type	Exclude Manufactured Home
Loan Purpose	Exclude Refinance-Not Specified
Occupancy	Principal & Second & Investor
Rate Deviation	Below 90 th percentile
Credit Score Average	Above 10 th percentile
Original Loan Amount	Below Fannie Mae Max
Debt-to-income	50% of Fannie Mae Limit

Range Analysis - Changes

Location:
The branch expanded to include all Nebraska areas.

Rate Deviation, Credit Score, Original Amount, Debt-to-income:
Lifted rate deviation threshold to 90th percentile, lowered credit score threshold to 10th percentile, so that a wider segment may qualify.

Expected Results

Segment	Segment Share of Total Market	Bank's Target Share of Segment	Default Rate	Bank's Expected Mortgage Volume	Target Share of Total NE Market
Segment G	Around 76%	Around 4%	~2.5%	Between \$72 and \$92 Million	3.04%
Segment H	Around 10%	Around 3%	~3.5%	Between \$8.1 and \$9.6 Million	0.30%
Aggregate				Between \$80.1 and \$101.6 Million	3.34%

Summary

- In this work, we predicted the “on-going” mortgages using machine learning algorithms, specifically Random forest classifiers.
- We found the random forest models to have the highest accuracy in predicting mortgages “in progress”, compared to other models tested.
- We conducted competitor analysis and set our reference point at midsize banks like Flagstar and Truist, in order to establish better entry strategy.
- We expect the future market to remain uncertain due to COVID-19, future increase in interest rate, worldwide supply chain issues, and labor shortages.
- We proposed a business plan with detailed segment for Year 1, Year 3, Year 5, & Year 10+. According to our business plan, Great Lakes Midwest Bank will reach 3.34% of Fixed-Rate-Mortgage market in Nebraska.

Thank you

From Team 46

Appendix A

Model assumptions, parameters, and performance

[Random Forest] The Prediction Model

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Full Random Forest Model Breakdown

Preparations:

Random Forest model was created from the decision trees and used on the dataset.

Results:

This model has 100% accuracy in predicting the mortgages that are in-progress but will be prepaid or matured during the term. It has a 95% accuracy in predicting the mortgages that will result in a delinquent status during their term. And it has 88% accuracy in predicting the mortgages that will result in a Deed-in-Lieu or REO disposition status.

This model gave us a high degree of confidence in predicting the outcomes of the currently in-progress mortgages.

	precision	recall	f1-score	support
P 1	1.00	1.00	1.00	58637
D 2	0.95	0.95	0.95	533
F 3	0.82	0.95	0.88	416
T 4	0.65	0.57	0.61	83
R 5	0.00	0.00	0.00	63
S 6	0.70	0.12	0.21	57
L 7	0.67	0.05	0.10	37
N 8	0.50	0.10	0.17	10
accuracy			1.00	59836
macro avg	0.66	0.47	0.49	59836
weighted avg	0.99	1.00	0.99	59836

P = Prepaid or Matured

D = Delinquent

T = Third Party Sale

F = Deed-in-Lieu; REO

Disposition

R = Repurchased

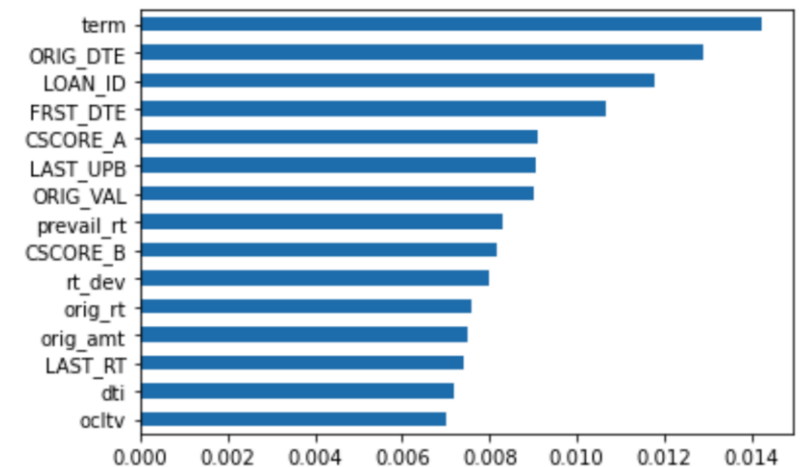
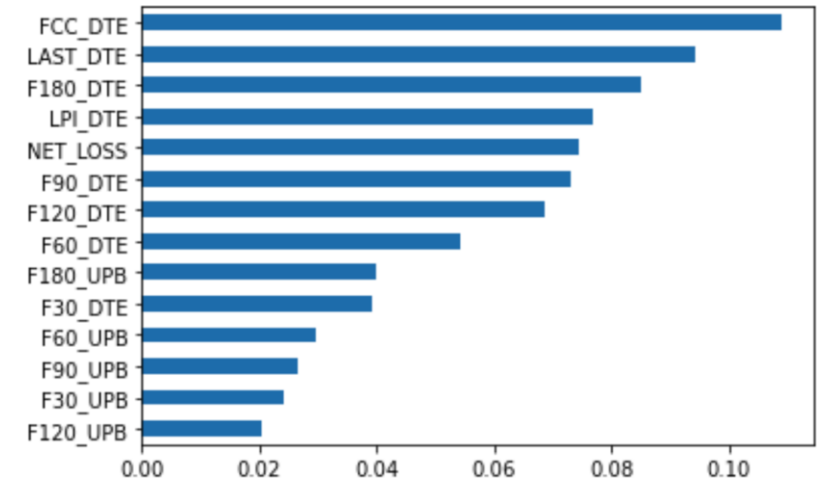
S = Short Sale

L = Reperforming Loan Sale

N = Notes Sales

Feature importance Score

- Random Forest Model Feature Scores
- The feature importance score gives us insight into the segments of choosing
- Since you cannot segmenting based on “_DTE” and “_UPB”, we main focus on the variables on the figures below.
- Note: The first figure has larger importance score than the second figure.



[Random Forest] Model Performance

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Confusion Matrix

	Prepaid or Matured	Delinquent	Deed-in-Lieu; REO Disposition
Prepaid or Matured	58610	26	0
Delinquent	26	507	0
Deed-in-Lieu; REO Disposition	0	0	395

Confusion Matrix

```
[1] "Confusion Matrix shown below:"
```

```
fn_prediction FALSE  TRUE
              0    18    24
              1   784 39001
[1] "Precision: 98.0294 %"
[1] "Recall: 99.9385 %"
[1] "F1 score: 98.9747 %"
```

[Linear Regression] Model Performance

Variable Summary

```
glm(formula = is_success ~ ., data = df7.5_train, na.action = "na.omit", family = binomial(link = "logit"))
```

Deviance Residuals:

Min	1Q	Median	3Q	Max
-4.0425	0.0795	0.1258	0.2008	2.3066

Coefficients:

	Estimate	Std. Error	z value	Pr(> z)
(Intercept)	-3.0783432027	3.7525940916	-0.820	0.412031
ORIG_CHNC	0.1892277068	0.0668237572	2.832	0.004630 ***
ORIG_CHNR	0.3194822537	0.0684346458	4.668	0.0000030351231 ***
orig_rt	0.1643475660	0.0313653321	5.240	0.0000001607646 ***
rt_dev	-0.4770119461	0.0456989168	-10.438	< 0.0000000000000002 ***
rt_increase	0.8862881960	0.0482558200	18.366	< 0.0000000000000002 ***
orig_amt	-0.0000008100	0.0000014103	-0.574	0.565742
ORIG_VAL	-0.0000014637	0.0000006454	-2.268	0.023340 *
init_mo_payment	0.0001073971	0.0000232066	4.628	0.0000036946095 ***
orig_trm	-0.0055848399	0.0003233562	-17.271	< 0.0000000000000002 ***
oltv	0.0171019189	0.0378564591	0.452	0.651444
ocltv	-0.0536037498	0.0379289479	-1.413	0.157577
oltv_percentage	-0.0225764954	0.0344879499	-0.655	0.512713
num_bo	0.6303605165	0.0389422849	16.187	< 0.0000000000000002 ***
dti	-0.0145144343	0.0016549330	-8.770	< 0.0000000000000002 ***
CSCORE_AVG	0.0159908545	0.0003746737	42.679	< 0.0000000000000002 ***
FTHB_FLGN	0.0246397492	0.0289941626	0.030	0.976288
FTHB_FLGY	-0.2945479059	0.8301387336	-0.355	0.722726
purposeP	0.6431408474	0.0594843574	10.812	< 0.0000000000000002 ***
purposeR	0.3659336077	0.0534820826	6.842	0.0000000000000078 ***
purposeU	-0.4019267869	0.6380623934	-0.630	0.528748
PROP_TYPMH	-1.0814100969	0.3002127464	-3.602	0.000316 ***
PROP_TYPPU	-0.0505574944	0.1964753255	-0.257	0.796930
PROP_TYPSF	-0.2801623370	0.1875985880	-1.493	0.135329
NUM_UNIT	-0.0212325413	0.1202181611	-0.177	0.859809
occ_statP	0.7528385233	0.0796572318	9.451	< 0.0000000000000002 ***
occ_statS	0.3444098052	0.1872873050	1.839	0.065924 .
msaother_msa	8.1941976969	72.2141283517	0.113	0.909657
msa24260	-0.5632235321	0.1482476929	-3.799	0.000145 ***
msa30700	0.1109985048	0.1430270261	0.776	0.437710
msa36540	0.1266430105	0.1130104554	1.121	0.262445
msa43580	-0.2407144985	0.2047614081	-1.176	0.239761
zip_3680	-0.4143967380	1.0399844758	-0.398	0.690288
zip_3681	-0.3784011207	1.0407716296	-0.364	0.716174
zip_3683	-0.5349400459	1.0410536506	-0.514	0.607360
zip_3684	-0.3293708641	1.0424716050	-0.316	0.752039
zip_3685	-0.2689893204	1.0451967392	-0.257	0.796903
zip_3686	-0.0615822909	1.0449965882	-0.059	0.953007
zip_3687	-0.0808993542	1.0428221384	-0.078	0.938164
zip_3688	0.0213839657	1.0420102183	0.021	0.983627
zip_3689	-0.3978371494	1.0432484850	-0.381	0.702948
zip_3690	0.0033960965	1.0735207322	0.003	0.997476
zip_3691	-0.3904518225	1.0421557198	-0.375	0.707915
zip_3692	-0.3357187031	1.0984870856	-0.306	0.759895
zip_3693	-0.5730429461	1.0422630052	-0.550	0.582452
mi_pct	-0.0083155782	0.0024071729	-3.454	0.000551 ***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for binomial family taken to be 1)

Null deviance: 31251 on 159303 degrees of freedom
Residual deviance: 25849 on 159258 degrees of freedom
AIC: 25941

Number of Fisher Scoring iterations: 11

Stochastic Gradient Descent

P = Prepaid or Matured

D = Delinquent

F = Deed-in-Lieu; REO Disposition

T = Third Party Sale

R = Repurchased

S = Short Sale

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	macro avg	0.46	0.42	0.41	59836
	weighted avg	0.99	0.99	0.99	59836

Decision Trees

P = Prepaid or Matured
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	S 6	0.22	0.23	0.23	57
	L 7	0.48	0.41	0.44	37
	N 8	0.38	0.30	0.33	10
	accuracy			0.99	59836
	macro avg	0.56	0.54	0.55	59836
	weighted avg	0.99	0.99	0.99	59836

Appendix B

Miscellaneous

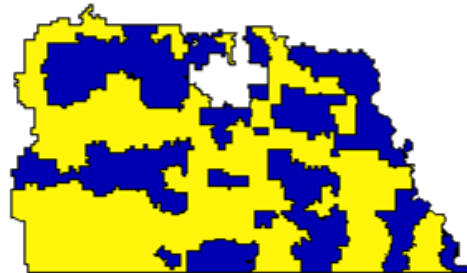
Confirmed that Dataframe represents appx. all NE conforming FRM sold to FNMA

- The team wanted to confirm if the dataframe in fact represents the entire Nebraska Conforming FRM that was sold to FNMA.
- According to “*Mortgage Bankers Association’s Databook of State and National Mortgage Originations 2013*” report, page 20 & 24, FNMA purchased between \$2 - 2.5 billion in mortgages in 2012 and 2013 each, which is broadly in line with the sum of `orig_amt` from our dataset in 2012 and 2013.
- The team therefore confirms that the dataset can be treated as the complete Nebraska Conforming FRM market that’s sold to FNMA, not a percentage of the total.

Maybe explain merging zip_3 == 683 & 684?

Rotman

- Because the map of 3-digit ZIP code map of 683 and 684 are random and intertwined, for our purpose they are treated as one.
- Throughout the slide, when zip_3 of 683 is invoked, it means the union of 683 and 684.



Thank you

Oct 13th, 2021