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Master of Management Analytics

2021 Datathon Case

Expansion into the Nebraska Mortgage Market

Toronto Consulting Group

Jiaqi Bi, Eric Lee, Jiaqi Li, Ruichen Lu, Scarlett Wang, Jiner Zheng

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Rotman School of Management
UNIVERSITY OF TORONTO

Introduction

2008 — Brief History

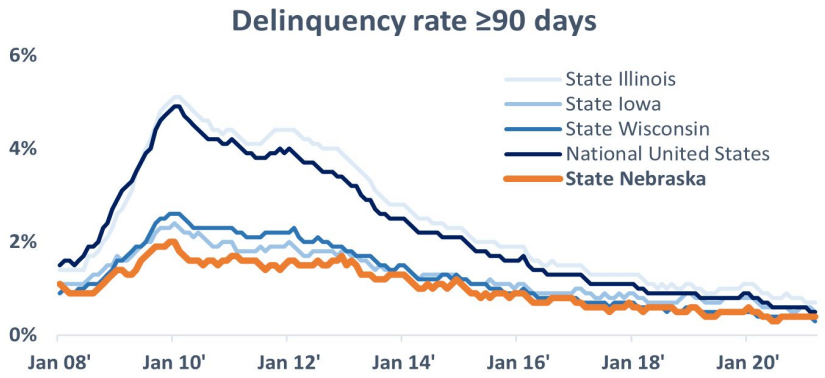

Figure 1) Historical % of 90+ day delinquent mortgages

2021 — Current Situation

Figure 2) Maximum unemployment rate by year - USA and Nebraska

2022 and Beyond — Future

Brief History

- After recovering from the 07' - 08' global financial crisis largely started by the subprime mortgage crisis, a lesson was learned on the importance of credit risk and management, with new regulations passed (e.g. the Dodd-Frank Act) to prevent such an event from happening again
- Since then, 90+ day delinquencies have been on a consistent downtrend despite the impact of COVID-19
- Nebraska has historically had a lower delinquency rate versus states that Great Lakes Midwest Bank currently operates in and the majority of other states

Current Situation

- COVID-19 is still disrupting many lives globally after causing an increase in the loss of life, record high unemployment in over 70 years reaching 14.8% in Apr 2020, and sustained supply chain disruptions still causing serious issues today
- Despite the fact, the unemployment rate has recovered to a 2021 year-to-date max of 6.3% as of Sept 2020 with percentage of longer delinquencies
- Nebraska has fared well versus the annual unemployment rate, reaching instead a max of 7.4% in 2020, with a 2021 year-to-date max of 2.2%, versus the annual average of 14.8% and 6.3% respectively

Future

- As Great Lakes Midwest Bank looks to expand mortgage operations to Nebraska, we sought to propose the best pathway forward
- While we can never be certain of the future, our analysis will look at historical mortgage data to properly segment our proposed targets, and include an analysis on possible future scenarios

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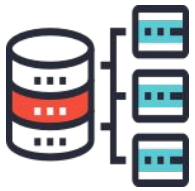
Analytics Flow

Data

We conducted analysis on dataset of all conventional single-family, fixed interest rate mortgages from 2000-2021 Q1 in the state of Illinois, Iowa and Wisconsin. We classified those loan types with "**Delinquent, Reperforming Loan Sale, REO Disposition, Repurchased, Short Sale, Notes Sales**" as the defaulting loan while the rest to be favorable loan for further data analysis.

Business Question

How to maximize dollar value of mortgages (maximize the mortgage amount) and limit the defaulting loan with the consideration of other concerns in the market.



Statistical Model

A logistics regression model with mixed effects models was used to perform analysis. We set whether the loan is defaulting as the binary response variable, and Metropolitan Statistical Area as the random effect. Also, we classified factors as primary factors and secondary factors.

Business Outcome

We carried out an actionable plan for Great Lake Midwest Bank to do the mortgage expansion on state of Nebraska.

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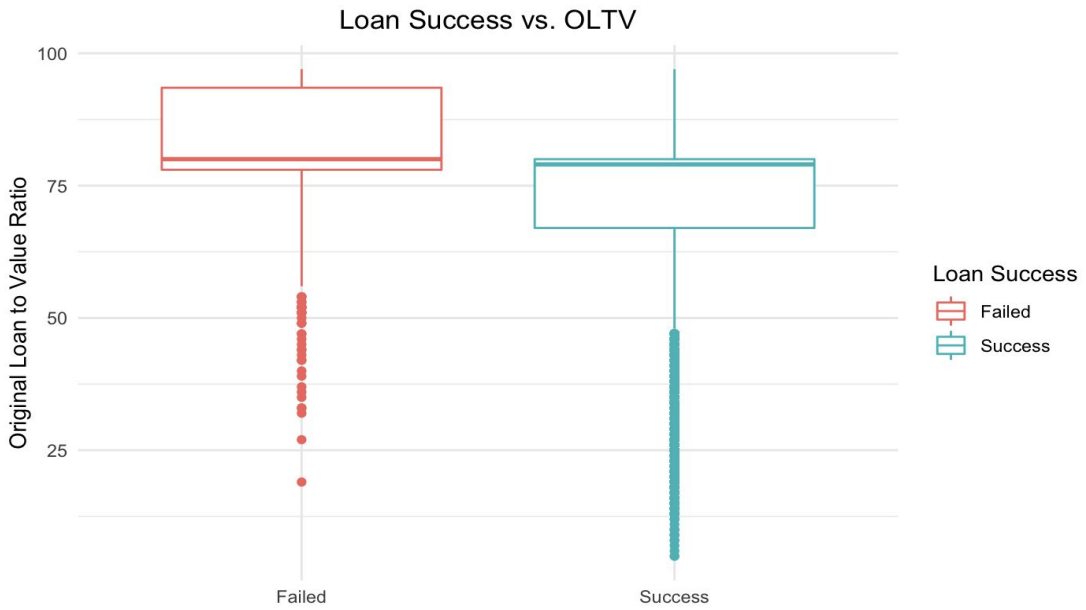
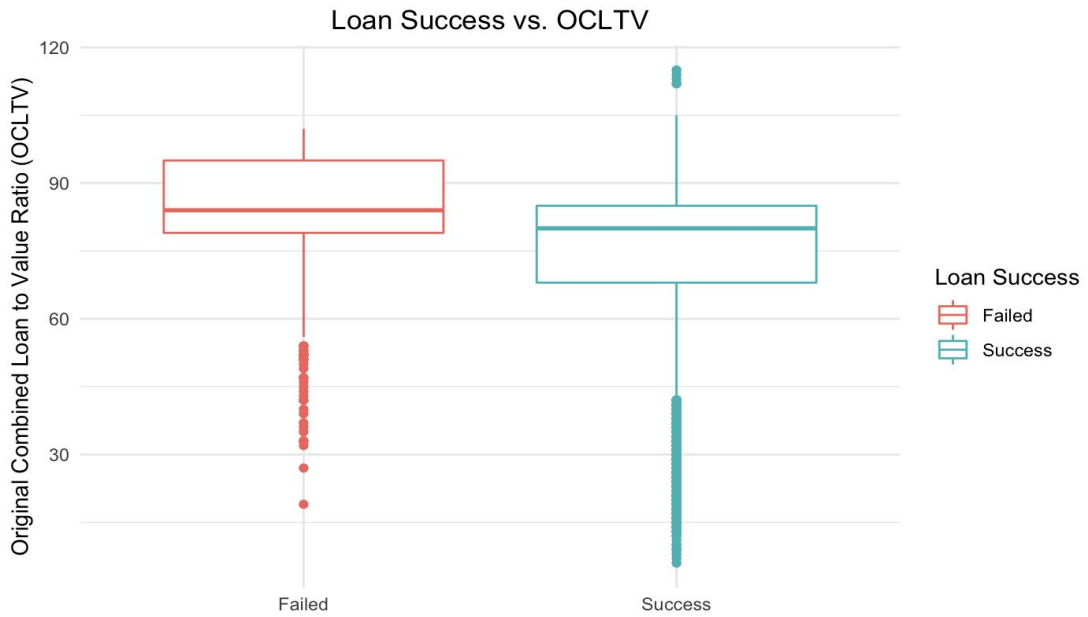
Loan Success

Original Loan-to-Value and Original Combined Loan-to-Value Ratio (Primary Factors)





Findings

- OLTV and OCLTV are primary factors that could affect the loan success rate. Statistically speaking, for each percentage increase in OLTV, the odds of being a successful loan decreases by 1.0481. In layman terms, **there is a very high correlation**.
- The average OCLTV for failure loan is around 84%, versus successful group, around 80%.
- The average OLTV for failure is around 80%, higher than the average OLTV for success that is around 79%. While the third quantile for failure is around 95% which gives a significance that higher the OLTV is, higher the failure rate is.

Recommendation

- OLTV and OCLTV are both important factors that can affect the success rate for mortgage. We recommend Great Lakes Midwest Bank to select borrowers with both low OLTV and OCLTV to limit the defaulting loans.

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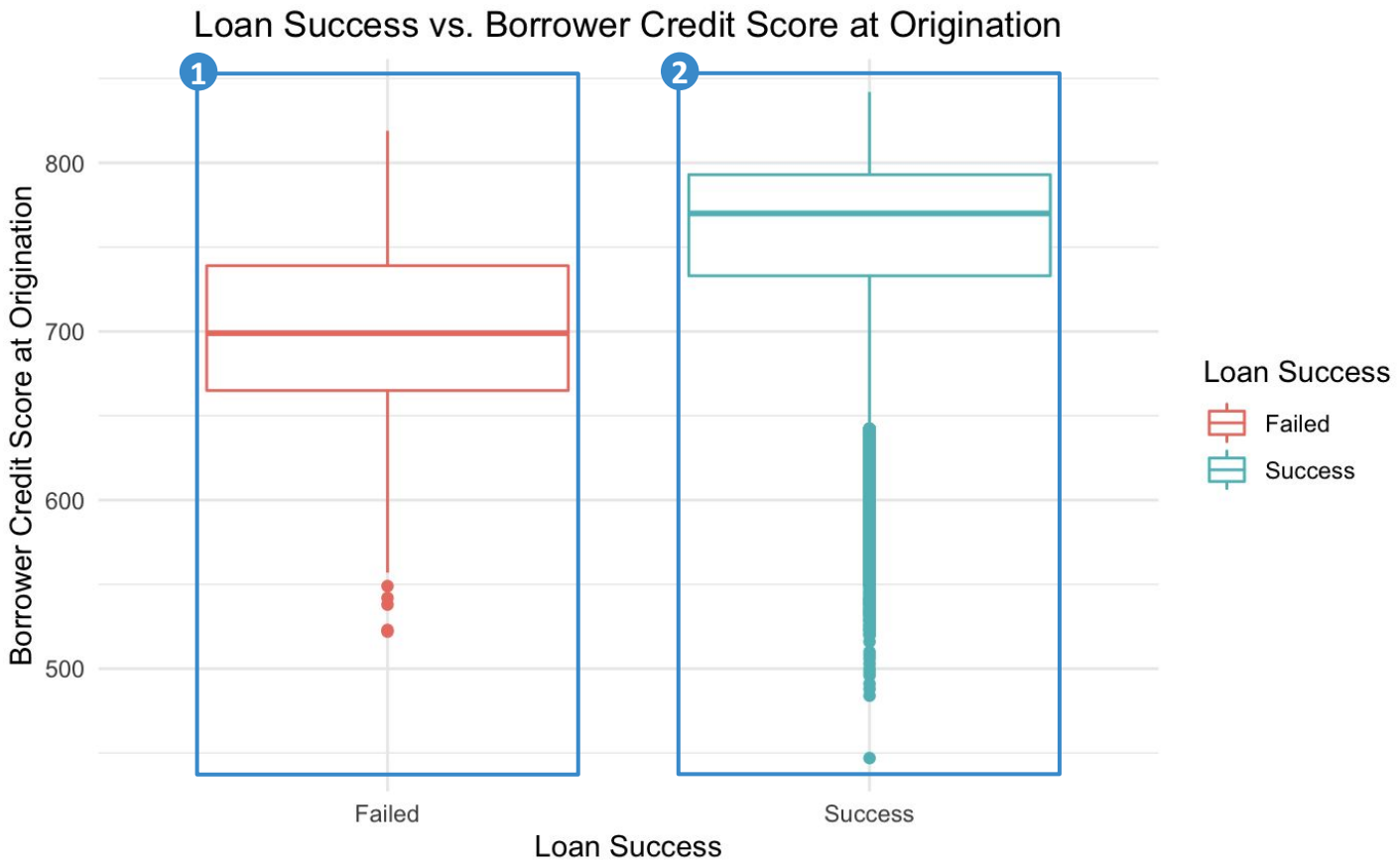
Loan Success

Borrower Credit Score (Primary Factor)



Findings

- Credit score can reflect a borrower's sense of responsibility and ability of paying back mortgages, and thus this is another strong factor for the financial risk.
  1. Unsuccessful borrowers' credit scores are mostly below 730, with a median less than 700.
  2. On the contrary, successful borrowers have higher credit scores where the median lies around 780.

Recommendation

- The bank should focus on those districts where the average of borrower's credit score is relatively high (>750), in order to minimize risk for mortgages

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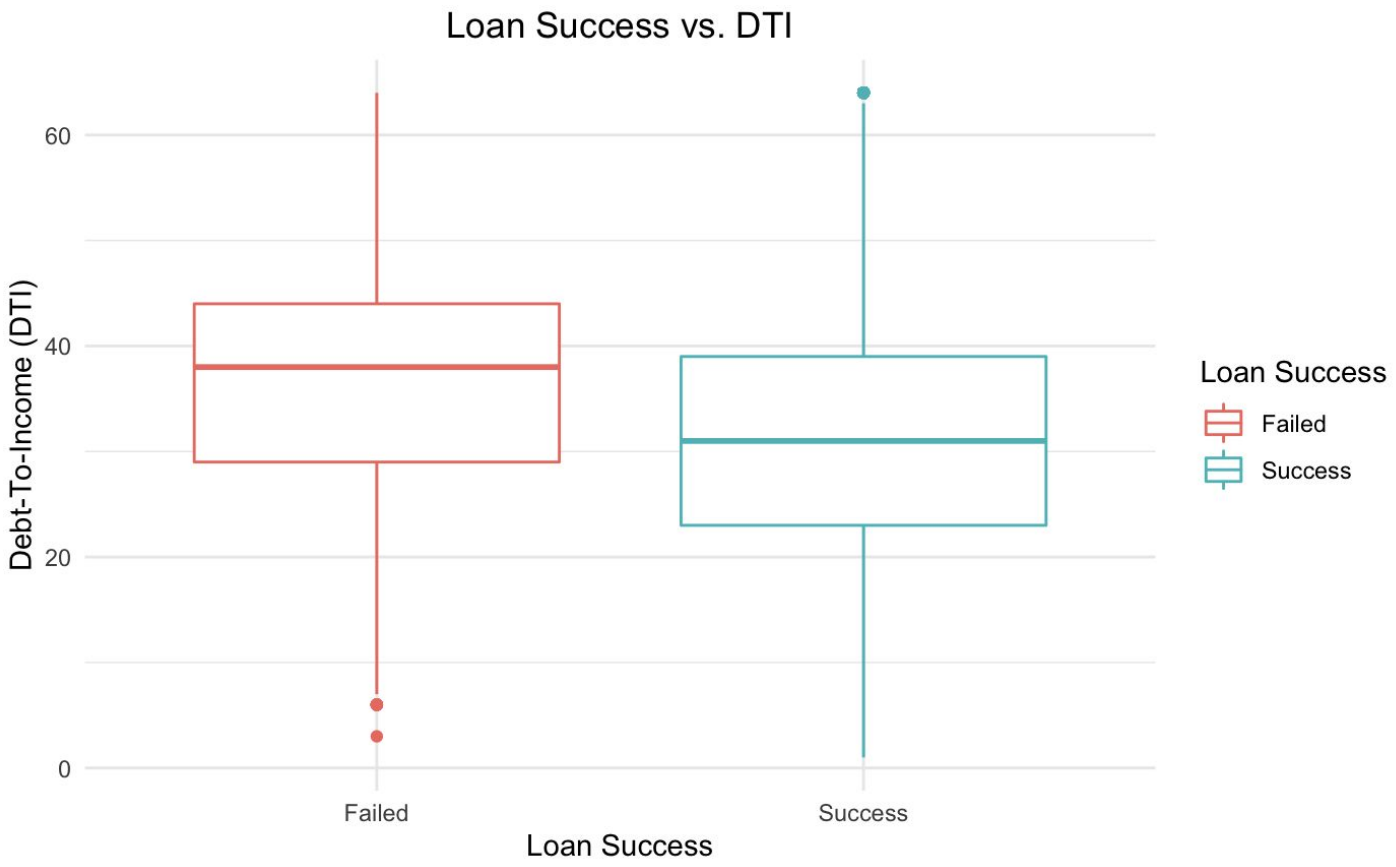
Loan Success

Debt-to-income (Primary Factor)



Findings

- The DTI ratio has a correlation with the loan success rate:
  - Higher DTI may lead to a higher possibility of loan failure
  - The graph shows that the successful loan has a median of around 36% of DTI, and the trend for DTI is approximately 5% lower than the failed loan
- We consider that a lower DTI gives the borrower more sufficient funds for his loan, and therefore the determination of mortgage repay ability is much easier than the higher DTIs.

Recommendation

- DTI is a strong factor for the determination of a borrower's financial risk.
- The bank's target segments should include a criteria for DTI

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Loan Success

Loan Success by Four Secondary Factors

	Success Loan	Failed Loan
1 Relocation Mortgage		
YES	947 (99.68%)	3 (0.32%)
NO	155049 (99.08%)	1436 (0.92%)
2 First Time Home Buyers Flag		
YES	15347 (98.47%)	239 (1.53%)
NO	140623 (99.15%)	1200 (0.85%)
3 Occupancy Status		
I (Investor)	7309 (98.12%)	140 (1.88%)
P (Principal)	146463 (99.13%)	1281 (0.87%)
S (Second)	2224 (99.197%)	18 (0.803%)
4 Purpose		
C (Cash-Out Refinance)	39345 (98.98%)	405 (1.02%)
P (Purchase)	58591 (99.003%)	590 (0.997%)
R (Refinance)	58037 (99.24%)	444 (0.76%)
U (Refinance-Not Specified)	23 (100%)	0 (0%)

Findings

The presented table includes the probability of loan success based on four secondary factors including relocation mortgage, first time home buyers flag, occupancy status, and loan purpose.

1. The proportion of success loan in **relocation mortgage** is slightly higher compared to that in non-relocation mortgage.
2. The proportion of success loan in a **NON-first time home buyer mortgage** is slightly higher.
3. **Second occupancy status** has slightly higher proportion of success loan compared to the other two occupancy status.
4. **Refinance mortgage**s have a slightly higher proportion of success loan compared to the other three loan purposes.

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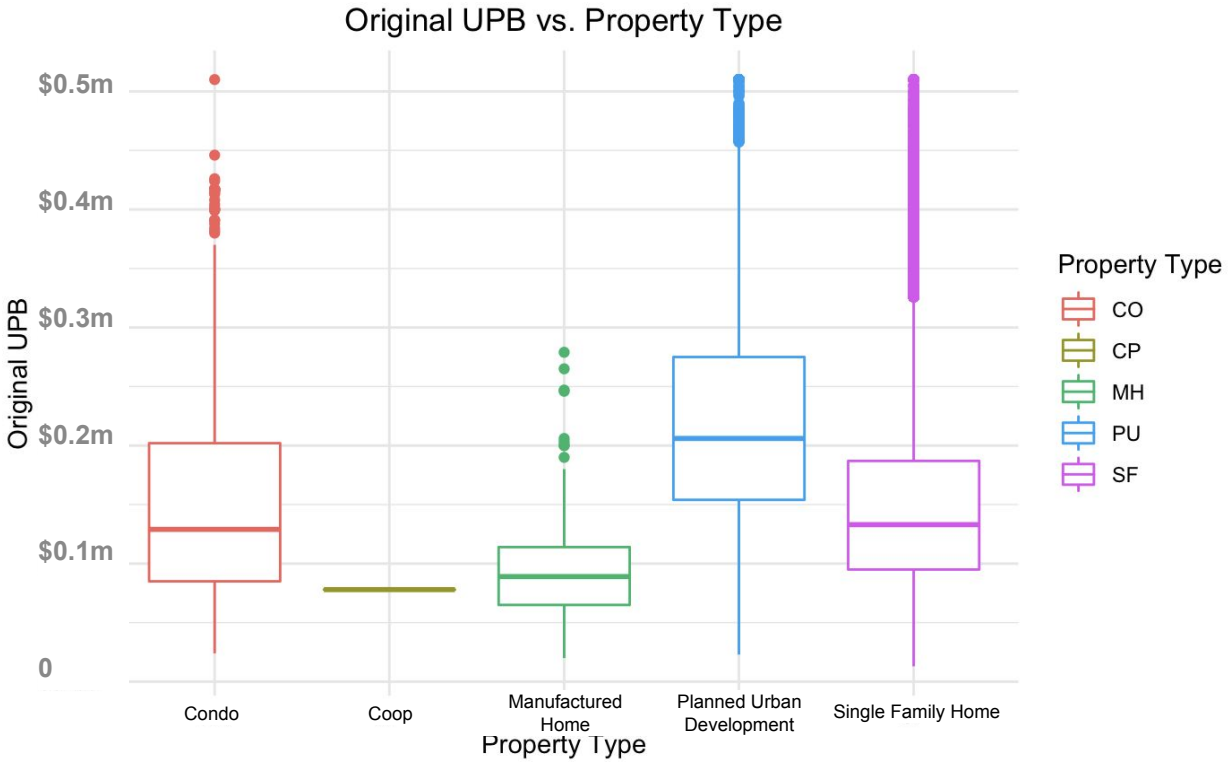
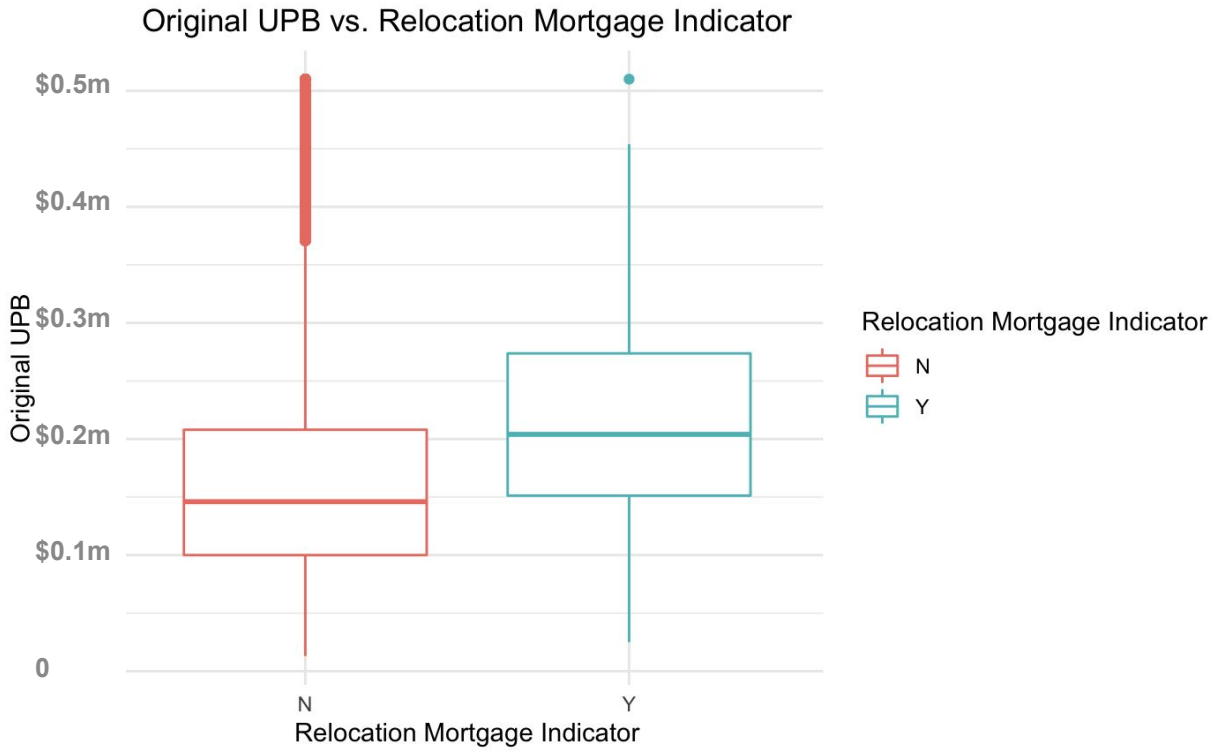
Mortgage Amount

Original Unpaid Balance (UPB) by Property Type and Relocation Mortgage (Secondary Factors)





Findings

- **Property Type**
  - The property type of **planned urban development** appears to have highest median of original UPB compared to all other types. Co-operative and manufactured home property types have relatively lower median of original UPB.
- **Relocation Mortgage Indicator**
  - **Relocation mortgage loan** appears to have comparatively higher median of the dollar amount of loan.

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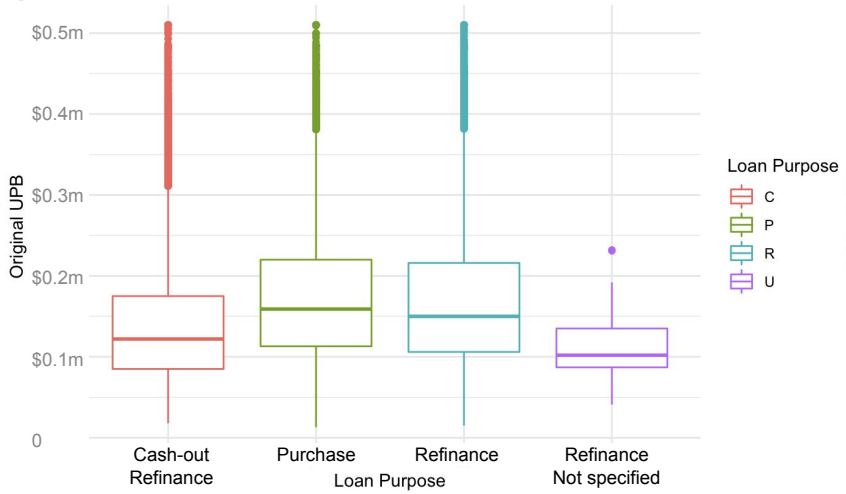
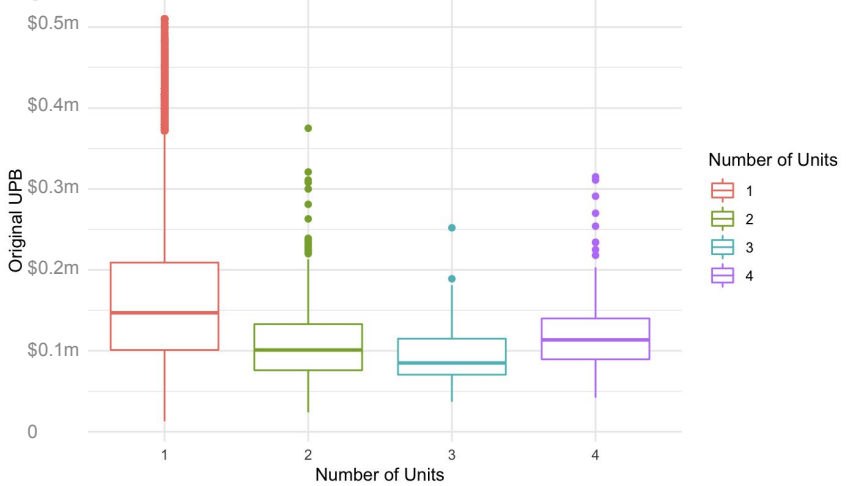
Mortgage Amount

Original UPB by Loan Purpose, Number of Units, and Occupancy Status (Secondary Factors)

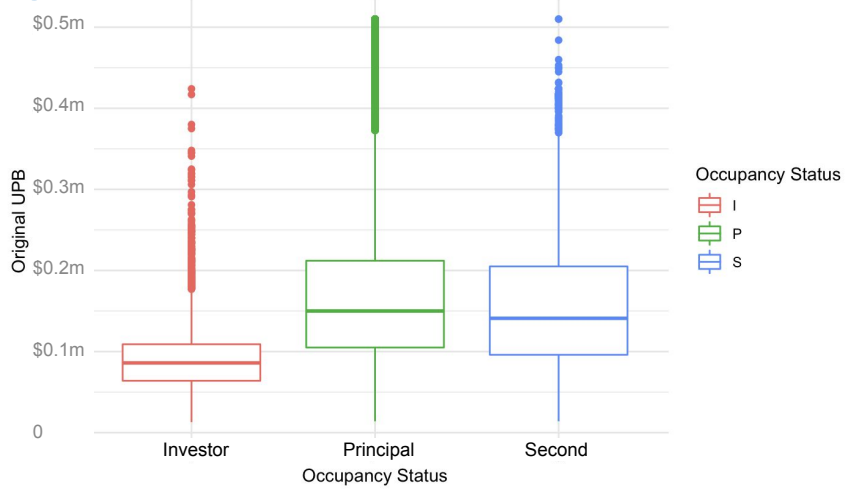
1



2



3



Findings

1 Loan Purpose

- **Purchase money mortgage** and **refinance mortgage** are both associated with a higher dollar amount of loan, while refinance with cash out and refinance - not specified mortgages seem to have relatively lower original UPB.

2 Number of Units

- **One unit** comprising the related mortgaged property seems to have a relatively higher dollar amount of loan, while the other number of units (two, three, or four) seem to be not significantly different from each other in terms of their corresponding original UPB.

3 Occupancy Status

- Investor property occupancy status seems to have comparatively lower dollar amount of loan, and there is not much difference in the higher dollar amount of loan between **principal and second** property occupancy status.

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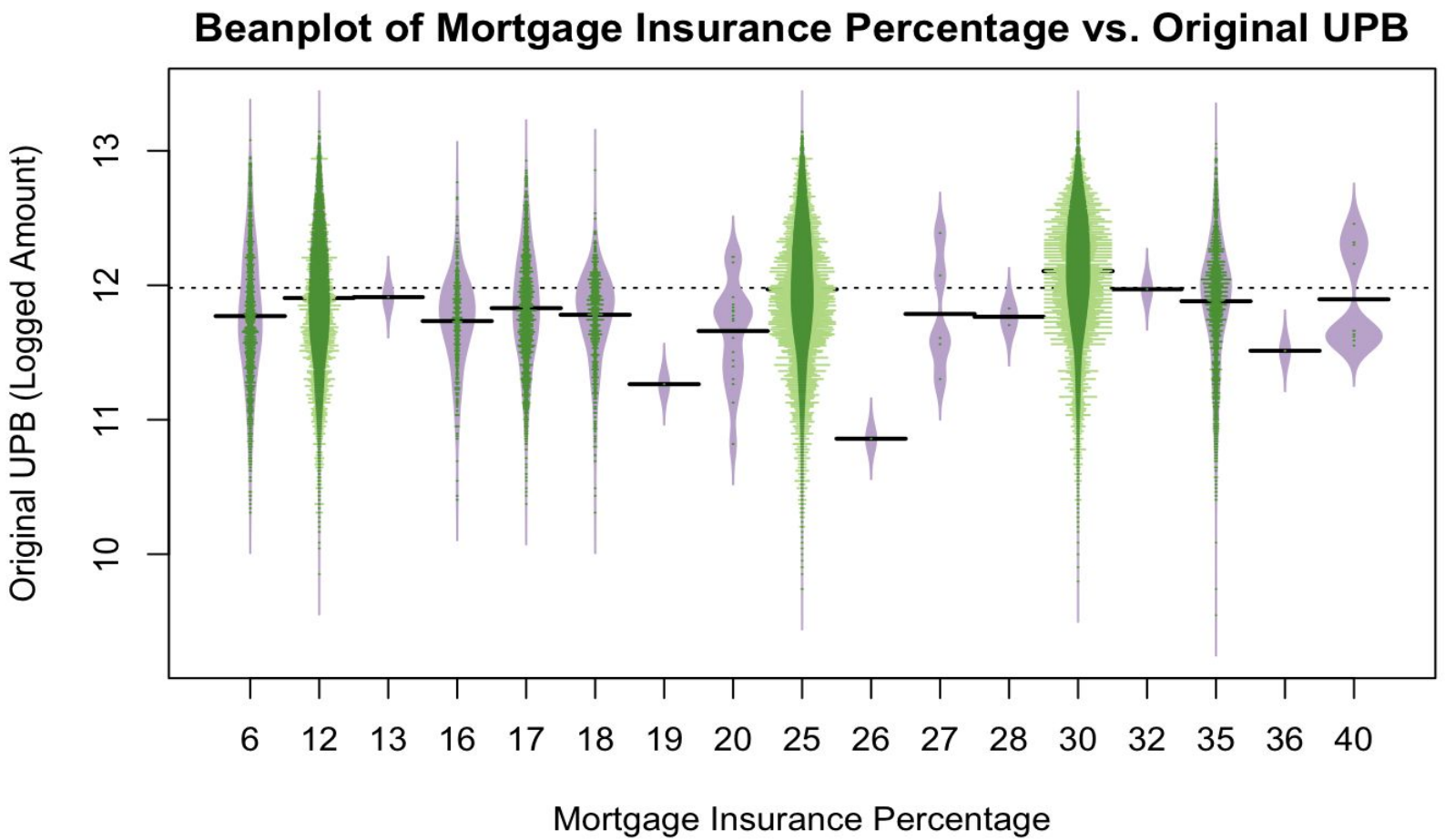
Mortgage Amount

Original Unpaid Balance (UPB) by Mortgage Insurance Percentage (Secondary Factors)



Findings

- We looked for a trend to see whether insured mortgages would have a lower UPB
- The graph shows the distribution of all types of Mortgage Insurance Percentage. Mortgages requiring mortgage insurance have a lower mean original UPB versus the mean of all mortgages
- Mortgage insurance percentages of 19%, 26%, and 36% have comparatively lower median for the original UPB

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Market Environment

Competitors

SELLER	AVE
Fifth Third Bank	335000.0
Finance of America Mortgage LLC	315250.0
J.P Morgan Madison Avenue Securities Trust	288000.0
PennyMac Loan Services, LLC	275250.0.
Truist Bank (Formerly SunTrust Bank)	259339.3
Pmt Credit Risk Transfer Trust	256142.9
NewRez LLC	253300.0
Movement Mortgage, LLC	252000.0
Fairway Independent Mortgage Corporation	249400.0
Truist Bank (Formerly Suntrust Bank)	247255.0

Rank by Average Mortgage Amount

SELLER	APPLICATIONS	AVE
Wells Fargo Bank, N.A.	18382	188096.0
Bank of America, N.A.	7976	141901.6
Franklin American Mortgage Company	4996	186175.1
Suntrust Mortgage Inc.	3972	145742.7
Citimortgage, Inc.	3457	155969.0
J.P Morgan Chase Bank, National Association	3127	172583.9
U.S. Bank N.A	2934	162702.8
Flagstar Bank, Fsb	2844	134657.9
First Tennessee bank National Association	2431	144830.5
Quicken Loans Inc.	1870	160284.0

Rank by successful loan applications

- The group lists the ten most competitive opponents in two ways. The first table uses the average mortgage loan amounts per application to rank the competitors and uses the successful loan applications to organize the second table.
- By comparing the two tables, the group noticed that J.P Morgan Chase exists in both tables, despite being in the different company branches, indicating that J.P Morgan Chase might be the strongest opponent.
- Despite the heavy amount of competition from large players, we believe by employing a targeted geographic strategy, we can be a strong competitor in the mortgage market in Nebraska

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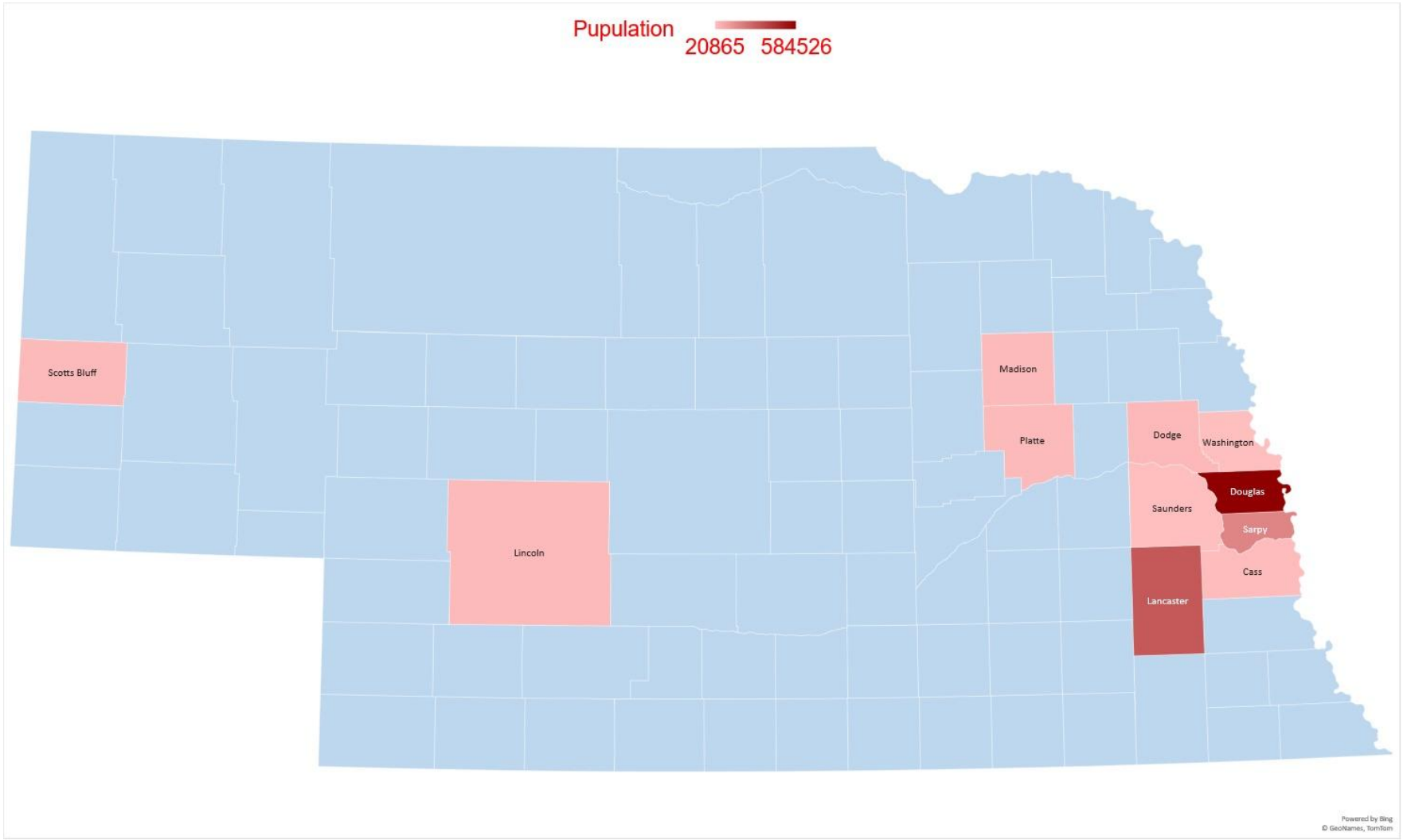
Market Environment

Population Map



Commentary

- By analyzing the population distribution in Nebraska state, the group found that most of the people are concentrated[1] in **Douglas County (584,526), Lancaster County (322,608), Sarpy County (190,604), Hall County (62,895)**
- Population in other counties are below 60,000. The population distribution indicates our initial branches should be focused in urban areas, in the cities of Lincoln, and Omaha.

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Recommendation

Our Target Segments

Primary Considerations

<79%	<80%	<32	>750
Original Loan-to-Value	Original Combined Loan-to-Value	Debt-to-Income	Borrower Credit Score

To limit the number of defaulting (Primary Factors) :

1. Our ideal market segment should include a criteria based on a borrowers' **original loan-to-value** and **original combined loan-to-value** Our findings showed that the lower the ratio is, the lower the chance it could be a defaulting loan.
2. Identify borrowers' **debt-to-income ratio** and **borrower credit score**, and whether it was in a delinquent status before. Among all four factors original loan-to-value as it had the the coefficient for minimizing the number of defaults in our model.

Secondary Considerations

Property Types	Number of Units	Loan Purpose	Mortgage Insurance	Occupancy Status	Urban Areas
1. Planned Urban Dev. 2. Single Family Homes 3. Condos	≤2 Units	• Refinance • Purchase	• No Mortgage Insurance	• Principal and Second	1. Douglas County 2. Lancaster County 3. Sarpy County 4. Hall County

To maximize dollar value of the mortgage (Secondary Factors):

1. Ideally, **anyone** who **meets our primary considerations** will be in our target segment
2. However, given that the Bank is a new entrant in Nebraska, it would be wise to spend marketing dollars specifically for the below criteria:
   a. We target the three largest property types **(Planned urban developments, Single Family Homes, and Condos)**
   b. We target the largest market for the **Number of Units, ≤2**
   c. We target those who are seeking a **Purchase and Refinance** mortgages
   d. We target those who **do not require Mortgage Insurance**
   e. We target those who are seeking a mortgage for either their **Principal or Second** homes
   f. We open branch locations in only **Urban areas**, where the largest amount of the mortgage market is

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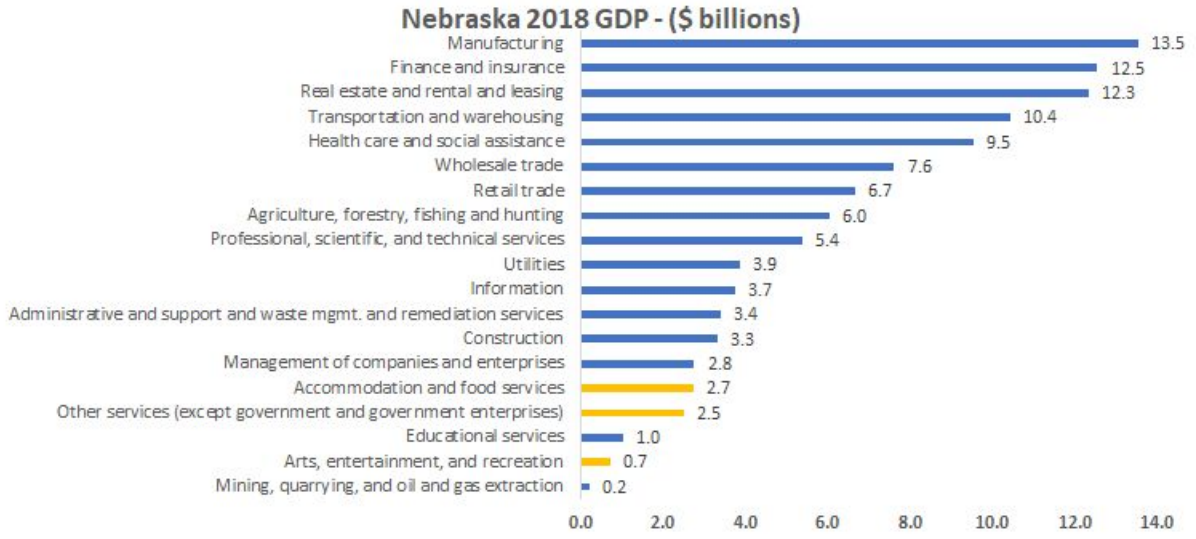
Consideration of Economic Scenarios

An Overview of Different Scenarios



Nebraska Economic Overview

- As mentioned in the introduction, Nebraska has been **more resilient** to **unemployment** versus the nation, and has historically had **lower delinquency rates**
- Nebraska has an incredibly diverse economy, ranging from Manufacturing to resource extraction
- According to IBISWorld[1], Nebraska has the 4th lowest economic exposure to COVID-19 out of 50 states in the United States

K-Shaped Recovery

- In an event of a **K-Shaped Recovery** (i.e. some sectors recover, some decline), the highest exposed areas[1] of the economy include Accomodation and Food services, Other services (excl. gov.), and the Arts, entertainment and recreation sectors, which make up 5.4% of the GDP
- However, as Nebraska has maintained resilience throughout the COVID-19 Pandemic, **we believe that a Nebraska expansion would be greatly beneficial, and would help diversify the mortgage portfolio of Great Lakes Midwest Bank**

U-Shaped Recovery

- In an event of a **U-Shaped Recovery** (i.e. a period of stagnation before recovery), we believe that due to the lower unemployment rate in Nebraska vs. the majority of other states, and the diverse economy, **we believe that a Nebraska expansion would still be greatly beneficial to Great Lakes Midwest Bank**
- While keeping in mind potential *interest rate fluctuations*, we note that U.S. mortgage terms are usually between 15-30 years long, which would minimize the impact to existing and future mortgage borrowers, and recommend that as long as they meet our segmentation criteria, that they should qualify for a loan

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Recommendation of Next Steps

- We need more data on borrowers' income to analyze the relationship on mortgage amount and income, and to also predict an accurate debt-to-income rate threshold based on the income.
- If the dataset can be provided for a longer series of time, we can conduct time series analysis to determine how if the mortgage market is being affected by COVID-19 and make further recommendations to the Bank.
- We might require borrowers' demographic information like age, employment, education and etc. to identify potential factors that lead to a defaulted loan, however we understand the application of these factors may be limited to prevent loan discrimination

Thank you

APPENDIX

Table of Content

- Logistics Regression Model with Mixed Effects
- Summary Output
- Variable Correlation Matrix
- GitHub Repository:
  https://github.com/Rachellu7/Datathon

APPENDIX

Logistics Regression Model with Mixed Effects

$$\widehat{\text{good\_loan}}_i \sim \text{Binomial}(n = 1, \text{prob}_{\text{good\_loan}=1} = \widehat{P})$$

$$\begin{aligned}\log\left[\frac{\hat{P}}{1-\hat{P}}\right] = {} & 7.04_{\alpha_{j[i]}} - 0.05_{\beta_1}(\text{oltv}) - 0.02_{\beta_2}(\text{dti}) + 0.02_{\beta_3}(\text{CSCORE\_B}) \; - 11.65_{\beta_4}(\text{FTHB\_FLG}_{\text{N}}) - \\ & 11.98_{\beta_5}(\text{FTHB\_FLG}_{\text{Y}}) + 0.57_{\beta_6}(\text{purpose}_{\text{P}}) + 0.18_{\beta_7}(\text{purpose}_{\text{R}}) \; + 13.9_{\beta_8}(\text{purpose}_{\text{U}}) + \\ & 0.92_{\beta_9}(\text{relo\_flg}_{\text{Y}}) + 1.1_{\beta_{10}}(\text{occ\_stat}_{\text{P}}) + 0.7_{\beta_{11}}(\text{occ\_stat}_{\text{S}}) \; + 0.35_{\beta_{12}}(\text{NUM\_UNIT}) - 0.03_{\beta_{13}}(\text{orig\_rt})\end{aligned}$$

$$\alpha_j \sim N\left(0, 0.06\right), \text{for msa j} = 1, \ldots, \text{J}$$

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APPENDIX

Summary Output for the Model

```
Random effects:
 Groups Name        Variance Std.Dev.
 msa    (Intercept) 0.003495 0.05912
Number of obs: 157435, groups:  msa, 12

Fixed effects:
             Estimate Std. Error z value Pr(>|z|)
(Intercept)  7.043e+00  4.429e+02   0.016   0.9873
oltv        -4.650e-02  3.002e-03 -15.491  < 2e-16 ***
dti         -2.276e-02  2.507e-03  -9.079  < 2e-16 ***
CSCORE_B     1.678e-02  5.176e-04  32.428  < 2e-16 ***
FTHB_FLGN   -1.165e+01  4.429e+02  -0.026   0.9790
FTHB_FLGY   -1.198e+01  4.429e+02  -0.027   0.9784
purposeP     5.685e-01  8.199e-02   6.933 4.11e-12 ***
purposeR     1.779e-01  7.164e-02   2.483   0.0130 *
purposeU     1.390e+01  1.717e+03   0.008   0.9935
relo_flgY    9.152e-01  5.839e-01   1.567   0.1170
occ_statP    1.102e+00  9.919e-02  11.112  < 2e-16 ***
occ_statS    6.983e-01  2.576e-01   2.711   0.0067 **
NUM_UNIT     3.480e-01  2.181e-01   1.595   0.1106
orig_rt     -2.975e-02  2.265e-02  -1.313   0.1891
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

The log odds of being successful loan for each percentage increasing in OLTV is 0.047,
then odds=exp(0.047)=1.0481, probability=1.0481/(1+1.0481)=51.17%

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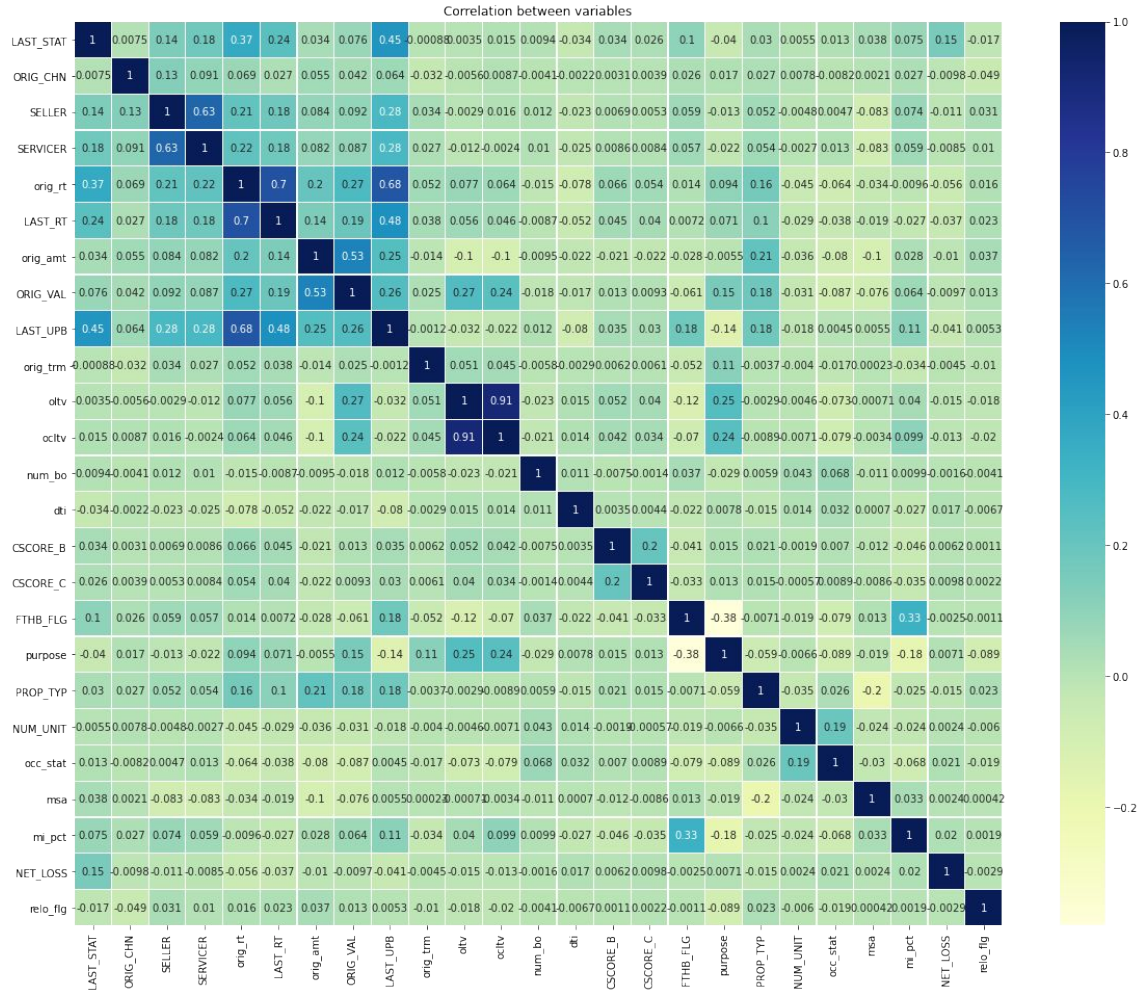
APPENDIX

Variable Correlation Matrix



Commentary

- The presented heat map contains the correlations between variables of interest.
  - Positive correlation between original interest rate (orig_rt) and current actual UPB (LAST_UPB): 0.68.
  - Positive correlation between last status (LAST_STAT) and current actual UPB (LAST_UPB): 0.47.
  - Positive correlation between first time home buyers (FTHB_FLG) and mortgage insurance percentage (mi_pct): 0.33.
  - Positive correlation between current actual UPB (LAST_UPB) and current interest rate (LAST_RT): 0.48.
  - Positive correlation between last status (LAST_STAT) and original interest rate (orig_rt): 0.37.

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