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ESTIMATING THE EFFECT OF NATURAL HAZARDS ON MORTGAGE LOSS SEVERITY

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PROJECT OBJECTIVES

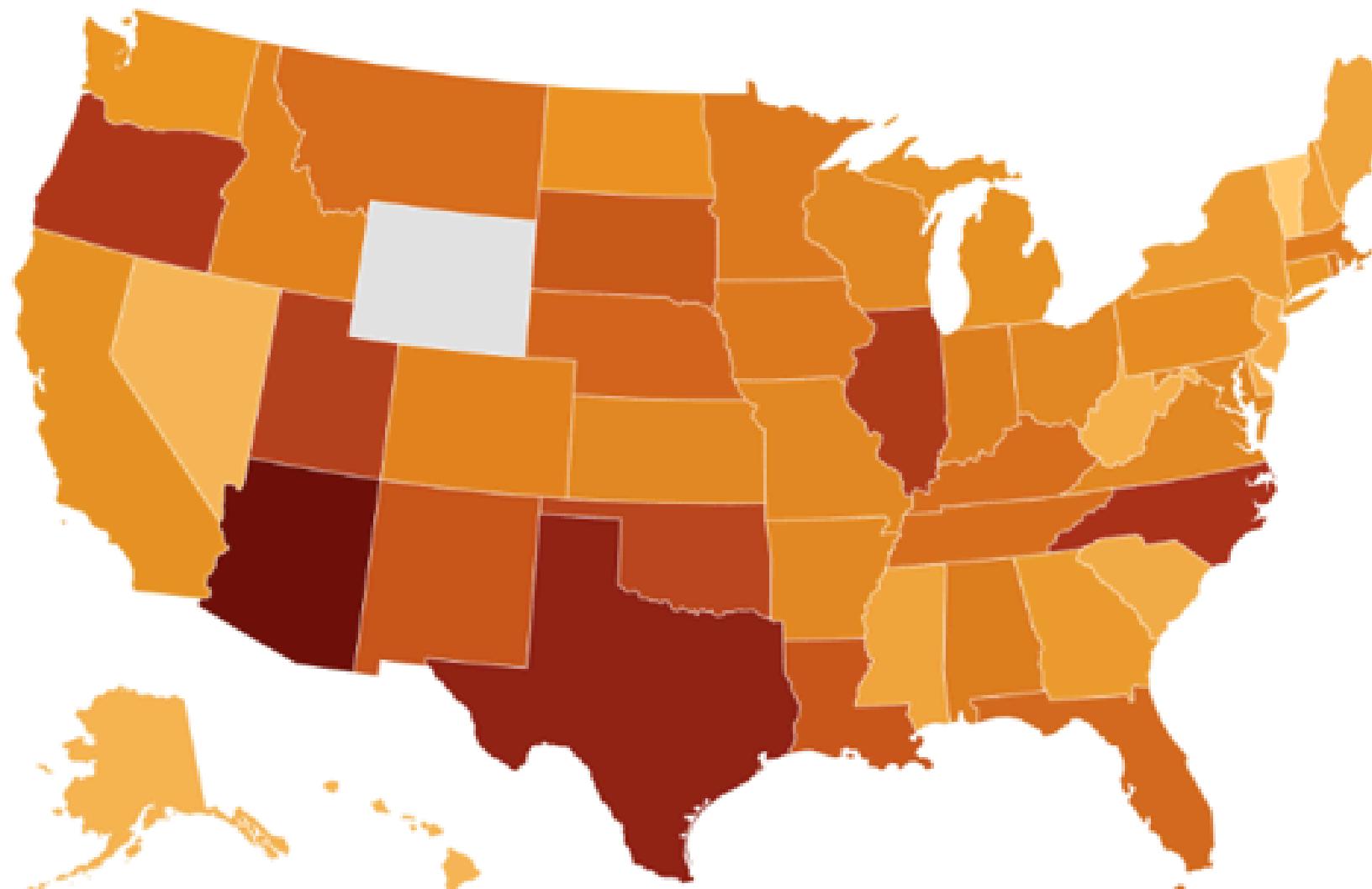
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MOTIVATION



Home Insurance Prices Are Rising Rapidly

Change in premiums from January 2022 to July 2023



Source: S&P Global Market Intelligence.

COUNCIL
ON
FOREIGN
RELATIONS

Climate change-driven insurance crisis threatens new US states

David Sherfinski Reuters

Published 11:14 a.m. ET May 2, 2024 | Updated 1:50 p.m. ET May 2, 2024

FORBES > MONEY > HEDGE FUNDS & PRIVATE EQUITY

U.S. Insurance: First In The Climate Crisis Line Of Fire

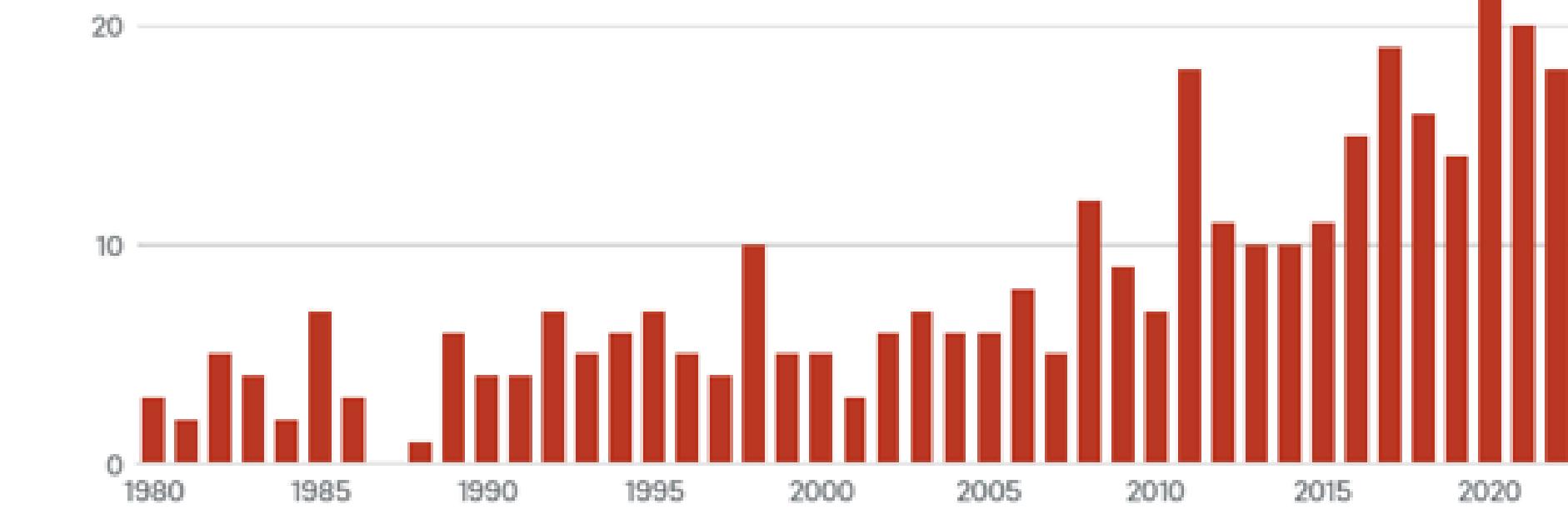
Millions of U.S. homes at risk of climate-related disasters, but few Americans know it

USA TODAY staff USA TODAY

Published 5:02 a.m. ET Aug. 11, 2021 | Updated 9:13 a.m. ET Aug. 12, 2021

Billion-Dollar Disasters Are Becoming More Common

Number of disasters affecting the United States that caused \$1 billion or more in damage



Source: National Oceanic and Atmospheric Administration.

COUNCIL
ON
FOREIGN
RELATIONS



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AGENDA

- O1** Evaluate the correlation between natural hazard risk and mortgage loss severity.
- O2** Assess how natural hazard risk influences the likelihood of mortgages transitioning to Short Sales (SS), Third Party Sales (TPS), and Real Estate Owned (REO) statuses.
- O3** Analyze the impact of natural hazard risk on the loss rates associated with mortgages in SS, TPS, and REO categories.
- O4** Investigate the relationship between specific types of natural hazards and their respective effects on mortgage loss severity and transition probabilities.



HOW DEFUALTS ARE TREATED?

O1 Loans may become inactive for a variety of reasons, including voluntary payoffs or credit events, known as “termination events”.

O2 **Real estate owned (REO)** is the term for a property owned by a lender because it failed to sell in a foreclosure auction after the borrower defaulted on their mortgage.

Short sales (SS) are an option for homeowners who are underwater on their mortgage to sell their property, and to avoid going into foreclosure. For many distressed homeowners, short sales are an alternative to foreclosure.

If a third-party outbids the lender's reserve price, the property will be acquired by the third party, and the sale is completed as a **third-party sale (TPS)**.



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THEORETICAL FOUNDATION





A New Loss Severity Model Framework for Residential Mortgages

Jian Chen
Junrong Liu
Tyler Yang



Literature Review and Foundation

Introduced new framework for modeling residential mortgage loss severity, building on prior research and improving understanding of loss severity drivers.



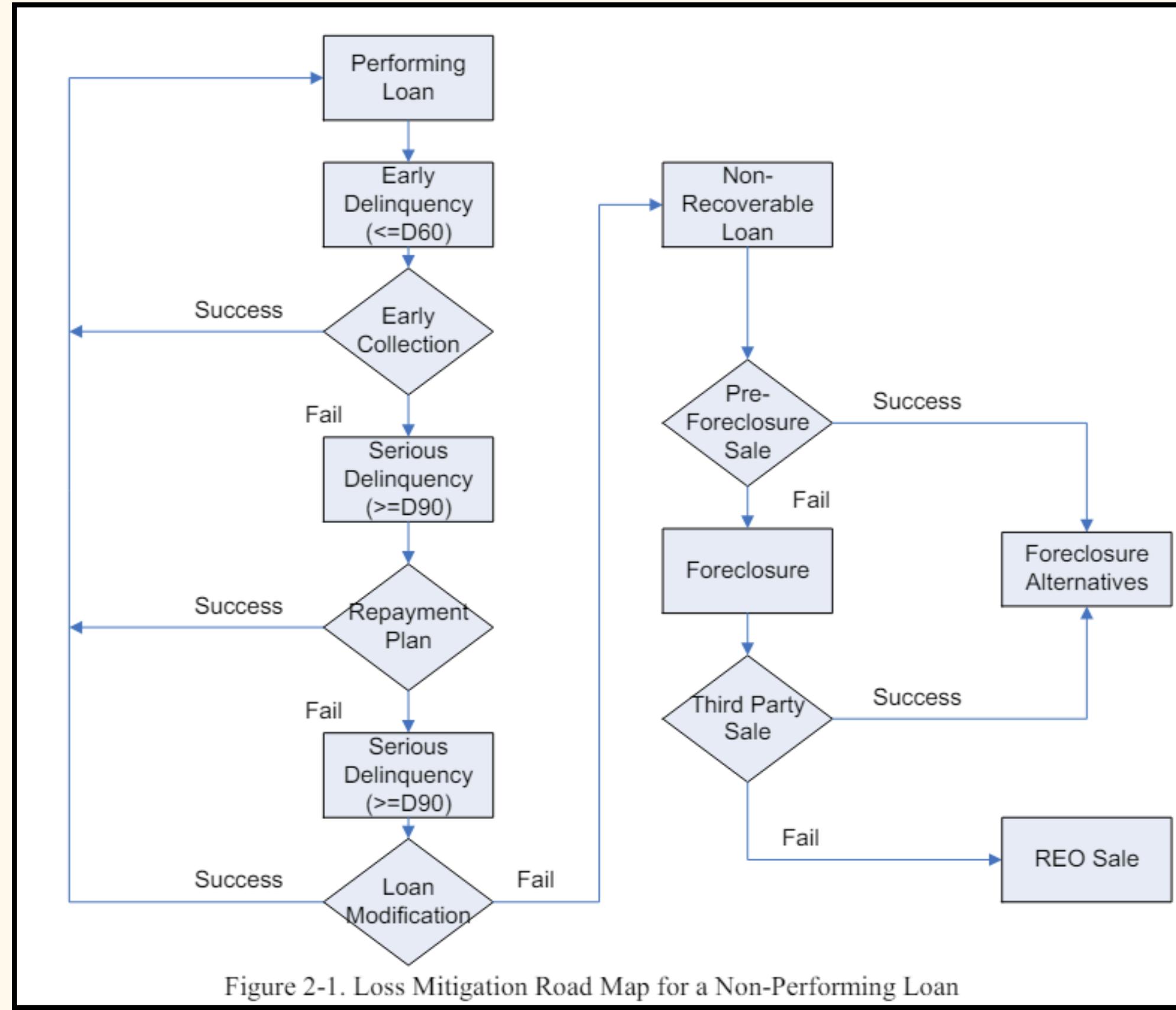
Model Setup

Authors specified LGD model for binary foreclosure outcomes, estimating F/A and REO probabilities with logistic regression, and loss rates with OLS.

$$\text{Loss Rate} = \text{Probability of REO} * \text{LossRate}_{\text{REO}} + \text{Probability of F/A} * \text{LossRate}_{\text{F/A}}$$



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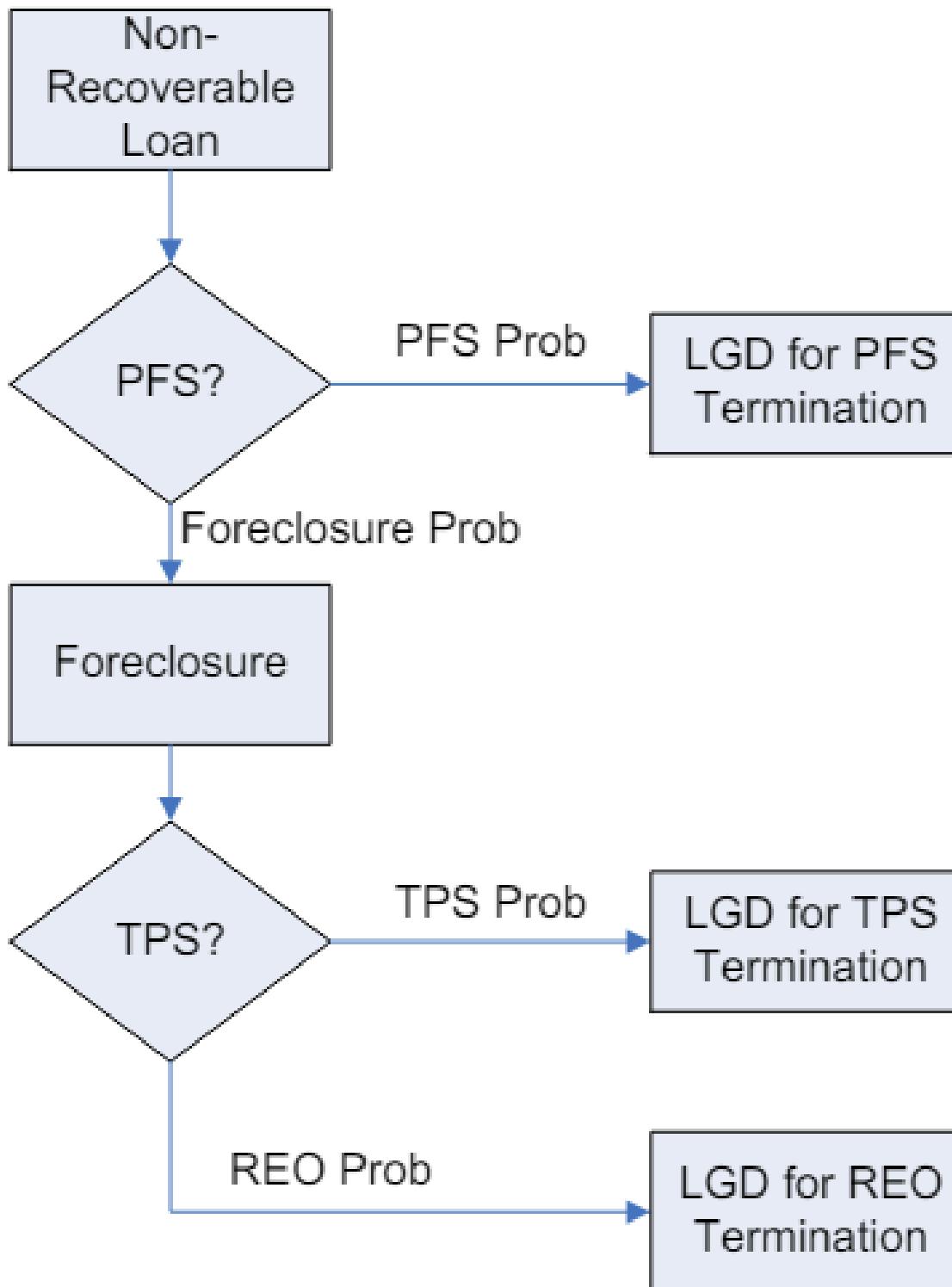


Figure 3-1. Ideal LGD Model Framework for Residential Mortgages



Mortgage Loss Severities: What keeps them so high?

Xudong Au
Larry Cordell



Literature Review and Foundation

Studies loss severity drivers over a longer time period using data from both GSEs, adding focus on vintage effects, new servicing rules, and idiosyncratic events (National Mortgage Settlement, Robo-signing scandal).

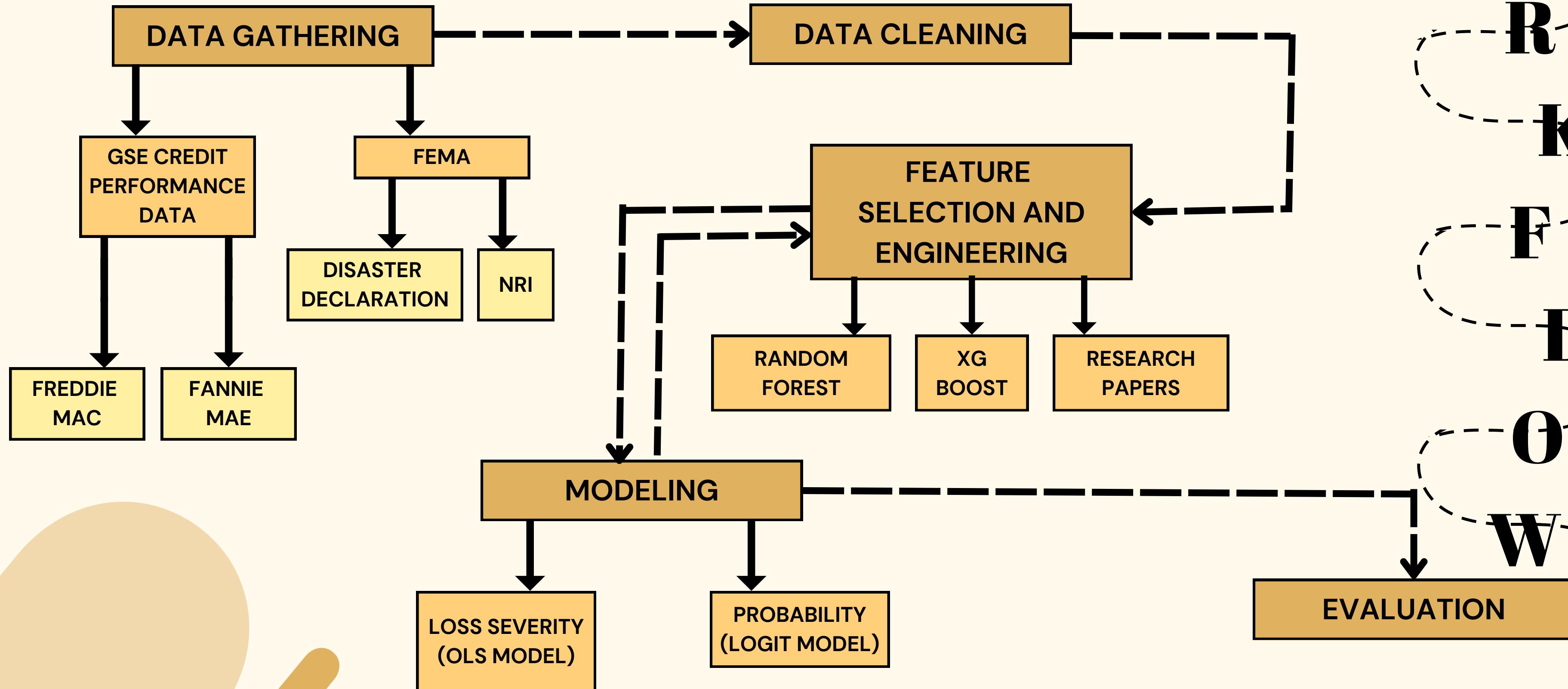


Model Setup

Specifies a loss severity model using generalized least squares (GLS) and adjusts for liquidated loan selection bias. Provides comparable summary statistics and R-squared statistic.



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DATA SOURCES

GSE PERFORMANCE AND ORIGINATION DATA

- Fannie Mae
- Freddie Mac

FEMA

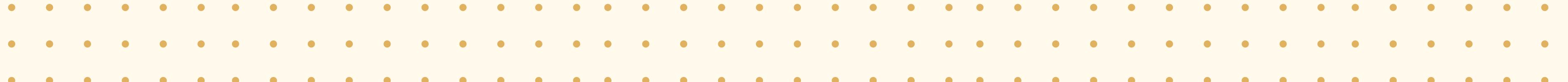
- National Risk Index (NRI)
- Disaster Declaration

MACRO ECONOMIC

- FHFA House Price Index (HPI)
- Interest Rates

STATE-LEVEL POLICY

- Judicial States
- Deficiency States





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EXPLORATORY DATA ANALYSIS



Fannie Mae®



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GSE DATA

- 01** Leveraged extensive Freddie Mac and Fannie Mae monthly loan-level data spanning 1999 to 2023 for comprehensive mortgage analysis.

- 02** A dataset of over 100 million loans was reduced to under a million, to understand how borrower profile data, including loan amount, loan-to-value ratio, credit score, and debt-to-income ratio, correlates with natural hazard risk and its impact on mortgage loss severity, transition probabilities (SS, TPS, REO), and loss rates.





KEY LOSS DATA DEFINITIONS

- O1 Adapted Freddie Mac's actual loss calculation method to estimate Fannie Mae's actual loss.

**Actual loss = Zero Balance Removal UPB + Delinquent Accrued Interest
– Net Sales Proceeds – MI Recoveries – Non MI Recoveries + Expenses**

- O2 Developed custom formulas for key components such as delinquent interest and expenses.

**Delinquent Accrued Interest = (Zero Balance Removal UPB – Non Interest bearing UPB) *
Min(Current Interest rate – 0.35, Current Interest Rate – Servicing Fee) * (Months between
Last Principal & Interest paid-to date and zero balance date) * 30/360/100.**

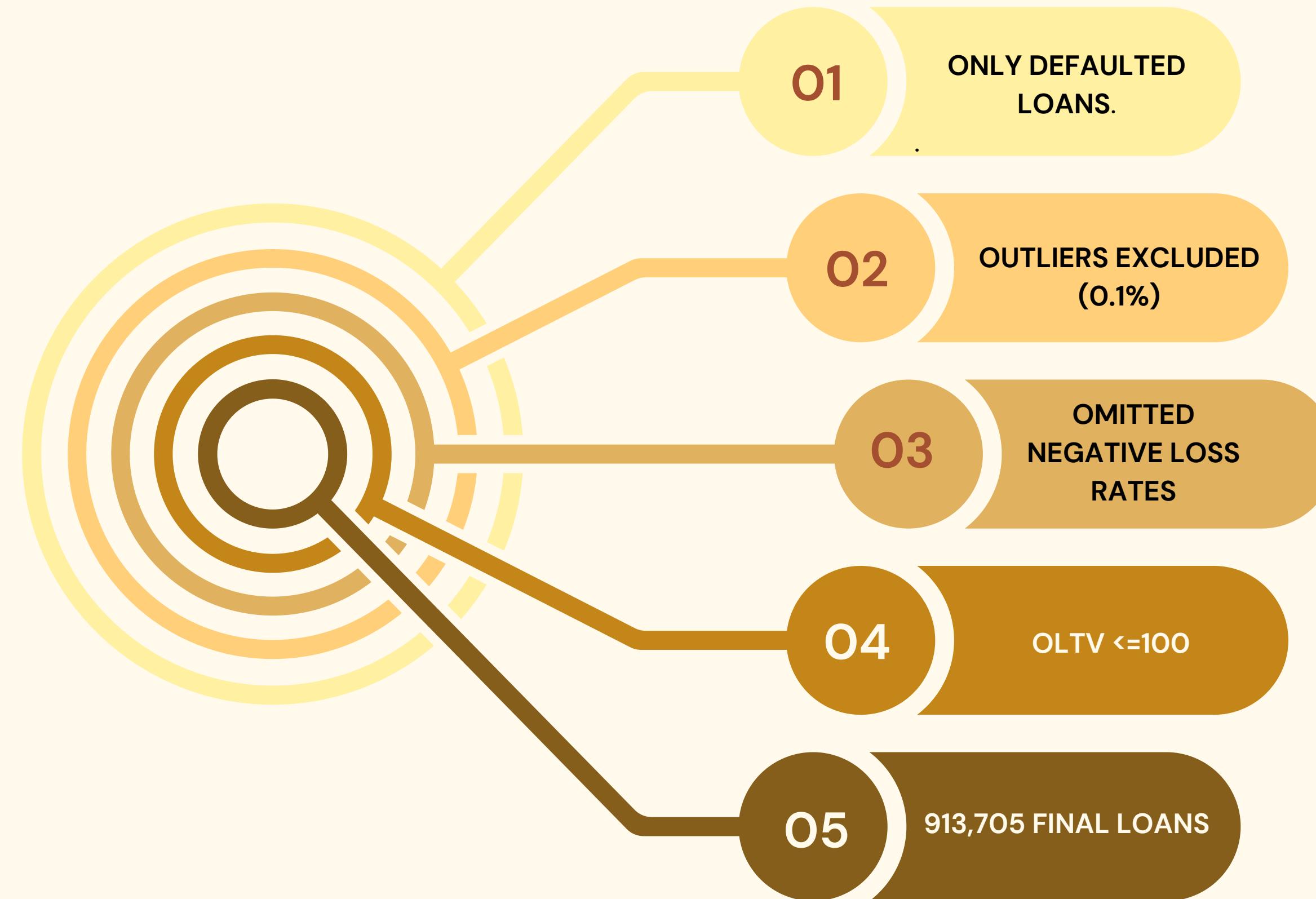
- O3 Calculate Loss Rate

Loss Rate = Actual Loss / Zero Balance Removal UPB



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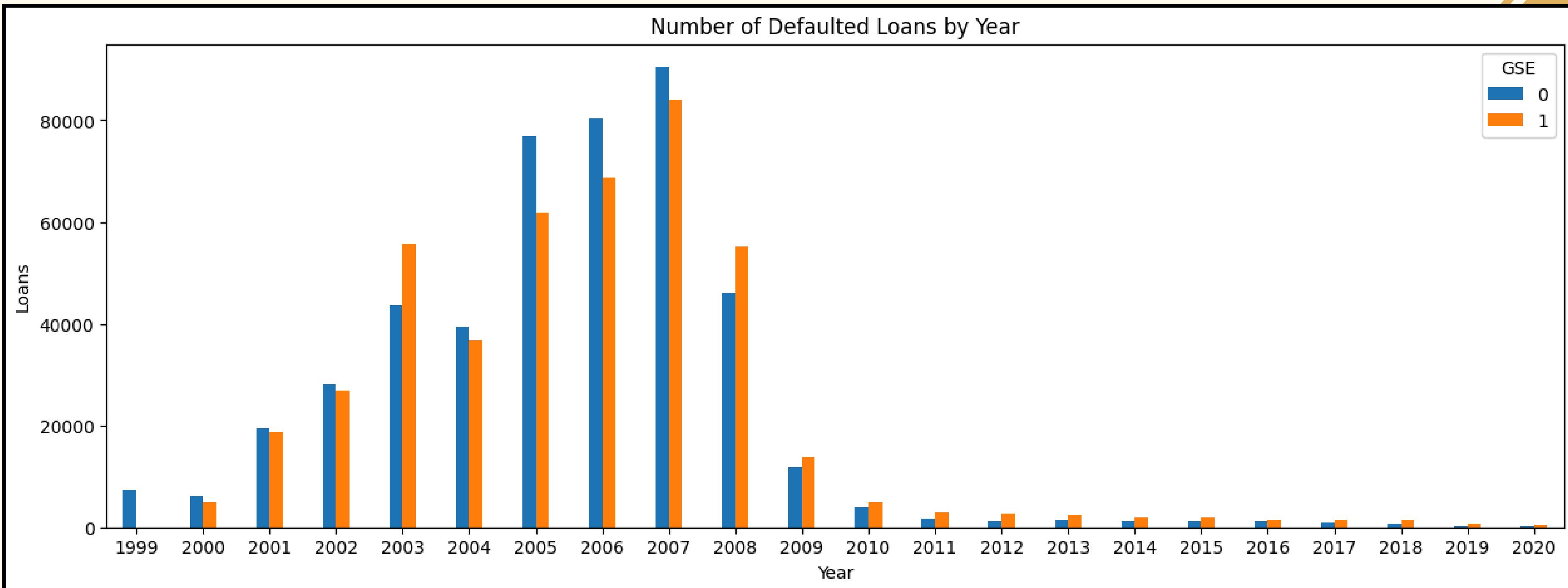
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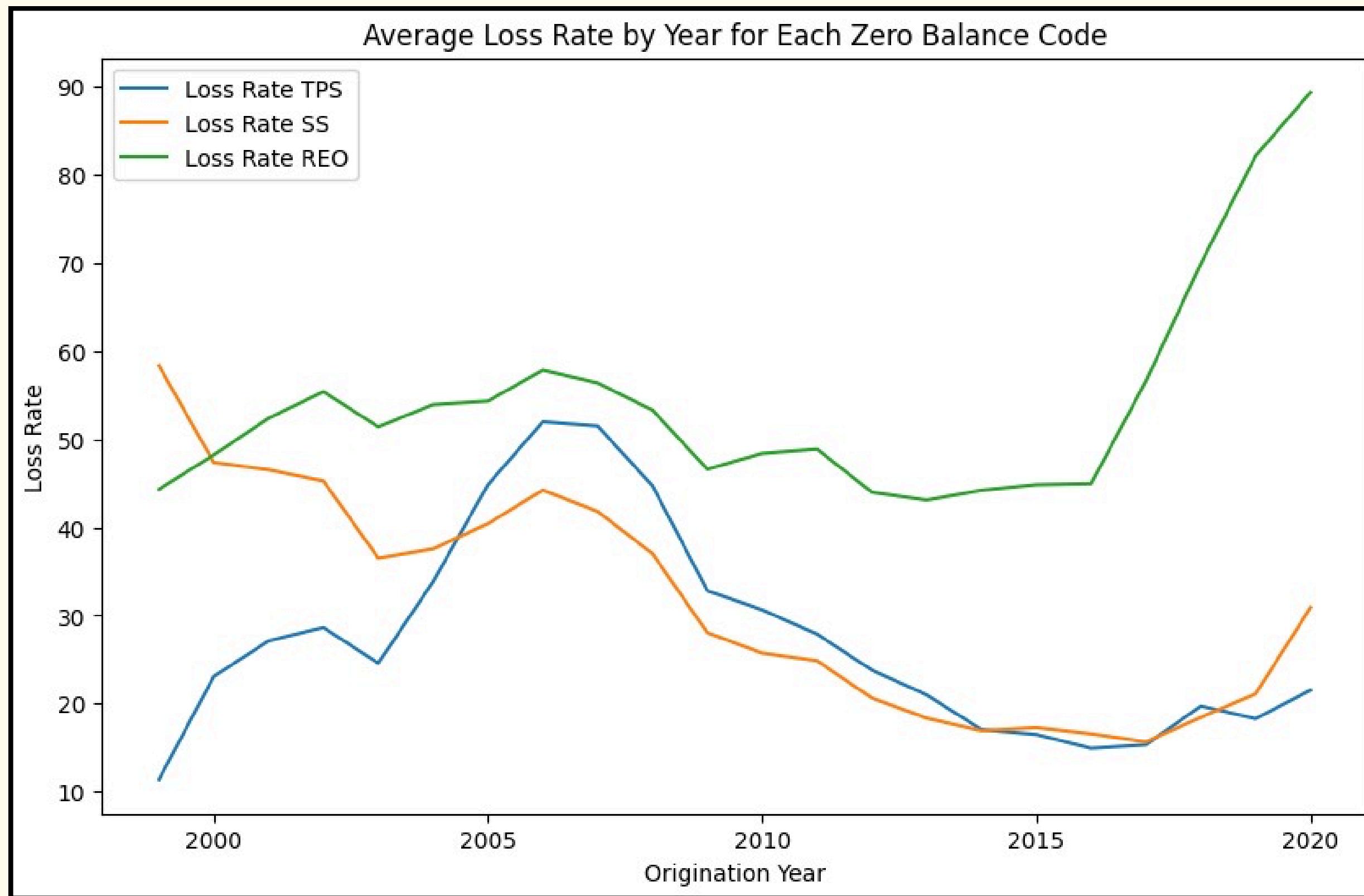
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Total Loans = 913,172





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GSE LOAN DISTRIBUTION

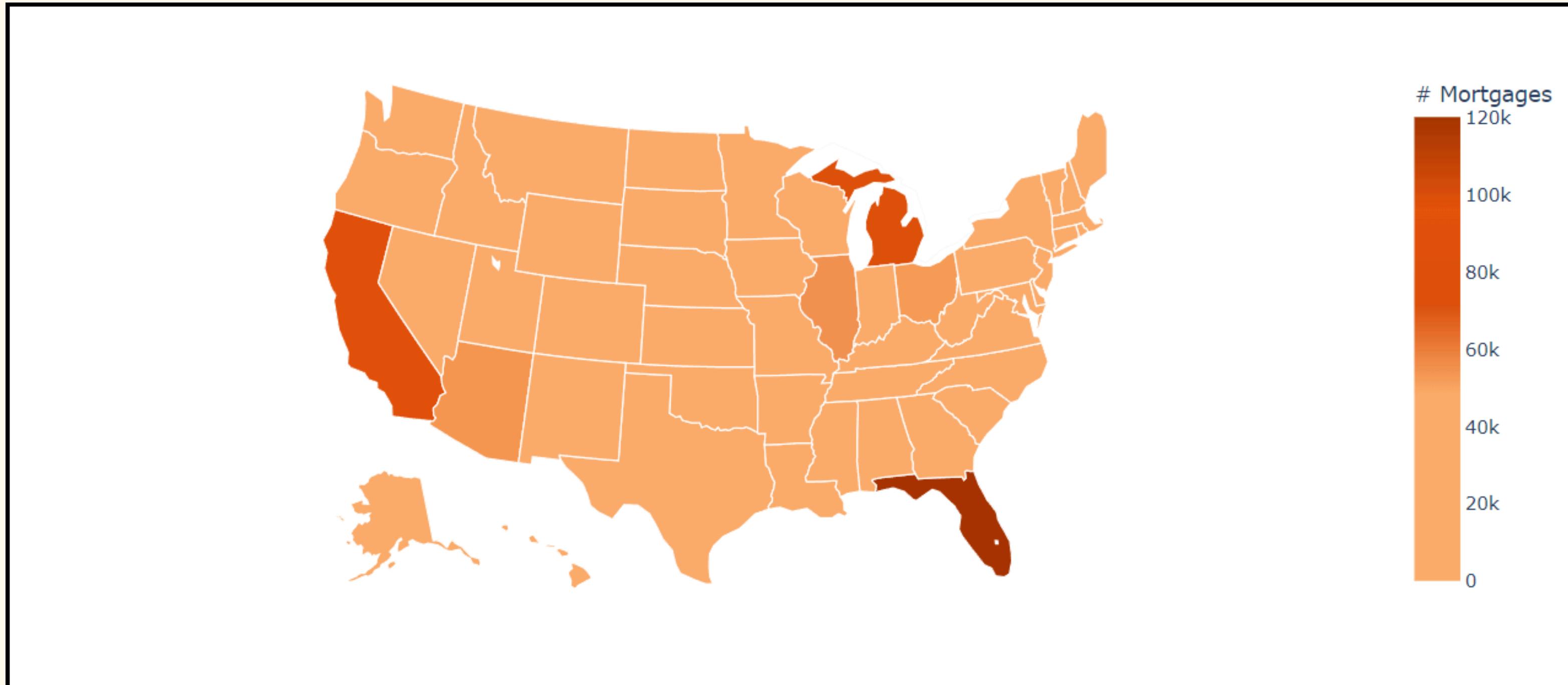
GSE	REO	TPS	SS
FREDDIE MAC	287,013	80,399	96,804
FANNIE MAE	331,566	30,475	86,915
TOTAL	618,579	110,874	183,719

TRAIN SET = 80% AND TEST SET = 20%



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DEFAUTLED LOANS BY STATE





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Loan Level Characteristics			
Variable	Source	Data Type	Description
Loan Default Status	GSE	Categorical	SS - Short Sale, TPS - Third Party Sale, REO - Real Estate-Owned Disposition
Prior Modification	GSE	Categorical	Indicates whether the loan has been modified in the current/prior period
Loan Age	GSE	Numeric	Number of months since first payment date / modification date
Borrower Attributes			
Variable	Source	Data Type	Description
FICO	GSE	Numeric	Borrower Credit Score
Original LTV/CLTV	GSE	Numeric	Original Loan-to-Value and Combined Loan-to-Value
Original DTI	GSE	Numeric	Original Debt-to-Income
Occupancy Status	GSE	Categorical	P - Primary, S - Second Home, I - Investor
FTHB	GSE	Categorical	First Time Homebuyer Flag
Number of Units	GSE	Numeric	
Original Interest Rate	GSE	Numeric	
Channel	GSE	Categorical	R - Retail, B - Broker, C - Correspondent
Loan Purpose	GSE	Categorical	P - Purchase, C - Cashout Refinance, N - No Cashout Refinance, R - Refinance Not Specified
Number of Borrowers	GSE	Numeric	Number of borrowers on the loan
Original UPB	GSE	Numeric	Original unpaid principal balance on loan
Maturity Date	GSE	Date	
Property Attributes			
Variable	Source	Data Type	Description
Property Type	GSE	Categorical	CO - Condo, PU - Planned Unit Dev., MH - Manufactured Housing, SF - Single Family, CP - CO-OP
Property State	GSE	Location	Property state
Number of Units	GSE	Numeric	Number of units
Zip3	GSE	Location	First 3 digits of zip code
MSA	GSE	Location	Metropolitan statistical area (or division) code



CONSTRUCTED VARIABLES

Current Combined Loan-to-Value Ratio (cltv_current): Original CLTV / (current HPI / HPI at origination).

- HPI = FHFA Monthly House Price Index
- HPI determined at MSA x Month level using FHFA data (state level used if MSA not found).
- Spline knots at 80 and 120.

Relative Loan Size (loansize): Origination UPB / median Orig. UPB at MSA level (state level used if MSA not found).

Short-Term House Price Appreciation (hpat2y): Current HPI / HPI 2 years ago.

Duration of Default Episode (dur_def_episode): Months between delinquency and foreclosure.

Mortgage Rate Spread (mr_sprd): Spread between current mortgage rate and 10-year Treasury rate.

flag_24: No. of units > 1

Underwriting Period Indicator: Normal (1999-2004), Boom (2005-2008Q2), Bust (2008Q3-2012), PostCrisis (2013-2020)

Judicial state: 0 – Non judicial state, 1– Judicial state

Deficiency state: 1 – Deficiency judgement state, 0 – Others

GSE: 0 – Freddie, 1 – Fannie



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EXPLORATORY DATA ANALYSIS



FEMA

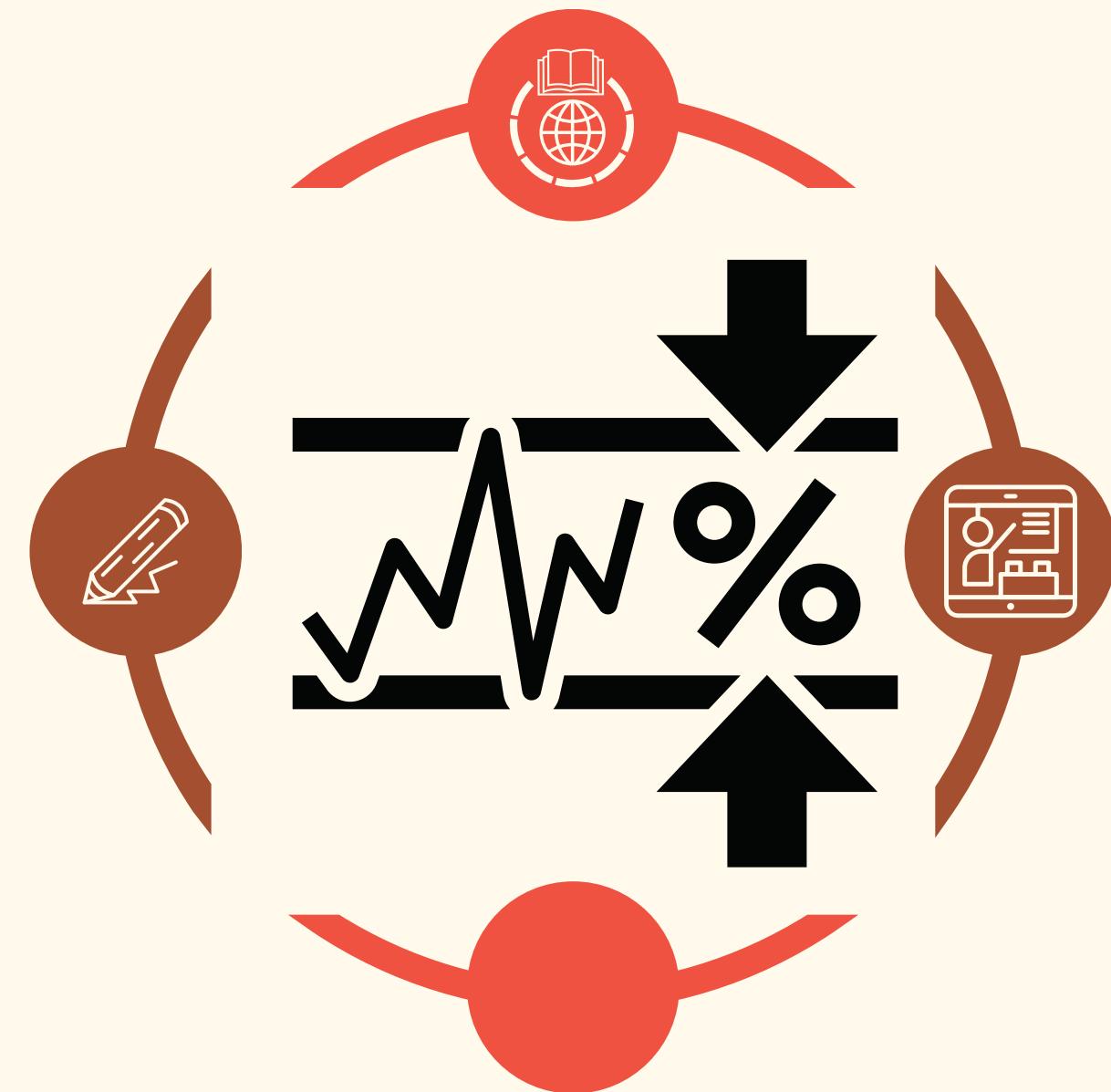


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NRI DATA

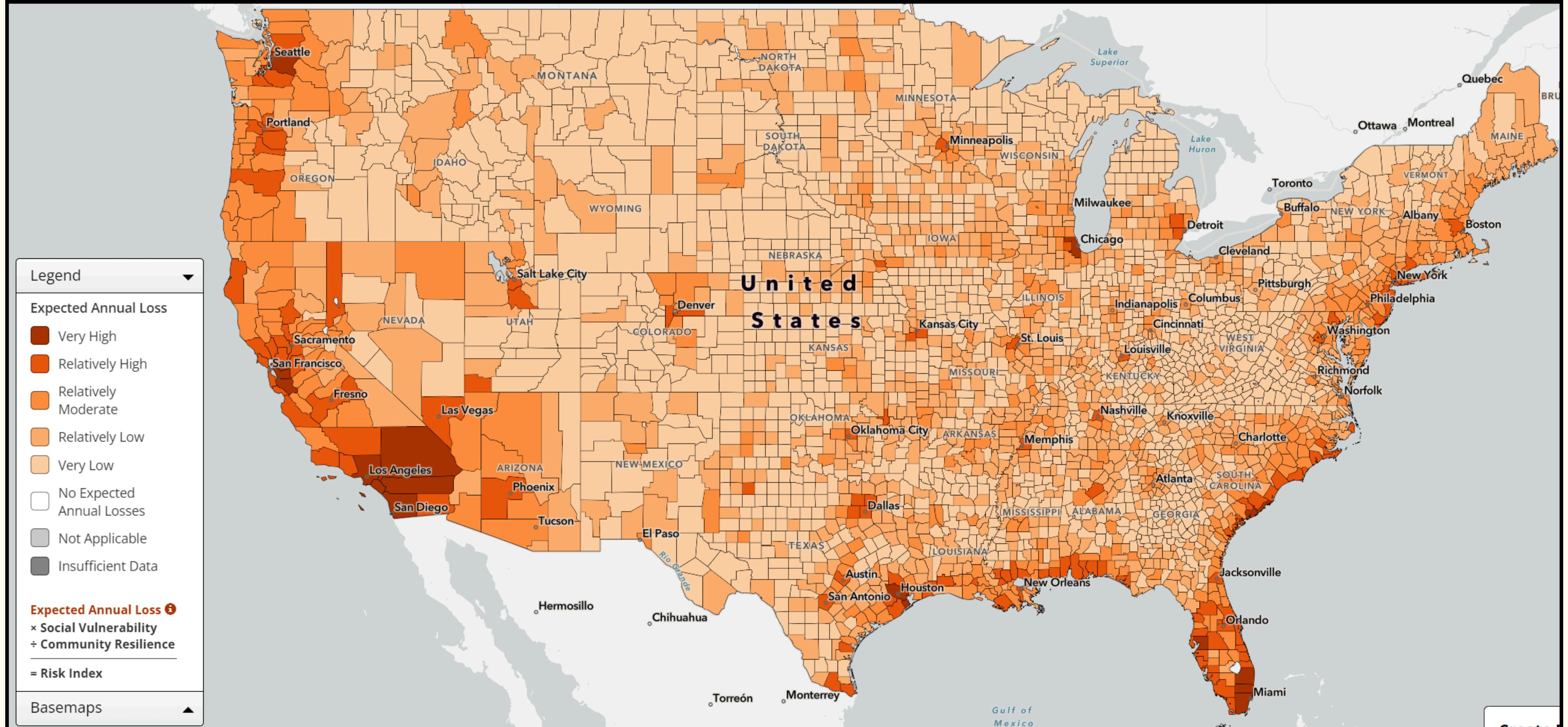
O1 Thorough risk evaluations were achieved by integrating FEMA's National Risk Index into the dataset, encompassing assessments for 18 different natural disasters, enhancing understanding of property risks.

O2 Location-specific insights into natural hazard risks were gained through the incorporation of FEMA NRI data, which covers county-wise risk information for 18 different disasters, enabling a more precise analysis of potential losses.





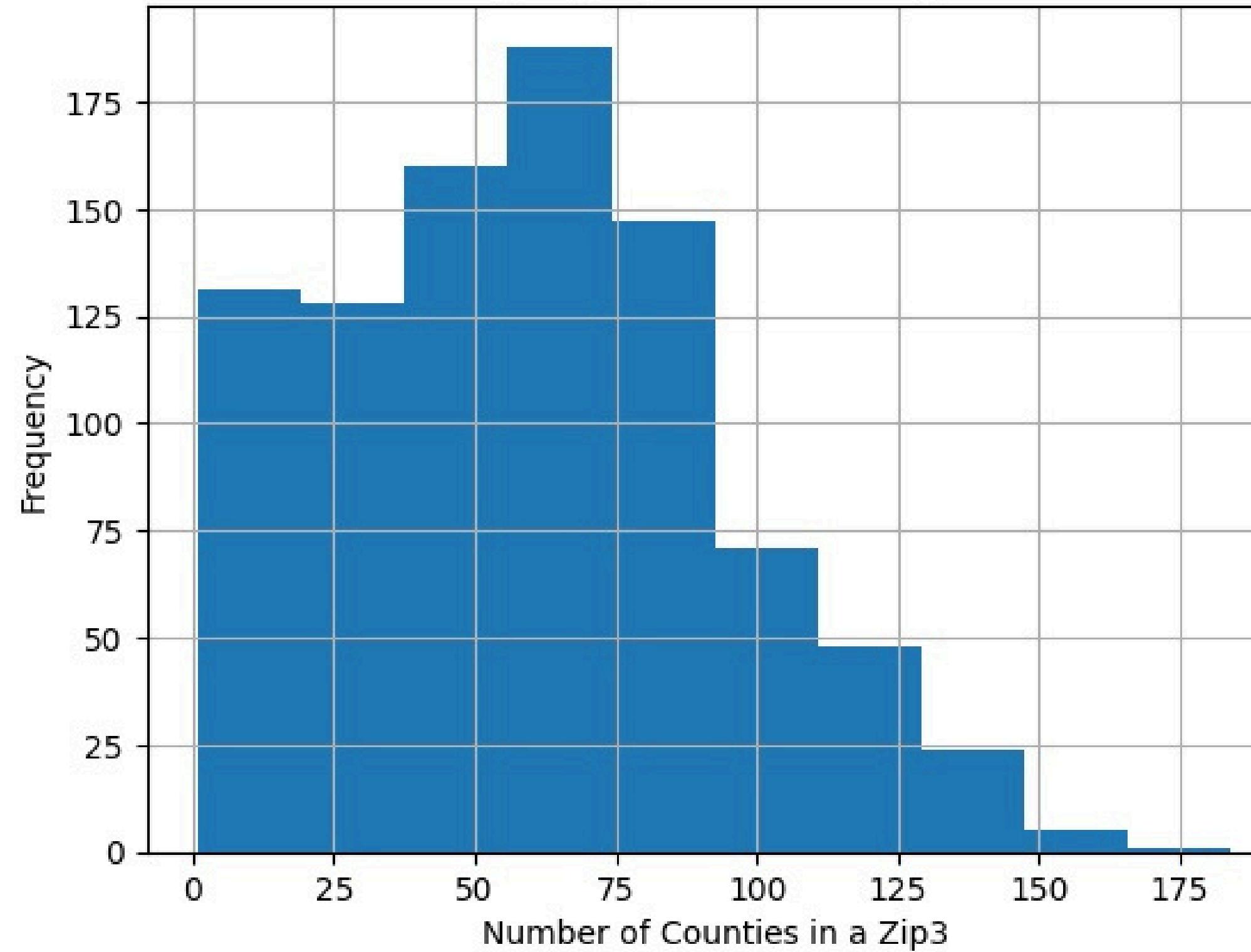
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NRI data grouping with first 3 digits of ZIP



MERGING GSE DATA WITH NRI DATA

The data was first converted to a Zip-3 level as the GSE data only contains the first 3 digits of the Zip code.



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We have these measures for all of the 18 disasters.

'EAL_VALT'

The Expected Annual Loss (EAL) based on historic losses (\$ amount)

'EAL_SCORE'

Score from 1 to 100 based on EAL Value

'EAL_RATING'

Risk Rated 1–5
5 = Very high,
1 = Very Low,
0 = Missing/Not applicable

'RISK_VALUE'

The Risk value based on EAL + social vulnerability + resilience

'RISK_SCORE'

Score from 1 to 100 based on Risk Value

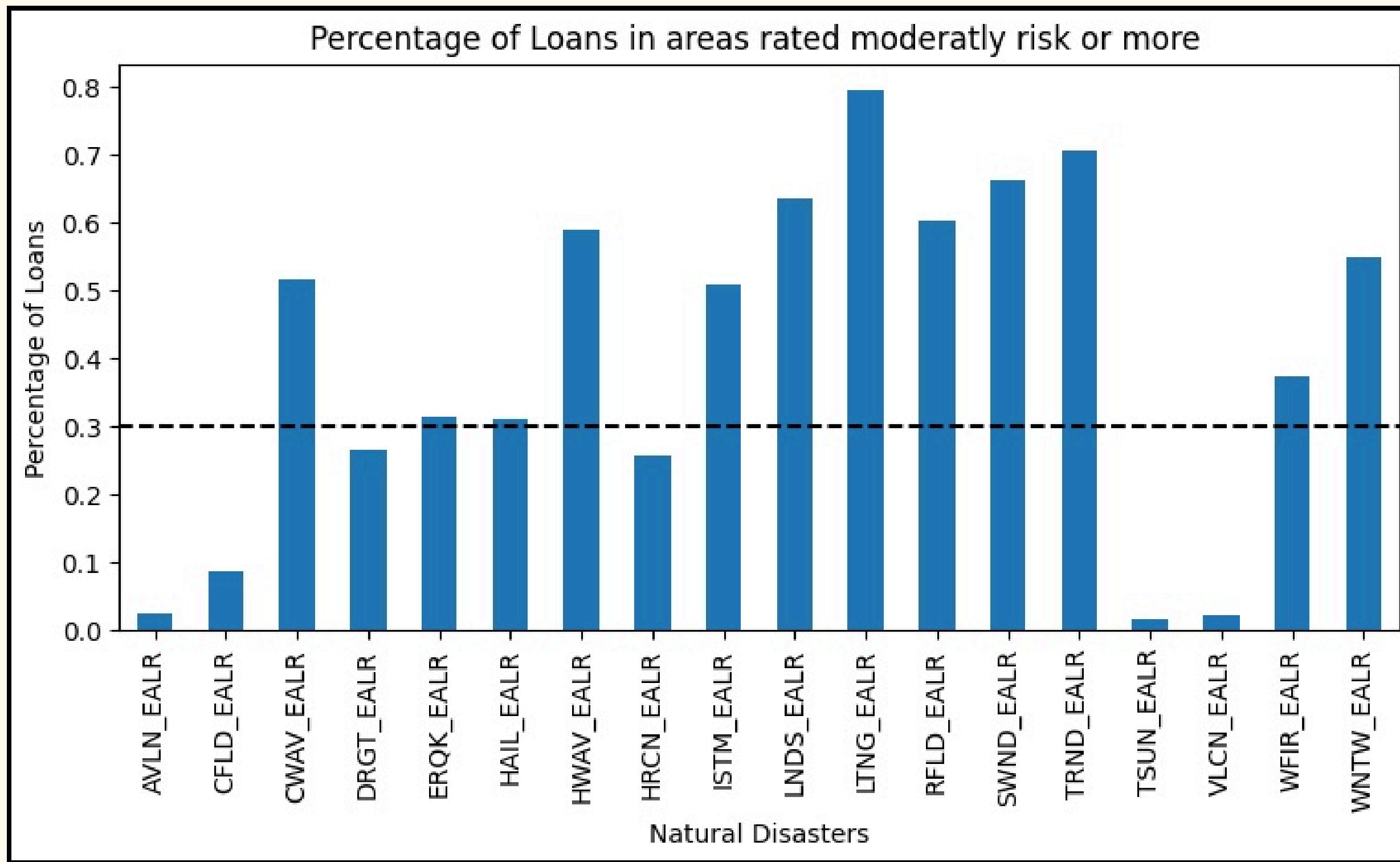
'RISK_RATING'

Risk Rated 1–5
5 = Very high,
1 = Very Low,
0 = Missing/Not applicable

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OLS

We chose to use EAL scores over other measures because the risk scores contained subjective social vulnerability and resilience factors that were not too relevant to loss rates. This decision was also supported by our models, as EAL had better R-squared values and accuracies.

WHY??

**EAL_Score over
other climate
variables**



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LOGIT

We utilized Expected Annual Loss (EAL) derived from historical data and prioritized EAL_RATING for each disaster. This approach improved understanding of natural hazard risk's impact on mortgage loss severity, enhancing accuracy in risk assessment and mitigation strategies for the mortgage lending sector.

WHY??
EAL_RATNG
over other
climate
variables



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DISASTER DATA

- 01** The information was originally gathered based on Zip-3 regions, limited to the first three digits of each Zip code, within the GSE dataset.
- 02** We assessed notable disasters within the six months preceding the delinquency period in the Zip codes corresponding to the subject properties.
- 03** We cataloged federal disaster declarations historically, organizing them by state, county, type of hazard, and year.

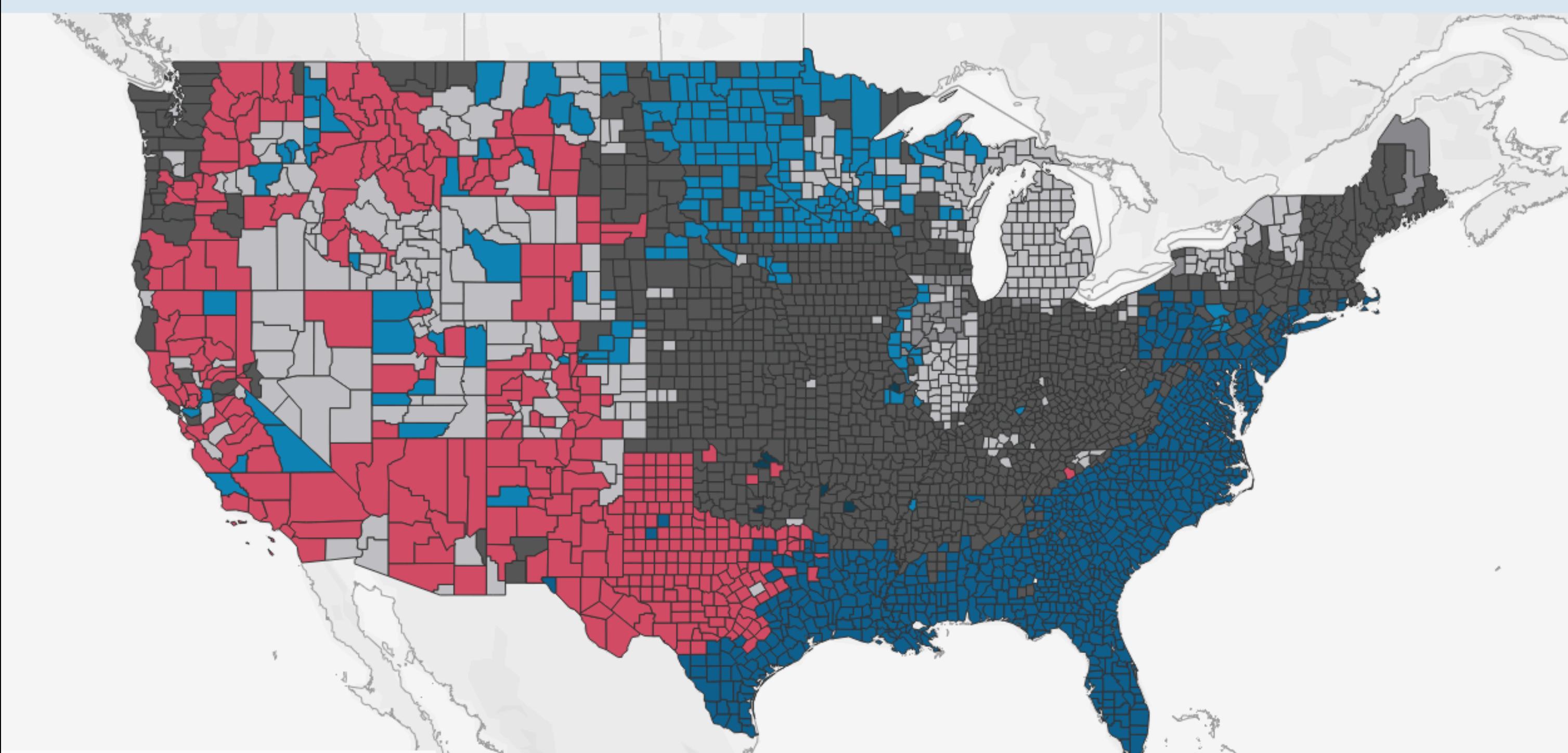




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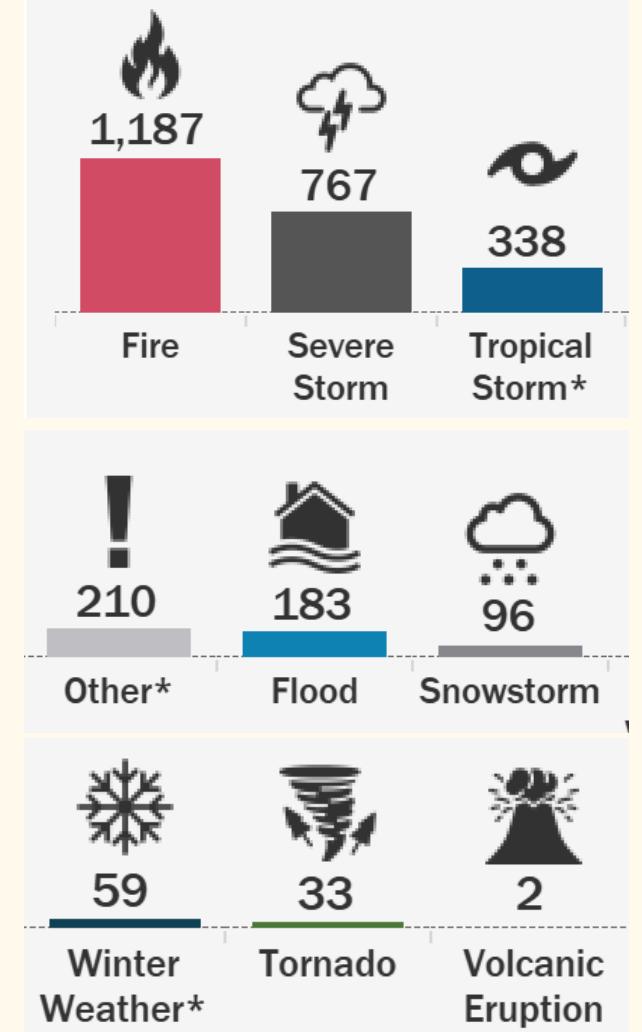
Most Frequent Incident Category by County

Statewide disasters are not included in the county disaster counts

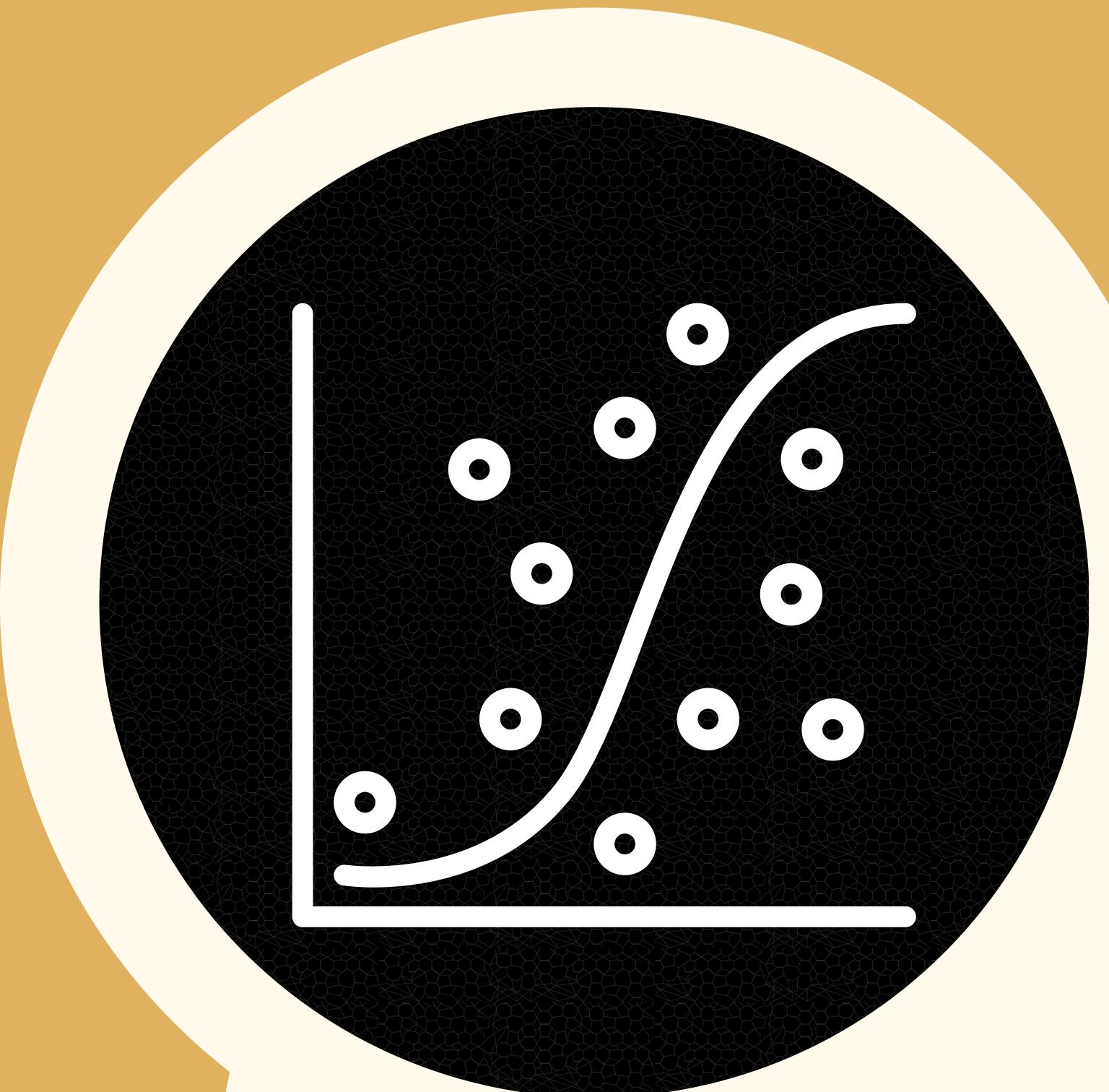


**2875 Disasters
declared from
1 Jan 1999 to
31 Dec 2020**

DISASTER(S) BY INCIDENT CATEGORY



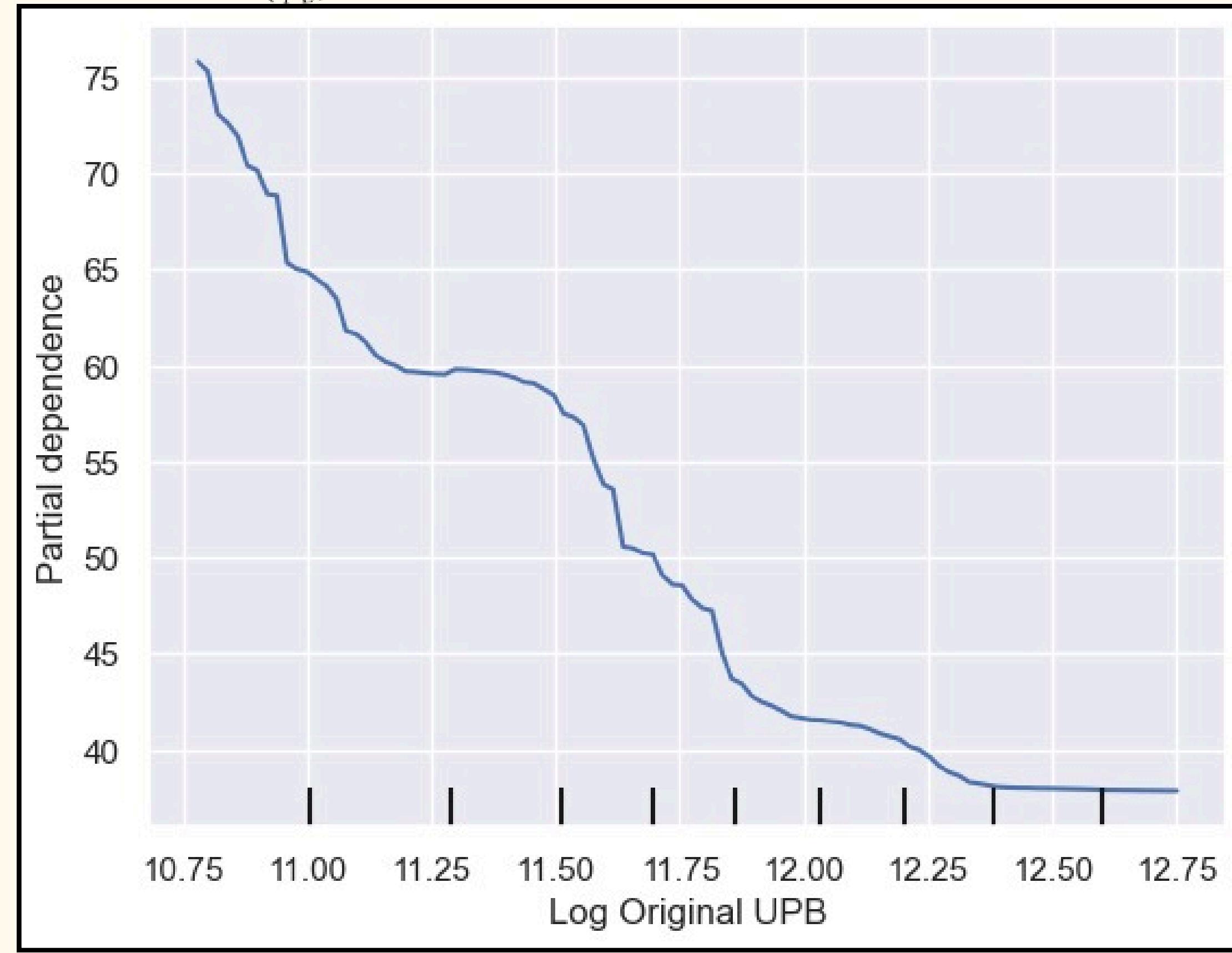
PARTIAL DEPENDENCE PLOTS USING RANDOM FORESTS





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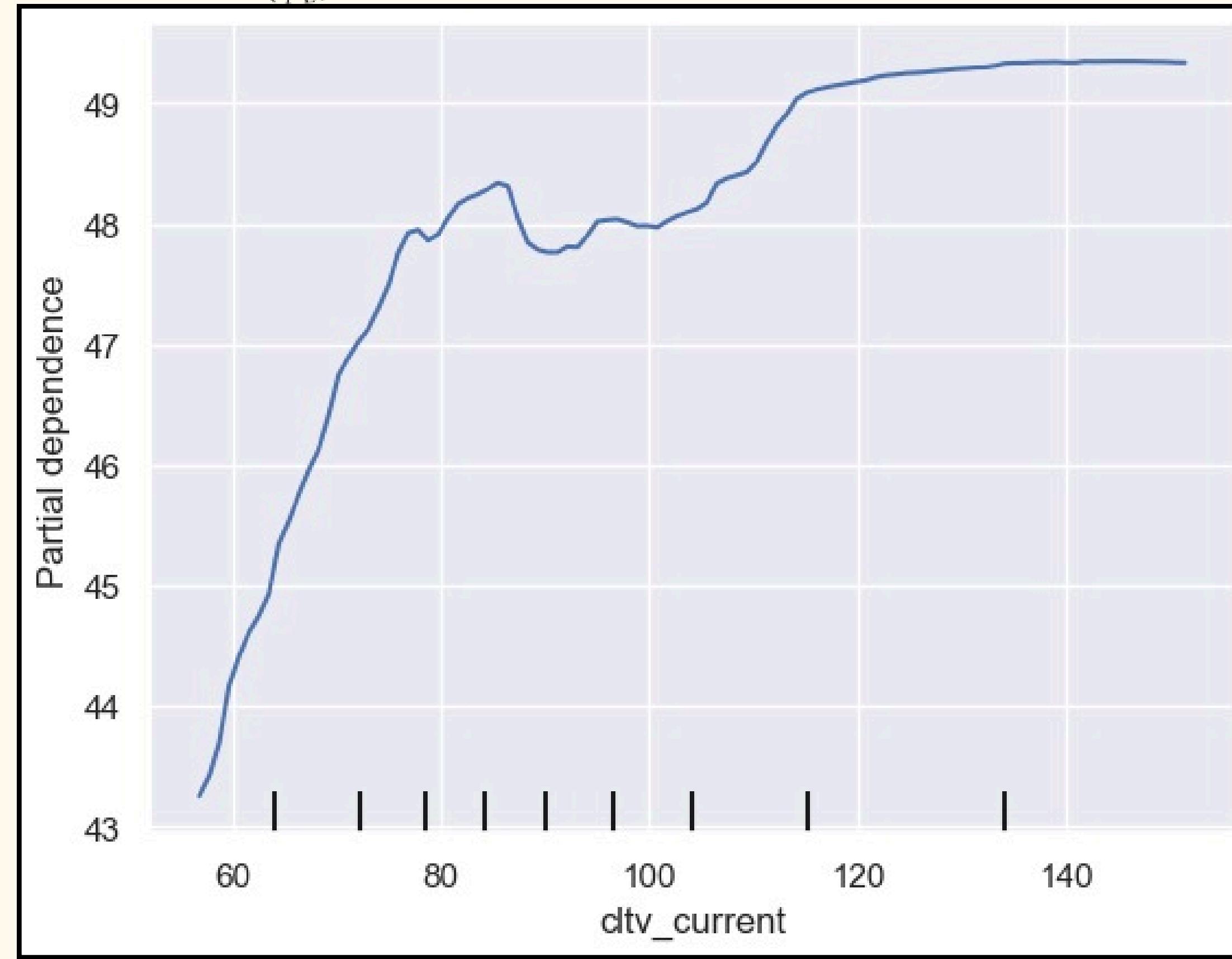
**Chose 11.25
as a knot
point for
the spline**





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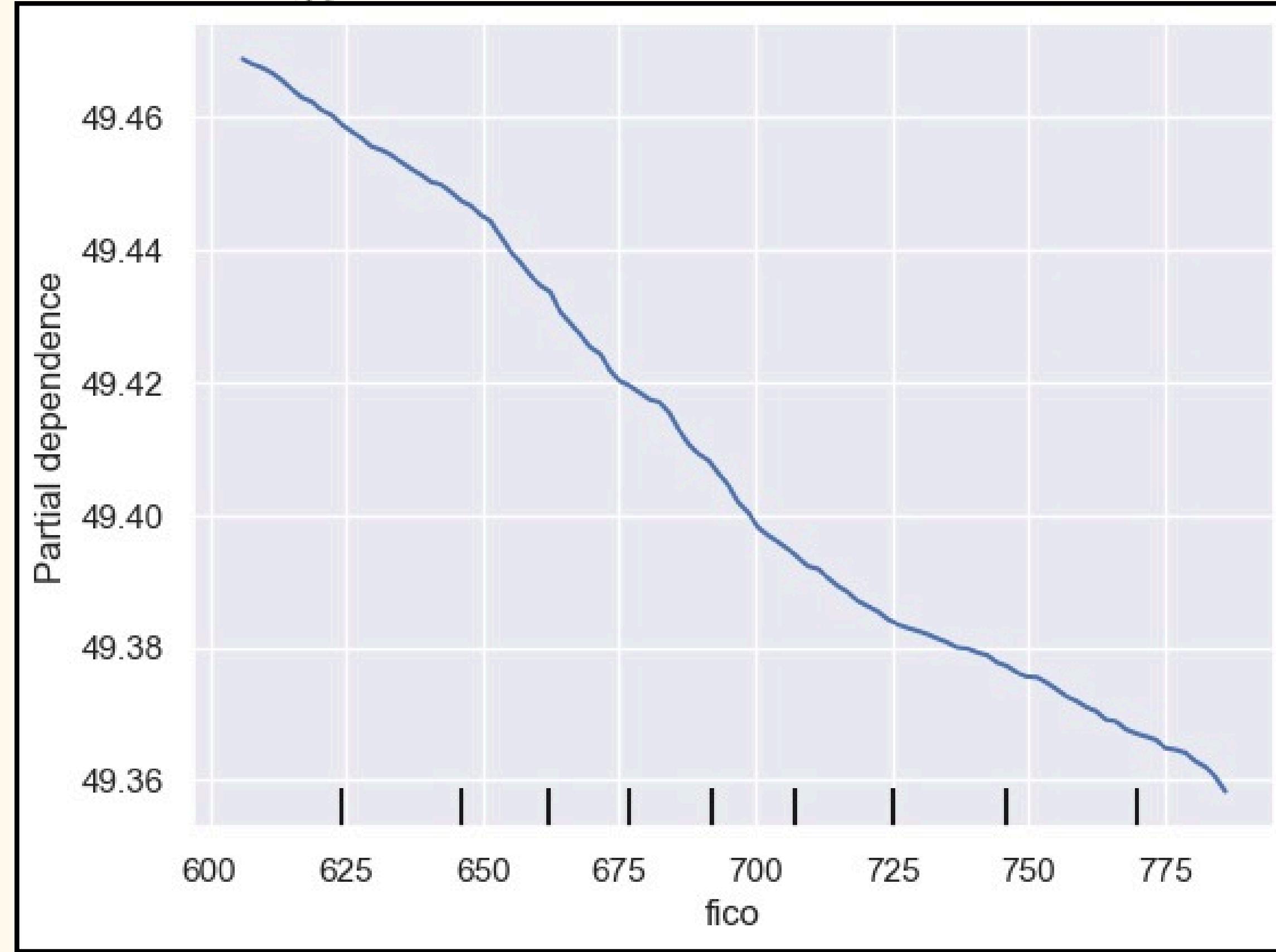
Chose 80
and 120 as
the knot
points for
the spline





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**Chose 620
and 750 as
the knot
points for
the spline**





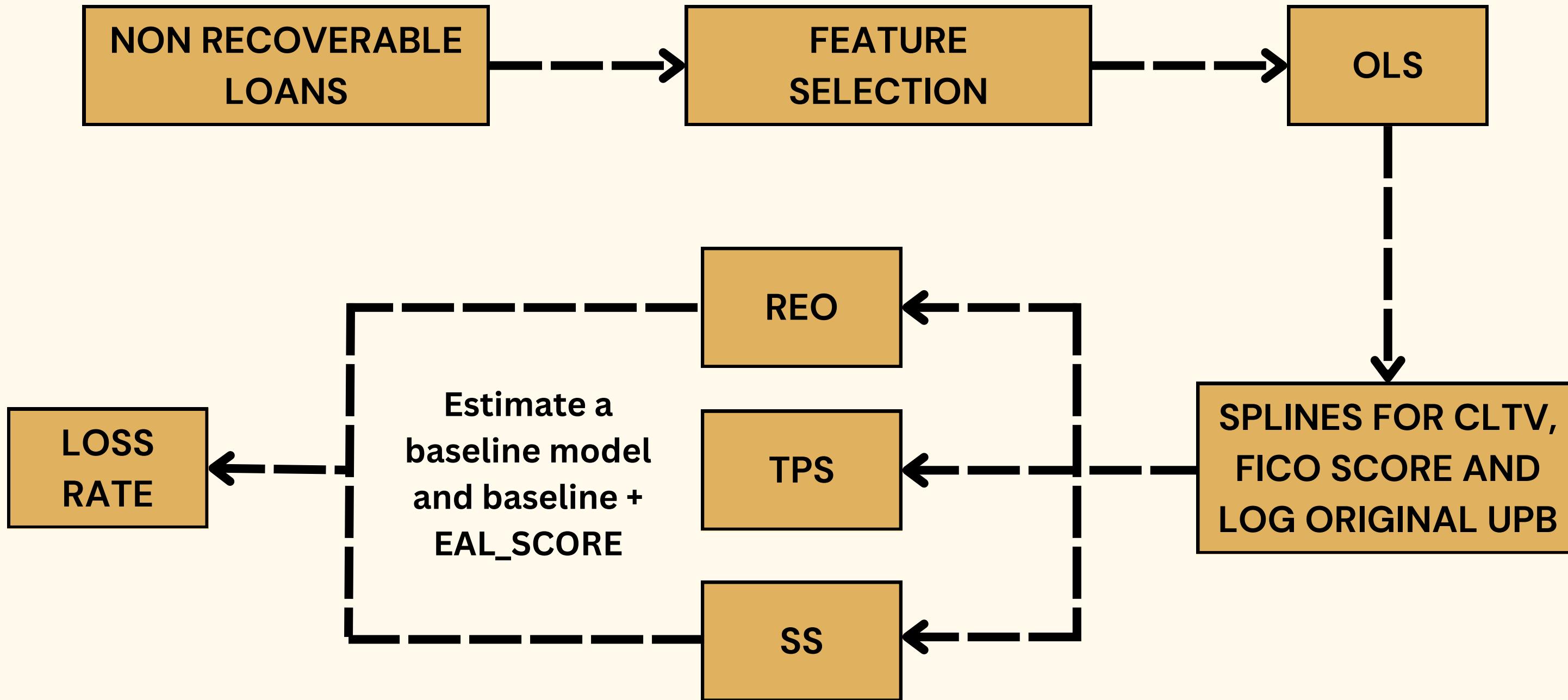
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LOSS RATE MODELS





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LOSS RATE MODEL RESULTS AND INTERPRETATION

	REO	SS	TPS
BASELINE MODEL R^2	0.4151	0.4328	0.459
BASELINE MODEL+ NRI R^2	0.4167	0.4401	0.459
BASELINE MODEL + DISASTER R^2	0.4152	0.4331	0.459
THE ADJUSTED R^2 FOR AU AND CORDELL'S OLS MODEL IS 0.4585			



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REO (Zero Balance Code = 9)			
Model	R-square	Train RMSE	Test RMSE
Baseline Model	0.4145	25.25	25.32
Baseline Model + NRI	0.4162	25.21	25.28
Baseline Model + Disaster	0.4146	25.25	25.32

SS (Zero Balance Code = 3)			
Model	R-square	Train RMSE	Test RMSE
Baseline Model	0.4337	19.73	19.76
Baseline Model + NRI	0.4410	19.60	19.63
Baseline Model + Disaster	0.4340	19.72	19.75

TPS (Zero Balance Code = 2)			
Model	R-square	Train RMSE	Test RMSE
Baseline Model	0.4603	24.63	24.60
Baseline Model + NRI	0.4603	24.63	24.09
Baseline Model + Disaster	0.4598	24.63	24.10

Model Results



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FORECLOSURE ALTERNATIVE SELECTION MODELS





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- Vanilla Logistic Regression
- Ordered Logit Model
- Multinomial Logit Model
- Sequential Logit Model

MODEL SELECTION

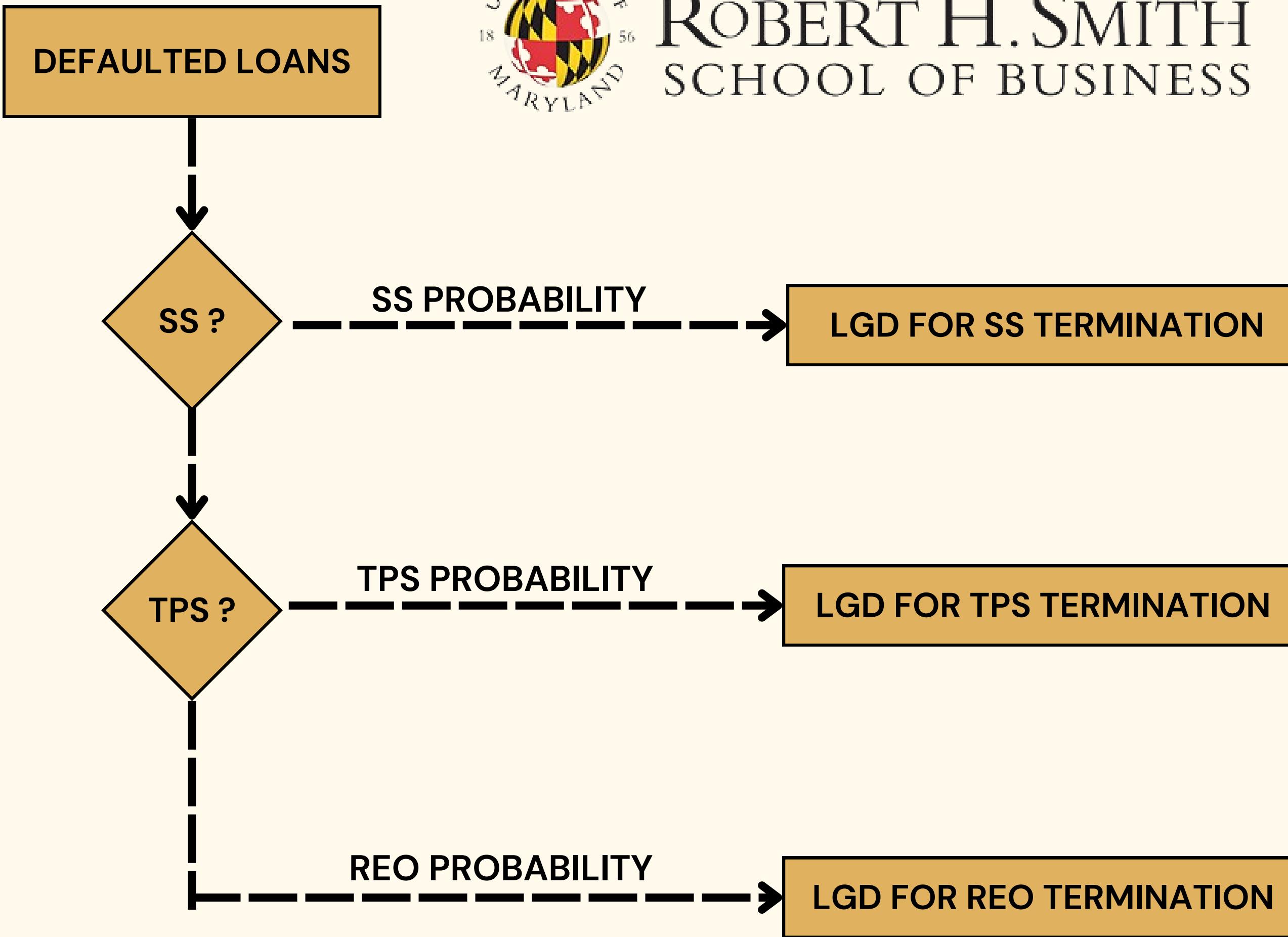
During the model exploration phase, we considered various methodologies to identify the most fitting approach for our objectives. We evaluated each model's suitability based on its ability to capture the nuances of the data and provide interpretable results. This involved a thorough examination of different model types to ensure they adequately addressed the complexities of the phenomenon under investigation.

After thorough evaluation, we selected the Sequential Logit Model for its ability to capture sequential dependencies in the data, offering valuable insights into our objectives.



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FORECLOSURE ALTERNATIVE SELECTION MODEL

RESULTS AND INTERPRETATION

SS (ZERO BALANCE CODE = 3) VS NON-SS

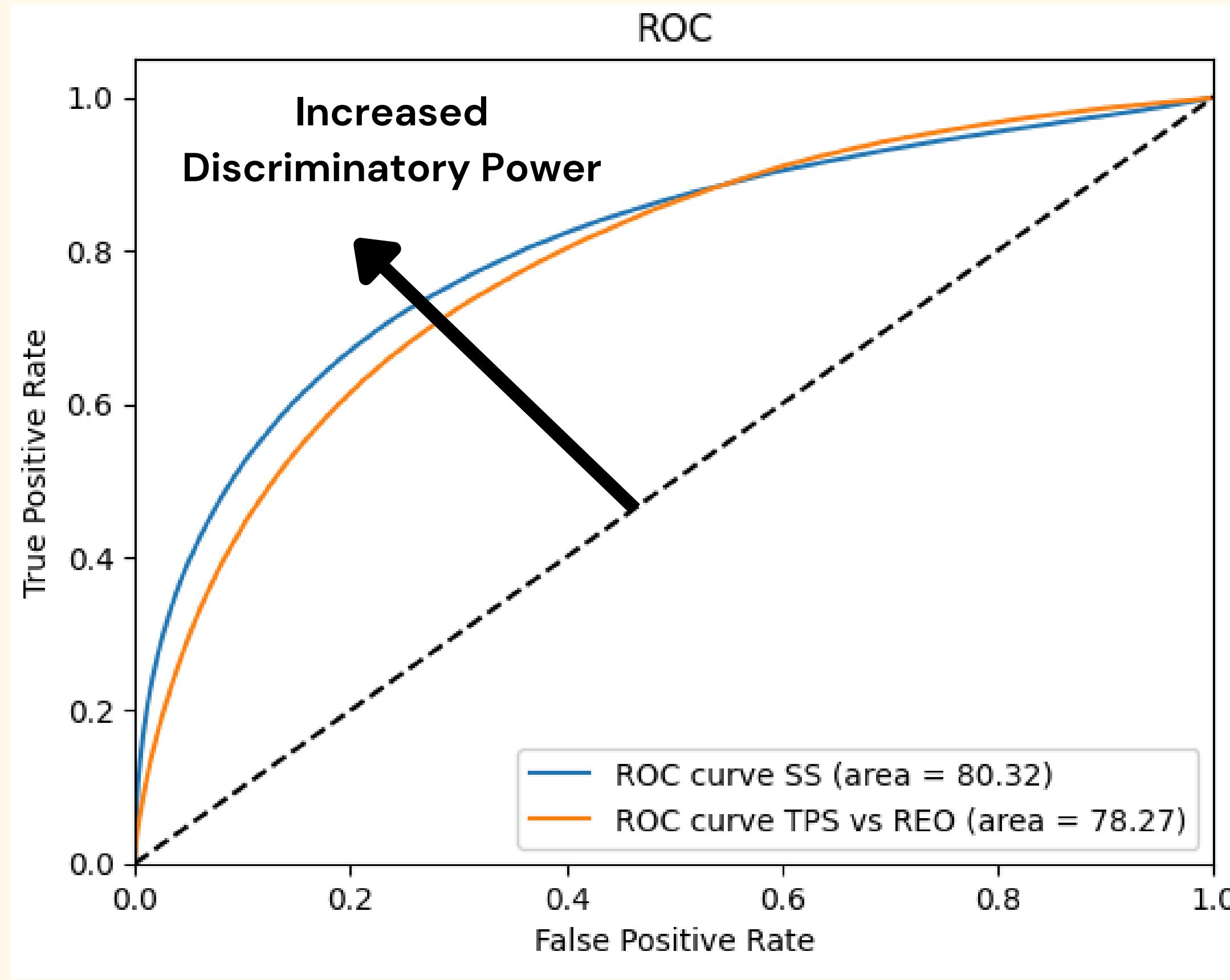
MODEL	KS	AUC-ROC
BASE	0.4717	80.32%
WITH NRI	0.4824	81.10%

REO (ZERO BALANCE CODE = 9) VS TPS(ZERO BALANCE CODE = 2)

MODEL	KS	AUC-ROC
BASE	0.4264	78.27%
WITH NRI	0.4777	81.40%



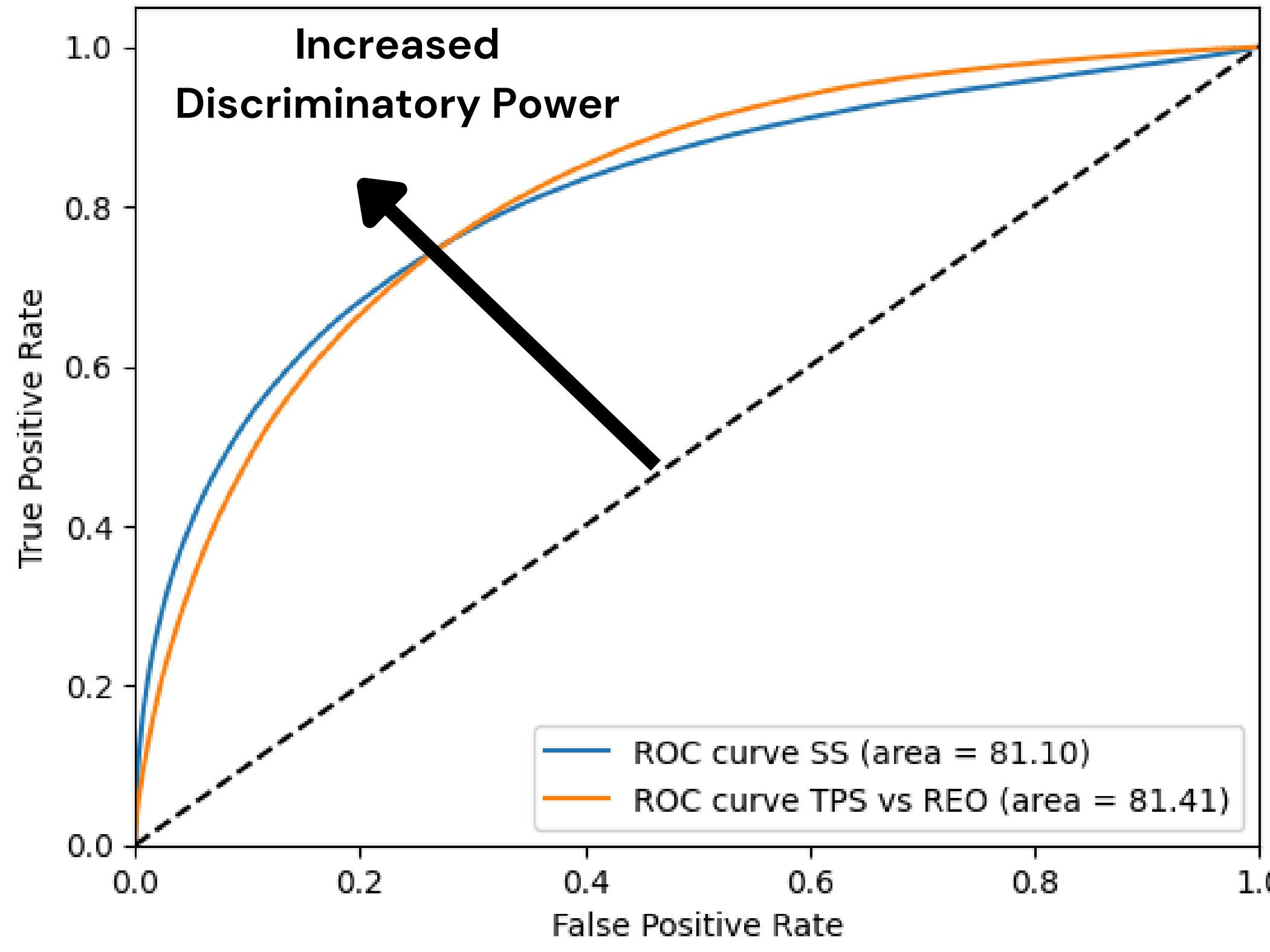
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ROC





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DATA LIMITATIONS

GEOGRAPHICAL PRECISION

A key limitation was the absence of precise geographical data, lacking exact zip codes for homes considered. This compromised climate data integration accuracy, potentially impacting the model's prediction reliability.

TEMPORAL MISMATCH

Another limitation arose from a temporal mismatch between climate and loan data; climate data from 2022 contrasted loans spanning 1999 to 2020, potentially skewing risk assessment accuracy and correlation with actual losses incurred.



RECOMMENDATIONS

- O1** FHFA should ensure GSE data comparability to maintain consistency and reliability in analysis and decision-making processes.
- O2** Fannie should adopt Freddie's practice of indicating disaster-related hardship reporting by servicers so that better disaster models can be implemented
- O3** FHFA should enhance data granularity by providing geographic details to facilitate more comprehensive and localized analysis insights.





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CONCLUSION

O1 SIGNIFICANCE BETWEEN RISK SCORE AND LOSS SEVERITY

Despite NRI data limitations, a significant positive relationship exists; more granular data from FHFA is recommended for stronger results.

O2 GSE EFFECT ON LOSS RATE AND LIKELIHOOD MODELS

We found a statistically significant GSE effect in the loss rate models and the probability models, indicating some variation in the way Freddie and Fannie handle such loans.

O3 IMPACT OF NATURAL DISASTERS ON HOMEOWNERS

Disaster impact on homeowners significant; informs product design for better climate risk management by Fannie and Freddie.

O4 DISASTER DECLARATION VARIABLES

Significant link to lower loss rates; possibly tied to insurance coverage, implying financial mitigation for homeowners.



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FUTURE SCOPE

- O1** Integrate macro economic and policy variables from Cordell paper for enhanced analysis.
- O2** Implement LTV amortization adjustments for accurate risk assessment.
- O3** Incorporate granular geographical data in the form of complete ZIP codes for precise modeling.
- O4** Assess individual hazards for varied loss severity implications.





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REFERENCES

01 Freddie Mac

<https://www.freddiemac.com/research/datasets/sf-loanlevel-dataset>

02 Fannie Mae

<https://capitalmarkets.fanniemae.com/credit-risk-transfer/single-family-credit-risk-transfer/fannie-mae-single-family-loan-performance-data>.

03 A New Loss Severity Model Framework for Residential Mortgages

<https://1library.net/document/zkoe34ly-new-loss-severity-model-framework-residential-mortgages.html>

04 Mortgage Loss Severities: What keeps them so high?

<https://www.philadelphiafed.org/-/media/frbp/assets/working-papers/2019/wp19-19.pdf>

05 FEMA

<https://www.fema.gov/about/openfema/data-sets>





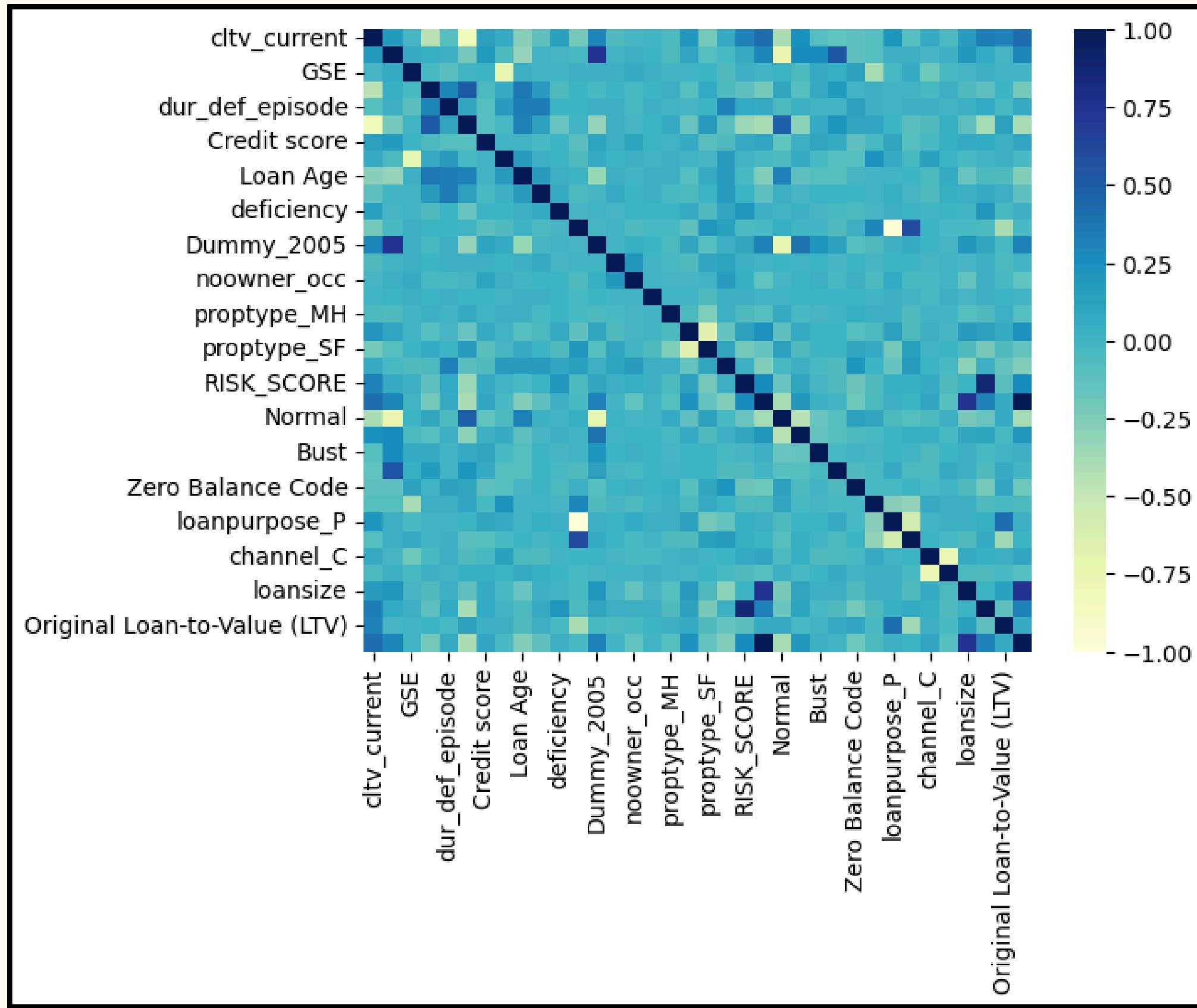
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APPENDIX





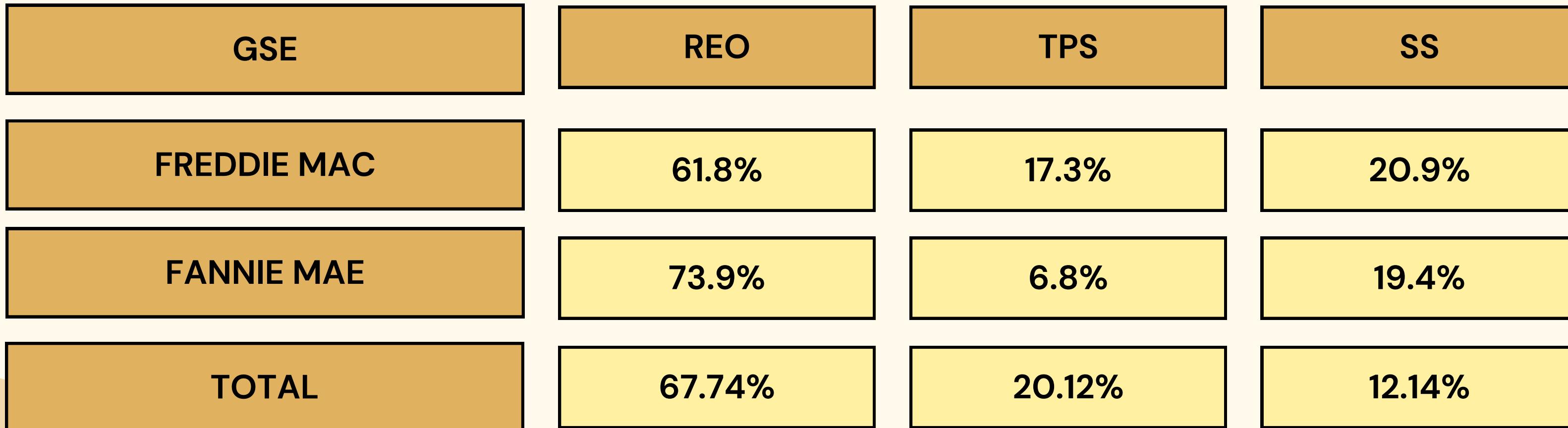
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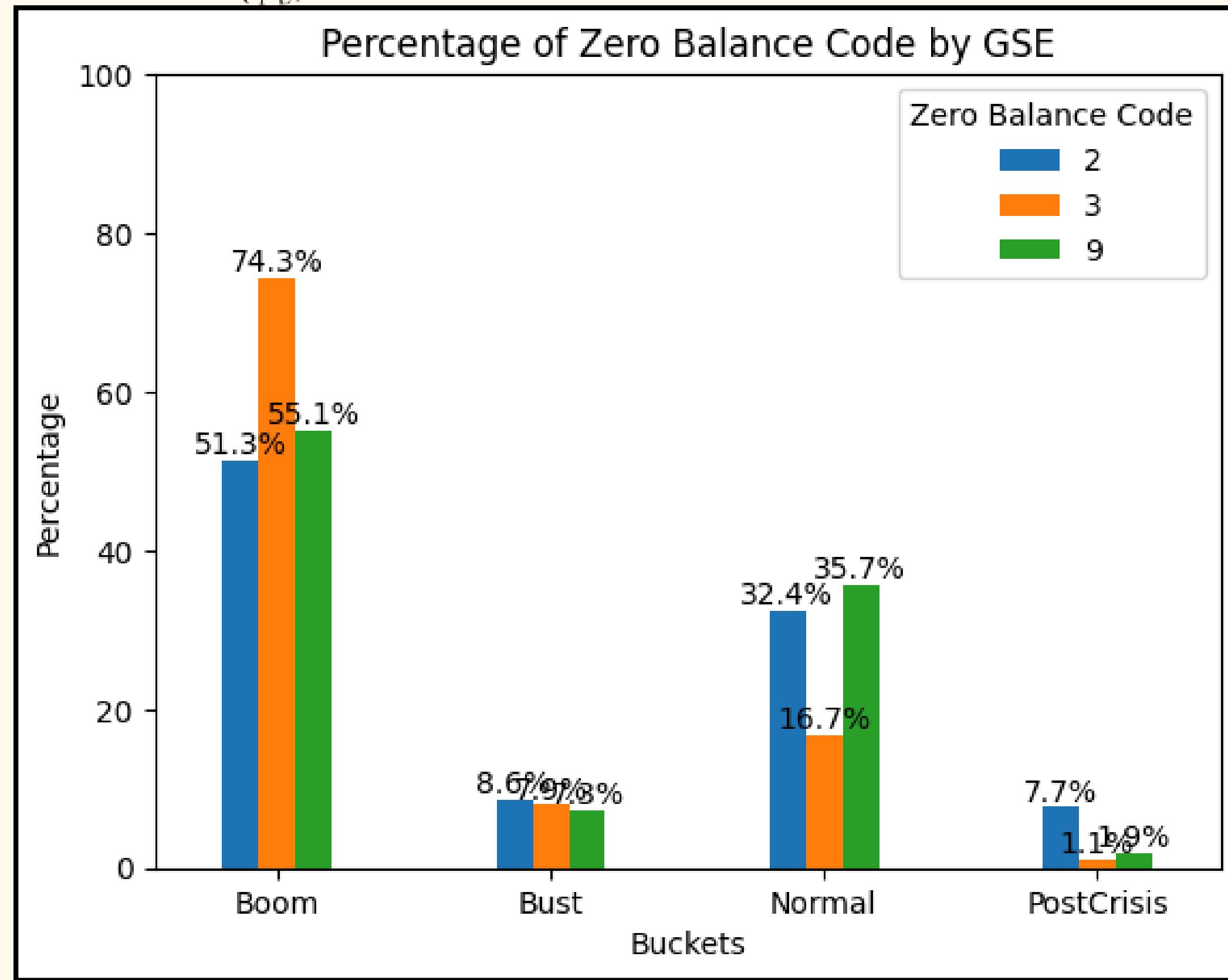
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GSE LOAN DISTRIBUTION BY REO, TPS AND SS



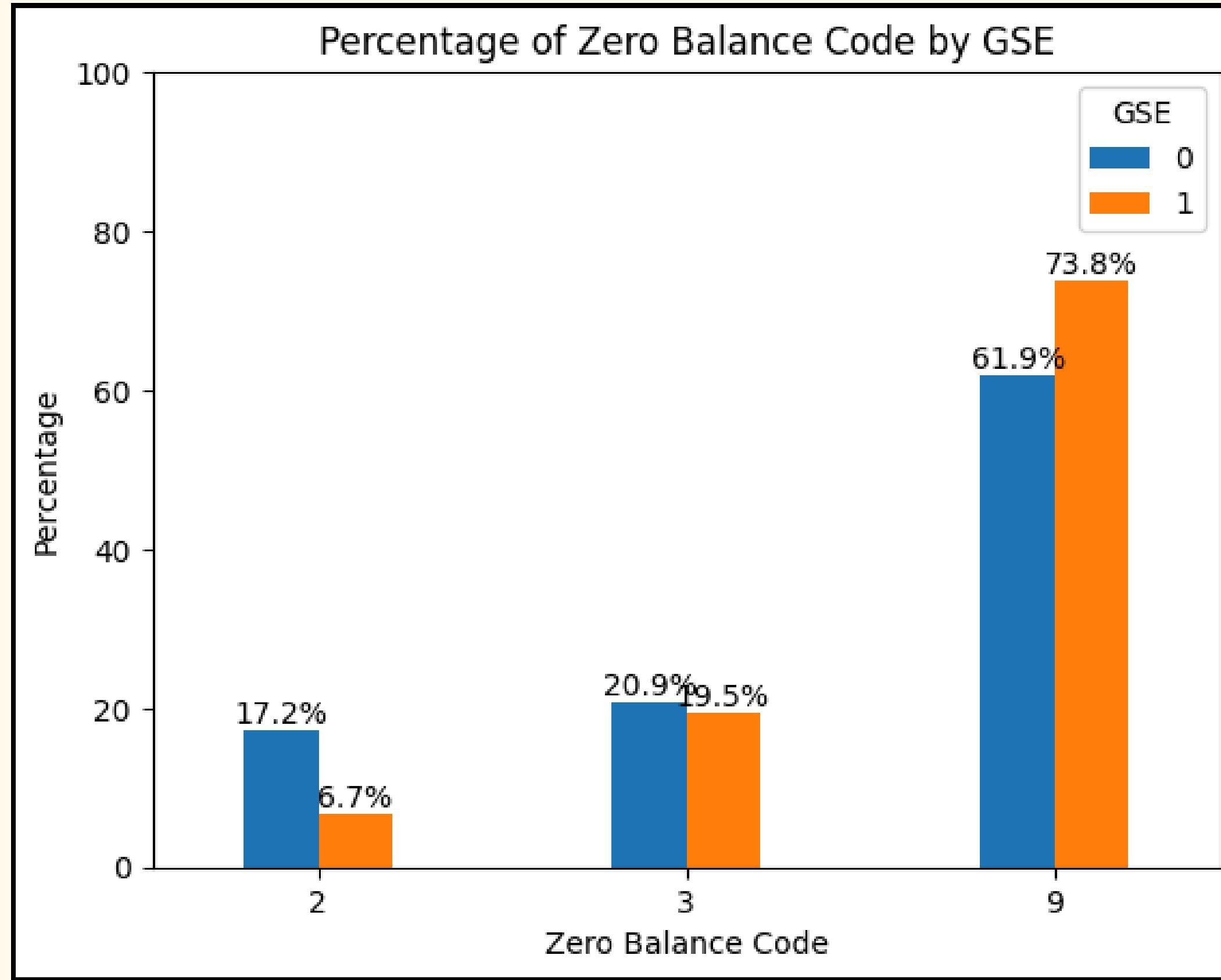


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orig_year	REO	TPS	SS
1999	71.29	23.24	5.47
2000	85.34	9.41	5.25
2001	83.56	9.83	6.61
2002	81.27	10.95	7.78
2003	75.15	13.66	11.19
2004	71.67	12.83	15.50
2005	63.73	12.23	24.04
2006	63.52	10.48	26.00
2007	64.14	9.85	26.01
2008	64.63	9.79	25.58
2009	63.56	14.23	22.21

orig_year	REO	TPS	SS
2010	64.25	20.81	14.95
2011	64.09	25.15	10.76
2012	61.76	29.62	8.62
2013	56.14	35.39	8.47
2014	57.27	34.60	8.13
2015	52.75	38.99	8.25
2016	48.05	43.46	8.48
2017	48.36	42.23	9.40
2018	44.54	45.63	9.83
2019	44.93	44.62	10.46
2020	45.07	49.83	5.10

LOAN
DISTRIBUTION
BY YEAR
(REO, TPS AND
SS)

OLS MODEL VARIABLES & COEFFICIENTS

Baseline				Baseline with NRI data				Baseline with disaster data			
	REO	TPS	SS		REO	TPS	SS		REO	TPS	SS
const	542.6909	317.8022	698.5565	const	543.3875	325.4823	696.7653	const	542.6557	325.4493	698.4685
cltv_current1	0.2728	0.7686	0.2341	cltv_current1	0.2741	0.7752	0.2343	cltv_current1	0.2727	0.7747	0.2332
cltv_current2	0.3065	0.5547	0.3843	cltv_current2	0.2963	0.553	0.3602	cltv_current2	0.3064	0.5531	0.3838
cltv_current3	0.182	0.1927	0.2139	cltv_current3	0.178	0.1952	0.2102	cltv_current3	0.1818	0.1952	0.2136
loansize	0.6646	-0.8495	-1.4733	loansize	1.7213	-0.6717	0.7398	loansize	0.6816	-0.6709	-1.4229
hpat2y	-50.3913	-34.4408	-28.6758	hpat2y	-50.233	-34.4237	-28.3752	hpat2y	-50.3678	-34.3907	-28.6863
loan_age	0.2115	0.1016	0.1099	loan_age	0.2115	0.1027	0.1067	loan_age	0.2115	0.1028	0.11
dur_def_episode	0.6416	0.693	0.7444	dur_def_episode	0.6349	0.6904	0.7353	dur_def_episode	0.6416	0.6906	0.7446
fico1	-0.039	-0.0012	-0.0304	fico1	-0.0379	0.0002	-0.0281	fico1	-0.039	0.0002	-0.0305
fico2	-0.0188	-0.0161	-0.0033	fico2	-0.0187	-0.0159	-0.0036	fico2	-0.0188	-0.0159	-0.0033
fico3	0.0107	0.0174	0.0082	fico3	0.0097	0.0164	0.0079	fico3	0.0107	0.0163	0.0081
Current Interest Rate	3.3749	2.5276	0.7789	Current Interest Rate	3.3679	2.5164	0.7942	Current Interest Rate	3.3744	2.5204	0.7823
judicial	3.3771	4.8717	-0.4722	judicial	3.1024	4.9224	-1.392	judicial	3.3639	4.917	-0.4802
deficiency	5.5214	5.6668	6.0367	deficiency	4.8445	5.6108	4.2082	deficiency	5.5113	5.618	5.9934
flag_24	15.3275	13.0865	14.5744	flag_24	14.98	12.9794	13.8735	flag_24	15.3219	12.9798	14.5645
noowner_occ	9.1362	8.379	7.6446	noowner_occ	8.8241	8.4792	7.4402	noowner_occ	9.1347	8.4798	7.6364
proptype_CP	19.8723	24.2358	-5.8844	proptype_CP	19.6752	22.7886	-6.1195	proptype_CP	19.88	22.8125	-5.8194
proptype_MH	3.5296	9.924	-1.6444	proptype_MH	4.4913	10.0347	-0.1748	proptype_MH	3.5428	10.042	-1.5935
proptype_PU	-6.951	-5.0834	-6.8077	proptype_PU	-6.5784	-5.0899	-6.1973	proptype_PU	-6.9397	-5.0818	-6.762
proptype_SF	0.776	2.4242	-2.4235	proptype_SF	1.4957	2.3814	-1.5326	proptype_SF	0.7861	2.3855	-2.3943
GSE	1.3098	-0.8547	-4.1837	GSE	1.1243	-0.7115	-4.2638	GSE	1.3097	-0.7062	-4.1826
prior_mod	14.8457	10.8023	7.4639	prior_mod	14.8668	10.7908	7.2655	prior_mod	14.8498	10.8025	7.4778
logupb1	-43.6196	-30.8942	-57.9958	logupb1	-44.2803	-31.6926	-59.2101	logupb1	-43.6168	-31.6826	-57.9711
logupb2	-21.91	-14.1617	-14.4387	logupb2	-23.4513	-14.1693	-17.4375	logupb2	-21.9389	-14.1705	-14.5216
channel_C	-1.3776	-0.8972	-1.1525	channel_C	-1.3854	-1.0148	-1.0467	channel_C	-1.3789	-1.0177	-1.1486
channel_R	-3.7924	-3.3423	-3.1743	channel_R	-3.6652	-3.3527	-2.8738	channel_R	-3.7916	-3.355	-3.1705
Boom	10.8471	9.3889	5.7251	Boom	10.9822	9.2521	5.9359	Boom	10.8526	9.2572	5.7472
Bust	15.8425	12.8405	6.8649	Bust	16.051	12.4927	7.0922	Bust	15.852	12.5017	6.904
PostCrisis	29.7966	15.4639	6.5045	PostCrisis	30.288	15.267	7.0348	PostCrisis	29.8266	15.3112	6.6605
loanpurpose_N	0.0867	-0.9153	0.4277	loanpurpose_N	0.0769	-1.0729	0.3922	loanpurpose_N	0.0871	-1.0783	0.4228
loanpurpose_P	-12.8403	-8.1881	-8.9744	loanpurpose_P	-12.8566	-8.4428	-8.9036	loanpurpose_P	-12.839	-8.4436	-8.9698
loanpurpose_C	4.8028	3.3667	3.0708	loanpurpose_C	4.7029	3.2889	2.8498	loanpurpose_C	4.8011	3.2836	3.0678
EAL_SCORE		0.075	0.0012	EAL_SCORE		0.075	0.1773	disaster_6m		-1.5328	-1.4265

OLS MODEL VARIABLE SIGNIFICANCE

Legend	
No Symbol	p<0.0005
**	p<0.005
*	p<0.05
"	p>0.05

Baseline Dummies	
loanpurpose_R	Refinance - Unknown
channel_T	Third-Party Origination
proptype_CO	Condo
Normal	1999<=year<=2004

Non-Climate Vars			
	REO	TPS	SS
const	542.691	317.802	698.556
cltv_current1	0.273	0.769	0.234
cltv_current2	0.306	0.555	0.384
cltv_current3	0.182	0.193	0.214
loansize	0.665	-0.85**	-1.473
hpat2y	-50.391	-34.441	-28.676
loan_age	0.211	0.102	0.11
dur_def_episode	0.642	0.693	0.744
fico1	-0.039	-0.001"	-0.03
fico2	-0.019	-0.016	-0.003*
fico3	0.011**	0.017*	0.008"
Current Interest Rate	3.375	2.528	0.779
judicial	3.377	4.872	-0.472
deficiency	5.521	5.667	6.037
flag_24	15.327	13.087	14.574
noowner_occ	9.136	8.379	7.645
proptype_CP	19.872	24.236	-5.884
proptype_MH	3.53	9.924	-1.644*
proptype_PU	-6.951	-5.083	-6.808
proptype_SF	0.776	2.424	-2.423
GSE	1.31	-0.855**	-4.184
prior_mod	14.846	10.802	7.464
logupb1	-43.62	-30.894	-57.996
logupb2	-21.91	-14.162	-14.439
channel_C	-1.378	-0.897*	-1.153
channel_R	-3.792	-3.342	-3.174
Boom	10.847	9.389	5.725
Bust	15.843	12.841	6.865
PostCrisis	29.797	15.464	6.504
loanpurpose_N	0.087"	-0.915*	0.428"
loanpurpose_P	-12.84	-8.188	-8.974
loanpurpose_C	4.803	3.367	3.071

Climate Vars			
	REO	TPS	SS
const	543.388	325.482	696.765
cltv_current1	0.274	0.775	0.234
cltv_current2	0.296	0.553	0.36
cltv_current3	0.178	0.195	0.21
loansize	1.721	-0.672**	0.74
hpat2y	-50.233	-34.424	-28.375
loan_age	0.211	0.103	0.107
dur_def_episode	0.635	0.69	0.735
fico1	-0.038	0"	-0.028
fico2	-0.019	-0.016	-0.004*
fico3	0.01*	0.016*	0.008"
Current Interest Rate	3.368	2.516	0.794
judicial	3.102	4.922	-1.392
deficiency	4.845	5.611	4.208
flag_24	14.98	12.979	13.873
noowner_occ	8.824	8.479	7.44
proptype_CP	19.675	22.789	-6.12
proptype_MH	4.491	10.035	-0.175
proptype_PU	-6.578	-5.09	-6.197
proptype_SF	1.496	2.381	-1.533
GSE	1.124	-0.711**	-4.264
prior_mod	14.867	10.791	7.266
logupb1	-44.28	-31.693	-59.21
logupb2	-23.451	-14.169	-17.438
channel_C	-1.385	-1.015**	-1.047
channel_R	-3.665	-3.353	-2.874
Boom	10.982	9.252	5.936
Bust	16.051	12.493	7.092
PostCrisis	30.288	15.267	7.035
loanpurpose_N	0.077"	-1.073*	0.392"
loanpurpose_P	-12.857	-8.443	-8.904
loanpurpose_C	4.703	3.289	2.85
EAL_SCORE	0.075	0.001"	0.177

Include disaster_6m			
	REO	TPS	SS
const	542.656	325.449	698.469
cltv_current1	0.273	0.775	0.233
cltv_current2	0.306	0.553	0.384
cltv_current3	0.182	0.195	0.214
loansize	0.682	-0.671**	-1.423
hpat2y	-50.368	-34.391	-28.686
loan_age	0.212	0.103	0.11
dur_def_episode	0.642	0.691	0.745
fico1	-0.039	0"	-0.03
fico2	-0.019	-0.016	-0.003*
fico3	0.011**	0.016*	0.008"
Current Interest Rate	3.374	2.52	0.782
judicial	3.364	4.917	-0.48
deficiency	5.511	5.618	5.993
flag_24	15.322	12.98	14.564
noowner_occ	9.135	8.48	7.636
proptype_CP	19.88	22.812	-5.819
proptype_MH	3.543	10.042	-1.594*
proptype_PU	-6.94	-5.082	-6.762
proptype_SF	0.786	2.385	-2.394
GSE	1.31	-0.706**	-4.183
prior_mod	14.85	10.802	7.478
logupb1	-43.617	-31.683	-57.971
logupb2	-21.939	-14.171	-14.522
channel_C	-1.379	-1.018**	-1.149
channel_R	-3.792	-3.355	-3.171
Boom	10.853	9.257	5.747
Bust	15.852	12.502	6.904
PostCrisis	29.827	15.311	6.66
loanpurpose_N	0.087"	-1.078*	0.423"
loanpurpose_P	-12.839	-8.444	-8.97
loanpurpose_C	4.801	3.284	3.068
disaster_6m	-1.533	-1.426*	-4.458

OLS MODEL INTERPRETATION

Overall Hypotheses	
cltv_current1	Higher current CLTV implies the loan is deeper underwater (note ours is not adjusted for amortization)
cltv_current2	Higher current CLTV implies the loan is deeper underwater (note ours is not adjusted for amortization)
cltv_current3	Higher current CLTV implies the loan is deeper underwater (note ours is not adjusted for amortization)
loansize	The higher the loan size is relative to the median MSA loan, the higher the loss severity (different from Yang's findings, which have negative coefficient)
hpat2y	Higher house price appreciation decreases loss rate as the property will be sold most likely at a higher market price.
loan_age	A longer loan age generally means a lower unpaid balance, which affects the denominator of loss rate more than the numerator (according to Yang).
dur_def_episode	The longer the mortgage is in delinquency, the higher the interest lost. A longer timeline implies the property is being sold at a lower price (likely due to property damage).
fico1	Generally, higher fico means less severe delinquency status
fico2	Generally, higher fico means less severe delinquency status
fico3	However, very high fico borrowers who have defaulted likely have had a more severe event impact them
Current Interest Rate	The higher the current interest rate, the more difficult it is to make payments. The loss severity should increase since the value of the loan is relatively higher to others in the market.
judicial	Judicial states can increase the foreclosure timeline, leading to higher loss severities. This does not matter as much for short-sale loans since it does not reach court (?)
deficiency	Expect loss rates to be lower, but that is not the case, and it is consistent with the tyler yang paper, maybe cost-benefit analysis of loss vs legal fees
flag_24	Properties with more units could be in worse condition
noowner_occ	Non-owner occupied units are likely to be in worse condition
proptype_CP	Worse condition
proptype_MH	Worse condition
proptype_PU	Planned Unit Development properties have HOA fees, which increase likelihood of maintaining the property value.
proptype_SF	
GSE	GSE 1(Fannie Mae) contributes positively to REO Loss Rate, and negatively to other 2 models, which means Fannie Mae does not handle their REO disposition as effectively as Freddie Mac, opposite for other 2
prior_mod	New servicing rules which increase loan modifications have lengthened timelines and elevated foreclosure costs (Cordell), which increase loss severity.
Log Original UPB	
channel_C	Correspondent and Retail channels have lower loss severity than Third Party originated loans.
channel_R	Correspondent and Retail channels have lower loss severity than Third Party originated loans.
Normal	Underwriting periods 1999 to 2004
Boom	Underwriting periods 2005 to mid 2008
Bust	Underwriting periods mid 2008 to 2011
PostCrisis	Underwriting periods 2012 to 2020: Loss severity has increased post-crisis due to lengthened foreclosure timelines
loanpurpose_N	
loanpurpose_P	
loanpurpose_C	Since the borrowers are taking out equity, this may be an indicator of bad financial conditions of the borrower. The borrower may also have stopped taking care of the property.
EAL_SCORE	Higher score, high loss rates
disaster_6m	Expected loss rates to be higher for higher number of disasters but that is not the case, could be due to them getting insurance money to repair their homes, but further investigation required

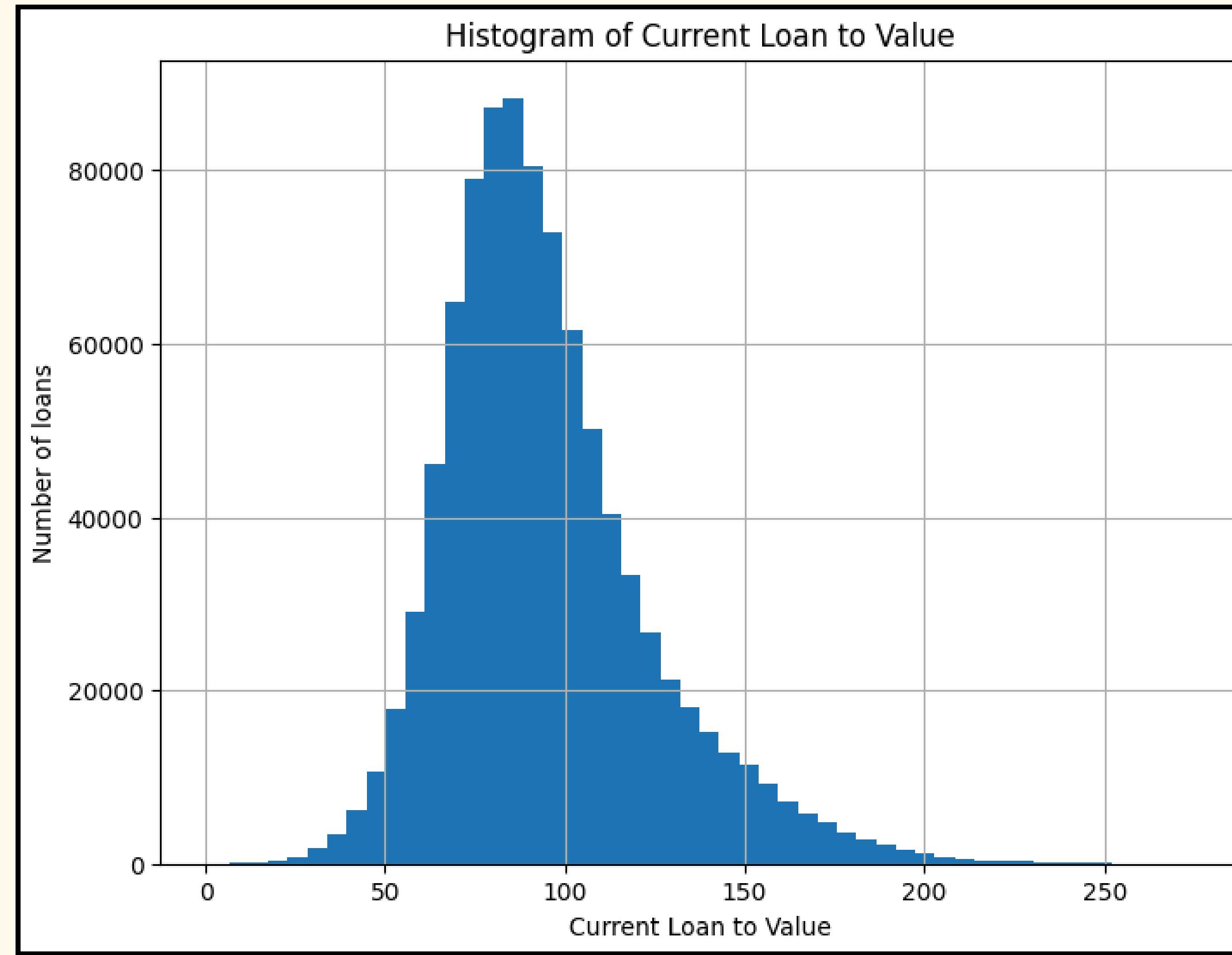
LOGIT MODEL COEFFICIENTS

& INTERPRETATION

Variables	SS vs Non SS		TPS vs REO		Higher Value leads to	
	Without NRI	With NRI	Without NRI	With NRI	Without NRI	With NRI
const	-15.989	-16.488	-6.979	-5.600	REO	REO
cltv_current1	0.019	0.023	-0.052	-0.046	SS	SS
cltv_current2	0.025	0.019	0.002	-0.009	SS	SS
cltv_current3	0.003	0.003	0.017	0.010	SS	SS
fico1	-0.002	-0.002	0.001	0.001	TPS	TPS
fico2	0.003	0.003	0.001	0.001	SS	SS
fico3	0.003	0.003	0.000	0.000	SS	SS
hpat2y	0.969	1.033	2.125	2.248	SS	SS
dur_def_episode	-0.083	-0.087	-0.031	-0.032	REO	REO
judicial	1.044	0.915	0.056	0.416	SS	SS
deficiency	-0.162	-0.136	0.384	0.070	TPS	TPS
flag_24	0.351	0.293	0.111	0.121	SS	SS
noowner_occ	0.141	0.104	-0.033	-0.153	SS	SS
proptype_CP	-0.318	-0.461	-0.599	-0.863	REO	REO
proptype_MH	-0.745	-0.695	-0.770	-0.840	REO	REO
proptype_PU	-0.272	-0.177	0.018	0.108	TPS	TPS
proptype_SF	-0.401	-0.262	-0.299	-0.100	REO	REO
GSE	-0.555	-0.573	-1.691	-1.783	REO	REO
Boom	0.167	0.180	0.343	0.352	SS	SS
Bust	0.242	0.267	0.537	0.596	SS	SS
PostCrisis	-0.450	-0.380	1.559	1.745	TPS	TPS
channel_C	-0.023	-0.005	0.149	0.141	TPS	TPS
channel_R	-0.059	-0.035	0.190	0.211	TPS	TPS
loanpurpose_N	-0.046	-0.053	0.037	0.007	TPS	TPS
loanpurpose_P	-0.110	-0.130	0.079	0.060	TPS	TPS
loanpurpose_C	0.082	-0.006	0.163	-0.008	SS	REO
Current Interest	-0.098	-0.095	-0.185	-0.185	REO	REO
loan_age	0.005	0.005	0.012	0.013	SS	SS
Log Original UPB	1.233	1.138	0.614	0.374	SS	SS
CWAV_EALR		0.026		-0.142		SS
ERQK_EALR		-0.078		0.280		TPS
HAIL_EALR		-0.228		0.009		TPS
HWAV_EALR		-0.006		0.062		TPS
ISTM_EALR		0.063		-0.098		SS
LNDS_EALR		0.265		0.078		SS
LTNG_EALR		0.125		0.118		SS
RFLD_EALR		0.120		0.045		SS
SWND_EALR		0.086		0.007		SS
TRND_EALR		-0.066		-0.006		REO
WFIR_EALR		0.092		0.054		SS
WNTW_EALR		-0.069		-0.065		REO

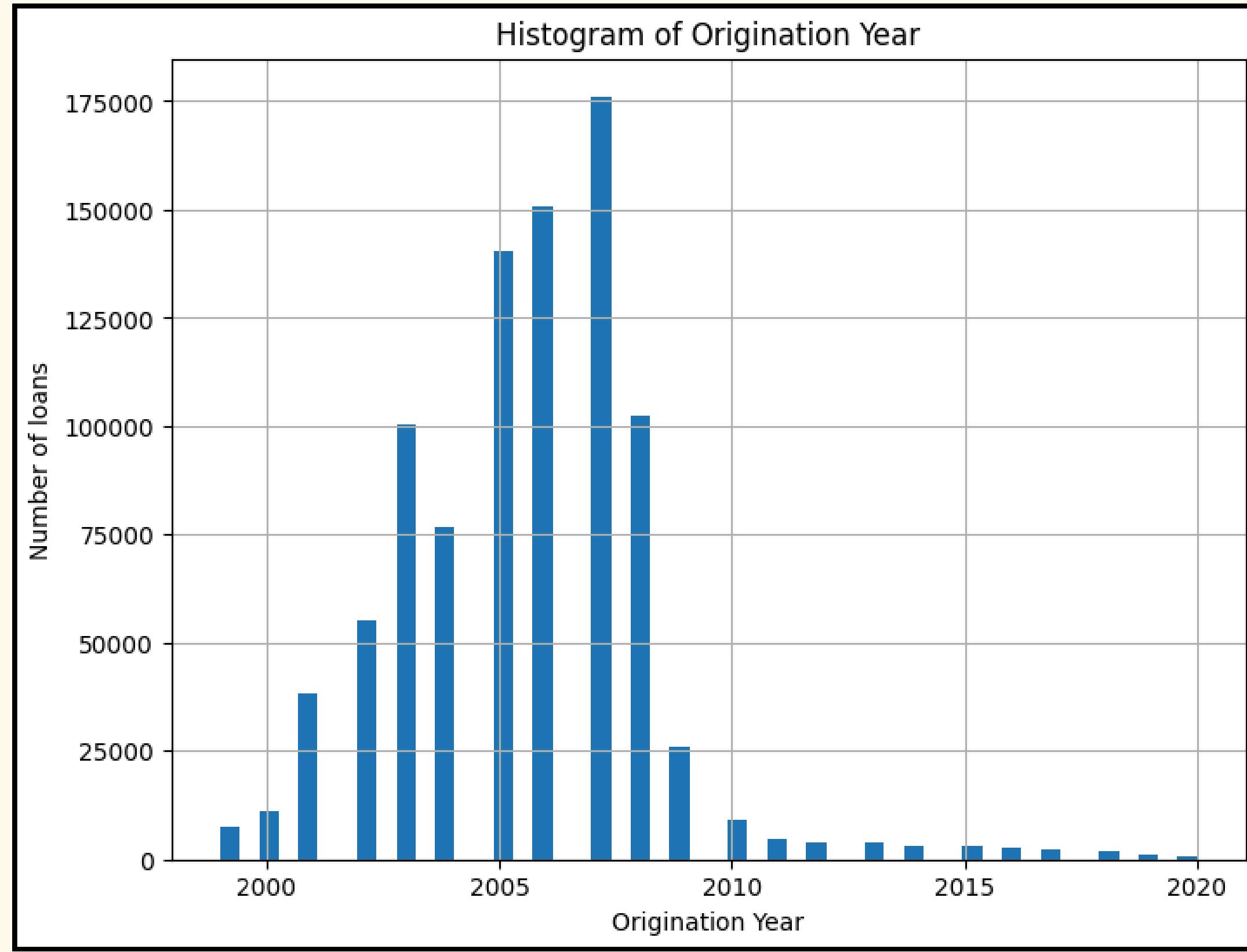


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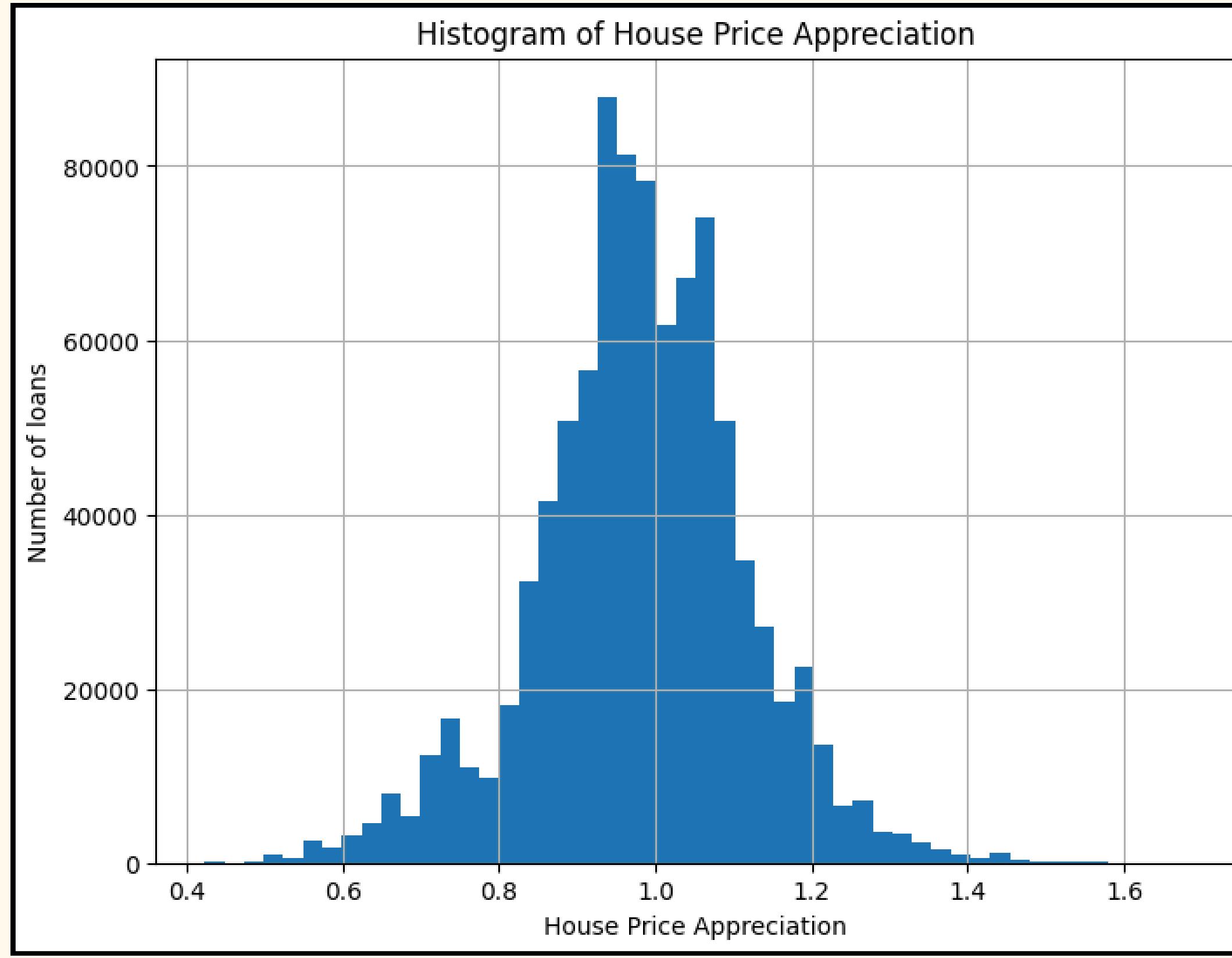


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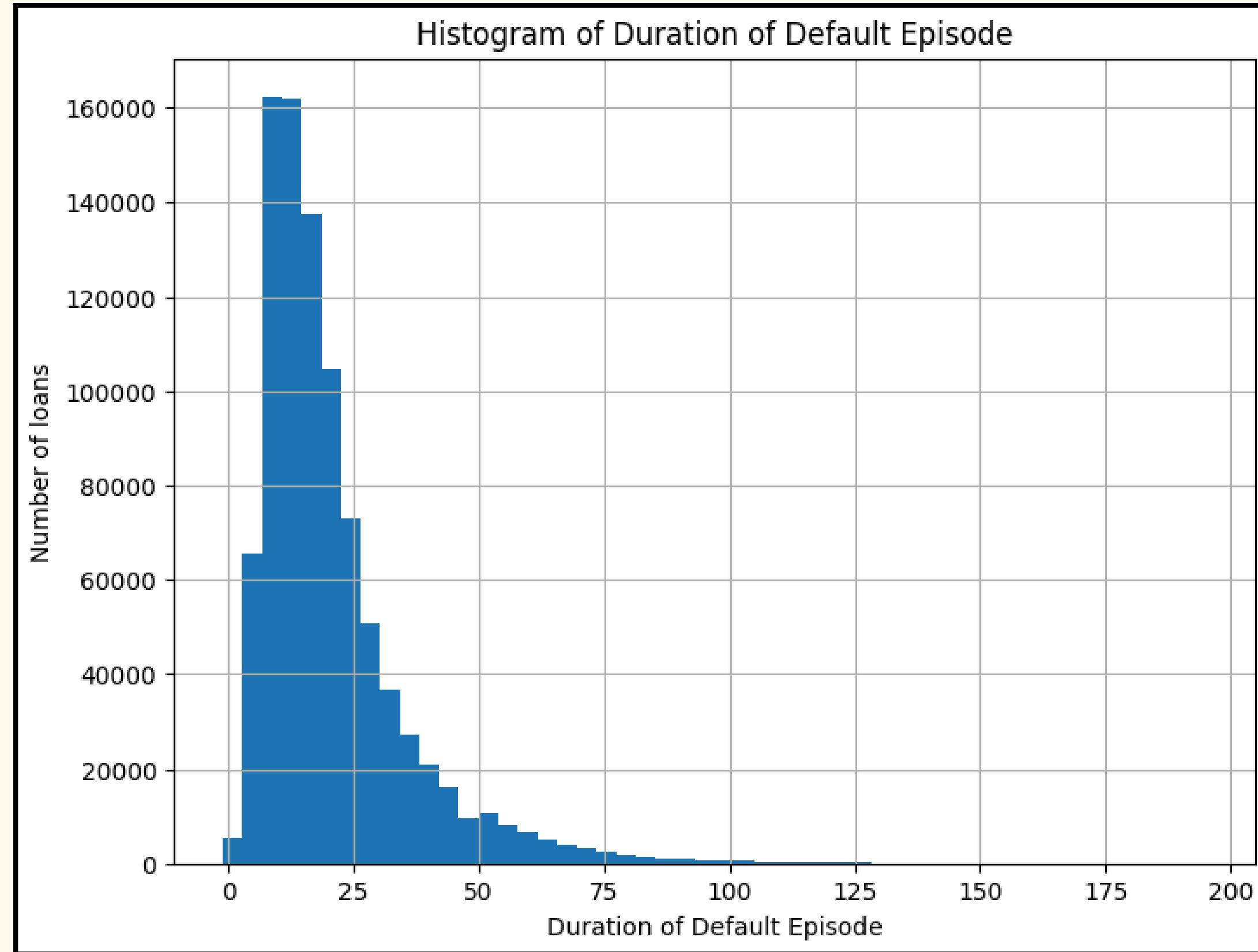


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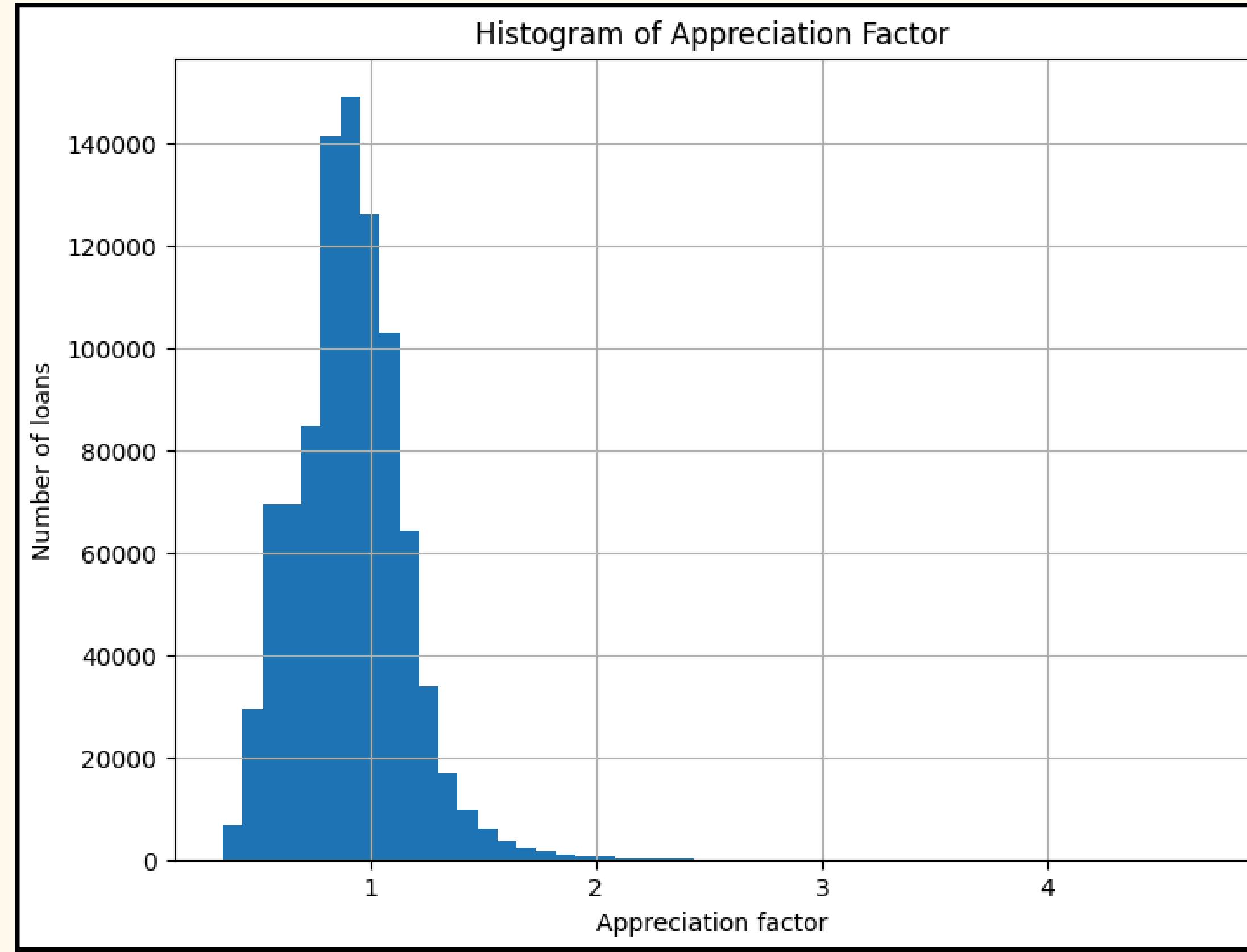


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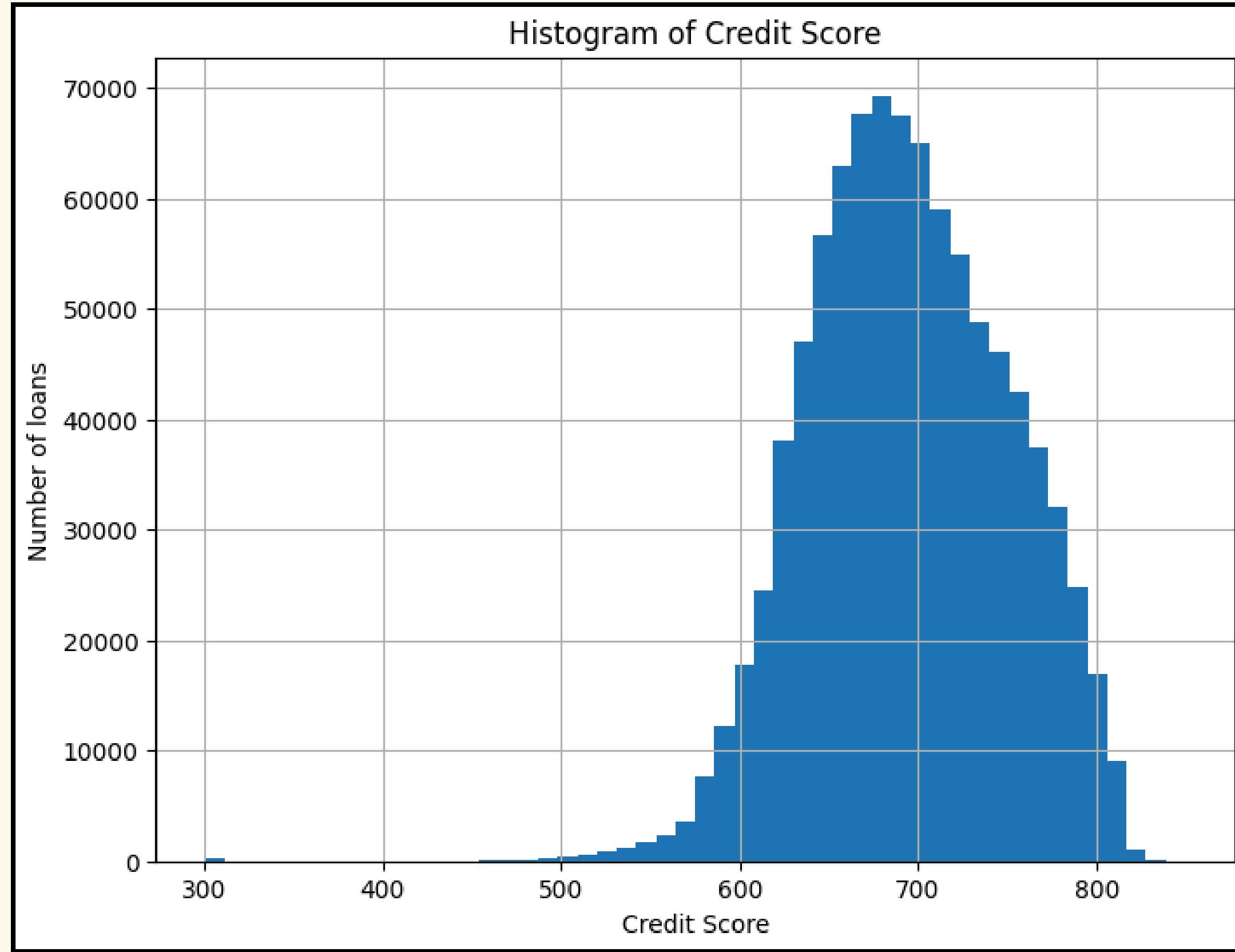


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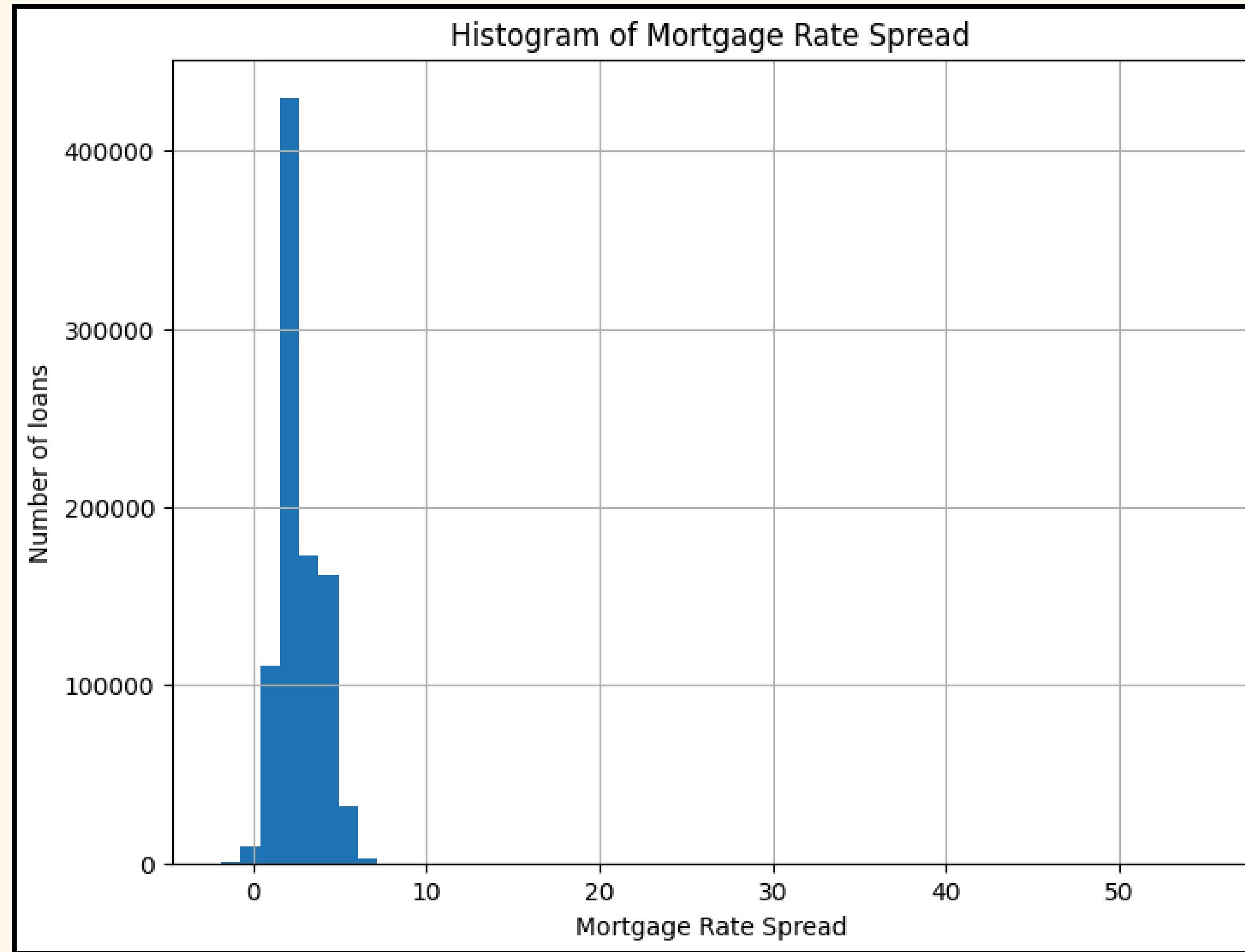


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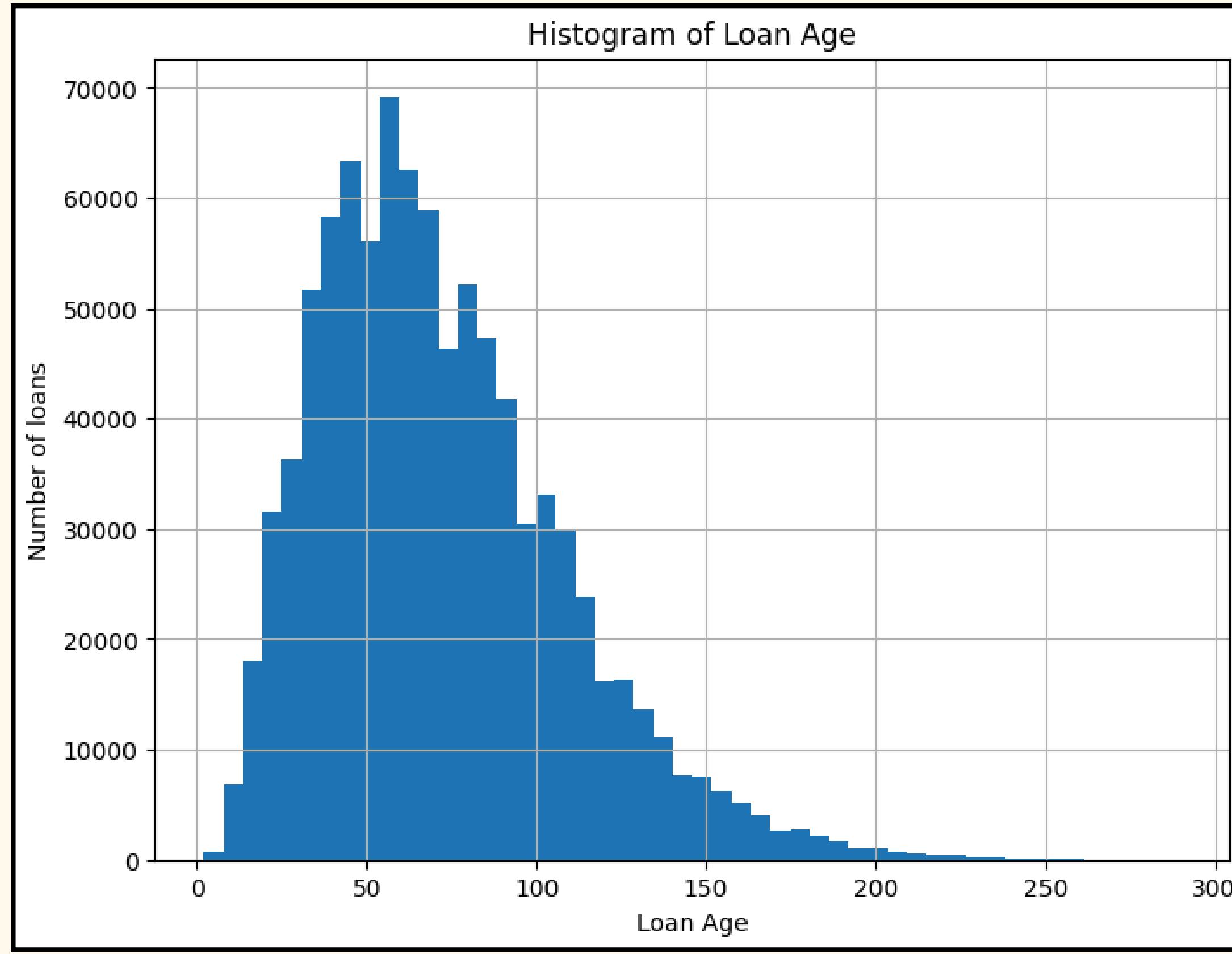


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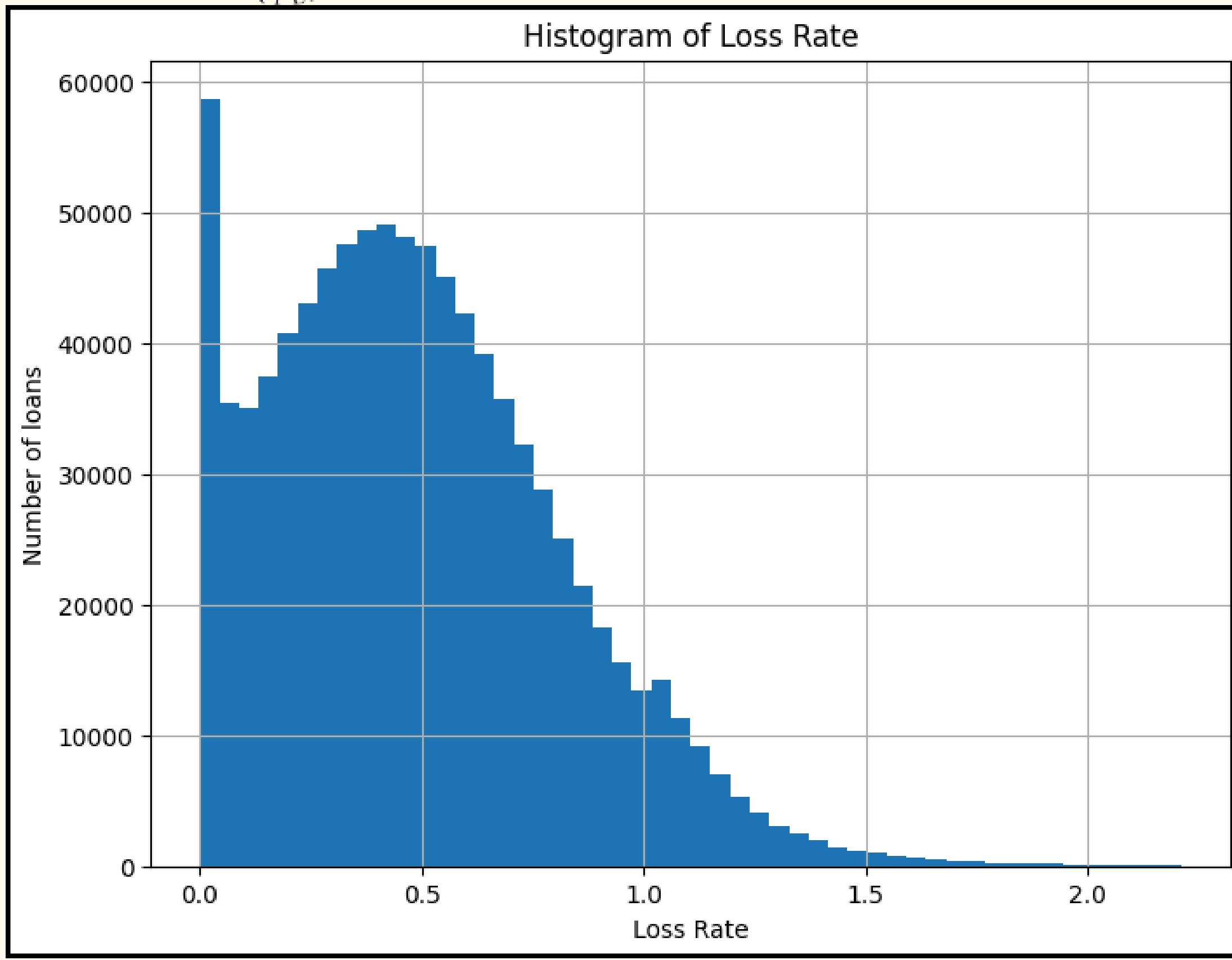


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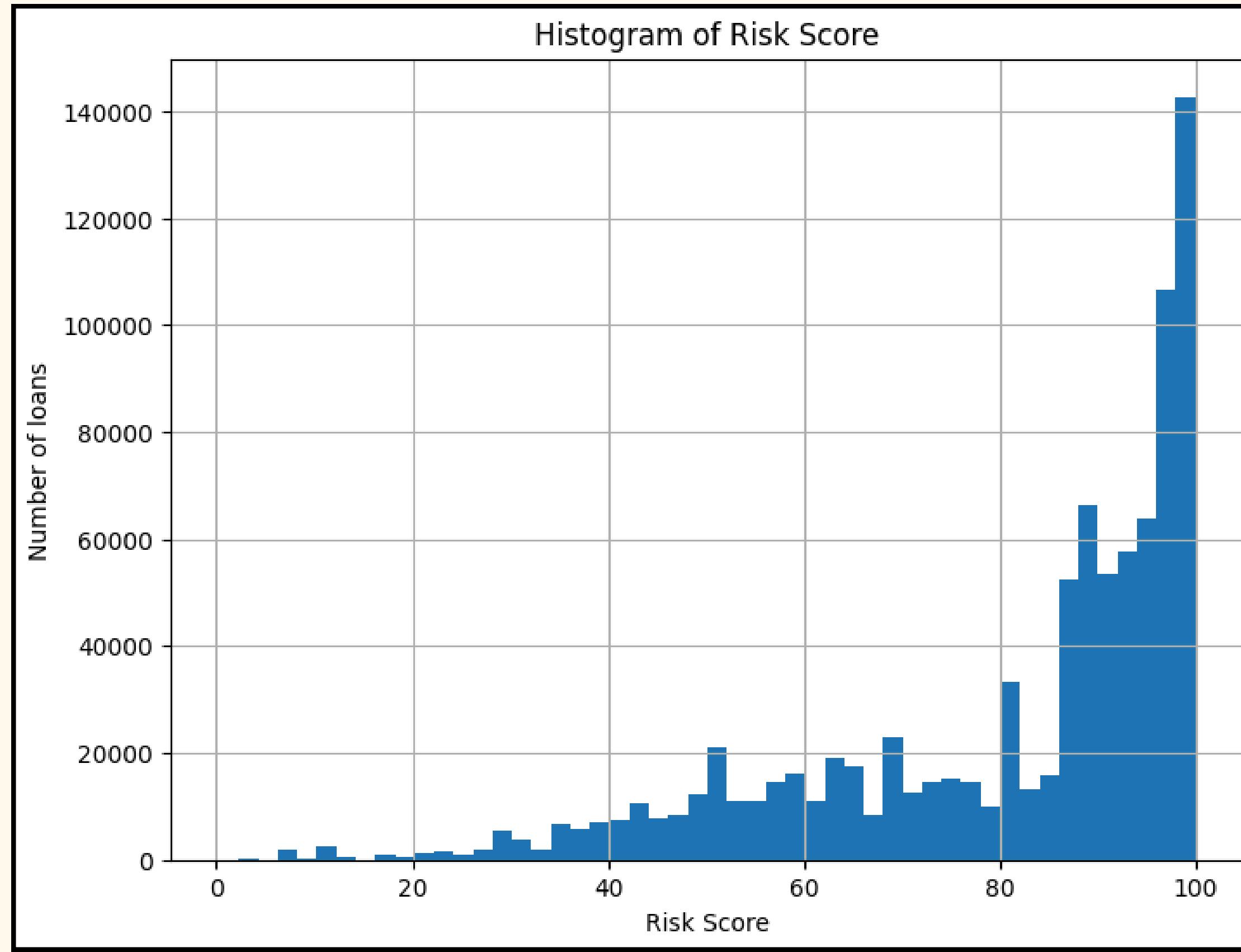


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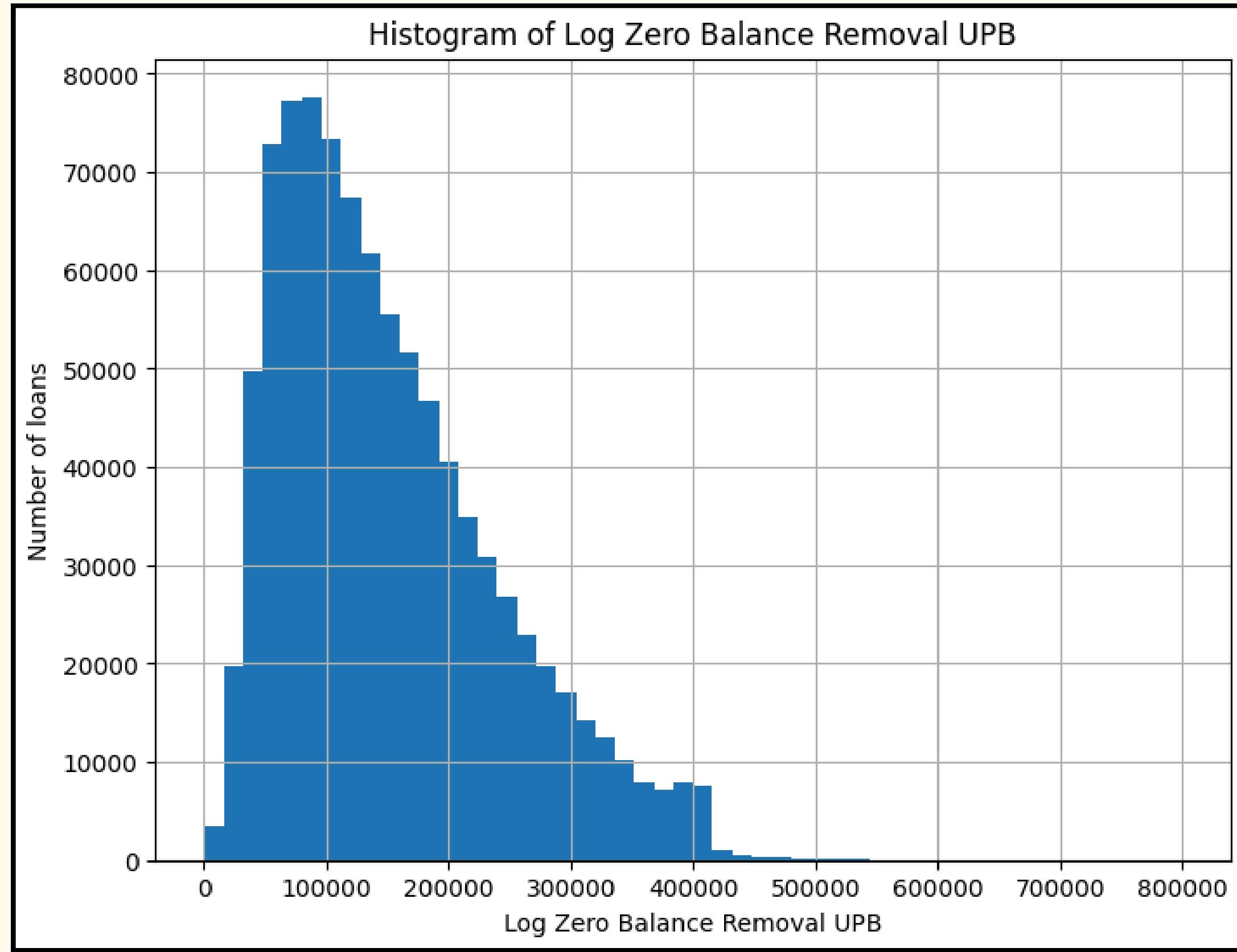


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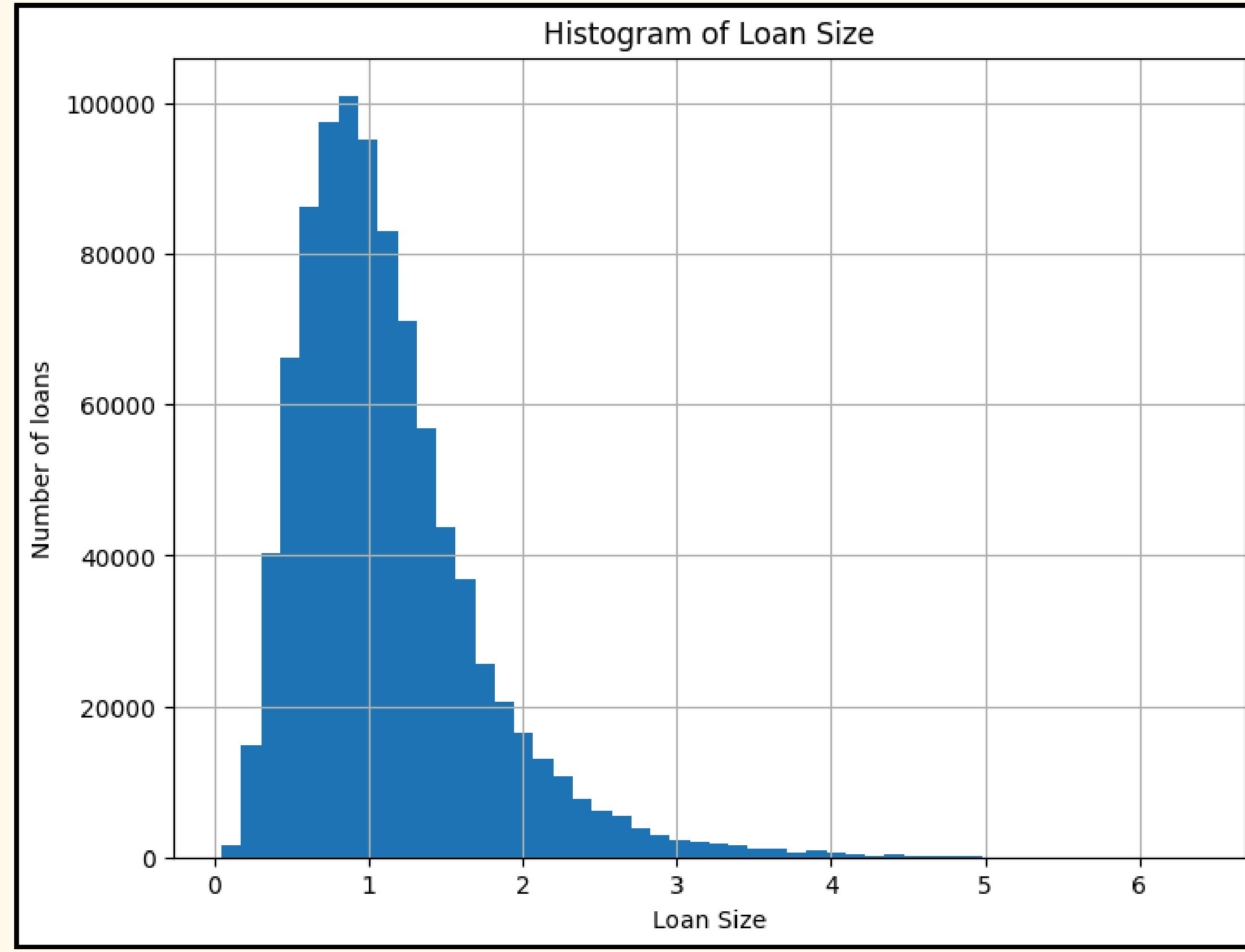


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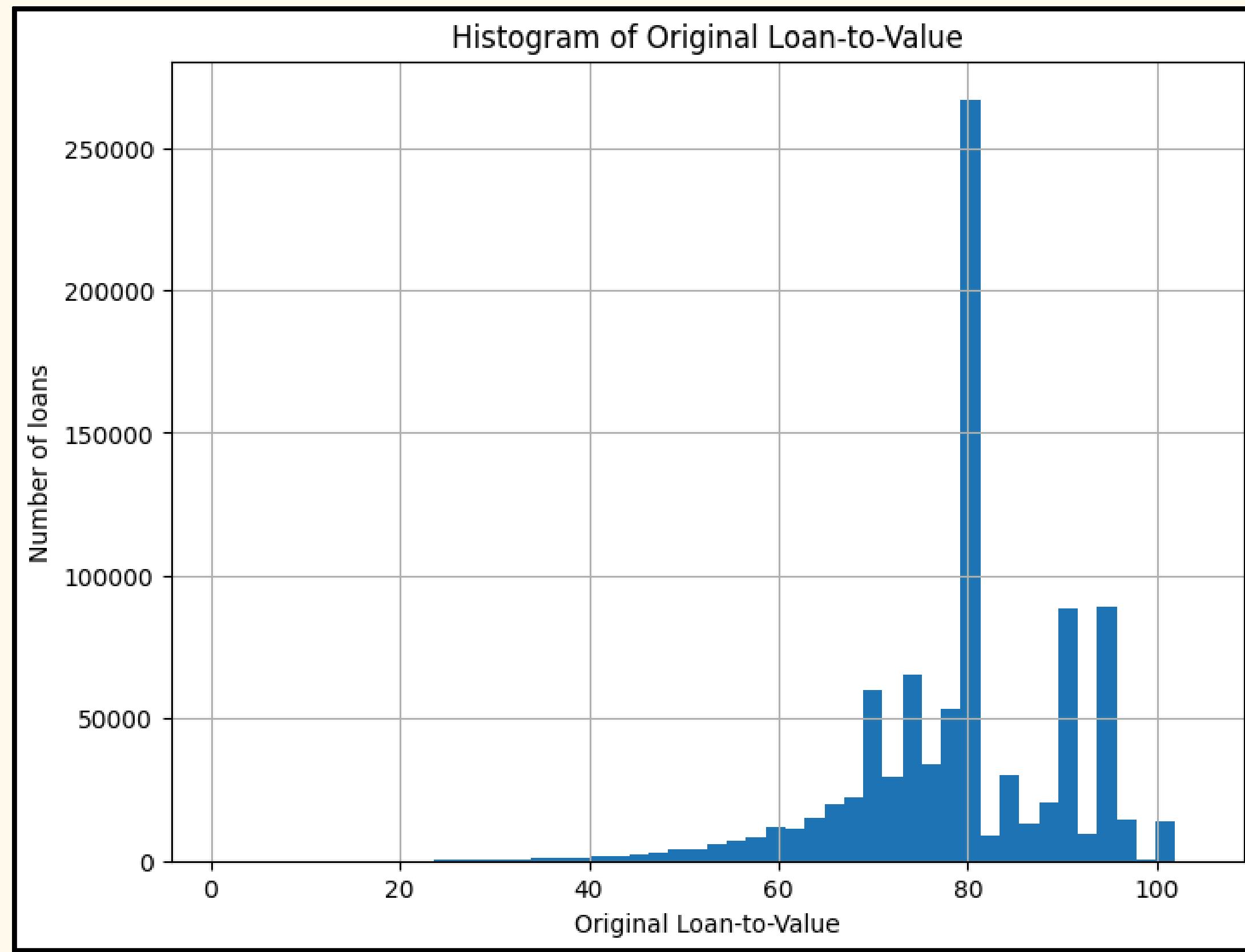


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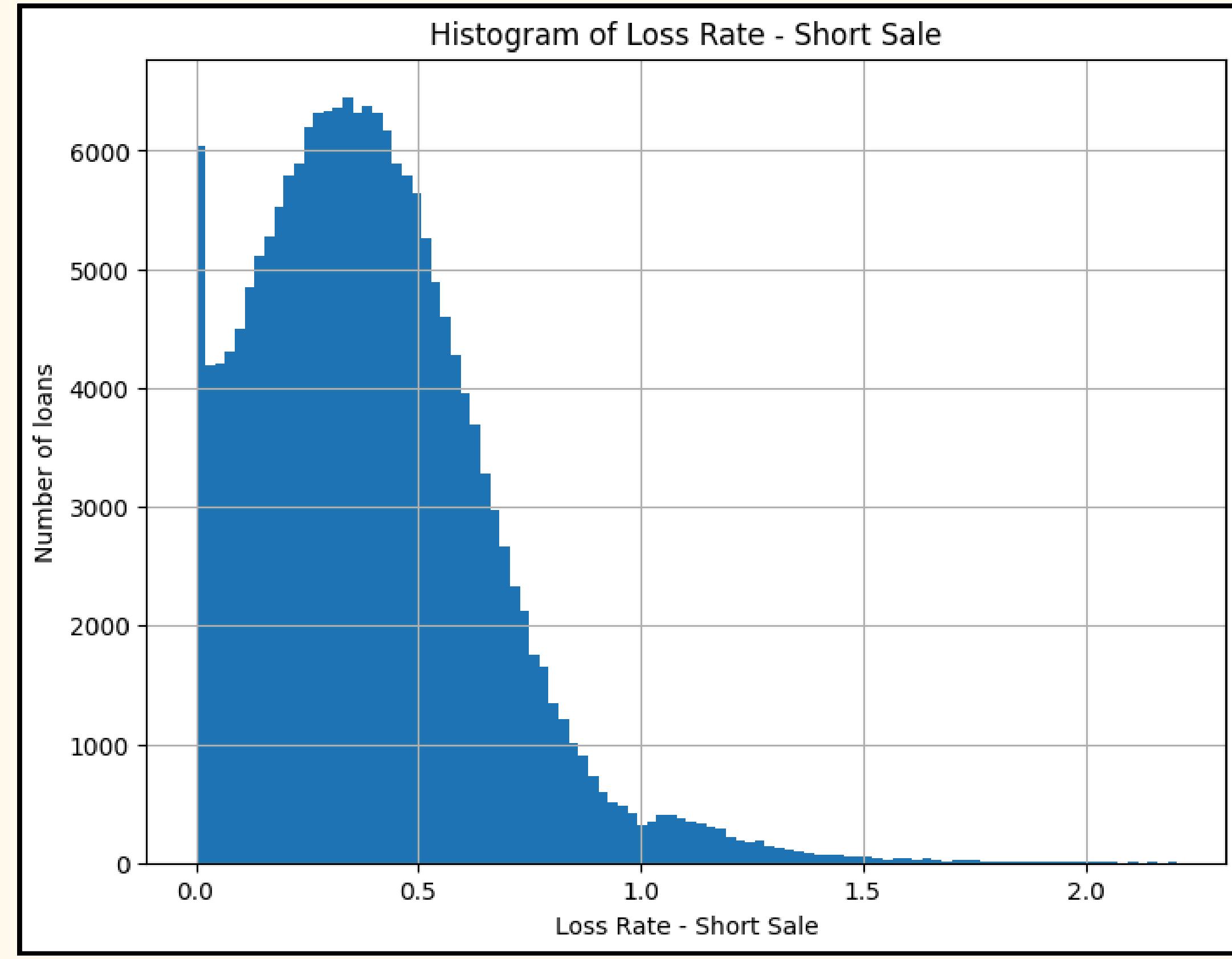


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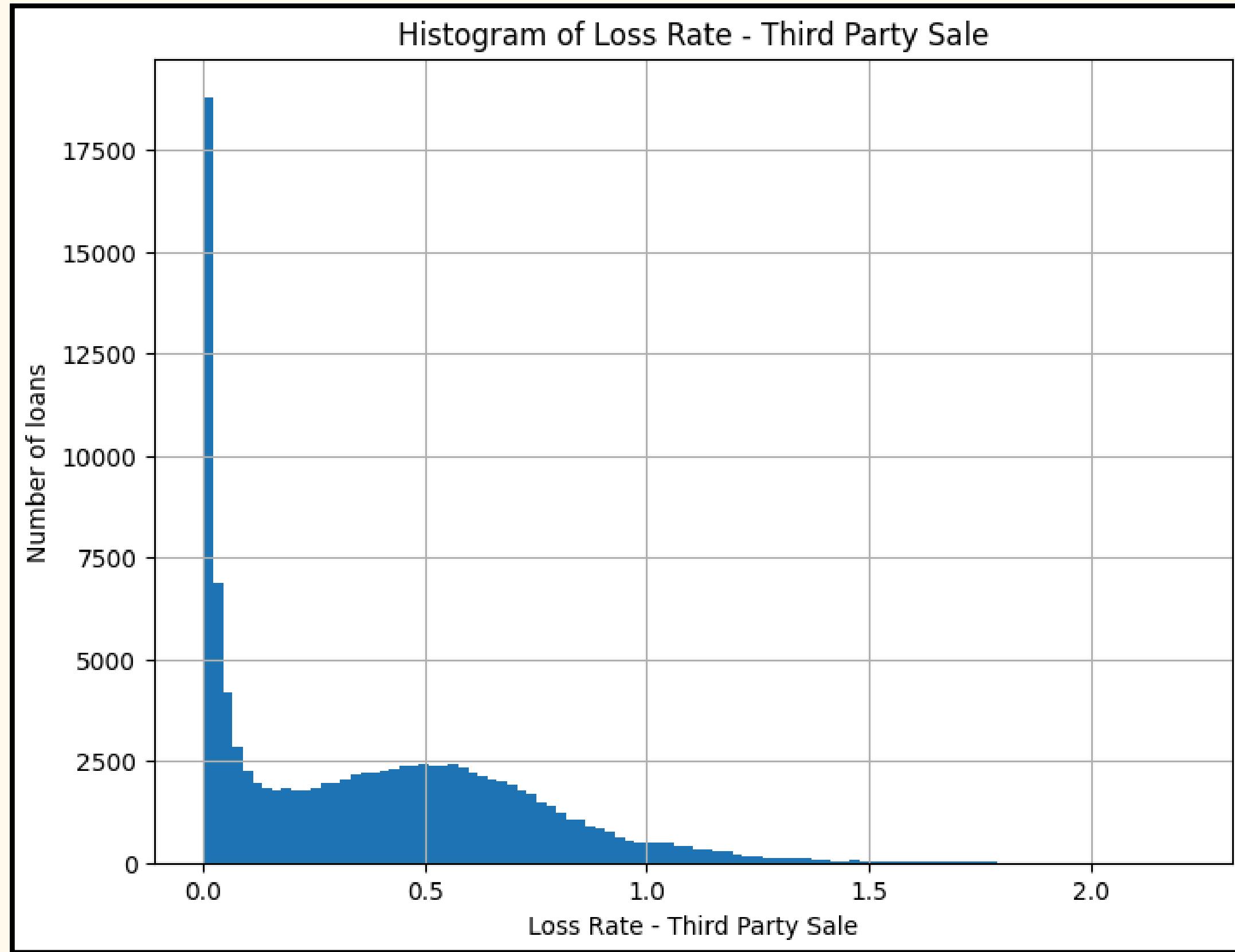


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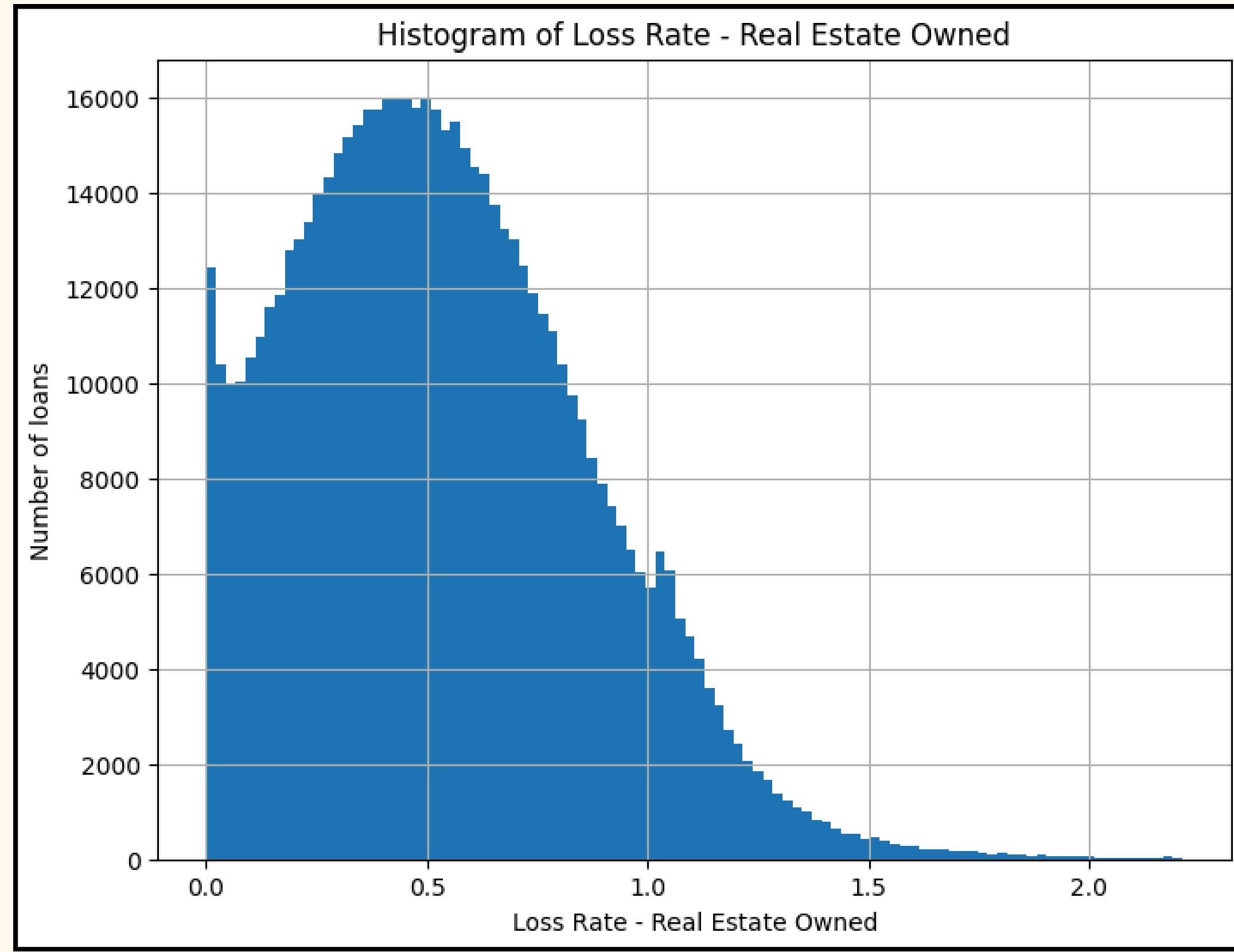


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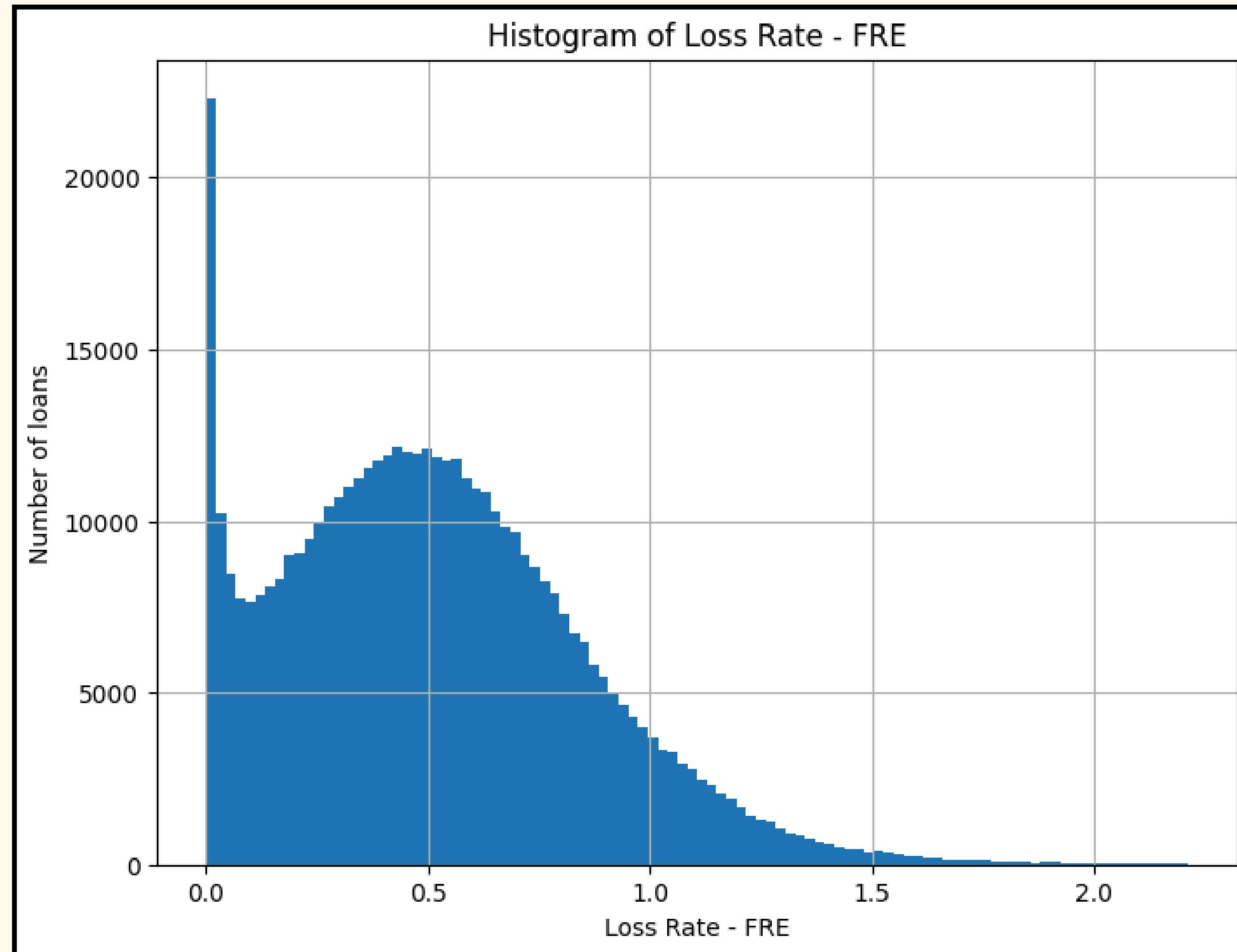


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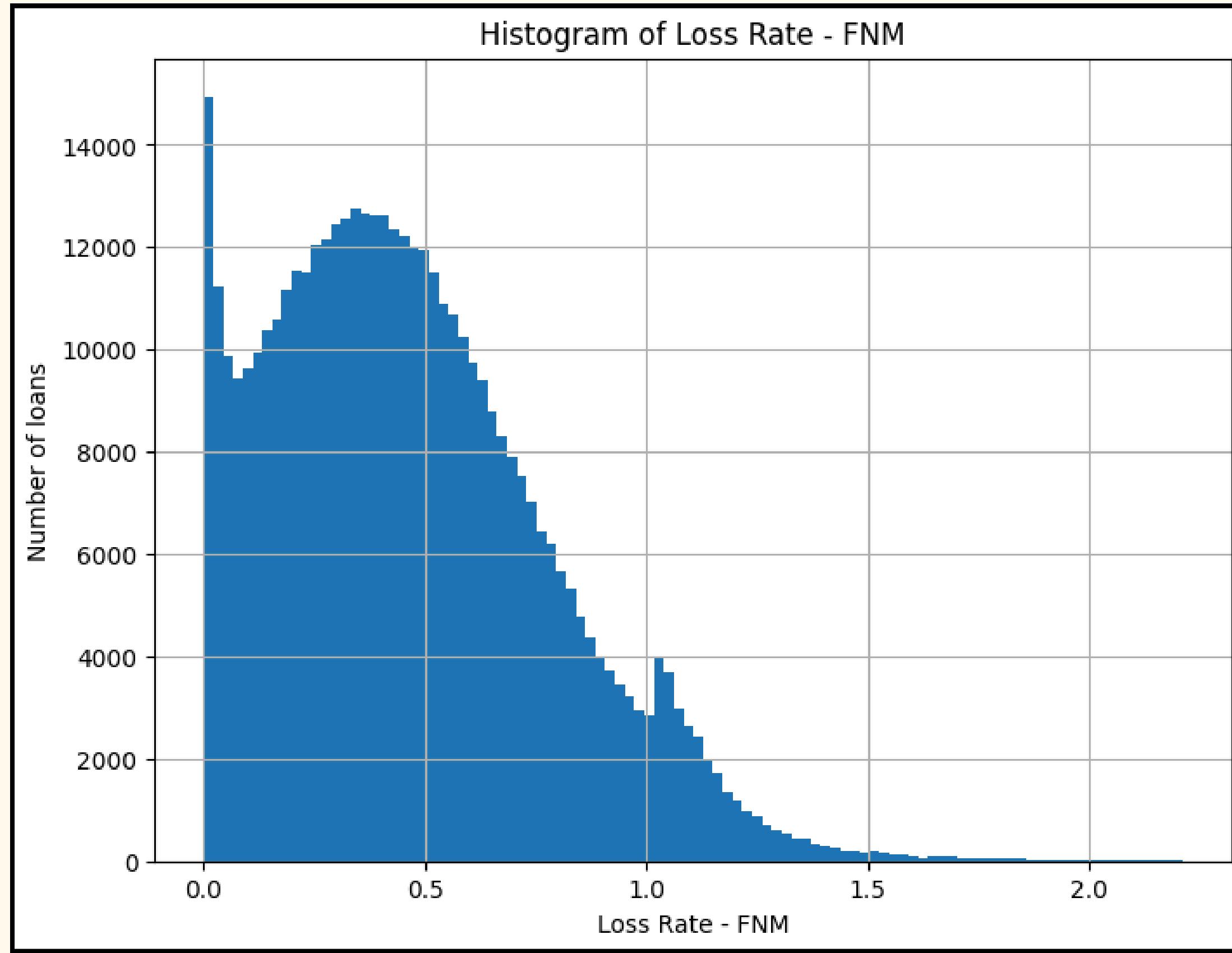


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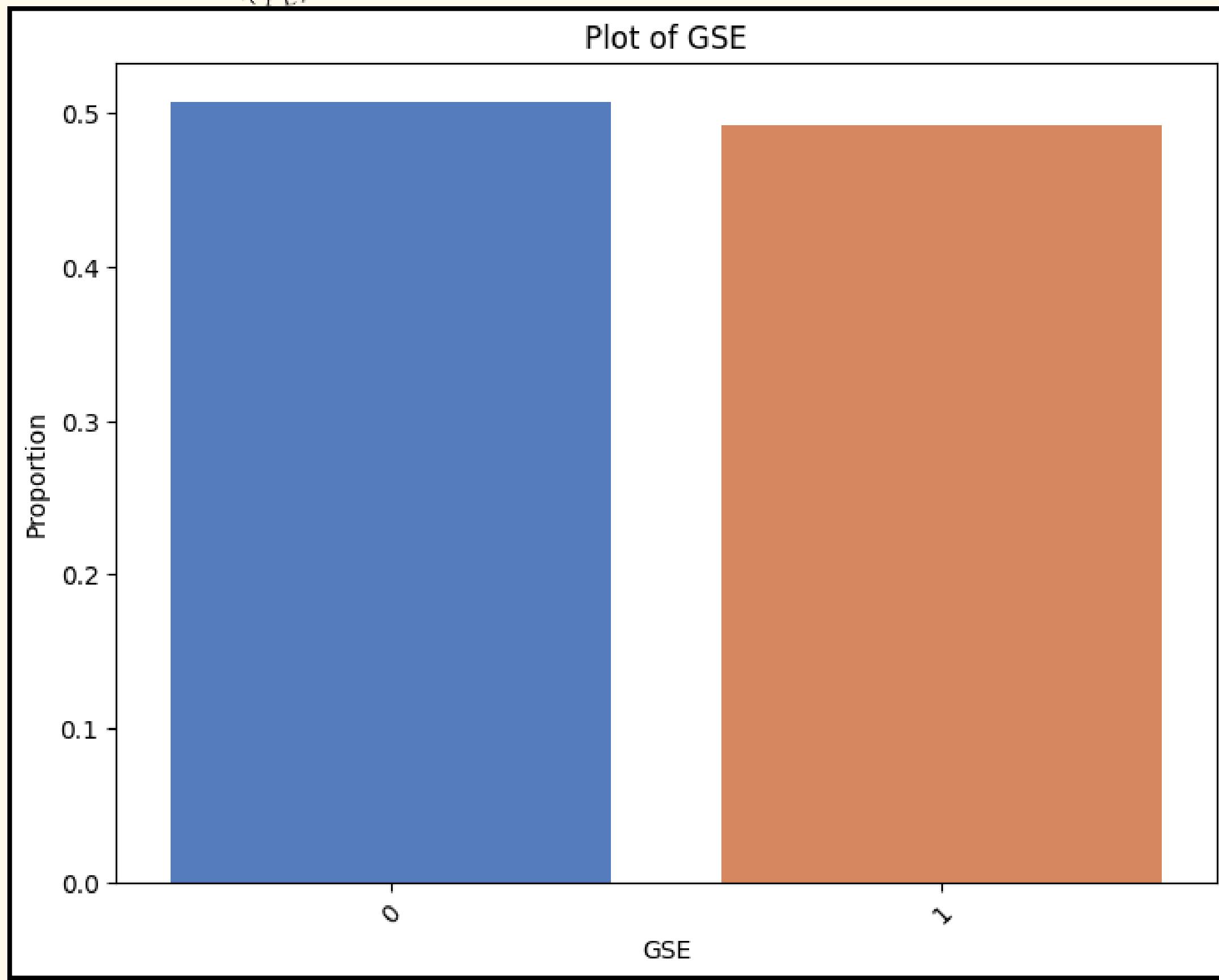


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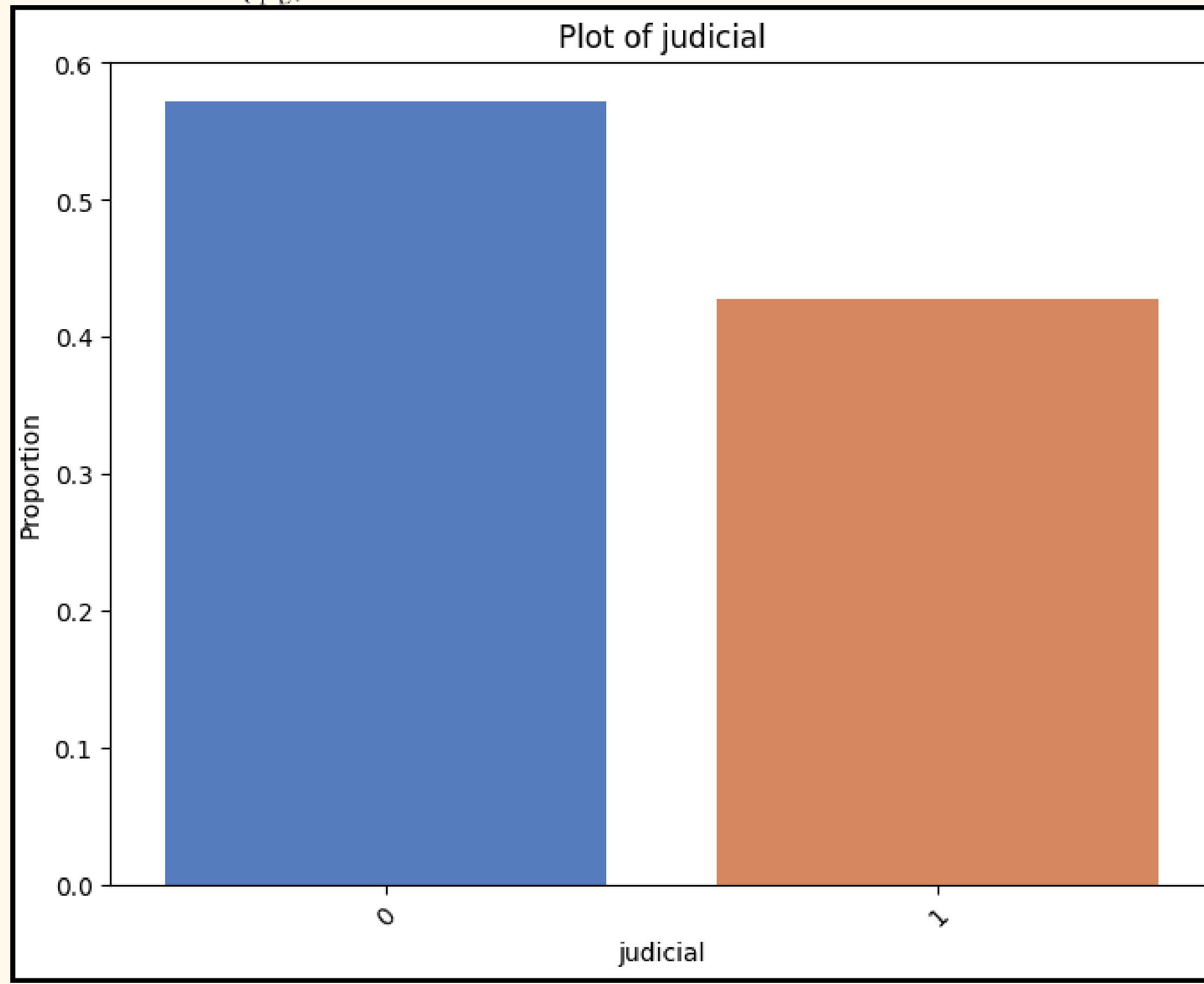


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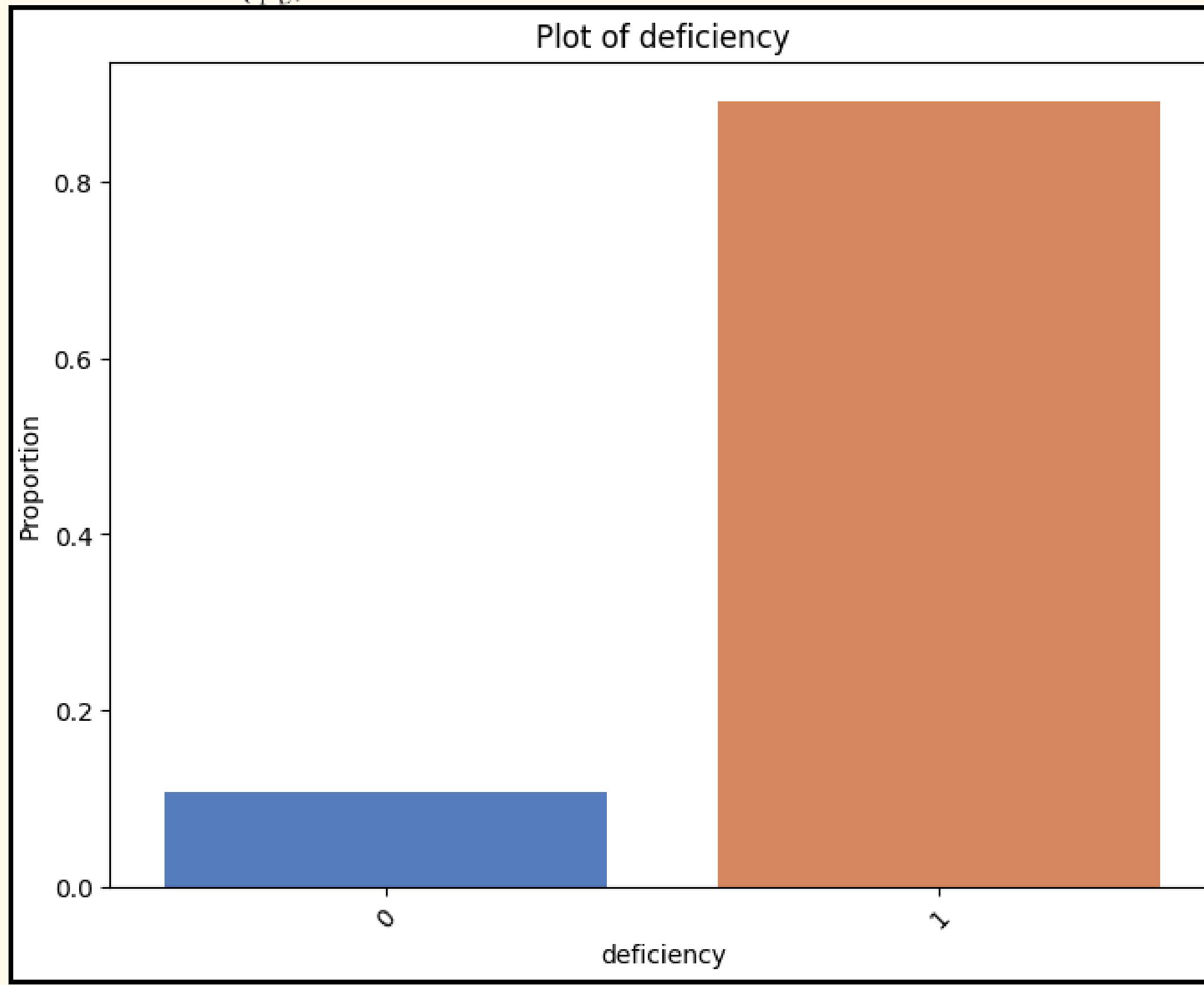


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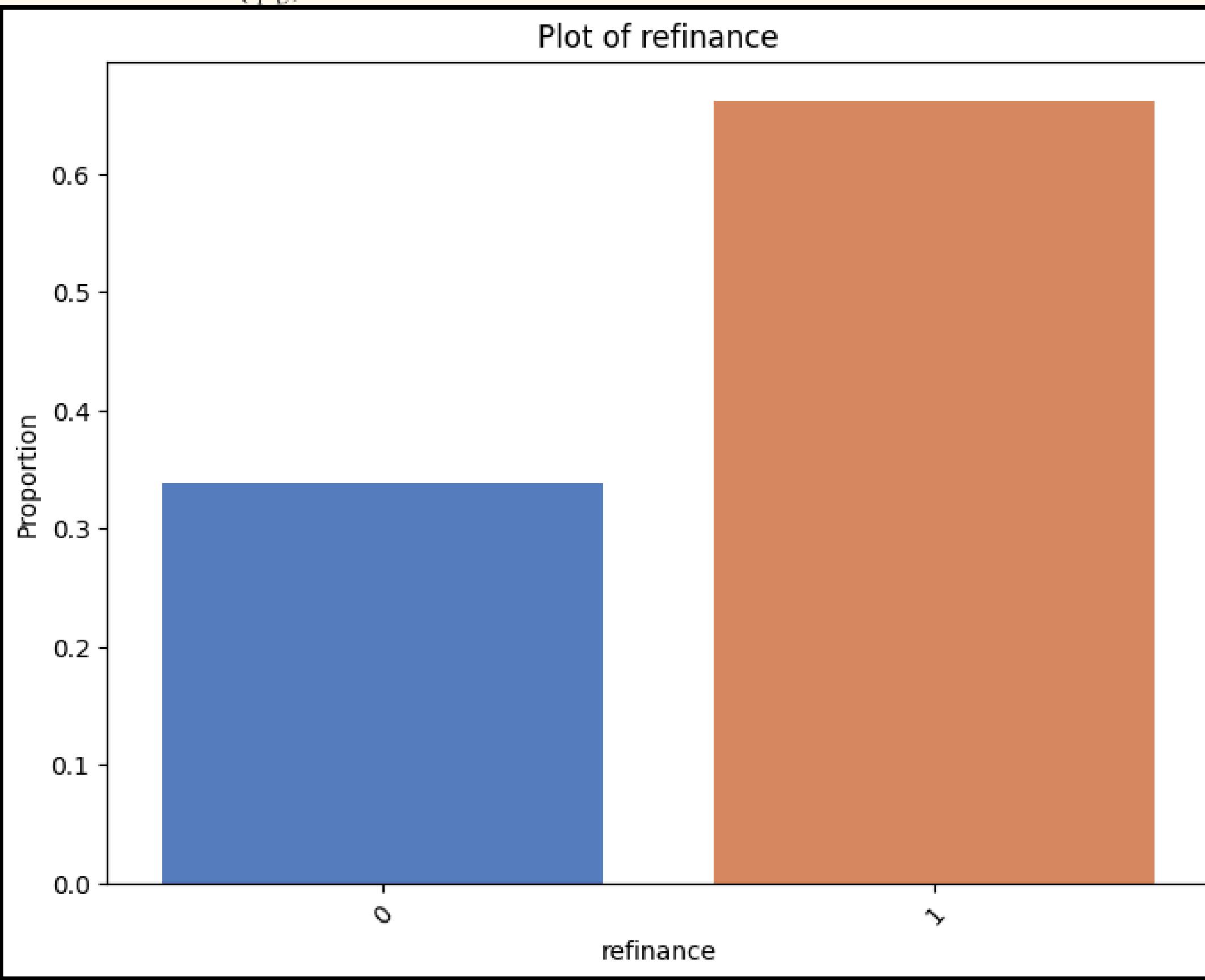


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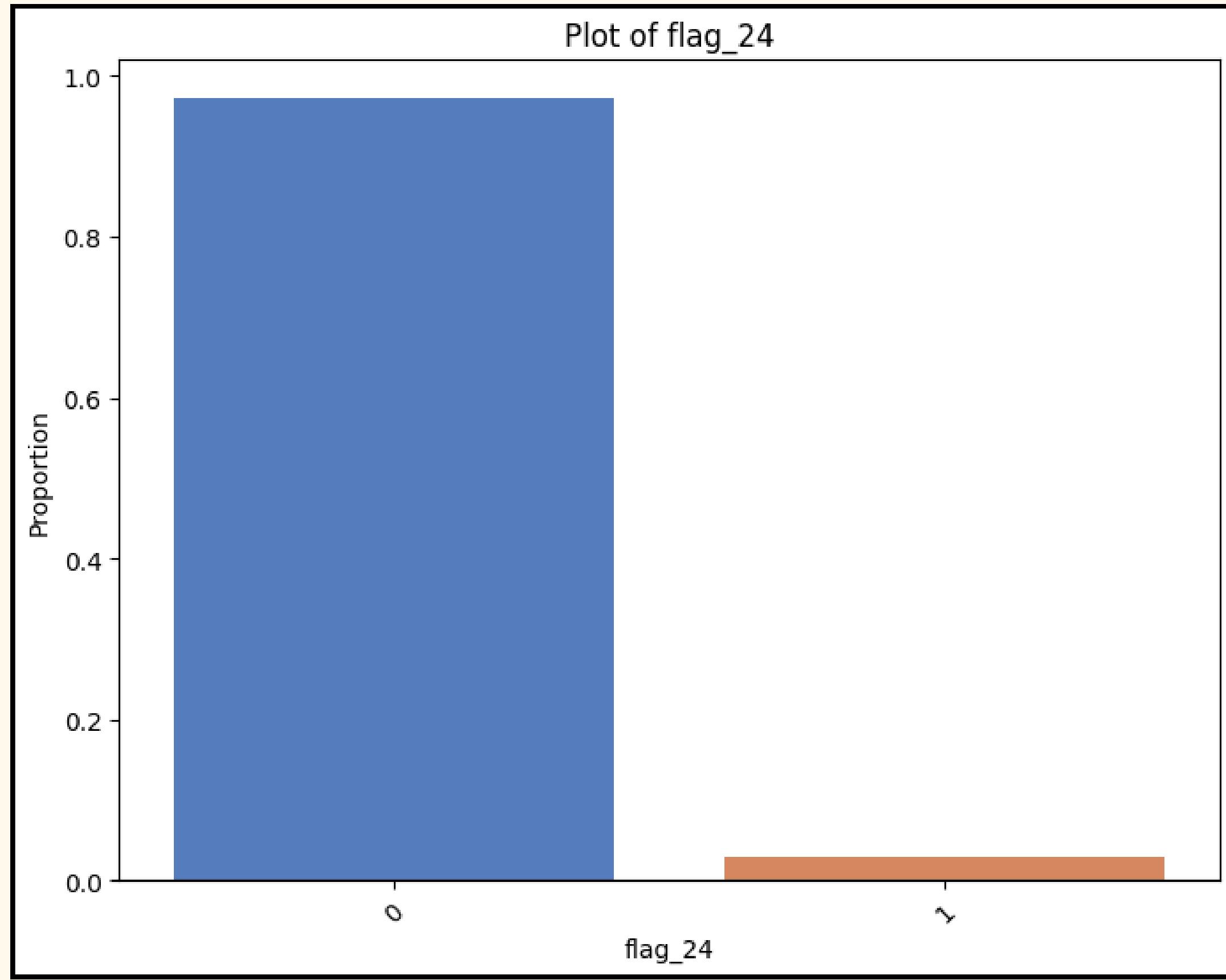


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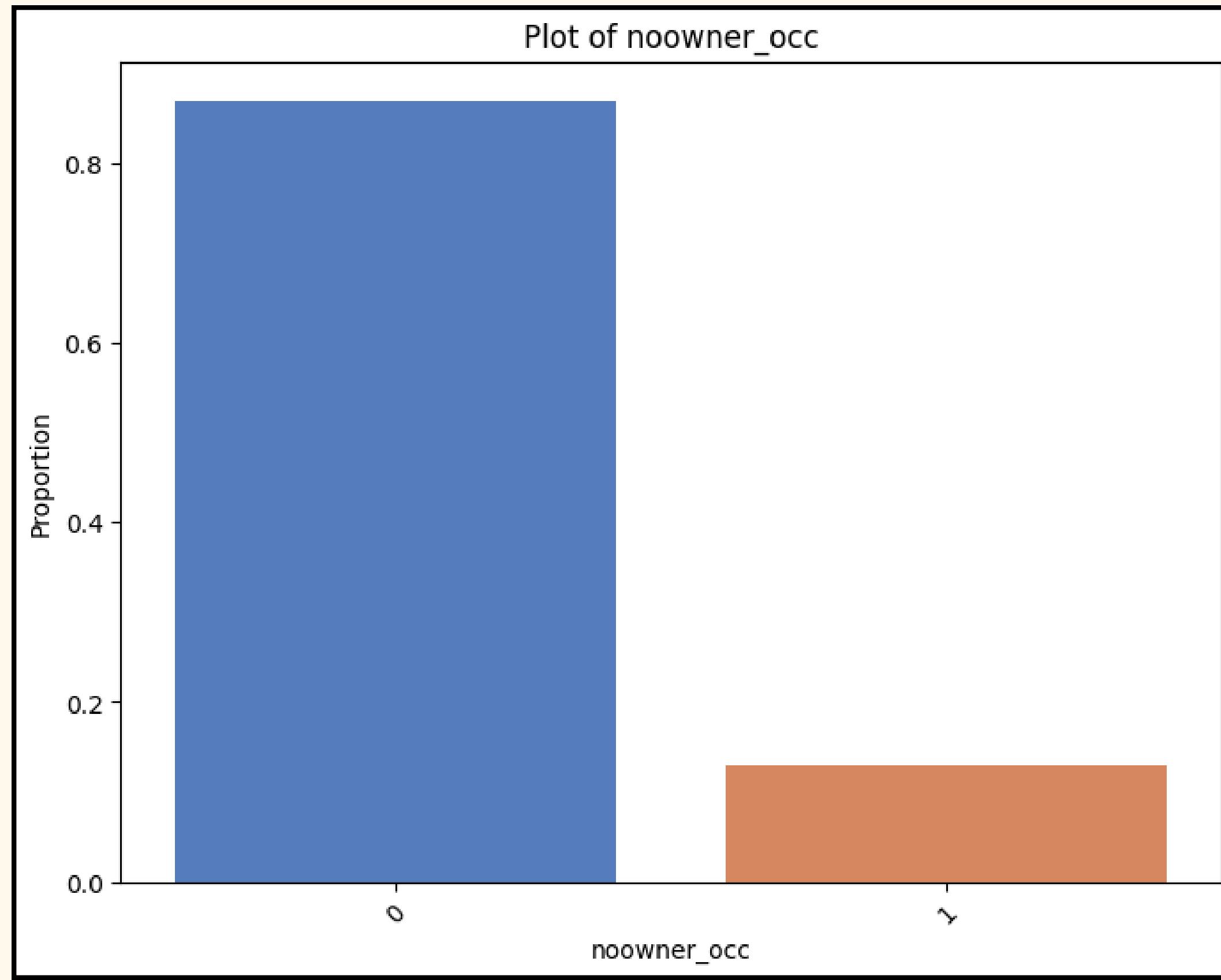


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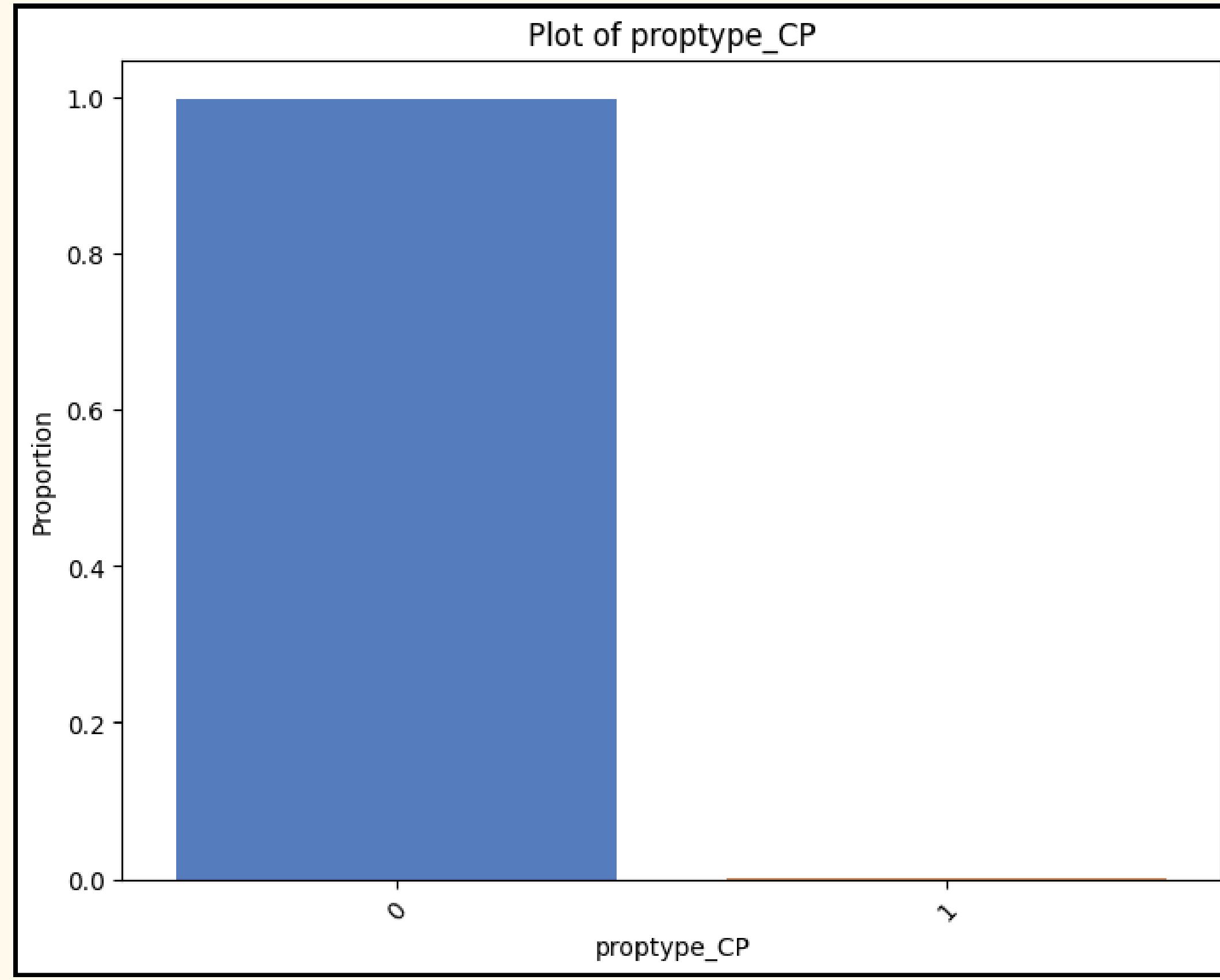


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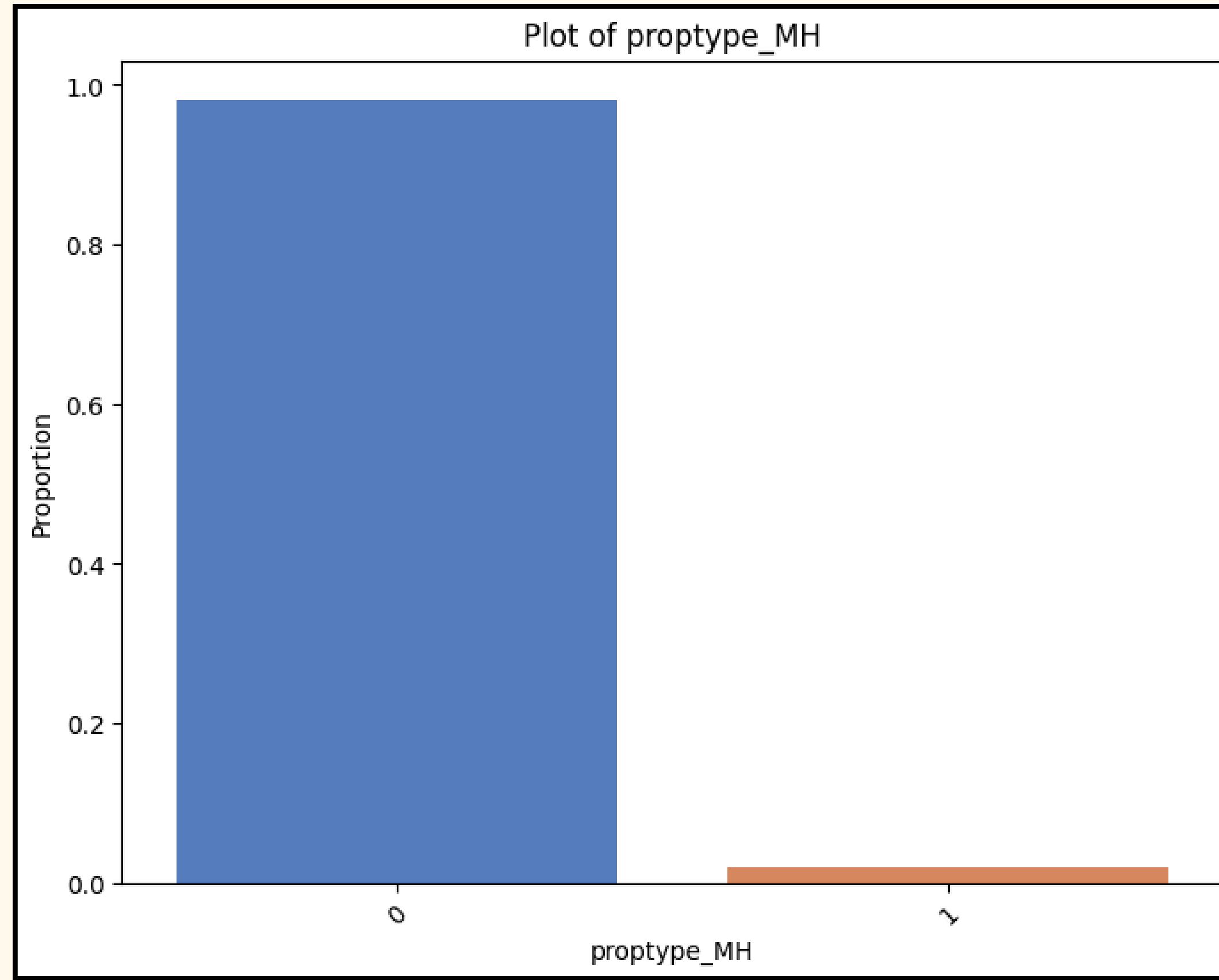


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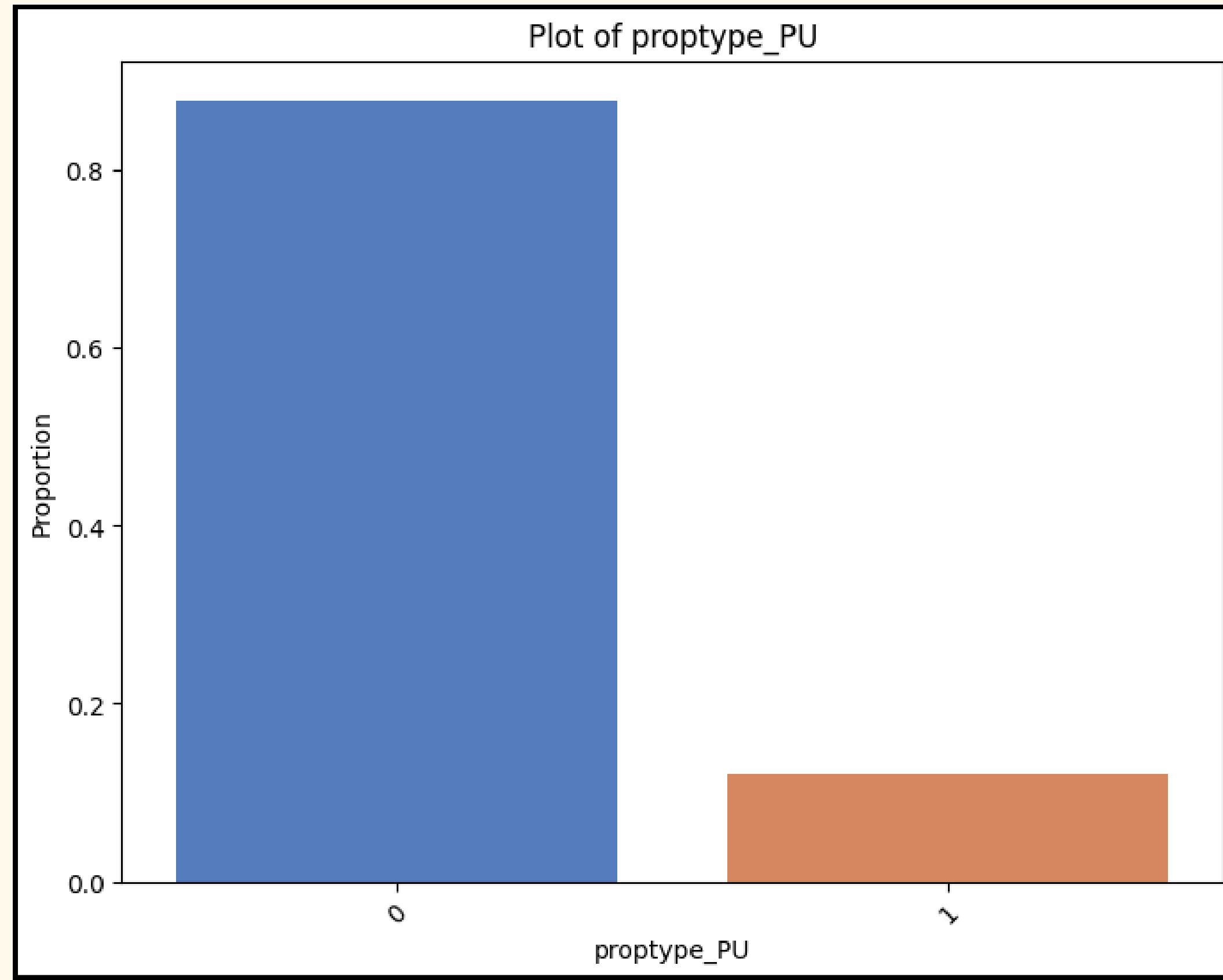


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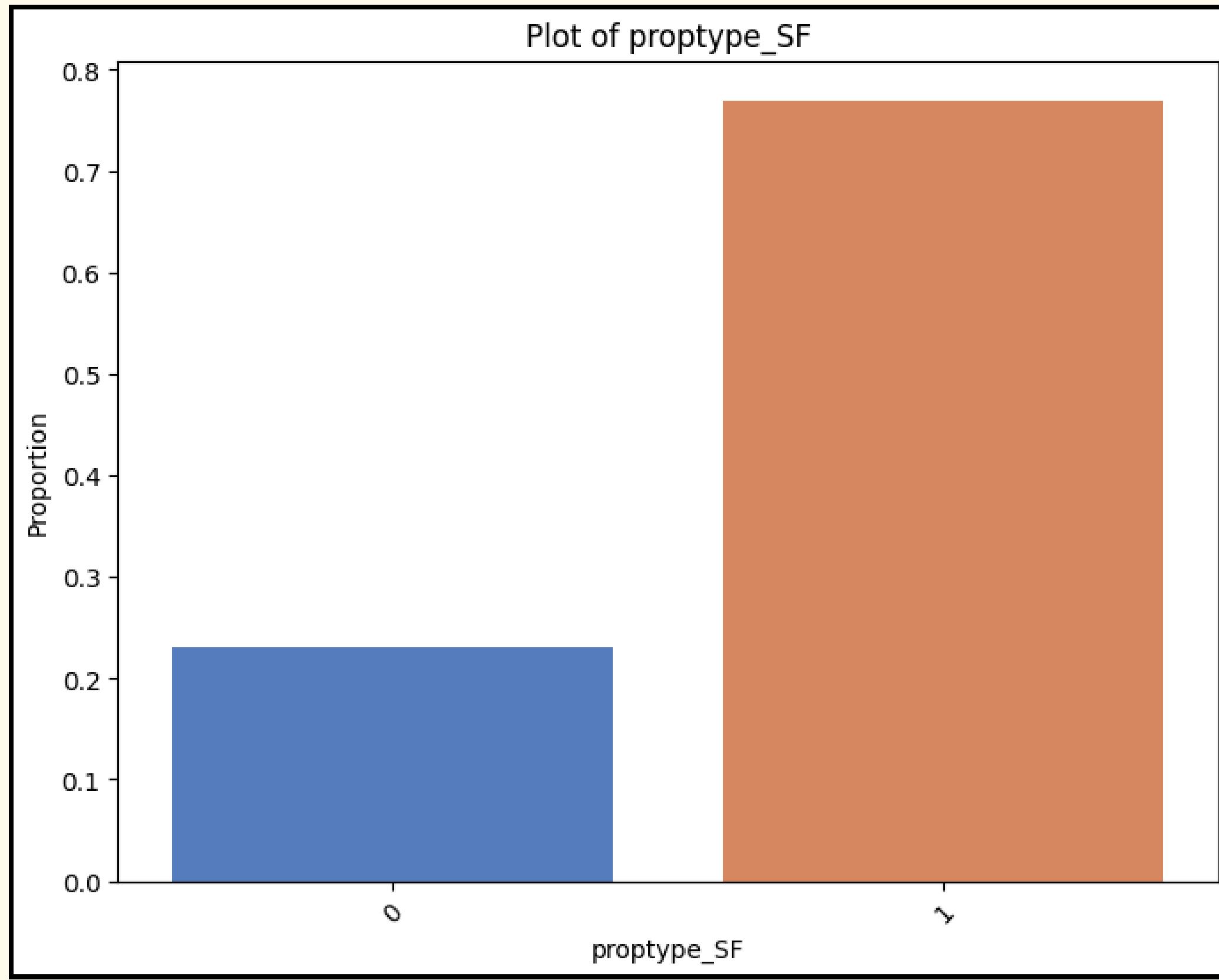


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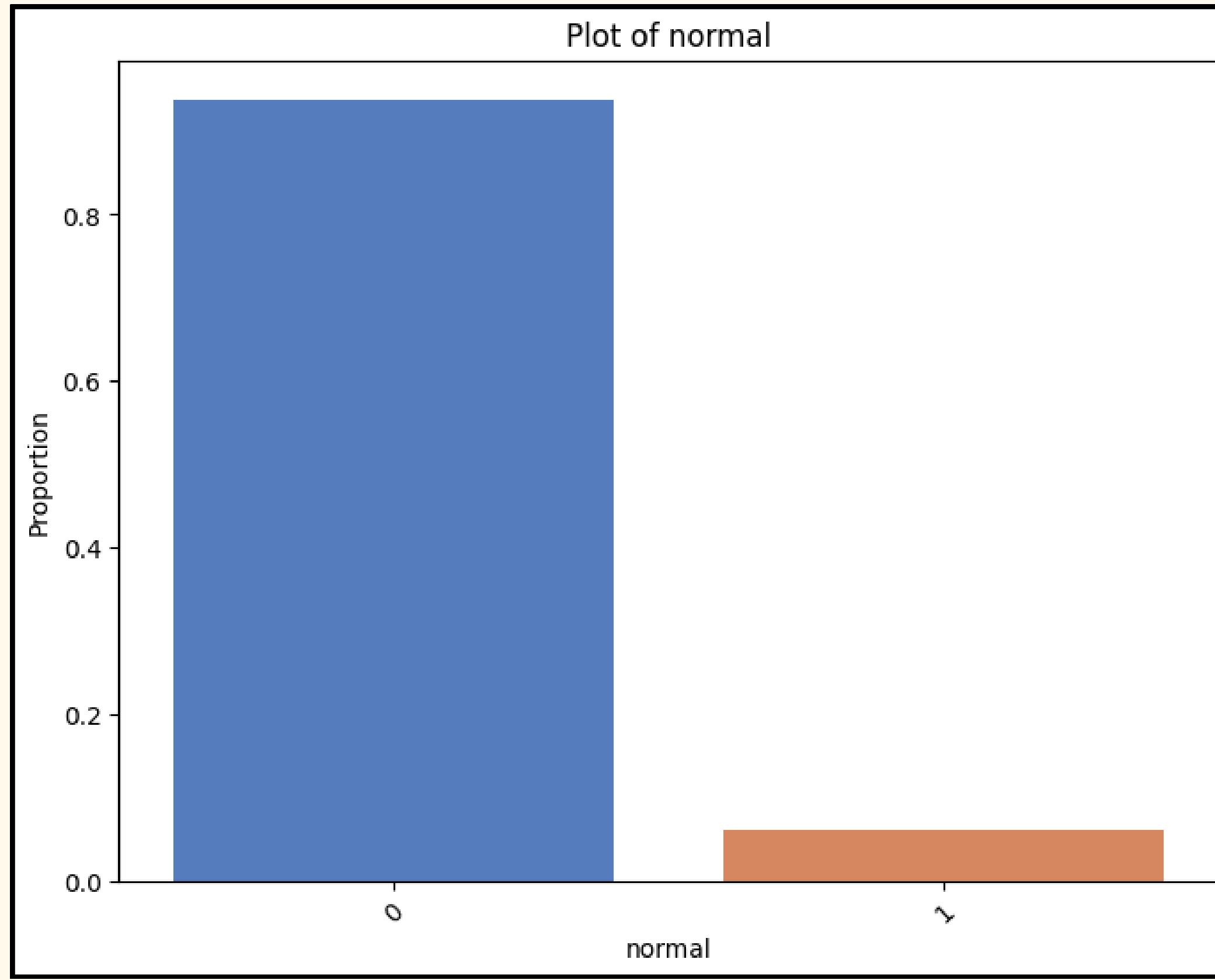


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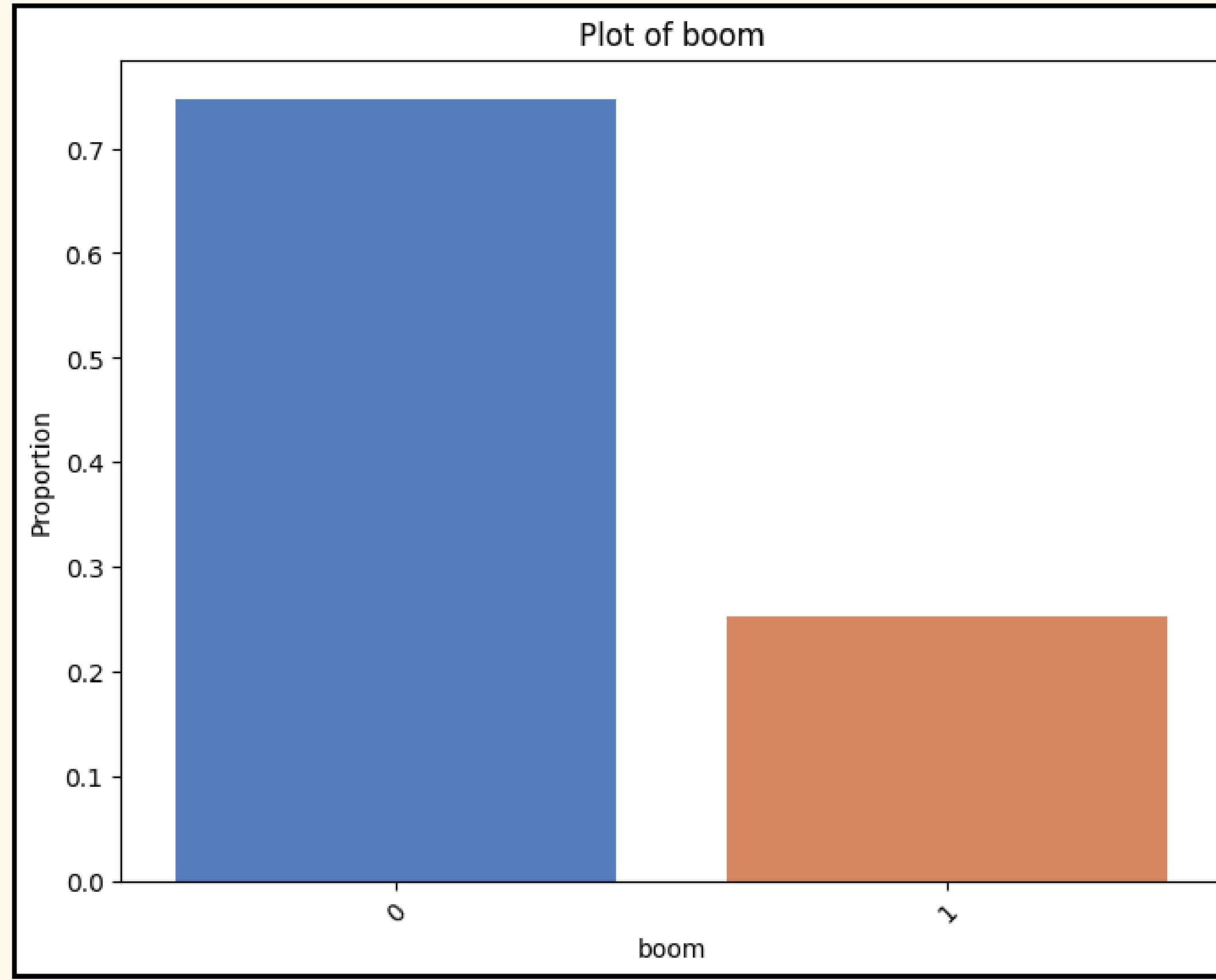


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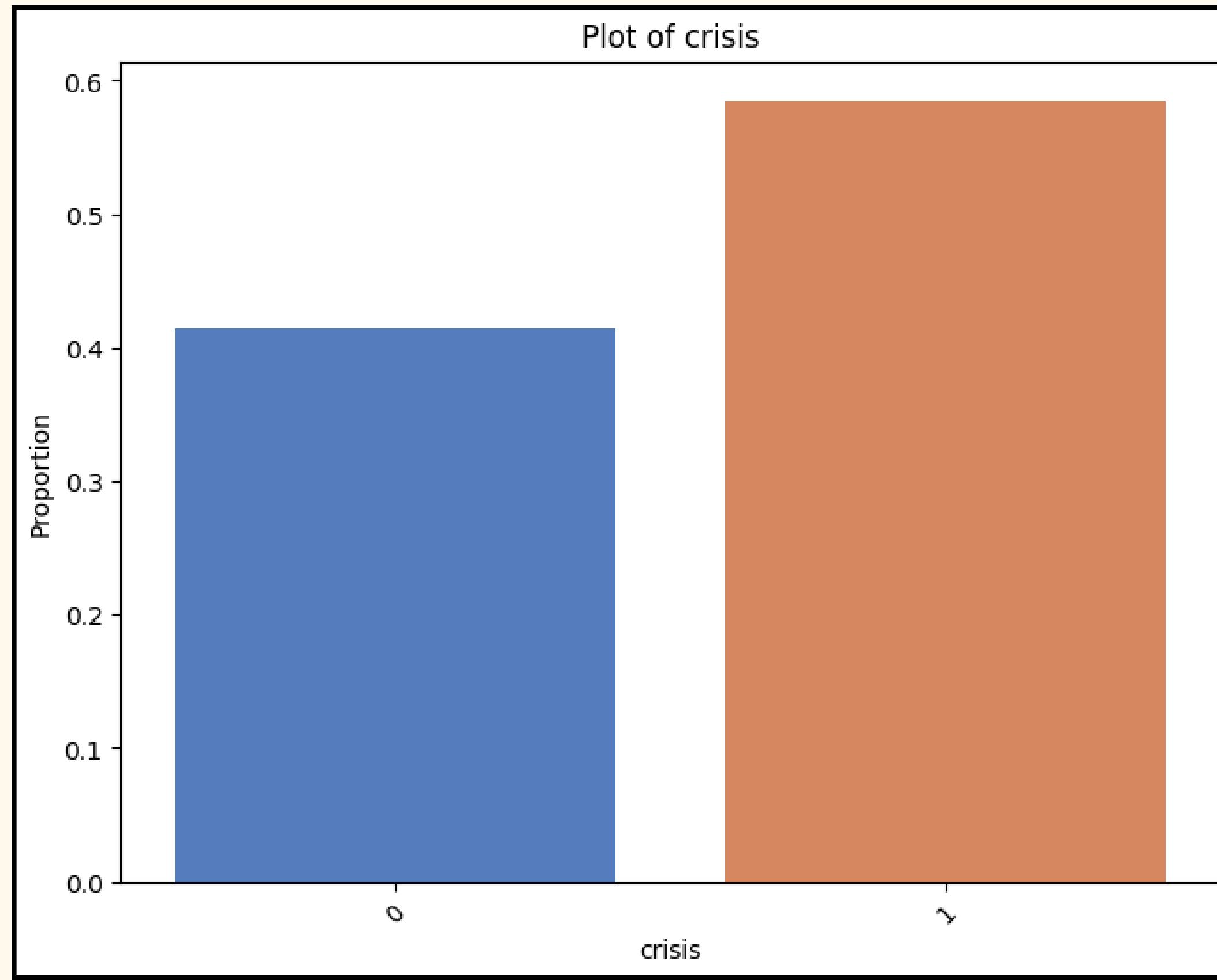


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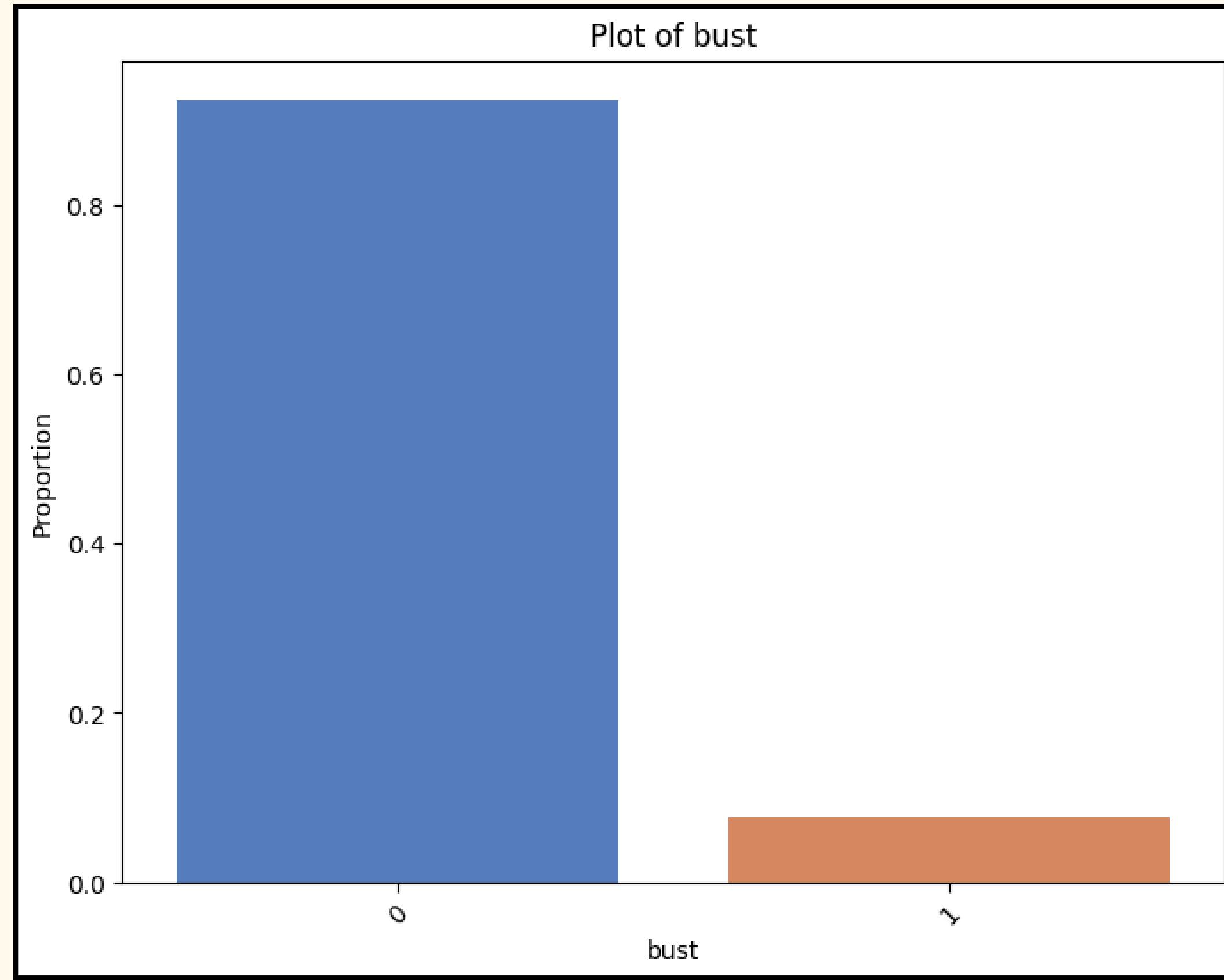


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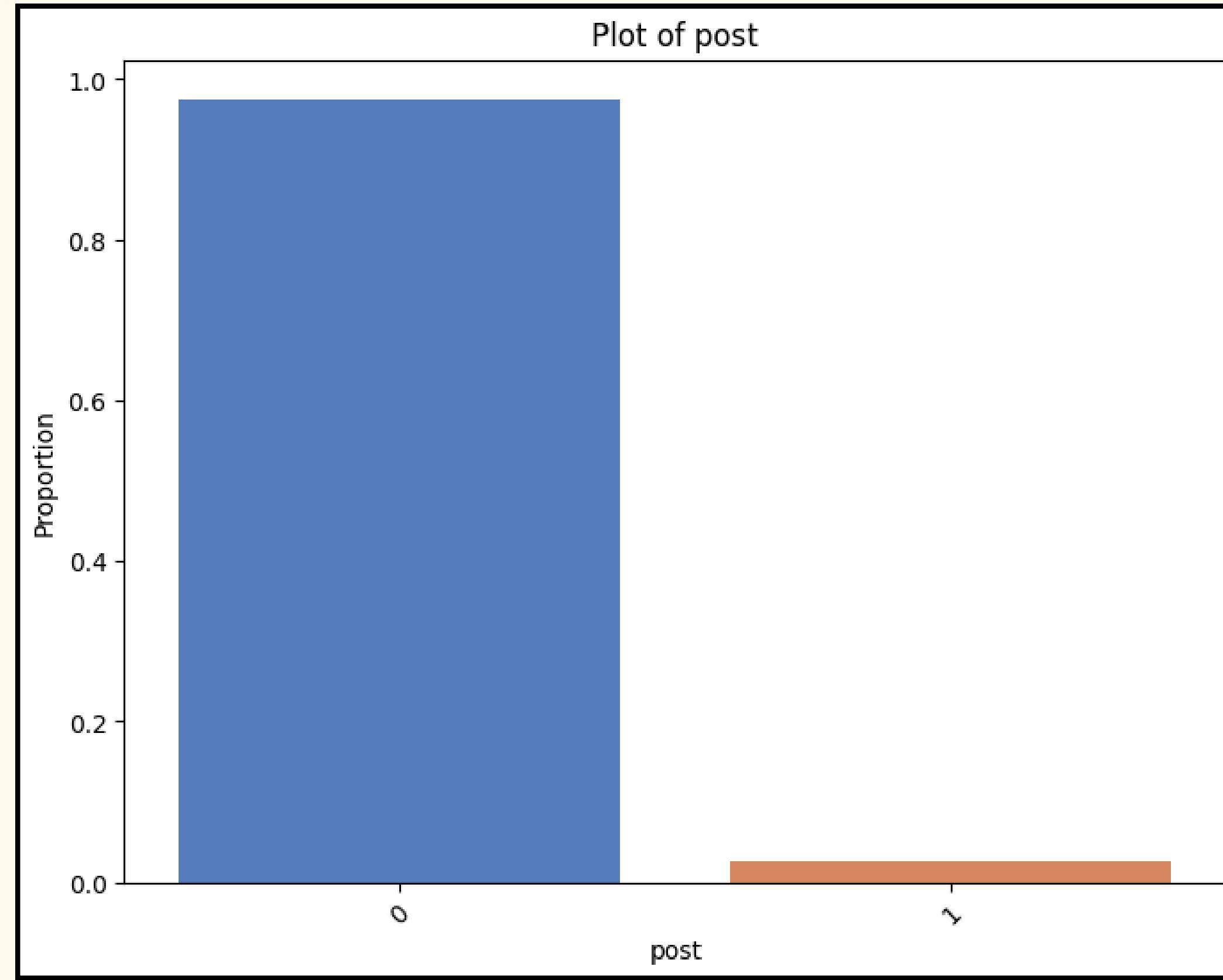


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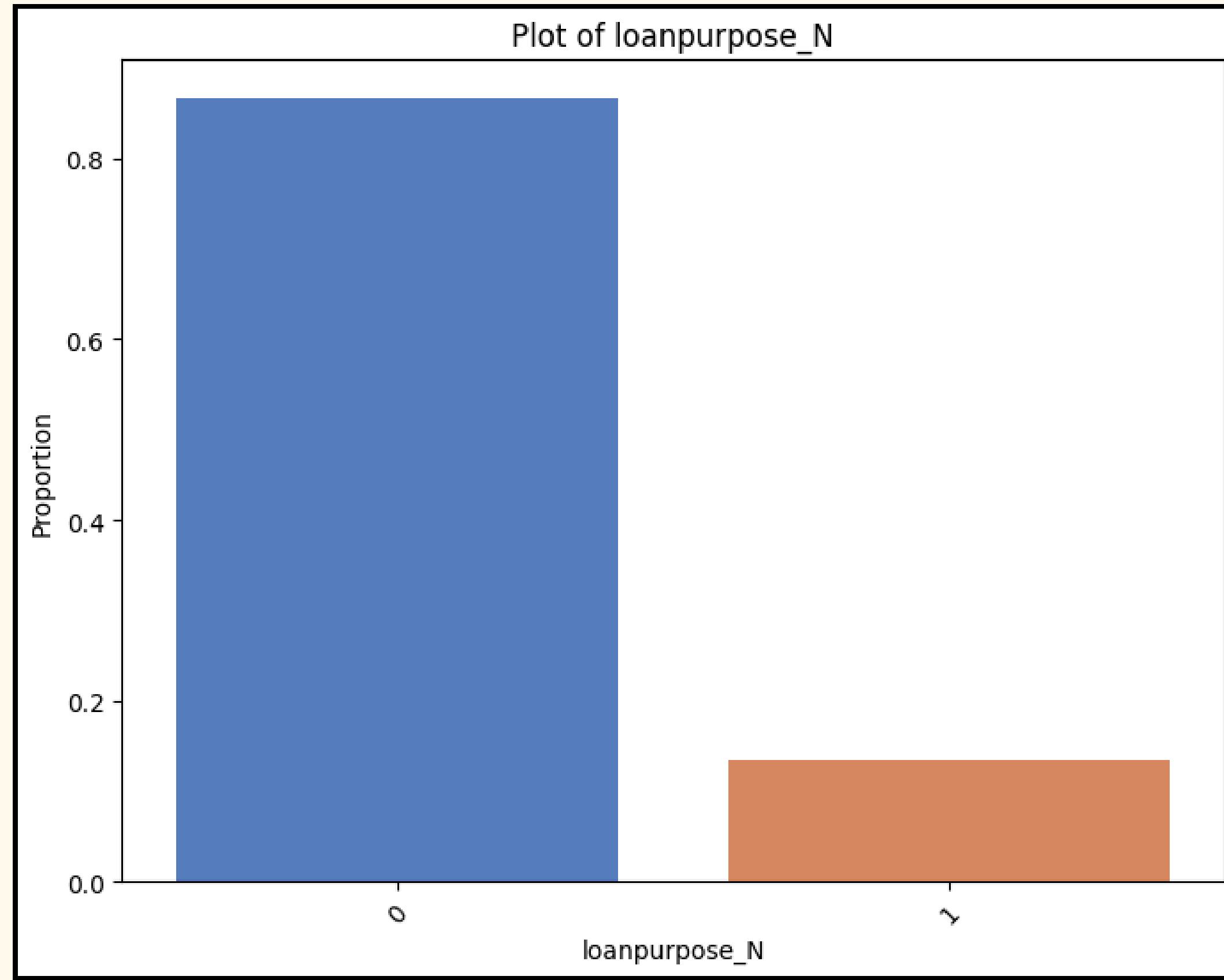


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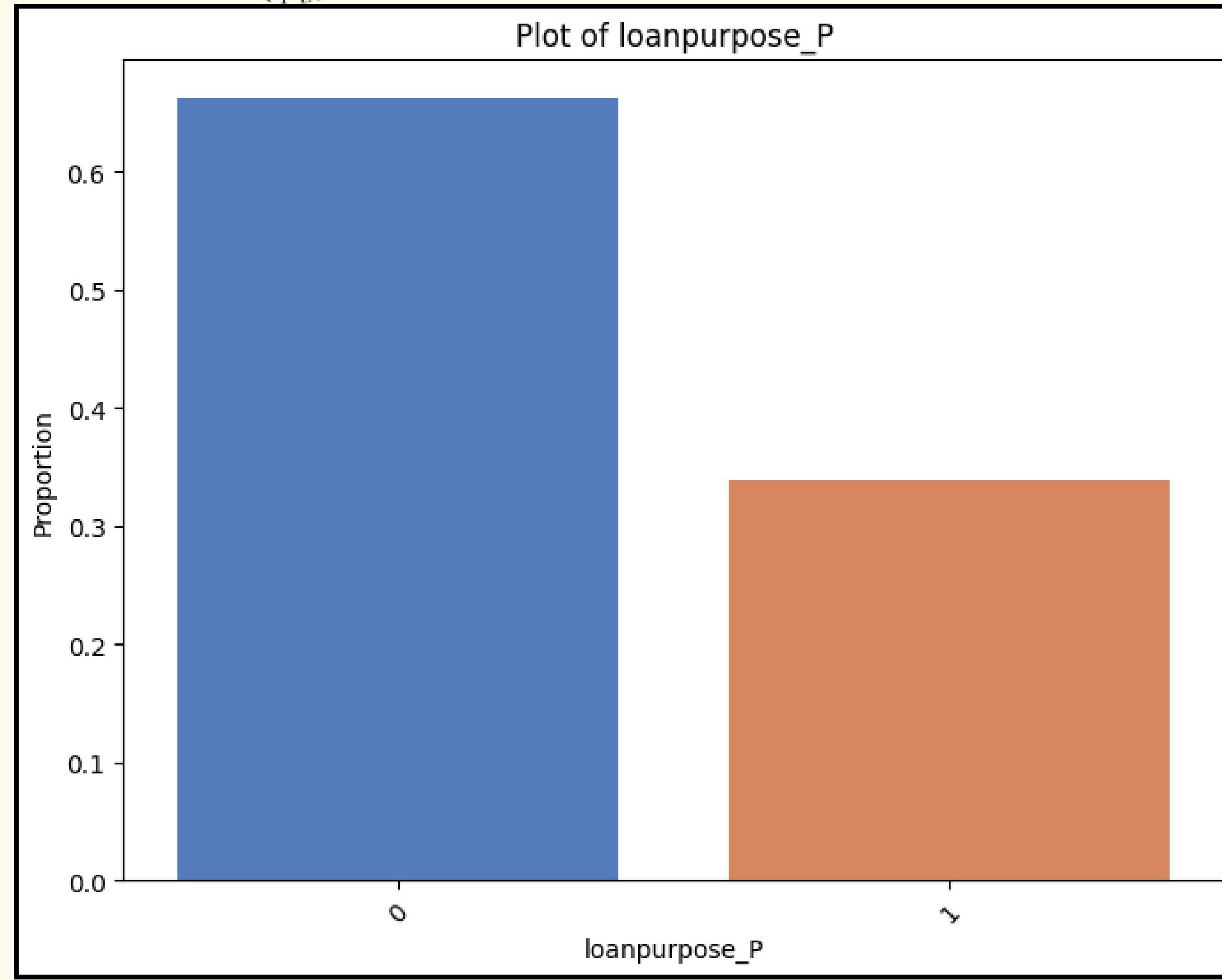


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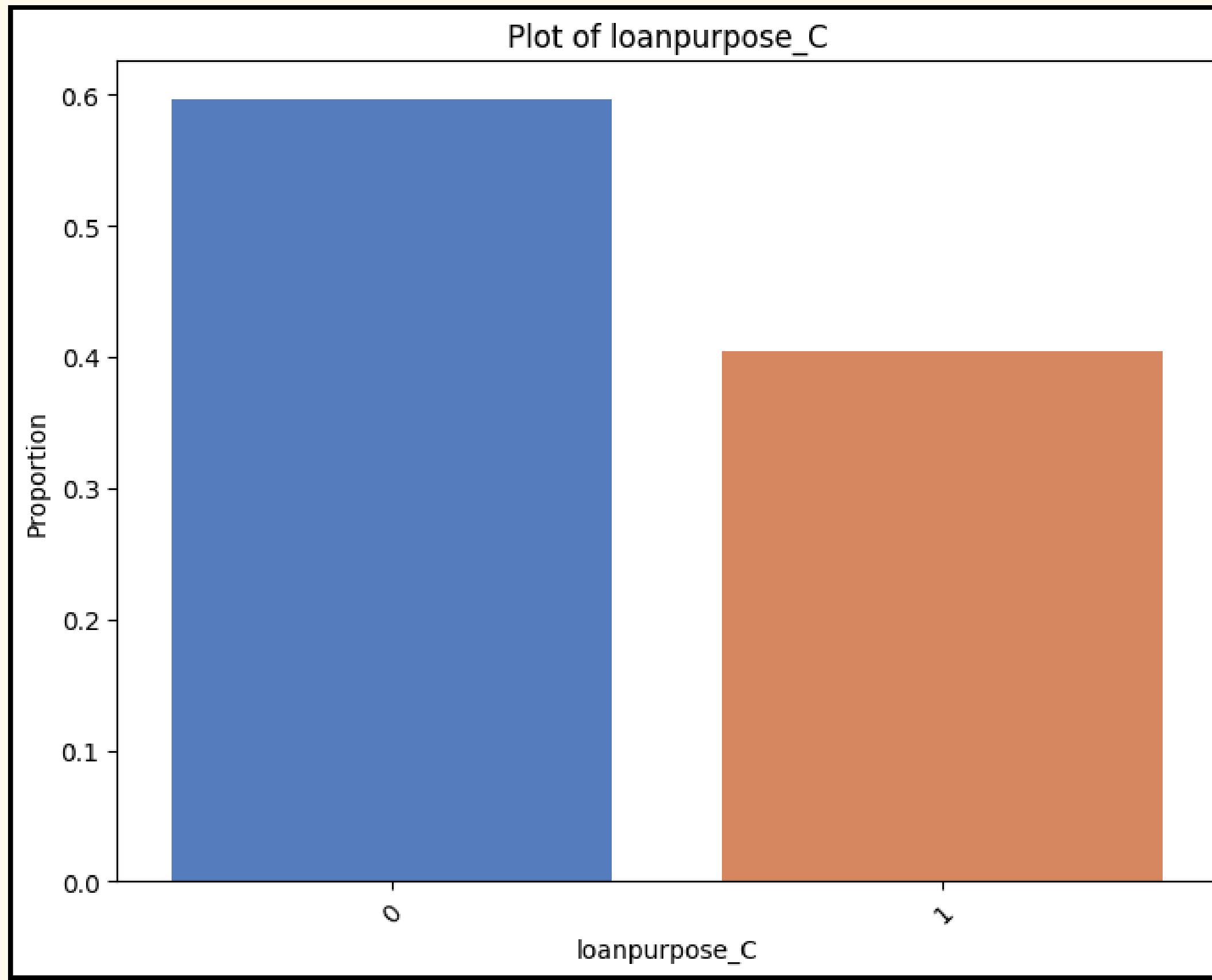


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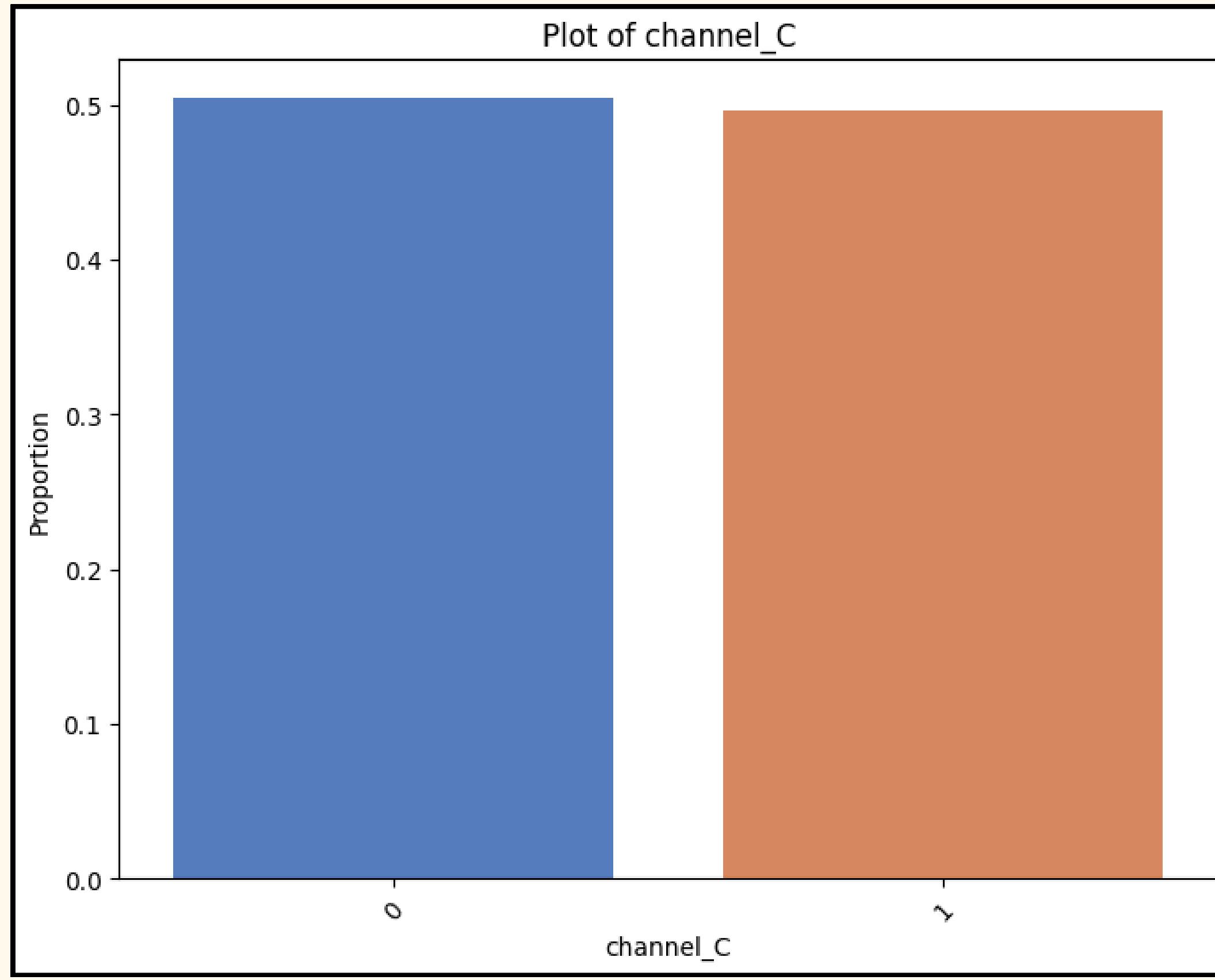


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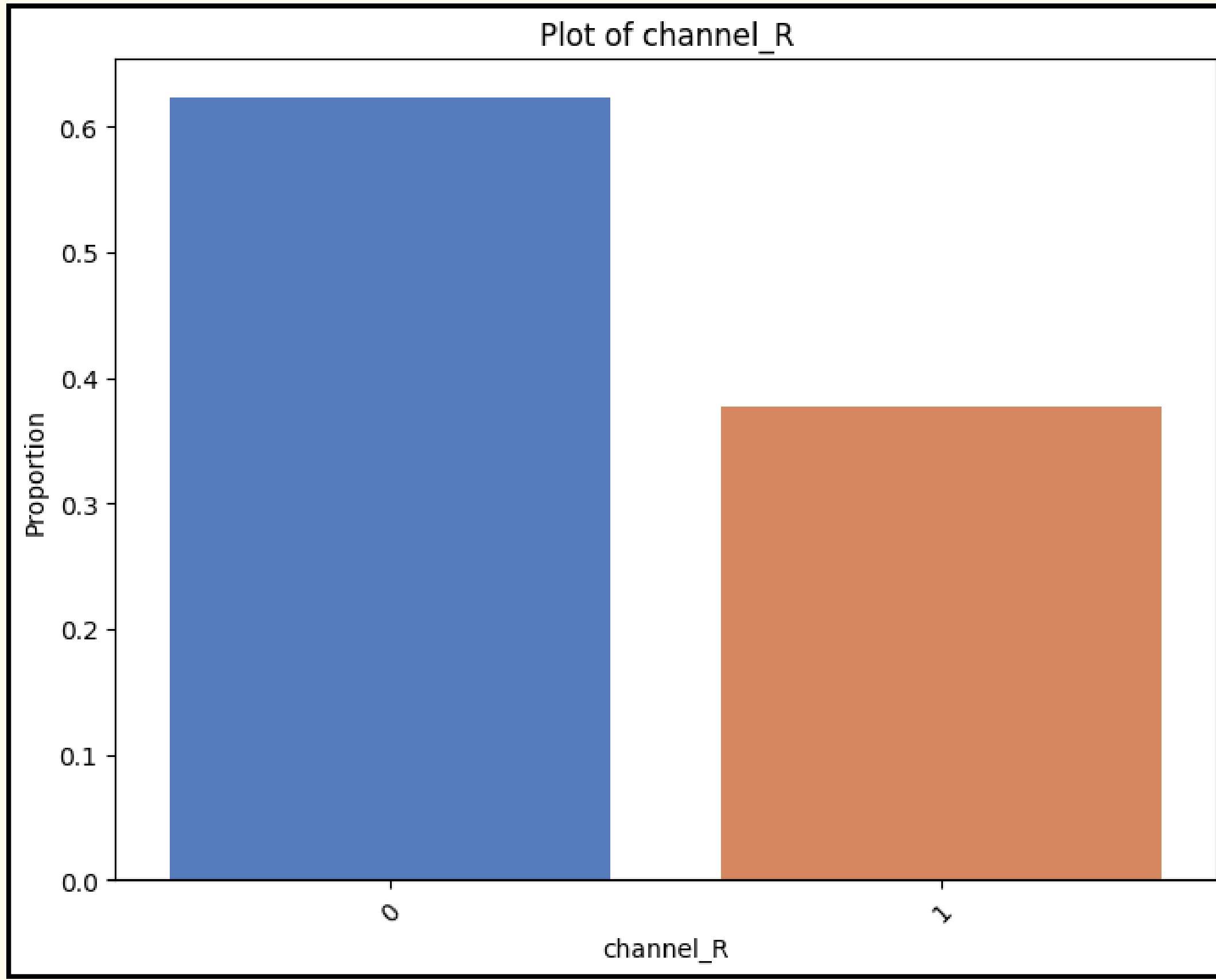


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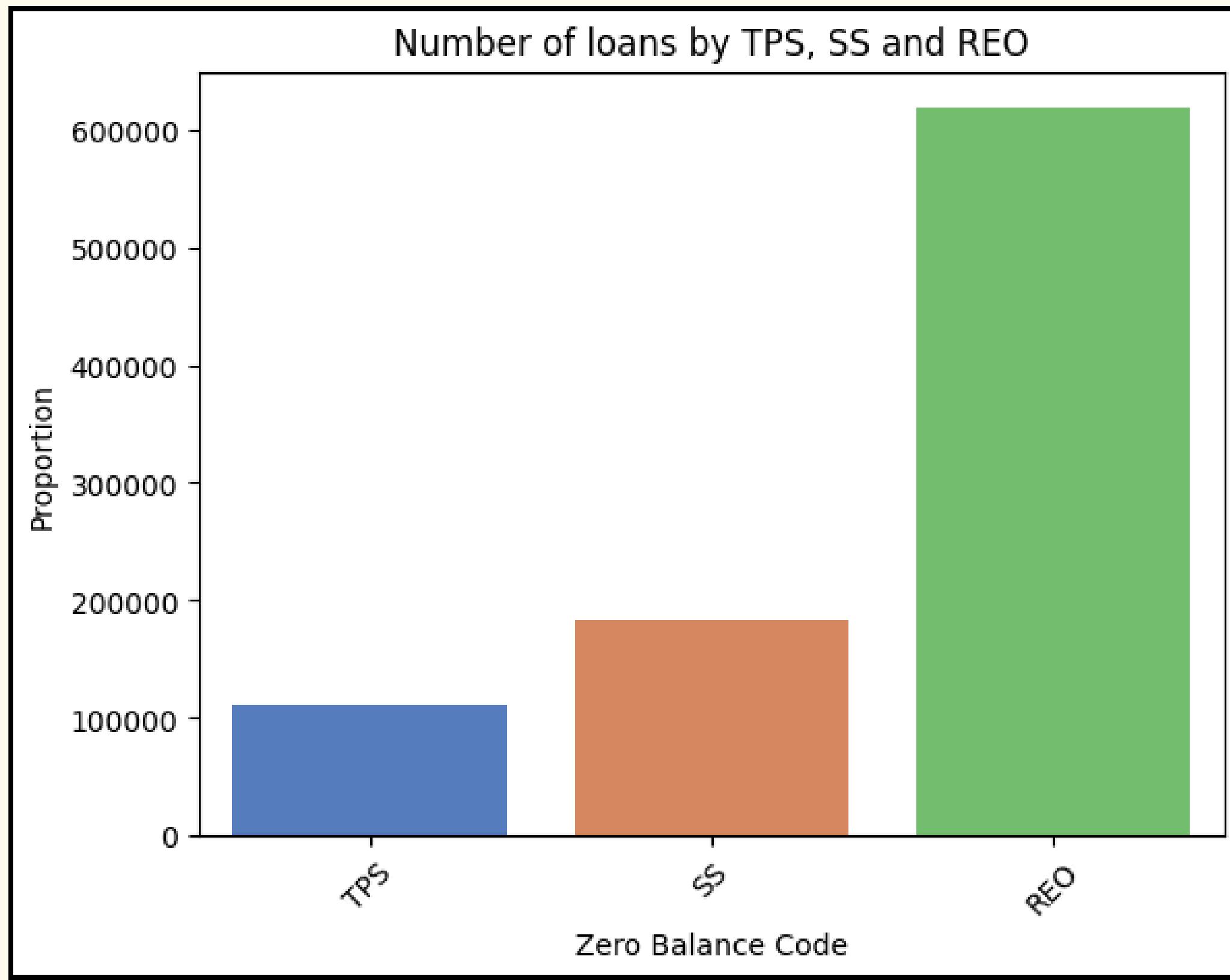


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DISASTER RISK RATING CORRELATION

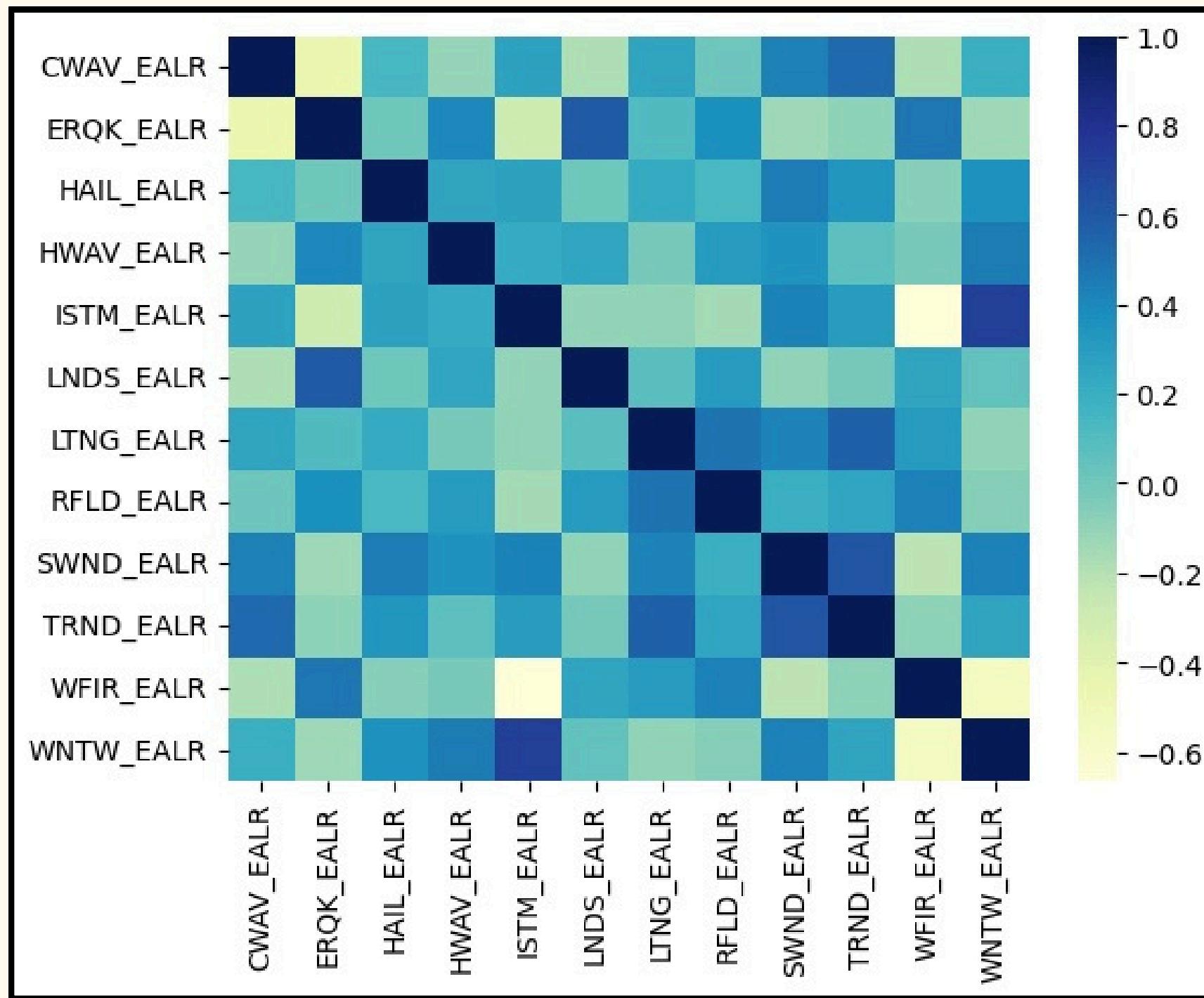
	CWAV_EALR	ERQK_EALR	HAIL_EALR	HWAV_EALR	ISTM_EALR	LNDS_EALR	LTNG_EALR	RFLD_EALR	SWND_EALR	TRND_EALR	WFIR_EALR	WNTW_EALR
CWAV_EALR	1.0000	-0.4568	0.1367	-0.1102	0.2681	-0.1828	0.2595	0.0156	0.4339	0.5270	-0.1803	0.1936
ERQK_EALR	-0.4568	1.0000	0.0011	0.4049	-0.3003	0.5935	0.1022	0.3711	-0.1377	-0.0923	0.4735	-0.1346
HAIL_EALR	0.1367	0.0011	1.0000	0.2588	0.2670	0.0103	0.2207	0.1315	0.4491	0.3417	-0.0733	0.3557
HWAV_EALR	-0.1102	0.4049	0.2588	1.0000	0.2185	0.2518	-0.0257	0.3058	0.3455	0.0635	-0.0241	0.4580
ISTM_EALR	0.2681	-0.3003	0.2670	0.2185	1.0000	-0.1048	-0.0946	-0.1505	0.4221	0.3001	-0.6663	0.7218
LNDS_EALR	-0.1828	0.5935	0.0103	0.2518	-0.1048	1.0000	0.0769	0.3157	-0.0941	-0.0172	0.2613	0.0441
LTNG_EALR	0.2595	0.1022	0.2207	-0.0257	-0.0946	0.0769	1.0000	0.4837	0.4149	0.5576	0.3106	-0.0947
RFLD_EALR	0.0156	0.3711	0.1315	0.3058	-0.1505	0.3157	0.4837	1.0000	0.1931	0.2545	0.4325	-0.0647
SWND_EALR	0.4339	-0.1377	0.4491	0.3455	0.4221	-0.0941	0.4149	0.1931	1.0000	0.6208	-0.2223	0.4282
TRND_EALR	0.5270	-0.0923	0.3417	0.0635	0.3001	-0.0172	0.5576	0.2545	0.6208	1.0000	-0.0823	0.2606
WFIR_EALR	-0.1803	0.4735	-0.0733	-0.0241	-0.6663	0.2613	0.3106	0.4325	-0.2223	-0.0823	1.0000	-0.5449
WNTW_EALR	0.1936	-0.1346	0.3557	0.4580	0.7218	0.0441	-0.0947	-0.0647	0.4282	0.2606	-0.5449	1.0000



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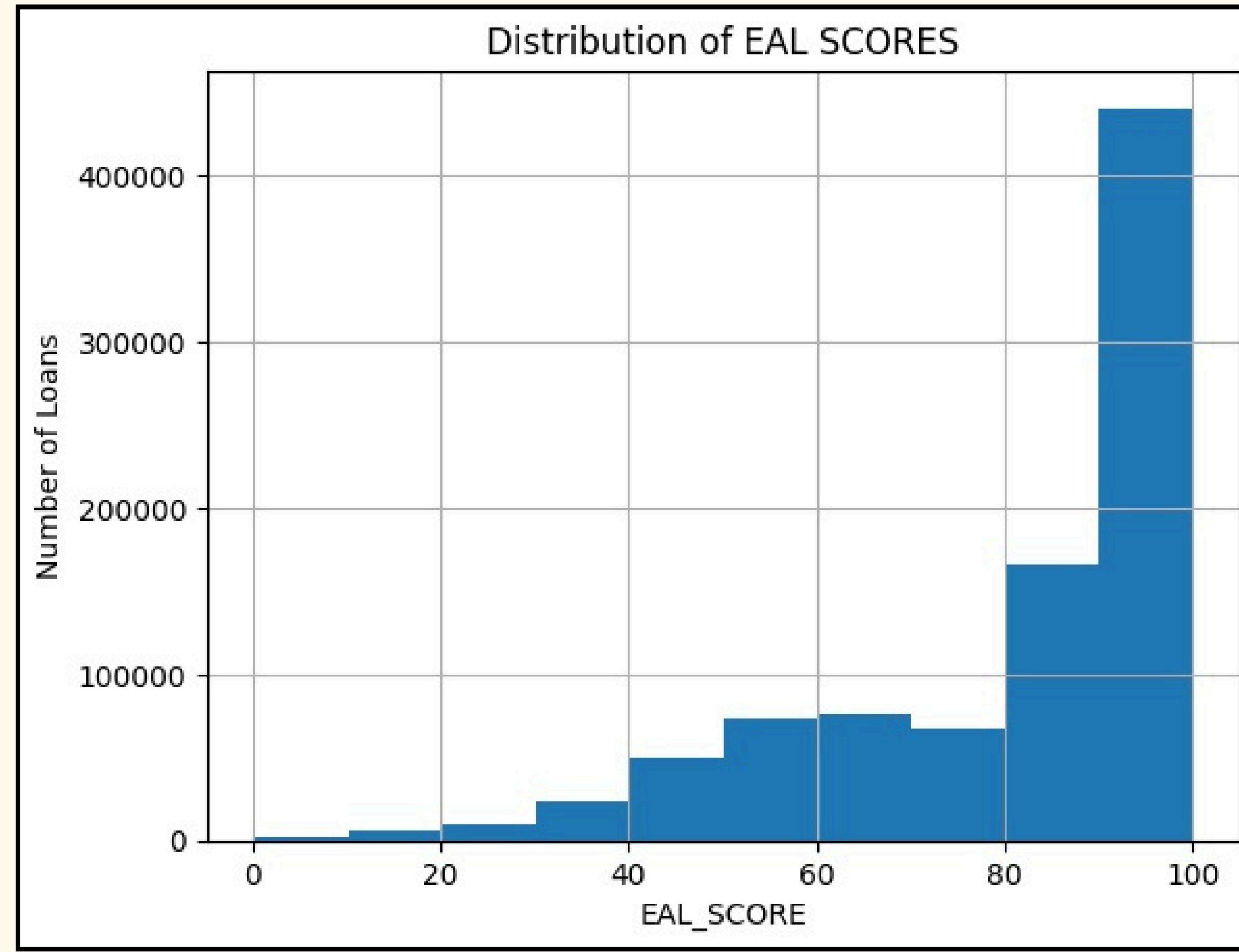


DISASTER RISK RATING CORRELATION



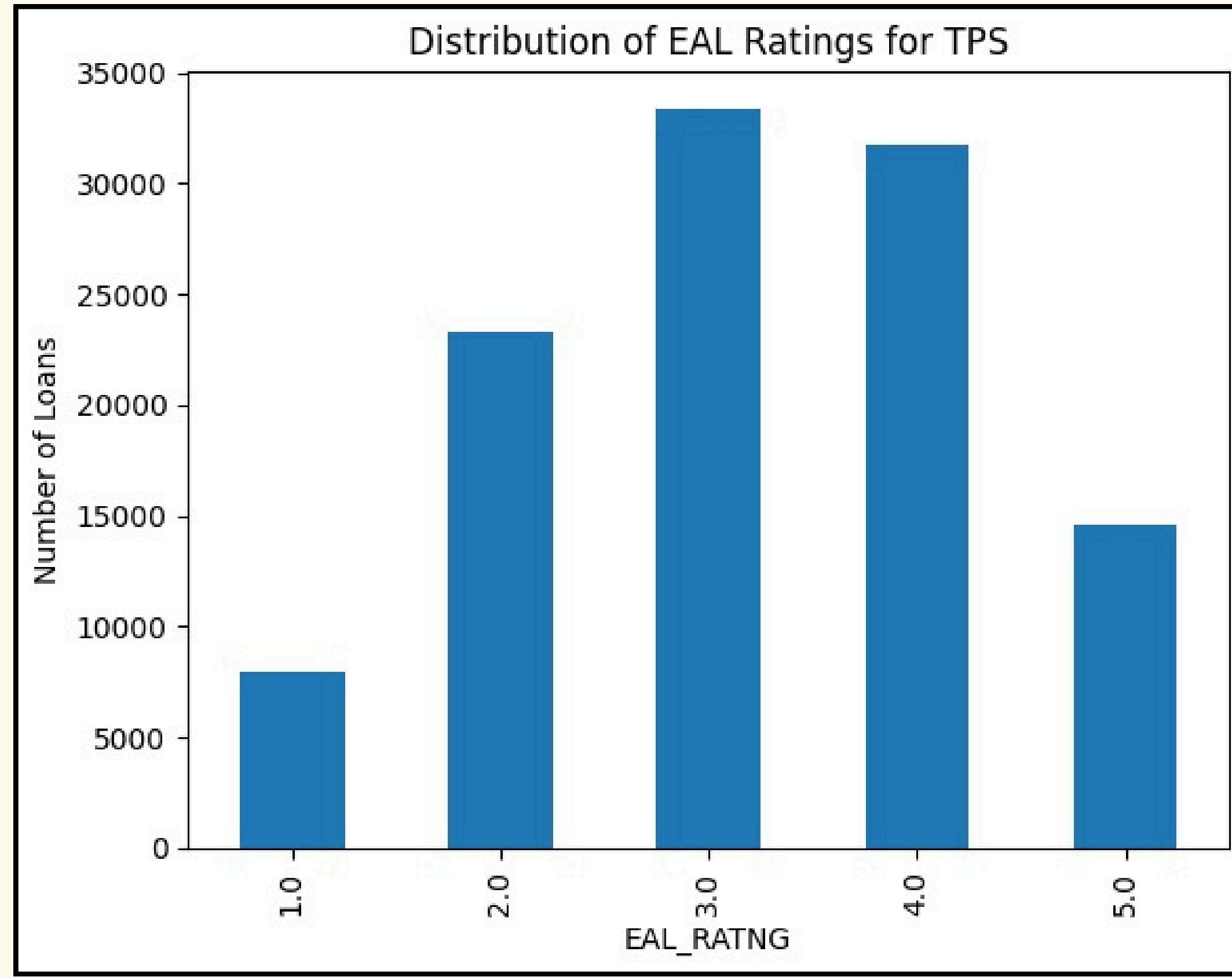


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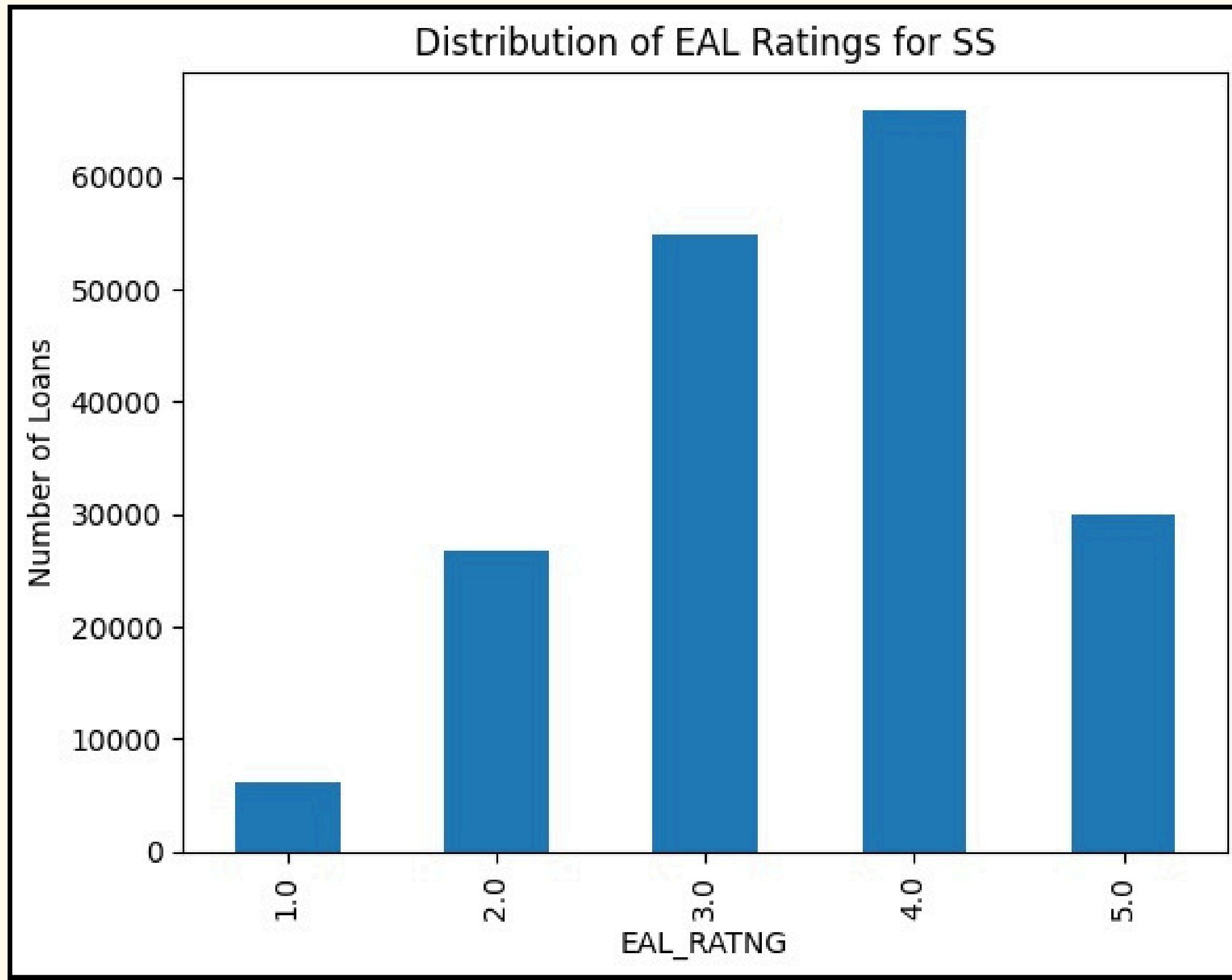


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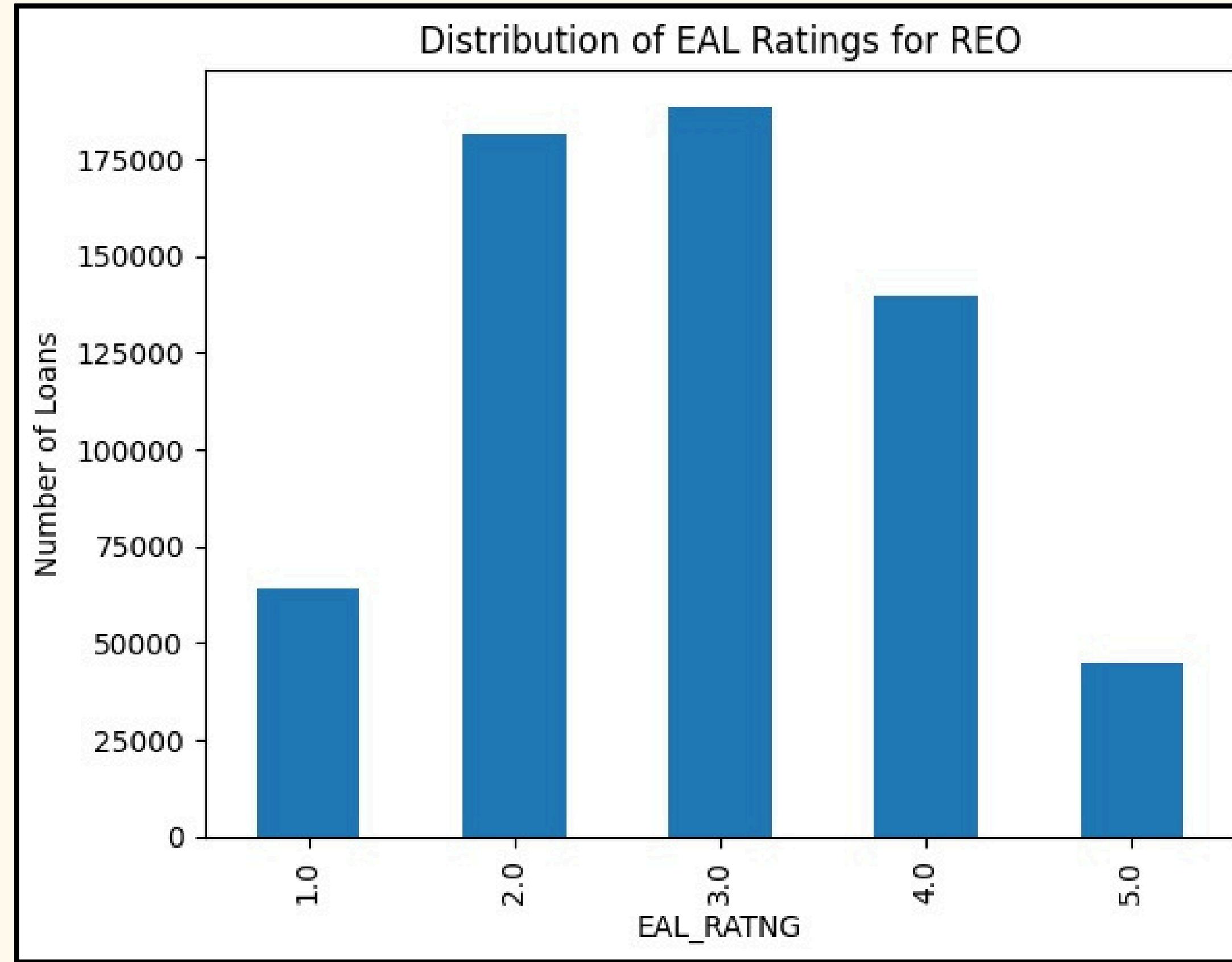


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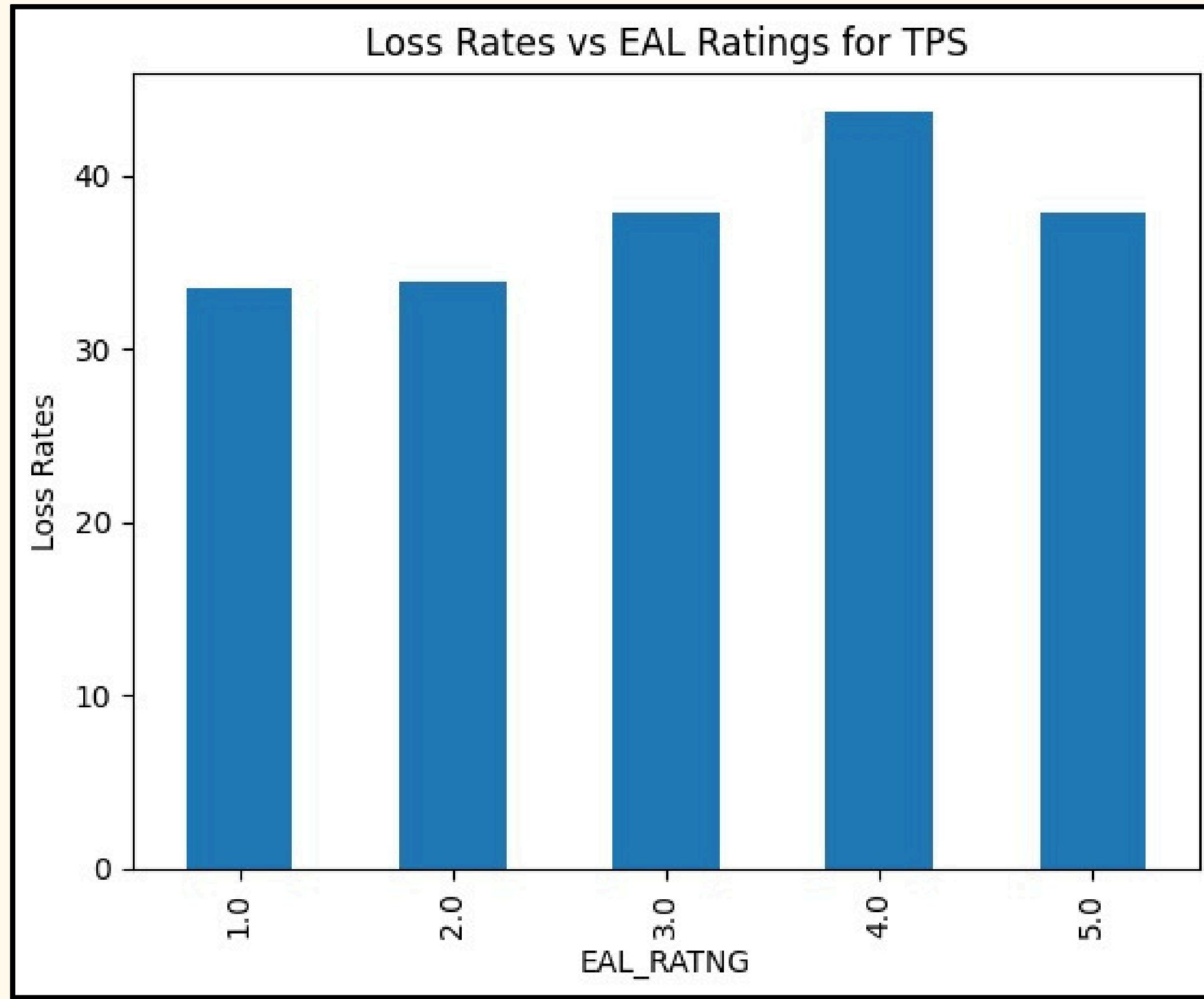


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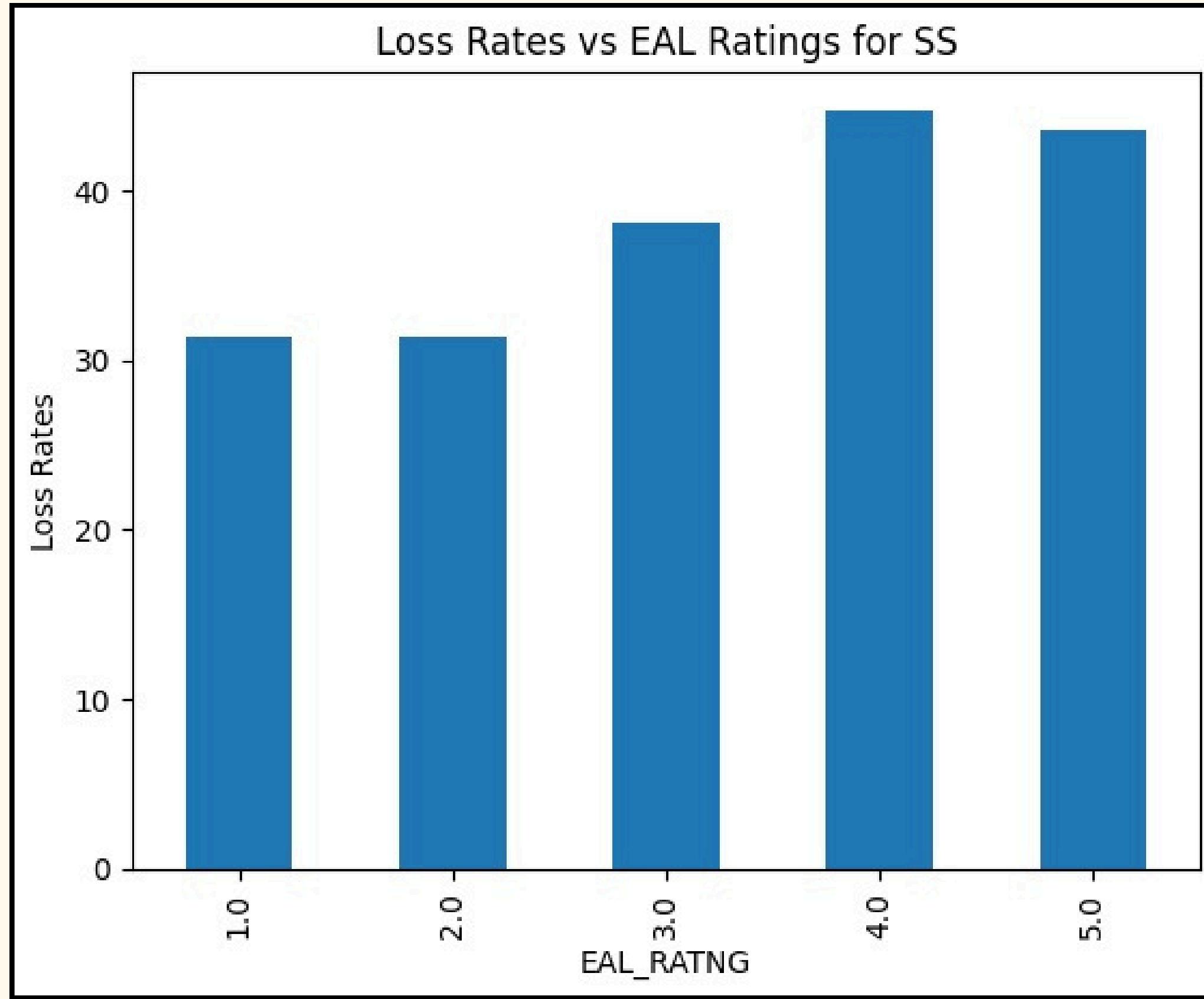


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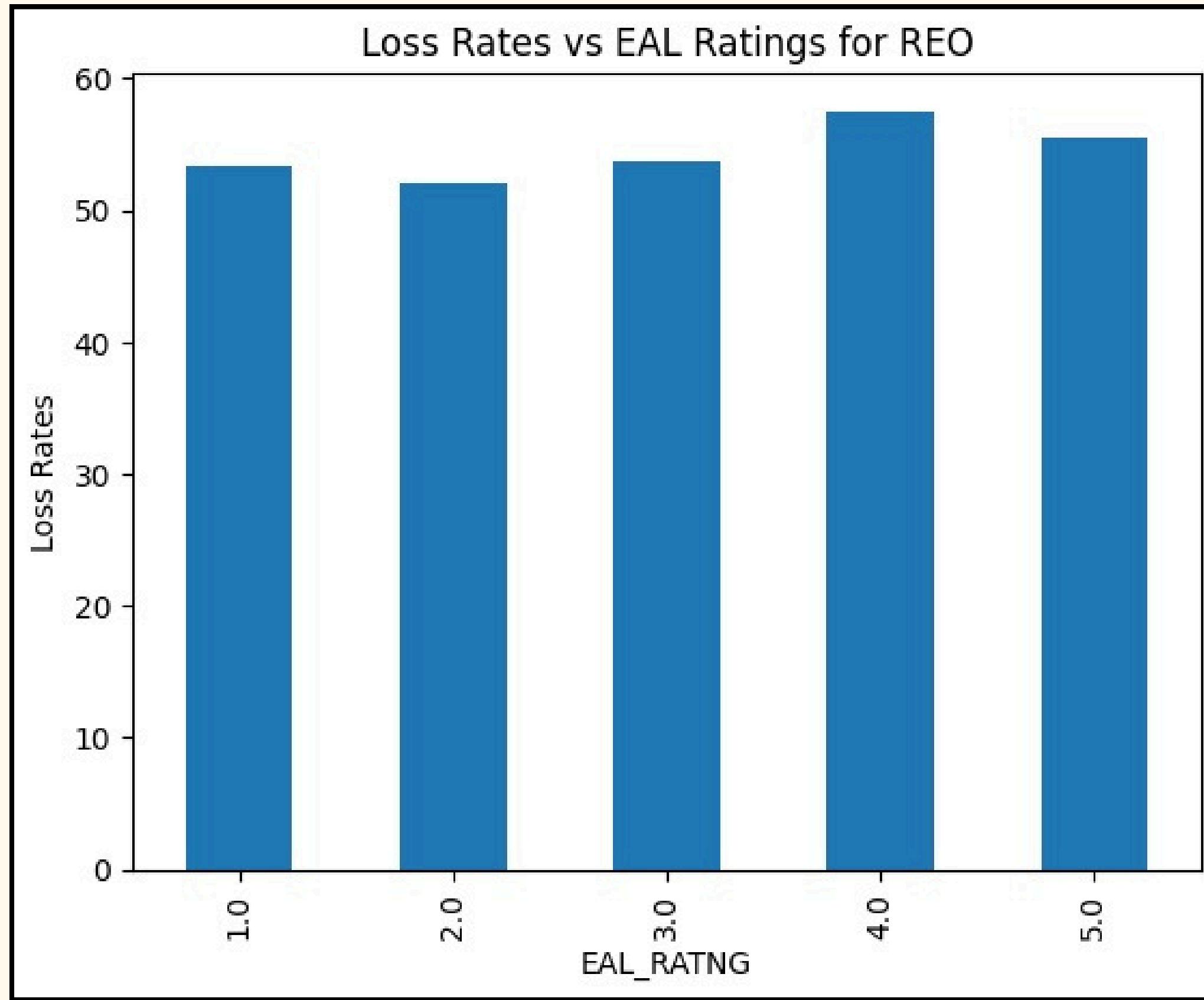


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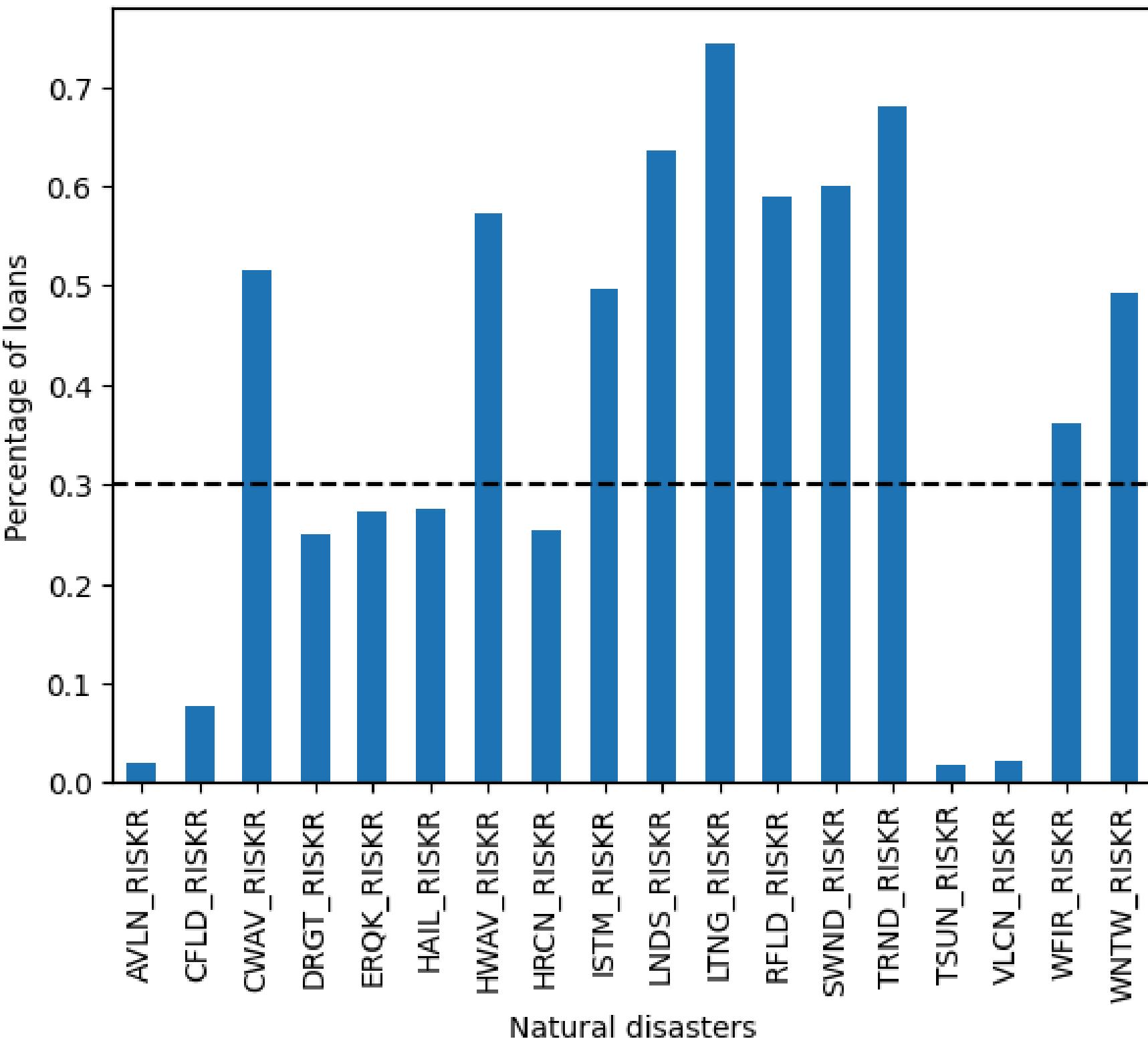
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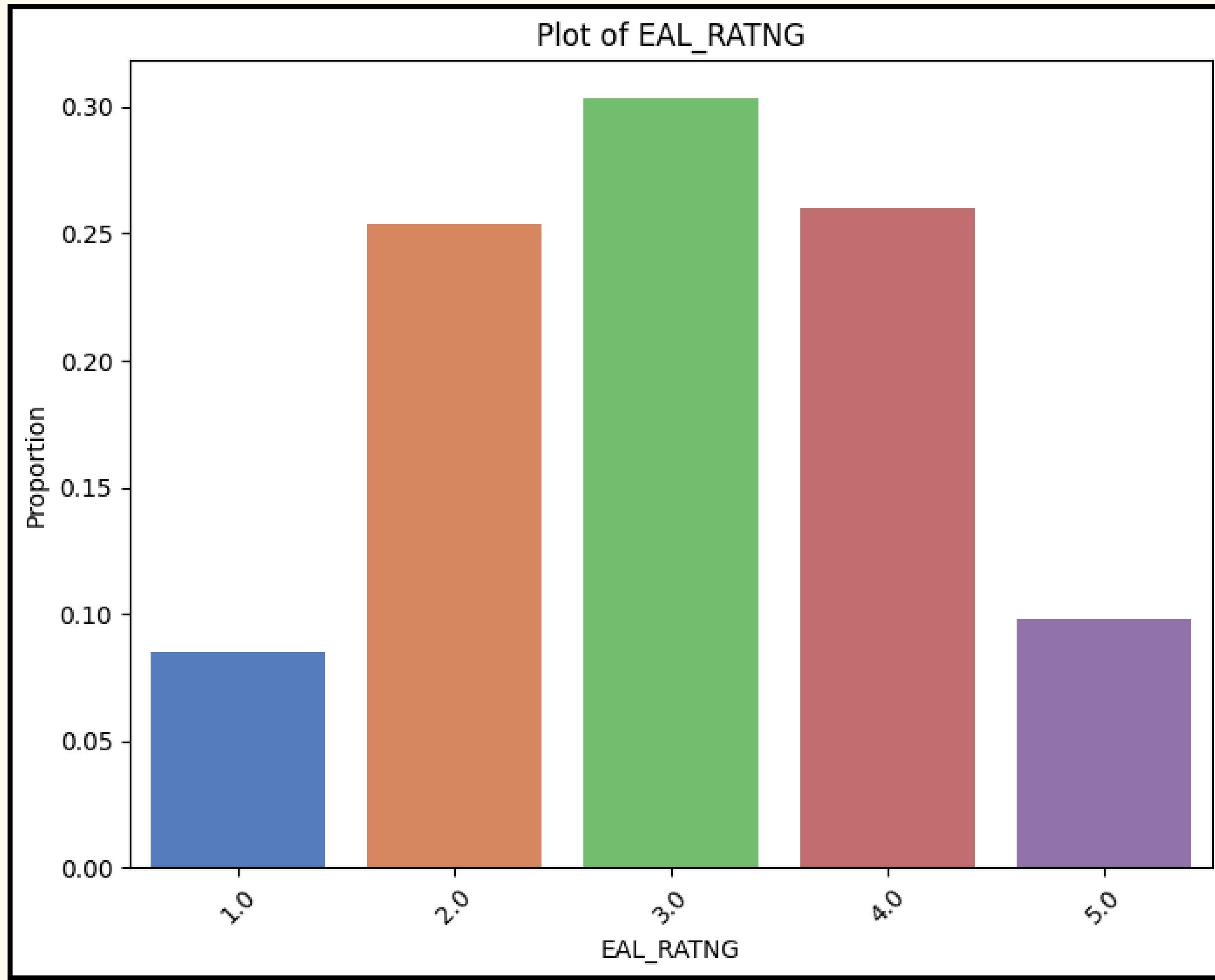
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Percentage of defaulted loans in areas rated moderately risky or more





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Thank
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