Evaluating Mortgage Lending Equity in the South Atlantic: A CRA-Linked HMDA Analysis for NCRC

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NCRC

Executive Summary

Data & Scope: 2022 HMDA merged with CRA data, South-Atlantic (**~932 k loans**)

Does a CRA rating still guarantee fairer mortgage access and pricing — and for whom?

+22% on **Black** Applicant's **Approval Rate** but creates new disparities among other race and ethnicity groups: **Hispanic or Latino (-11%~-20%)** & **Native Hawaiian(-59%)**

Mandatory disclosure to address racial gap

CRA backfired on **low-income** borrowers**:** approval rate **15.89 %** (CRA) vs **22.60 %** (non-CRA)

Loan Assistance Programs

Black borrowers faced highest interest rate spread (**+66.8 bps**) even being benefited from higher approval rate from CRA-rated banks

Refinancing Options

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SCQ: CRA Ratings Promise Fair Lending — Do They Still Deliver?

Situation

Data & Scope: 2022 HMDA, South-Atlantic (**~932 k loans**).

Purpose of CRA : rates how well banks serve low- & moderate-income & marginalised borrowers.

Why it matters to NCRC : CRA score is NCRC's primary flag for fair-lending gaps..

Complication

Overall approvals climb at CRA lenders (+12 pp).

Low-income borrowers lag at CRA banks (-6.71 pp).

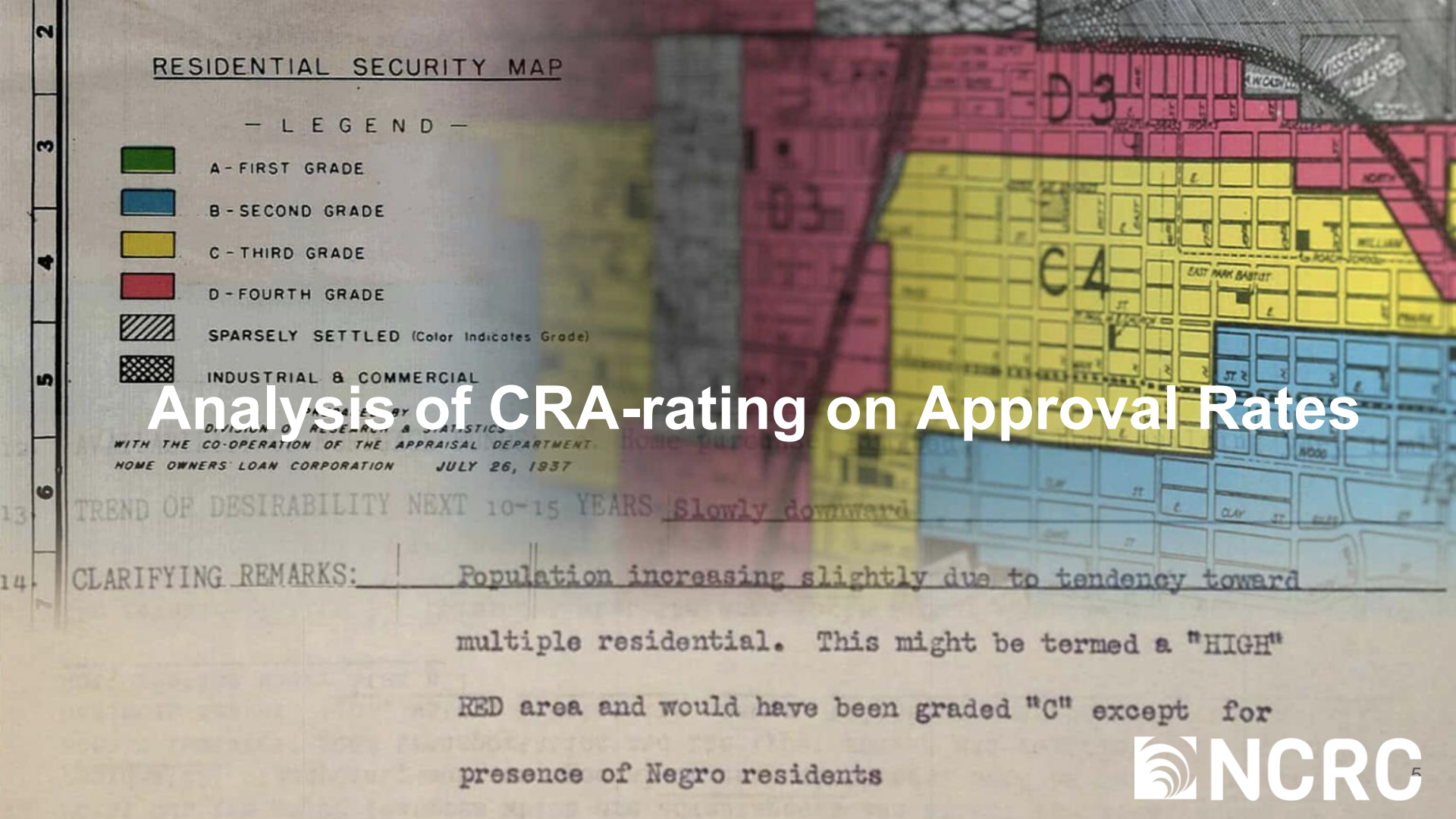
Cost gap widens: average rate-spread at CRA banks increases (+0.30 pp).

Key Questions

Does a CRA rating still guarantee fairer mortgage access and pricing — and for whom?

We'll test whether CRA helps or harms different communities and recommend how to close the gaps.

* *pp" = percentage-points; All figures CRA – non-CRA; p < 0.001. Data prep & diagnostics in appendix.*



Analysis of CRA-rating on Approval Rates

CRA Boosted Overall Approvals, but Backfired on Low-Income Borrowers

CRA Significantly Increases Overall Approval Likelihood

- Applications to CRA-rated institutions are **11.78% more likely to be approved** than those to non-CRA lenders ($p < 0.001$).
- **41 % (CRA) vs 29 % (non-CRA)**
- This appears to validate CRA's intended effect—**but only at the surface level.**

CRA Underperforms on Low-income Applicants

- Low-income borrowers are **6.71% less** likely to be approved by CRA institutions compared to non-CRA lenders ($p < 0.001$).
- **15.89 % (CRA) vs 22.60 % (non-CRA)**
- While CRA improved access broadly, it **fails to serve high-risk communities** most in need.

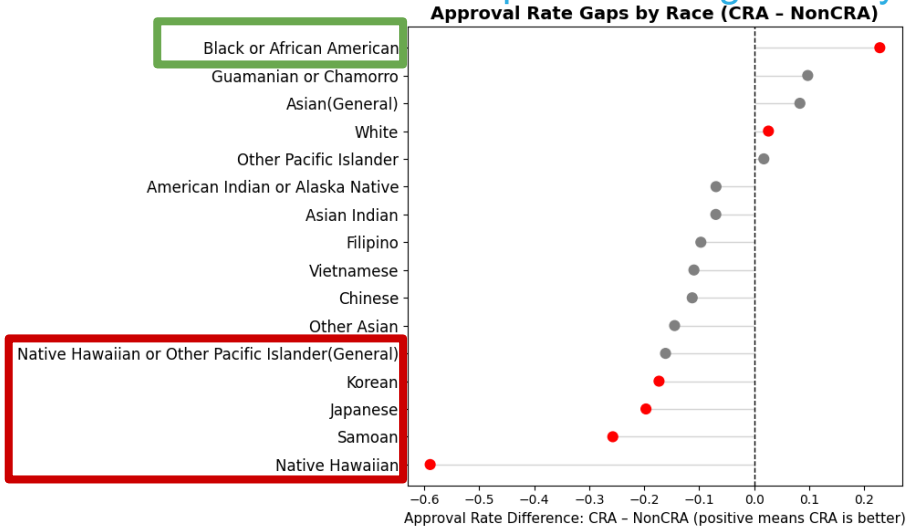
Raises Concerns:

Some **non-CRA lenders**—such as nonbanks—may approve more loans, but under **predatory conditions.**

Native Hawaiian and Pacific Islander Experience the Largest Disparities

Racial disparities persist—even under CRA.

- **Native Hawaiian and Pacific Islander** applicants experience the largest **approval rate gap** (59% **less likely**) between CRA and non-CRA institutions.
- While **Black** applicants saw modest gains **under CRA (+22.8%)**, groups like **Japanese and Korean** borrowers experienced significantly **lower approval rates**.



Race	Difference(CRA – Non-CRA)
Native Hawaiian	- 0.589286
Samoan	- 0.257143
Japanese	- 0.196796
Korean	- 0.173077
Black or African American	+ 0.228523

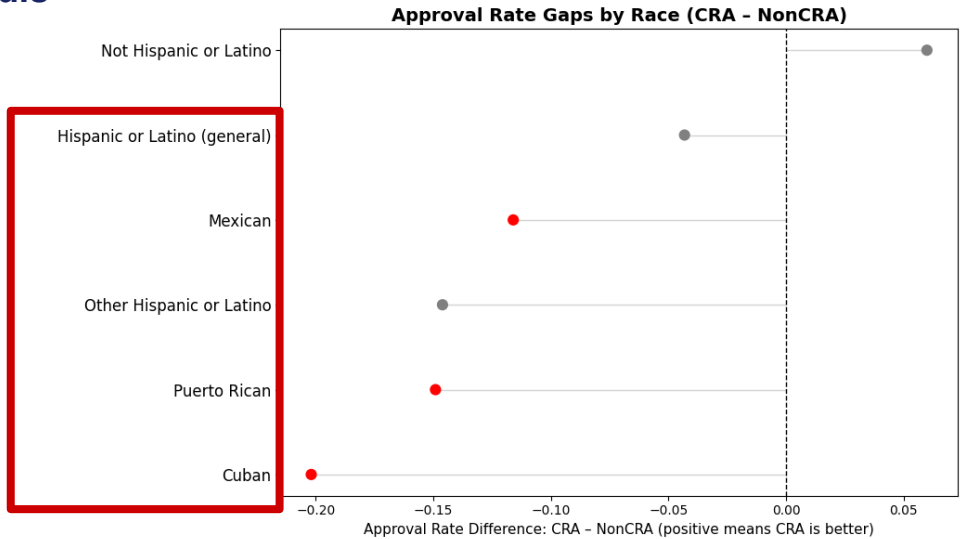
Note: Difference = CRA approval rate – Non-CRA approval rate

All Hispanic or Latino Subgroups Face Negative Differences

- **All Hispanic or Latino** subgroups face **negative differences**, with **Cubans** experiencing the **largest gap at - 20%**.
- **Puerto Rican, Other Hispanic/Latino, and Mexican applicants** also show consistent **disadvantage**, though to varying degrees.

These patterns suggest **systemic ethnic disparities** that warrant further investigation

Ethnicity	Difference
Cuban	-0.201906
Puerto Rican	-0.149075
Other Hispanic or Latino	-0.146093
Mexican	-0.116011

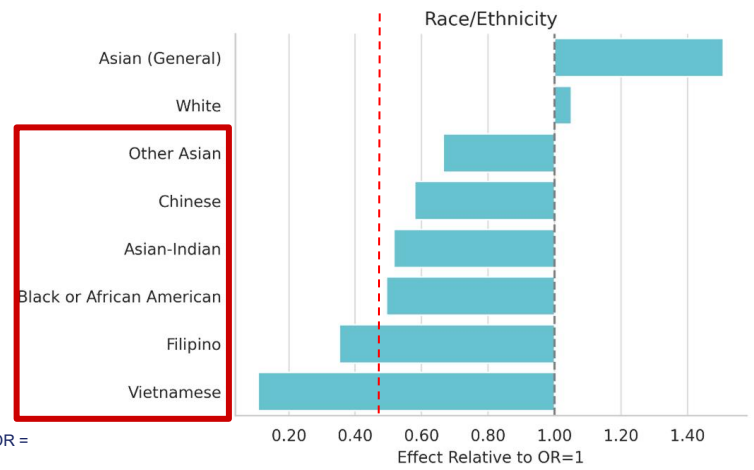


CRA Support Helps, but Inequality Persists

- Odds Ratios Based on Logistic Regression (All Datasets)

After controlling ten different variables, we found

- CRA helps a little (OR ≈ 1.06) — but **not enough**
- Being **low-income** cuts approval **odds in half** (face ~50% lower odds of approval (OR ≈ 0.52))
- CRA banks **don't fully protect low-income borrowers** (CRA × Low-Income OR ≈ 0.37)



Race still matters:

- **Filipino, Black, and especially Vietnamese** applicants experience the sharpest approval gaps
- Vietnamese applicants face nearly **90% lower odds**

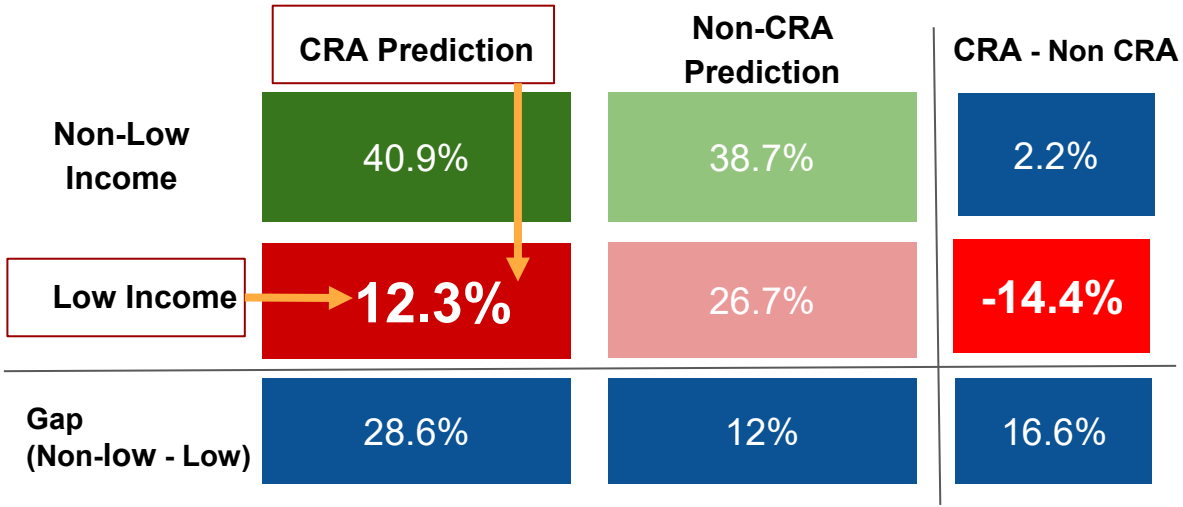
Note:
1. We use a **logistic regression model** controlling for **loan amount, loan term, loan type, loan purpose, and geographic fixed effects** to isolate the impact of **CRA affiliation, income level, and race/ethnicity on loan approval.**
2. Odds Ratio (OR) = e^(coef). OR > 1 indicates an increased probability of approval; OR < 1 indicates a decreased probability of approval; OR = 1 indicates no effect on approval probability.
3. For model, LLR pvalue: 0.000; Log-Likelihood: -2.6036e+05; Pseudo-R-squared: 0.1443

12% Predicted Approval Rate of a Low-income Applicant at a CRA-rated Bank

We defined a **baseline** borrower profile by setting:

- **Loan amount and term:** Sample Medians
- **Applicant sex, race, loan type, loan purpose**: Most Frequent Categories
- **MSA, open-end line, balloon payment, interest-only**: Most Frequent

After controlling these variables, CRA **may benefit middle- and high-income applicants**, but potentially **disadvantage low-income individuals**.



CRA: Mitigating Some Inequality, Reinforcing or Creating New Issues

Due to **sample imbalance**, we ran separate regressions for the **CRA and non-CRA subsamples**.

	CRA OR (exp)	Non-CRA OR (exp)	CRA OR/Non-CRA OR
Black or African American	1.18	0.36	3.24 ↑
Asian (General)	1.73	1.24	1.39 ↑
Native Hawaiian and Other Pacific Islander (General)	0.22	1.10	0.20 ↓
White	1.74	1.28	1.36 ↑

CRA isn't a failure — but it's incomplete.

CRA helps **improve access for some underserved groups.**

- **Black and Asian** borrowers face significantly **higher approval odds** at CRA-rated institutions compared to non-CRA lenders (e.g., **OR ↑3.24**).

CRA may **introduce new disparities.**

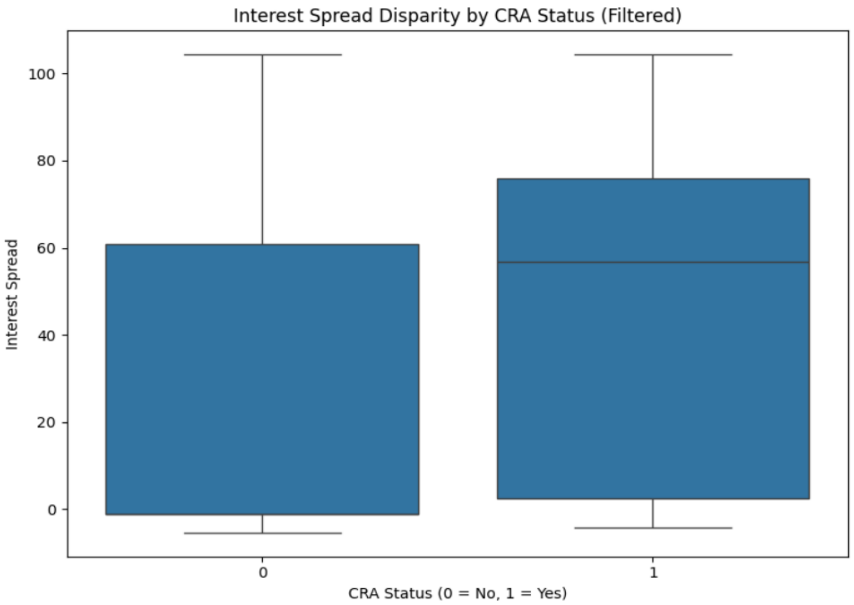
- **Native Hawaiian and Other Pacific Islanders** appear to be more **disadvantaged** at CRA institutions (OR = 0.22 vs 1.10), suggesting that CRA benefits are not evenly distributed.

Analysis of Borrowing Costs After Approval

CRA-rated banks have a higher mean interest spread than non-CRA banks

T-test Result

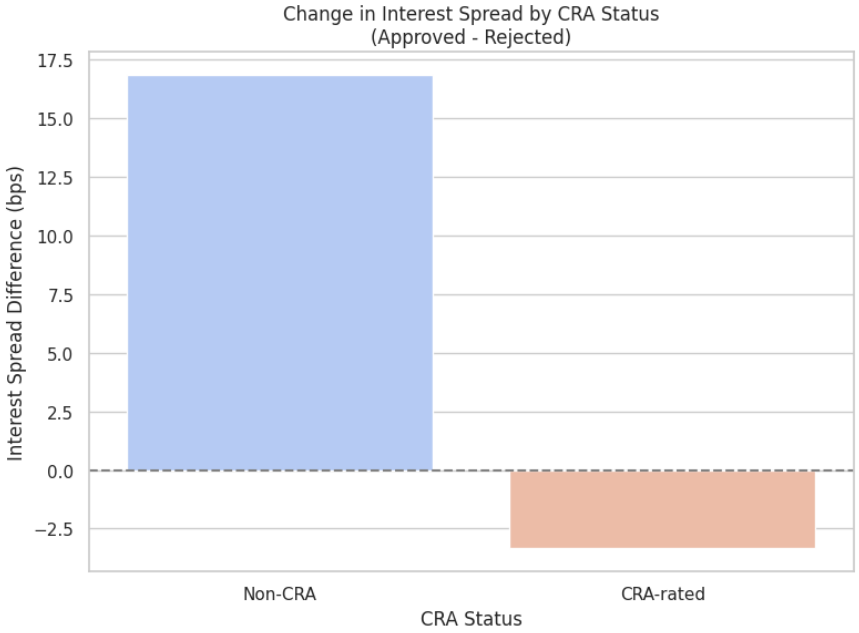
- Mean Interest Spread (CRA = 1): 53.87 bps
- Mean Interest Spread (CRA = 0): 24.07 bps
- T-statistic = 28.90, p-value < 0.001
  → **Statistically significant**



💡 Why might CRA-rated banks charge more?

- **Higher-risk borrower mix**: CRA banks may serve more low-income or underserved clients, raising average spreads.
- **Signals disparity**: Sets the stage to examine spread differences by race—even among approved loans.

CRA Banks Show Selective Generosity:
Lower Spreads for Approved Loans, But Overall Pricing Remains Higher



Comparison Result

- Non-CRA banks **increase interest spread by ~17 bps** after approval — implying that approved borrowers pay more than rejected ones on average.
- CRA-rated banks, however, show **a decrease in spread (about −2.5 bps) after approval** — meaning they may offer better terms to approved borrowers.

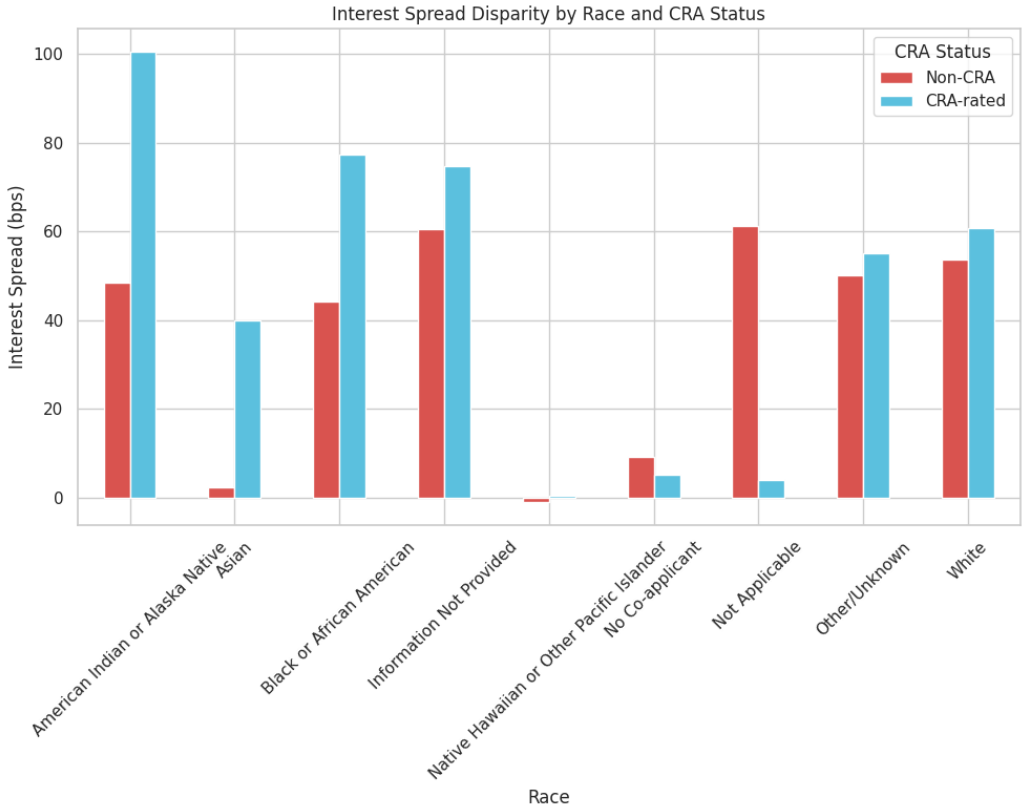
Showing that

- Non-CRA institutions appear to penalize approved borrowers more heavily with higher spreads.
- CRA institutions seem more generous post-approval—but earlier their overall spreads are still higher.

Raises Concerns:

Generosity is selective and may mask disparities across borrower types

Largest disparity of interest spread in American Indian/Alaska Native

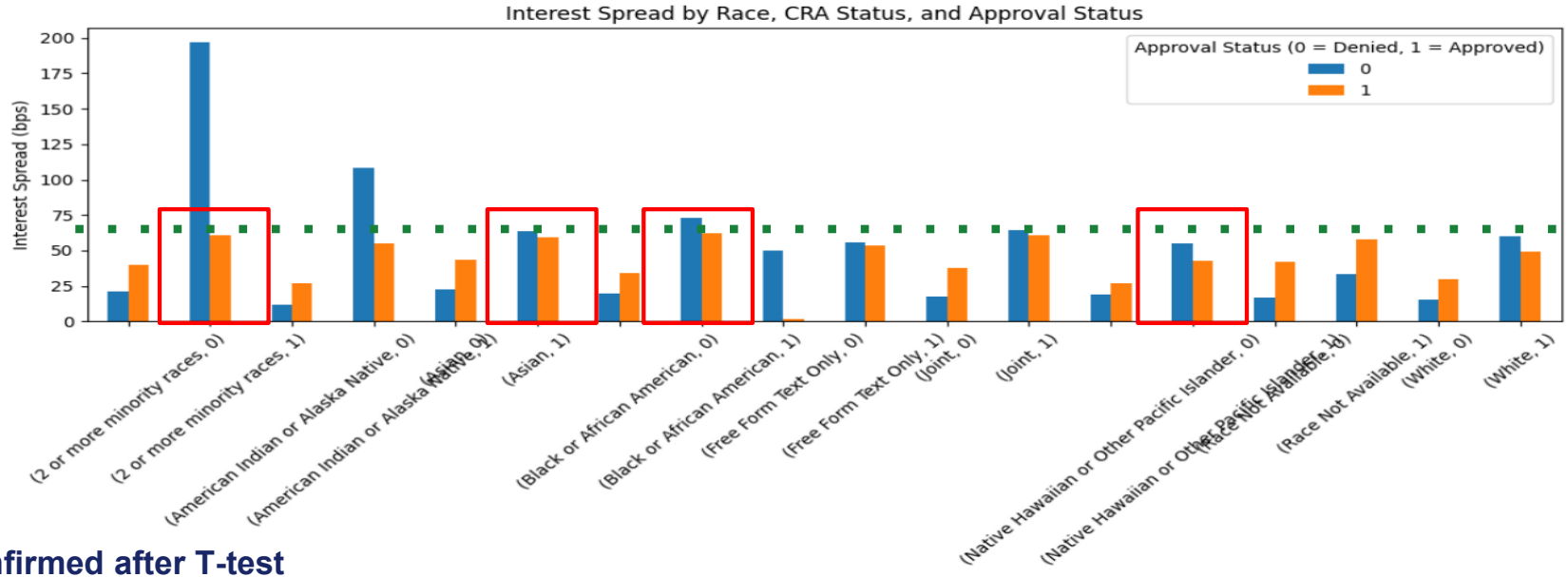


Key Insights

- CRA-rated banks charge higher interest spreads than non-CRA banks **across most racial groups**.
- The widest disparity is observed in **American Indian/Alaska Native** applicants — over +50 bps higher under CRA banks.
- **Black and Asian**: notable increase, with CRA spreads exceeding 60–75 bps.
- **White** applicants experience a smaller gap (CRA: ~60 bps, Non-CRA: ~53 bps), but the trend still holds.

The pattern is systemic, suggesting CRA status may not ensure equitable lending outcomes.

Even Approved, Minority Borrowers Pay More at CRA Banks



Confirmed after T-test

- **Even after approval**, CRA-rated banks continue to charge higher spreads **across most racial groups**.
- **2+ Minority Races, American Indian/Alaska Native, Black, Asian, and Pacific Islander** borrowers all exceed the 60 bps threshold.
- The trend persists regardless of loan approval, signaling **systemic pricing disparities—not just risk-based decisions.**

Gender, credit score, geography, income and sex affect interest spreads

- CRA banks **consistently charge higher spreads** among all racial groups, especially to minority groups.
- Race-CRA interactions are statistically significant, showing **systemic pricing disparities**.
- Gender, credit score, geography, and income also affect interest spreads.
- Sex appears to play a role in pricing — especially when missing/unknown, rates increase sharply.

Factor	Effect on Spread	Interpretation
Low Credit Score	↑ (e.g., T.3–T.5)	Risk-based pricing pattern
Missing Gender / Unknown	↑ Spike	Data gaps trigger pricing penalties
State (DE, GA, MD, NC)	↑	Regional structural disparities
Loan Amount	+3.87 bps per unit ↑	Larger loans costlier
Neighborhood Income (MSA %)↓	−0.010 per unit ↓	Lower income areas face higher spreads
Loan Approval	+4.71 bps	Approved loans slightly more expensive

CRA Mitigated Some Inequality but Reinforced or Created New Issues

22% Improvement
on Black Applicant's Approval Rate

CRA ratings significantly improve approval rates, especially for Black or African American applicants but creates new disparities among other race and ethnicity groups:Hispanic or Latino (-11%~-20%) & Native Hawaiian(-59%).

Mandatory disclosure to address racial gap

88% Denied
Predicted Probability of Low-income Applicant from CRA Lender

CRA may benefit middle- and high-income applicants, but potentially disadvantage low-income individuals.

Loan Assistance Programs

+54 bps vs +24 bps
CRA-rated interest spread vs non-CRA-rated interest spread

CRA failed to control mortgage costs as CRA-rated banks charged more after controlling race and approval status.

	White	Black	Native American	Asian
Interest Spread Difference	+2 bps	+66.8 bps	+43.8 bps	+41.8bps

Refinancing Options

Thank you!

Please reach out with any questions!

JOHNS HOPKINS
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Appendix A-Data Preparation

Steps of Merging:

1. Filter and Prepare CRA Data

- Chunk the data for more efficient processing and dropped the columns with more than 50% missing value
- Focused on South Atlantic (SA) states using FIPS-to-abbreviation mapping
- Calculated average CRA rating per bank.
- Filtered to banks with at least one exam in SA states.
- Standardized bank names for matching.

2. Prepare LEI Data for Matching

- Standardized respondent names from LEI data.
- Created a unique set of respondent names for fuzzy matching.

3. Fuzzy Match Bank Names

- Matched LEI respondent names to SA banks using fuzzywuzzy with token set ratio ≥ 85.
- Merged successful matches with average CRA ratings.

4. Merge CRA Ratings into LEI Data

- Merged CRA ratings into the full LEI dataset via standardized name key (resp_key).

```python
import pandas as pd

file_path = 'D:/data/filtered_sa_data.csv'
output_path = 'D:/data/cleaned_sa_data.csv'

na_values = ['<NA>', 'NAN', 'NaN', 'nan', '', 'null', 'NULL']
chunksize = 20000
first_write = True

for i, chunk in enumerate(pd.read_csv(file_path, dtype=str, na_values=na_values, chunksize=chunksize)):
    print(f"Processing chunk {i+1}")

    # Only drop columns with more than 50% missing values
    threshold = len(chunk) * 0.5
    chunk = chunk.dropna(axis=1, thresh=threshold)

    # Write to file
    if not chunk.empty:
        chunk.to_csv(output_path, mode='w' if first_write else 'a', header=first_write, index=False)
        first_write = False

print("✅ Column-level cleaning complete. Saved to:", output_path)
```

```
# ---------------------------------
# 0. Define South Atlantic states
# ---------------------------------
sa_states = ['DE','DC','FL','GA','MD','NC','SC','VA','WV']
# FIPS → abbreviation mapping for HMDA 'state_code'
fips_to_abbr = {
    '10':'DE','11':'DC','12':'FL','13':'GA','24':'MD',
    '37':'NC','45':'SC','51':'VA','54':'WV'
}


file_path = '/content/drive/MyDrive/cra_rating.csv'

cra_df = pd.read_csv(file_path, dtype=str)
cra_df['Rating'] = pd.to_numeric(cra_df['Rating'], errors='coerce')

# Compute overall average per Bank_Name
cra_avg = (
    cra_df
      .groupby('Bank_Name', as_index=False)['Rating']
      .mean()
      .rename(columns={'Rating':'avg_cra_rating'})
)

# Identify banks with at least one exam in SA region
sa_banks = cra_df[cra_df['State'].isin(sa_states)]['Bank_Name'].unique()
cra_avg_sa = cra_avg[cra_avg['Bank_Name'].isin(sa_banks)].copy()
cra_avg_sa['bank_key'] = cra_avg_sa['Bank_Name'].str.upper().str.strip()
```

```
# ---------------------------------
# 2. Fuzzy-match SA avg ratings into LEI table
# ---------------------------------
lei_df = pd.read_csv('/content/drive/MyDrive/lei_data.csv', dtype=str)
lei_df['resp_key'] = lei_df['respondent_name'].str.upper().str.strip()

# Prepare unique respondent keys
unique_resp = lei_df[['resp_key']].drop_duplicates().reset_index(drop=True)

# Matching function against SA bank keys
def match_sa_bank(name):
    res = process.extractOne(name, cra_avg_sa['bank_key'], scorer=fuzz.token_set_ratio)
    if res and res[1] >= 85:
        return res[0]
    return None

unique_resp['sa_match'] = unique_resp['resp_key'].apply(match_sa_bank)
```

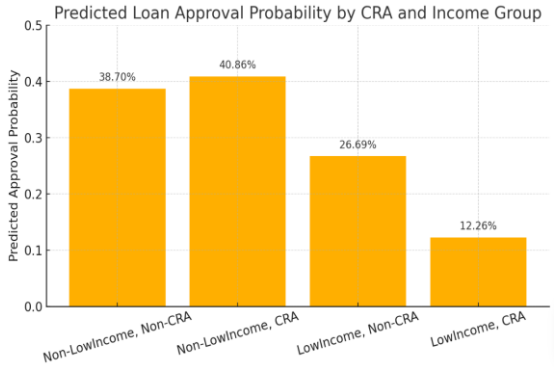
```
# ── 1. Build mapping with the correct column name ──────────────
mapping_sa = (
    unique_resp
      .merge(
          cra_avg_sa[['bank_key','avg_cra_rating']],
          left_on='sa_match',
          right_on='bank_key',
          how='inner'
      )
      # rename avg_cra_rating → cra_rating here
      .rename(columns={'avg_cra_rating':'cra_rating'})
      # keep only the key + renamed rating
      .loc[:, ['resp_key','cra_rating']]
)

# ── 2. Ensure resp_key exists on lei_df ────────────────────────
lei_df['resp_key'] = lei_df['respondent_name'].str.upper().str.strip()

# ── 3. Now merge in the renamed column ─────────────────────────
lei_df = lei_df.merge(
    mapping_sa,   # now has ['resp_key','cra_rating']
    on='resp_key',
    how='left'
)

# ── 4. Clean up helper column ──────────────────────────────────
lei_df.drop(columns=['resp_key'], inplace=True)
```

Appendix B - Difference between different groups

CRA-rated approval rate: 40.67%
Non-CRA-rated approval rate: 28.89%
T-statistic:
100.1487
P-value: 0.0000

Low Income
CRA-rated: 15.89%
Non-CRA-rated: 22.6%
T-statistic: -22.063
p-value: 1.01e-106

Group/Prob	CRA Prediction	Non-CRA Prediction	CRA - Non CRA
Non-low Income	40.9%	38.7%	**+2.2%**
Low Income	12.3%	26.7%	**–14.4%**
Gap (Non-low - Low)	**+ 28.6%**	**+12%**	**+16.6%**



Appendix C-Logit Model Specification for Loan Approval Probability

$$\begin{aligned}\text{Approved} = \beta_0 &+ \beta_1 \cdot \text{Has CRA Rating} + \beta_2 \cdot \text{Low Income} \\ &+ \beta_4 \cdot \text{Loan Amount} + \beta_5 \cdot \text{Loan Term} + \beta_6 \cdot \\ &+ \beta_7 \cdot \text{Balloon Payment} + \beta_8 \cdot \text{Interest-Only} \\ &+ \beta_{10} \cdot \text{Race (NCRC Sub)} + \beta_{11} \cdot \text{Loan Type} \\ &+ \beta_{13} \cdot \text{Derived MSA MD}\end{aligned}$$

Where:

- *Has CRA Rating* refers to the presence of a CRA rating.
- *Low Income* indicates whether the applicant is classified as low-income.
- *CRA Low Income* is an interaction term between CRA rating and low-income status.
- *Loan Amount* and *Loan Term* are continuous variables representing the amount of the loan and its term length.
- *Open-End Line of Credit, Balloon Payment, Interest-Only Payment* are categorical variables indicating specific features of the loan.
- *Applicant Sex, Race, Loan Type, Loan Purpose, Derived MSA MD* are categorical variables corresponding to the applicant's sex, race (as per NCRC subcategories), loan type, loan purpose, and geographical region.

1. CRA & Income-Related Factors

`has_cra_rating`: Whether the loan was issued by a CRA-rated institution

`low_income`: Whether the applicant is low-income

`cra_low_income`: Interaction term between CRA and low-income status

2. Loan Amount & Term

`loan_amount`: Total amount of the loan application

`loan_term`: Duration of the loan in months

3. Loan Product Features

`open_end_line_of_credit`: Whether the loan is an open-end credit line

`balloon_payment`: Whether the loan includes a balloon payment structure

`interest_only_payment`: Whether the loan requires interest-only payments

4. Applicant Demographics

`applicant_sex`: Applicant's gender

`race_ncrc_sub`: Applicant's race or ethnicity subgroup

5. Loan Type & Purpose

`loan_type`: Type of loan (e.g., conventional, FHA)

`loan_purpose`: Purpose of the loan (e.g., home purchase, refinance)

6. Geographic Controls

`derived_msa_md`: Metropolitan statistical area (MSA) fixed effects

Appendix D - Results of Logistic Regression

Variable	Coefficient (p-value)	Interpretation
has_cra_rating	+0.0568 ($p < 0.001$)	CRA rating is positively associated with approval, even after controlling for other factors.
low_income	-0.6605 ($p < 0.001$)	Low-income applicants are significantly less likely to be approved.
cra_low_income	-0.9908 ($p < 0.001$)	Low-income applicants in CRA areas have the lowest approval odds, suggesting structural issues.
loan_amount	Positive (very small)	Larger loan amounts slightly increase approval probability.
loan_term	Positive (very significant)	Longer loan terms are associated with higher approval likelihood.
interest_only_payment	1.0163	Strongly increases approval probability — may signal strong creditworthiness.

Logit Regression Results

Dep. Variable:	approved	No. Observations:	582209
Model:	Logit	Df Residuals:	582080
Method:	MLE	Df Model:	128
Date:	Thu, 01 May 2025	Pseudo R-squ.:	0.1443
Time:	11:08:55	Log-Likelihood:	-2.6036e+05
converged:	True	LL-Null:	-3.0427e+05
Covariance Type:	nonrobust	LLR p-value:	0.000

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-2.9484	0.161	-18.283	0.000	-3.264	-2.632
C(open_end_line_of_credit)[T.1.0]	0.3401	0.026	12.855	0.000	0.288	0.392
C(balloon_payment)[T.1.0]	-0.3437	0.016	-20.867	0.000	-0.376	-0.311
C(interest_only_payment)[T.1.0]	1.0163	0.011	88.426	0.000	0.994	1.039
C(applicant_sex)[T.2]	0.0079	0.012	0.683	0.494	-0.015	0.031
C(applicant_sex)[T.3]	-2.0685	0.023	-90.669	0.000	-2.113	-2.024
C(applicant_sex)[T.4]	-0.7126	0.100	-7.113	0.000	-0.909	-0.516
C(applicant_sex)[T.5]	-1.9037	5.63e+06	-3.38e-07	1.000	-1.1e+07	1.1e+07
C(applicant_sex)[T.6]	-0.4240	0.295	-1.439	0.150	-1.002	0.154
C(race_ncrc_sub)[T.Asian Indian]	-0.6608	0.098	-6.738	0.000	-0.853	-0.469
C(race_ncrc_sub)[T.Asian(General)]	0.4111	0.054	7.679	0.000	0.306	0.516
C(race_ncrc_sub)[T.Black or African American]	-0.7050	0.054	-13.091	0.000	-0.811	-0.599
C(race_ncrc_sub)[T.Chinese]	-0.5466	0.243	-2.247	0.025	-1.023	-0.070
C(race_ncrc_sub)[T.Filipino]	-1.0452	0.273	-3.822	0.000	-1.581	-0.509
C(race_ncrc_sub)[T.Guamanian or Chamorro]	0.0485	0.841	0.058	0.954	-1.600	1.696
C(race_ncrc_sub)[T.Information Not Provided]	0.3445	0.054	6.417	0.000	0.239	0.450
C(race_ncrc_sub)[T.Japanese]	0.0898	0.607	0.148	0.882	-1.100	1.280
C(race_ncrc_sub)[T.Korean]	-0.6110	0.327	-1.867	0.062	-1.253	0.031
C(race_ncrc_sub)[T.Native Hawaiian]	-0.8550	1.104	-0.774	0.439	-3.020	1.310
C(race_ncrc_sub)[T.Native Hawaiian or Other Pacific Islander(General)]	0.7196	0.112	6.435	0.000	0.500	0.939
C(race_ncrc_sub)[T.No Co-applicant]	-1.9037	5.63e+06	-3.38e-07	1.000	-1.1e+07	1.1e+07
C(race_ncrc_sub)[T.Not Applicable]	-0.6649	0.113	-5.873	0.000	-0.887	-0.443

C(race_ncrc_sub)[T.Other Asian]	-0.4081	0.154	-2.643	0.008	-0.711	-0.105
C(race_ncrc_sub)[T.Other Pacific Islander]	-0.3650	0.253	-1.443	0.149	-0.861	0.131
C(race_ncrc_sub)[T.Other/Unknown]	-2.9526	1.012	-2.917	0.004	-4.936	-0.969
C(race_ncrc_sub)[T.Samoan]	-30.6616	4.93e+06	-6.22e-06	1.000	-9.66e+06	9.66e+06
C(race_ncrc_sub)[T.Vietnamese]	-2.2243	0.595	-3.739	0.000	-3.390	-1.058
C(race_ncrc_sub)[T.White]	0.0494	0.052	0.943	0.345	-0.053	0.152
C(loan_type)[T.2]	-0.0127	0.010	-1.271	0.204	-0.032	0.007
C(loan_type)[T.3]	-0.1992	0.010	-20.684	0.000	-0.218	-0.180
C(loan_type)[T.4]	0.0631	0.046	1.381	0.167	-0.026	0.153
C(loan_purpose)[T.2]	-1.7207	0.031	-56.360	0.000	-1.781	-1.661
C(loan_purpose)[T.31]	-0.1099	0.011	-9.976	0.000	-0.131	-0.088
C(loan_purpose)[T.32]	-0.7713	0.008	-91.013	0.000	-0.788	-0.755
C(loan_purpose)[T.4]	-2.2099	0.032	-69.175	0.000	-2.273	-2.147
C(loan_purpose)[T.5]	-2.5092	0.393	-6.382	0.000	-3.280	-1.739
C(derived_msa_md)[T.10500]	2.4638	0.167	14.722	0.000	2.136	2.792
C(derived_msa_md)[T.11700]	2.1557	0.159	13.563	0.000	1.844	2.467
C(derived_msa_md)[T.12020]	2.2225	0.173	12.817	0.000	1.883	2.562
C(derived_msa_md)[T.12060]	2.3689	0.153	15.488	0.000	2.069	2.669
C(derived_msa_md)[T.12260]	2.3236	0.156	14.900	0.000	2.018	2.629
C(derived_msa_md)[T.12580]	2.2037	0.154	14.317	0.000	1.902	2.505
C(derived_msa_md)[T.13220]	2.0560	0.190	10.797	0.000	1.683	2.429
C(derived_msa_md)[T.13980]	2.5800	0.175	14.718	0.000	2.236	2.924
C(derived_msa_md)[T.15260]	2.3136	0.174	13.308	0.000	1.973	2.654
C(derived_msa_md)[T.15500]	2.5529	0.169	15.127	0.000	2.222	2.884
C(derived_msa_md)[T.15680]	2.3651	0.172	13.774	0.000	2.029	2.702
C(derived_msa_md)[T.15980]	2.0876	0.156	13.403	0.000	1.782	2.393
C(derived_msa_md)[T.16620]	1.7458	0.173	10.073	0.000	1.406	2.085
C(derived_msa_md)[T.16700]	2.1508	0.155	13.882	0.000	1.847	2.454
C(derived_msa_md)[T.16740]	2.3620	0.154	15.384	0.000	2.061	2.663
C(derived_msa_md)[T.16820]	2.8570	0.163	17.531	0.000	2.538	3.176
C(derived_msa_md)[T.16860]	2.4972	0.163	15.287	0.000	2.177	2.817
C(derived_msa_md)[T.17900]	2.3975	0.155	15.473	0.000	2.094	2.701
C(derived_msa_md)[T.17980]	2.2399	0.161	13.907	0.000	1.924	2.556
C(derived_msa_md)[T.18880]	2.7004	0.155	17.368	0.000	2.396	3.005

C(derived_msa_md)[T.19060]	3.4594	0.173	20.049	0.000	3.121	3.798
C(derived_msa_md)[T.19140]	2.7780	0.166	16.705	0.000	2.452	3.104
C(derived_msa_md)[T.19660]	2.2685	0.155	14.613	0.000	1.964	2.573
C(derived_msa_md)[T.20100]	2.3042	0.161	14.278	0.000	1.988	2.621
C(derived_msa_md)[T.20500]	2.3303	0.158	14.720	0.000	2.020	2.641
C(derived_msa_md)[T.22180]	2.5472	0.155	16.432	0.000	2.243	2.851
C(derived_msa_md)[T.22500]	1.9741	0.169	11.711	0.000	1.644	2.304
C(derived_msa_md)[T.22744]	1.9531	0.155	12.631	0.000	1.650	2.256
C(derived_msa_md)[T.23224]	2.0465	0.156	13.094	0.000	1.740	2.353
C(derived_msa_md)[T.23540]	2.1925	0.160	13.684	0.000	1.878	2.506
C(derived_msa_md)[T.23580]	2.0926	0.167	12.562	0.000	1.766	2.419
C(derived_msa_md)[T.24140]	2.4960	0.170	14.714	0.000	2.164	2.828
C(derived_msa_md)[T.24660]	2.3748	0.157	15.143	0.000	2.067	2.682
C(derived_msa_md)[T.24780]	2.1427	0.172	12.450	0.000	1.805	2.480
C(derived_msa_md)[T.24860]	2.3066	0.156	14.833	0.000	2.002	2.611
C(derived_msa_md)[T.25180]	2.0602	0.162	12.750	0.000	1.743	2.377
C(derived_msa_md)[T.25500]	2.1706	0.188	11.535	0.000	1.802	2.539
C(derived_msa_md)[T.25860]	2.3854	0.160	14.866	0.000	2.071	2.700
C(derived_msa_md)[T.25940]	2.1562	0.161	13.394	0.000	1.841	2.472
C(derived_msa_md)[T.25980]	2.5987	0.162	16.060	0.000	2.282	2.916
C(derived_msa_md)[T.26140]	2.4996	0.161	15.532	0.000	2.184	2.815
C(derived_msa_md)[T.26580]	2.0414	0.174	11.702	0.000	1.699	2.383
C(derived_msa_md)[T.27260]	2.0775	0.154	13.499	0.000	1.776	2.379
C(derived_msa_md)[T.27340]	2.4916	0.158	15.773	0.000	2.182	2.801
C(derived_msa_md)[T.28700]	2.0482	0.192	10.689	0.000	1.673	2.424
C(derived_msa_md)[T.29460]	2.1808	0.155	14.068	0.000	1.877	2.485
C(derived_msa_md)[T.31340]	2.5588	0.162	15.784	0.000	2.241	2.877
C(derived_msa_md)[T.31420]	2.4434	0.163	14.954	0.000	2.123	2.764
C(derived_msa_md)[T.33124]	2.0527	0.154	13.294	0.000	1.750	2.355
C(derived_msa_md)[T.34060]	1.7346	0.200	8.680	0.000	1.343	2.126
C(derived_msa_md)[T.34820]	2.0040	0.157	12.804	0.000	1.697	2.311
C(derived_msa_md)[T.34940]	1.9009	0.161	11.775	0.000	1.585	2.217
C(derived_msa_md)[T.35100]	2.1289	0.167	12.712	0.000	1.801	2.457
C(derived_msa_md)[T.35840]	1.9114	0.156	12.255	0.000	1.606	2.217

C(derived_msa_md)[T.36100]	2.0743	0.157	13.200	0.000	1.766	2.382
C(derived_msa_md)[T.36740]	2.2465	0.154	14.634	0.000	1.946	2.547
C(derived_msa_md)[T.37340]	2.4359	0.155	15.698	0.000	2.132	2.740
C(derived_msa_md)[T.37460]	2.6288	0.158	16.630	0.000	2.319	2.939
C(derived_msa_md)[T.37620]	2.0925	0.201	10.433	0.000	1.699	2.486
C(derived_msa_md)[T.37860]	2.1768	0.156	13.981	0.000	1.872	2.482
C(derived_msa_md)[T.38940]	2.2463	0.157	14.349	0.000	1.939	2.553
C(derived_msa_md)[T.39460]	1.9433	0.163	11.919	0.000	1.624	2.263
C(derived_msa_md)[T.39580]	2.3599	0.154	15.289	0.000	2.057	2.662
C(derived_msa_md)[T.40060]	2.3753	0.155	15.345	0.000	2.072	2.679
C(derived_msa_md)[T.40220]	2.5889	0.161	16.036	0.000	2.273	2.905
C(derived_msa_md)[T.40580]	2.3084	0.170	13.604	0.000	1.976	2.641
C(derived_msa_md)[T.40660]	2.7789	0.172	16.157	0.000	2.442	3.116
C(derived_msa_md)[T.41540]	2.3555	0.157	14.963	0.000	2.047	2.664
C(derived_msa_md)[T.42340]	2.4543	0.156	15.697	0.000	2.148	2.761
C(derived_msa_md)[T.42680]	2.2591	0.166	13.587	0.000	1.933	2.585
C(derived_msa_md)[T.42700]	2.1550	0.175	12.296	0.000	1.811	2.499
C(derived_msa_md)[T.43900]	2.3547	0.159	14.838	0.000	2.044	2.666
C(derived_msa_md)[T.44420]	2.3995	0.176	13.633	0.000	2.055	2.745
C(derived_msa_md)[T.44940]	2.2092	0.166	13.298	0.000	1.884	2.535
C(derived_msa_md)[T.45220]	2.2376	0.160	13.945	0.000	1.923	2.552
C(derived_msa_md)[T.45300]	2.1803	0.153	14.217	0.000	1.880	2.481
C(derived_msa_md)[T.45540]	1.9876	0.176	11.284	0.000	1.642	2.333
C(derived_msa_md)[T.46660]	2.9001	0.163	17.829	0.000	2.581	3.219
C(derived_msa_md)[T.47260]	2.2641	0.154	14.714	0.000	1.963	2.566
C(derived_msa_md)[T.47580]	2.4580	0.161	15.308	0.000	2.143	2.773
C(derived_msa_md)[T.47894]	2.2348	0.153	14.595	0.000	1.935	2.535
C(derived_msa_md)[T.48260]	1.8008	0.258	6.976	0.000	1.295	2.307
C(derived_msa_md)[T.48424]	2.1423	0.155	13.827	0.000	1.839	2.446
C(derived_msa_md)[T.48540]	1.5830	0.248	6.379	0.000	1.097	2.069
C(derived_msa_md)[T.48864]	2.5798	0.156	16.567	0.000	2.275	2.885
C(derived_msa_md)[T.48900]	2.4043	0.161	14.944	0.000	2.089	2.720
C(derived_msa_md)[T.49020]	1.9983	0.175	11.433	0.000	1.656	2.341
C(derived_msa_md)[T.49180]	2.1903	0.158	13.905	0.000	1.882	2.499
C(derived_msa_md)[T.99999]	2.1170	0.153	13.829	0.000	1.817	2.417
has_cra_rating	0.0568	0.012	4.775	0.000	0.033	0.080
low_income	-0.6605	0.012	-56.630	0.000	-0.683	-0.638
cra_low_income	-0.9908	0.036	-27.417	0.000	-1.062	-0.920
loan_amount	1.305e-07	1.23e-08	10.570	0.000	1.06e-07	1.55e-07
loan_term	0.0002	2.76e-06	55.771	0.000	0.000	0.000

Appendix E: logistics Regression Comparison Table (CRA vs Non CRA)

Variable	CRA Coef.	CRA Sig.	Non-CRA Coef.	Non-CRA Sig.	Interpretation
Black or African American	0.1657	***	-1.0101	***	CRA reduces racial gap; Non-CRA strongly negative
Asian (General)	0.5468	***	0.2142	***	Positive in both, stronger in CRA
Asian Indian	0.0552	not	0.2434	***	Only significant in Non-CRA
Vietnamese	-0.3684	not	-0.3684	not	Consistently negative, not sig.
Native Hawaiian	-1.1754	not	1.5185	not	Reversal, neither significant
NHPI (General)	-1.5251	***	0.0929	***	Sharp divergence; CRA negative
Filipino	-0.0475	not	0.1136	not	Not significant in both
White	0.5553	***	0.2495	***	Favored group under both
Low Income	-0.7334	***	-0.8096	***	Strong negative effect in both
Interest-Only Loan	1.0176	***	0.9286	***	High positive impact in both
Balloon Payment	-0.2878	***	-0.1824	***	Negative impact in both
Open-End Line	0.2557	***	0.1928	***	Mild positive
Loan Amount	0.000001554	***	3.028E-07	***	Positive, small
Loan Term	0.0024	***	-0.00005885	***	Direction flips (small effect)

$$\log\left(\frac{P(\text{approved}=1)}{1-P(\text{approved}=1)}\right) = \beta_0 + \beta_1 \cdot \text{low\_income} + \beta_2 \cdot \text{loan\_amount} + \beta_3 \cdot \text{loan\_term} + \sum_j \gamma_j \cdot D_j^{\text{race}} + \sum_k \delta_k \cdot D_k^{\text{loan\_type}}$$

Where:

- low_income: Binary indicator for low-income applicant
- loan_amount, loan_term: Numeric predictors
- D_j^{race}: Dummy variables for race/ethnicity categories from `race_ncrc_sub`
- $D_k^{\text{loan\_type}}$: Dummy variables for loan type

logistics Regression Comparison Table (CRA)

```
Optimization terminated successfully.
         Current function value: 0.605169
         Iterations 7
                           Logit Regression Results
==============================================================================
Dep. Variable:                approved   No. Observations:               216506
Model:                           Logit   Df Residuals:                   216480
Method:                           MLE   Df Model:                           25
Date:                Tue, 06 May 2025   Pseudo R-squ.:                  0.1041
Time:                        20:39:06   Log-Likelihood:            -1.3102e+05
converged:                       True   LL-Null:                   -1.4624e+05
Covariance Type:            nonrobust   LLR p-value:                    0.000
==============================================================================
```

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-1.0929	0.043	-25.382	0.000	-1.177	-1.009
C(race_ncrc_sub)[T.Asian Indian]	0.0552	0.069	0.794	0.427	-0.081	0.191
C(race_ncrc_sub)[T.Asian(General)]	0.5468	0.048	11.502	0.000	0.454	0.640
C(race_ncrc_sub)[T.Black or African American]	0.1657	0.045	3.683	0.000	0.078	0.254
C(race_ncrc_sub)[T.Chinese]	0.1846	0.160	1.152	0.249	-0.130	0.499
C(race_ncrc_sub)[T.Filipino]	-0.0475	0.158	-0.302	0.763	-0.356	0.261
C(race_ncrc_sub)[T.Guamanian or Chamorro]	0.5085	0.624	0.815	0.415	-0.714	1.731
C(race_ncrc_sub)[T.Information Not Provided]	-0.0466	0.045	-1.037	0.300	-0.135	0.041
C(race_ncrc_sub)[T.Japanese]	0.0924	0.488	0.189	0.850	-0.865	1.050
C(race_ncrc_sub)[T.Korean]	-0.1268	0.220	-0.576	0.564	-0.558	0.304
C(race_ncrc_sub)[T.Native Hawaiian]	-1.1754	1.074	-1.094	0.274	-3.281	0.930
C(race_ncrc_sub)[T.Native Hawaiian or Other Pacific Islander(General)]	-1.5251	0.061	-25.030	0.000	-1.645	-1.406
C(race_ncrc_sub)[T.No Co-applicant]	1.2457	0.050	24.898	0.000	1.148	1.344
C(race_ncrc_sub)[T.Not Applicable]	-2.0258	0.054	-37.660	0.000	-2.131	-1.920
C(race_ncrc_sub)[T.Other Asian]	-0.3028	0.108	-2.803	0.005	-0.515	-0.091
C(race_ncrc_sub)[T.Other Pacific Islander]	0.0181	0.156	0.116	0.907	-0.287	0.324
C(race_ncrc_sub)[T.Other/Unknown]	-0.2997	0.172	-1.744	0.081	-0.637	0.037
C(race_ncrc_sub)[T.Samoan]	-1.0466	1.088	-0.962	0.336	-3.178	1.085
C(race_ncrc_sub)[T.Vietnamese]	-0.6428	0.203	-3.167	0.002	-1.041	-0.245
C(race_ncrc_sub)[T.White]	0.5553	0.043	12.823	0.000	0.470	0.640
C(loan_type)[T.2]	0.2126	0.023	9.214	0.000	0.167	0.258
C(loan_type)[T.3]	0.5331	0.018	29.710	0.000	0.498	0.568
C(loan_type)[T.4]	1.0084	0.098	10.311	0.000	0.817	1.200
low_income	-0.7334	0.026	-28.719	0.000	-0.783	-0.683
loan_amount	1.554e-06	2.2e-08	70.506	0.000	1.51e-06	1.6e-06
loan_term	0.0024	5.17e-05	45.494	0.000	0.002	0.002

logistics Regression Comparison Table (Non CRA)

```
Optimization terminated successfully.
         Current function value: 0.569597
         Iterations 6
                           Logit Regression Results
==============================================================================
Dep. Variable:                approved   No. Observations:               715679
Model:                           Logit   Df Residuals:                   715653
Method:                           MLE   Df Model:                           25
Date:                Tue, 06 May 2025   Pseudo R-squ.:                0.06809
Time:                        20:39:39   Log-Likelihood:            -4.0765e+05
converged:                       True   LL-Null:                   -4.3743e+05
Covariance Type:            nonrobust   LLR p-value:                    0.000
==============================================================================
```

	coef	std err	z	P>|z|	[0.025	0.975]
Intercept	-0.4923	0.039	-12.535	0.000	-0.569	-0.415
C(race_ncrc_sub)[T.Asian Indian]	0.2434	0.083	2.927	0.003	0.080	0.406
C(race_ncrc_sub)[T.Asian(General)]	0.2142	0.040	5.419	0.000	0.137	0.292
C(race_ncrc_sub)[T.Black or African American]	-1.0101	0.040	-25.263	0.000	-1.088	-0.932
C(race_ncrc_sub)[T.Chinese]	0.4478	0.208	2.149	0.032	0.039	0.856
C(race_ncrc_sub)[T.Filipino]	0.1136	0.128	0.888	0.375	-0.137	0.364
C(race_ncrc_sub)[T.Guamanian or Chamorro]	-0.2177	0.559	-0.389	0.697	-1.314	0.879
C(race_ncrc_sub)[T.Information Not Provided]	-0.2547	0.040	-6.367	0.000	-0.333	-0.176
C(race_ncrc_sub)[T.Japanese]	0.7303	0.424	1.722	0.085	-0.101	1.562
C(race_ncrc_sub)[T.Korean]	0.4359	0.223	1.954	0.051	-0.001	0.873
C(race_ncrc_sub)[T.Native Hawaiian]	1.5185	0.851	1.785	0.074	-0.149	3.186
C(race_ncrc_sub)[T.Native Hawaiian or Other Pacific Islander(General)]	0.0929	0.040	2.298	0.022	0.014	0.172
C(race_ncrc_sub)[T.No Co-applicant]	-0.4083	0.040	-10.200	0.000	-0.487	-0.330
C(race_ncrc_sub)[T.Not Applicable]	-1.6300	0.041	-40.180	0.000	-1.710	-1.551
C(race_ncrc_sub)[T.Other Asian]	0.1328	0.127	1.049	0.294	-0.115	0.381
C(race_ncrc_sub)[T.Other Pacific Islander]	-0.3568	0.181	-1.967	0.049	-0.712	-0.001
C(race_ncrc_sub)[T.Other/Unknown]	-1.7759	1.051	-1.689	0.091	-3.836	0.284
C(race_ncrc_sub)[T.Samoan]	0.1419	0.655	0.217	0.829	-1.142	1.426
C(race_ncrc_sub)[T.Vietnamese]	-0.3684	0.239	-1.540	0.123	-0.837	0.100
C(race_ncrc_sub)[T.White]	0.2495	0.039	6.327	0.000	0.172	0.327
C(loan_type)[T.2]	-0.1698	0.008	-22.633	0.000	-0.184	-0.155
C(loan_type)[T.3]	0.0209	0.007	2.996	0.003	0.007	0.034
C(loan_type)[T.4]	-0.1824	0.039	-4.690	0.000	-0.259	-0.106
low_income	-0.8096	0.010	-84.598	0.000	-0.828	-0.791
loan_amount	3.028e-07	1.53e-08	19.772	0.000	2.73e-07	3.33e-07
loan_term	-5.885e-05	2.45e-06	-24.026	0.000	-6.37e-05	-5.41e-05

Mean Interest Spread by Race and CRA Status:

race_ncrc_sub	has_cra_rating = 0	has_cra_rating = 1
American Indian or Alaska Native	48.406160	100.514331
Asian Indian	72.499761	65.513763
Asian(General)	1.650681	35.120831
Black or African American	44.139603	77.228228
Chinese	70.698145	57.512373
Filipino	67.949806	66.833184
Guamanian or Chamorro	88.644000	77.549900
Information Not Provided	60.568212	74.684037
Japanese	46.881765	65.831727
Korean	68.720923	58.102219
Native Hawaiian	53.743167	60.233250
Native Hawaiian or Other Pacific Islander(General)	-1.180097	-0.207944
No Co-applicant	9.095771	5.033439
Not Applicable	61.125932	4.009662
Other Asian	64.044849	62.659090
Other Pacific Islander	50.946523	45.221947
Other/Unknown	50.054333	55.032596
Samoan	58.965500	43.327000
Vietnamese	62.616588	55.565118
White	53.554115	60.808516

Mean Interest Spread by Race, CRA Status, and Approval Status:

derived_race	has_cra_rating	approved = 0	approved = 1
2 or more minority races	0	20.869499	39.636896
	1	196.936582	61.139349
American Indian or Alaska Native	0	12.107832	27.011935
	1	107.995814	54.770976
Asian	0	22.631440	43.726258
	1	63.441298	59.467995
Black or African American	0	19.767913	33.909184
	1	73.378654	62.595136
Free Form Text Only	0	50.054333	1.465000
	1	55.726713	53.800184
Joint	0	17.314704	37.980621
	1	64.235542	60.570621
Native Hawaiian or Other Pacific Islander	0	19.156400	27.237725
	1	55.359378	43.022602
Race Not Available	0	16.694056	41.757195
	1	33.573626	57.772740
White	0	15.369095	29.511920
	1	60.014487	48.974971