fAIrplay
FAIRNESS-AS-A-SERVICE

Neutrality is a Fallacy

PHILADELPHIA FEDERAL RESERVE

Workshop on Payments, Lending and Innovations in Consumer Finance

October 27, 2022

What's the HMDA Database?

What's the Definition of Fairness?

Home Mortgage Disclosure Act Database:

+ Contains loan-level data for almost all mortgage applications in a given year going back to 1990

+ In 2021, there were 23m loan applications which resulted in 15m mortgage loan originations, approximately a 65% approval rate. For purposes of this analysis we concern ourselves with 'First' mortgages only.
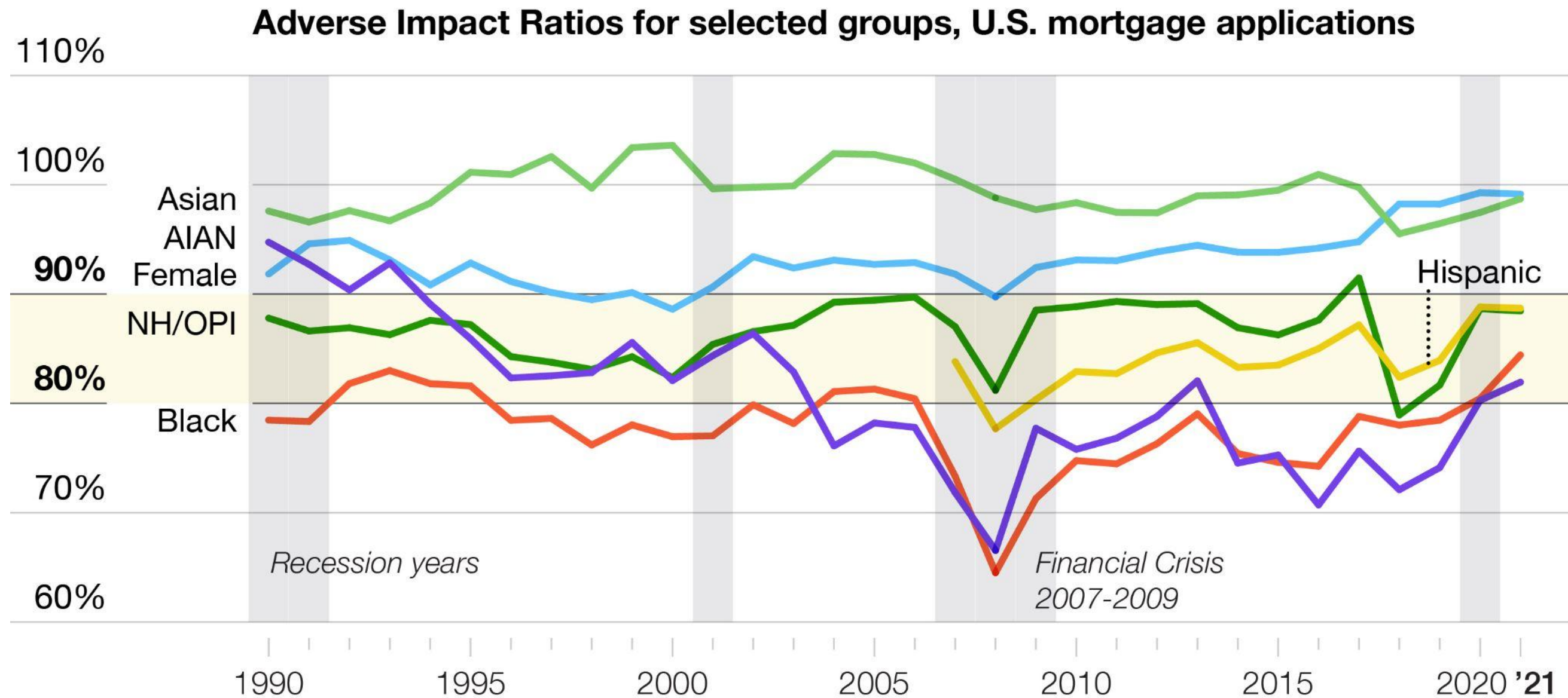
Adverse Impact Ratio:

+ Is a protected group approved at a higher or lower rate than the control group?

+ There are no concrete thresholds for what's considered fair, but in the employment context courts rely on the 4/5ths rule.
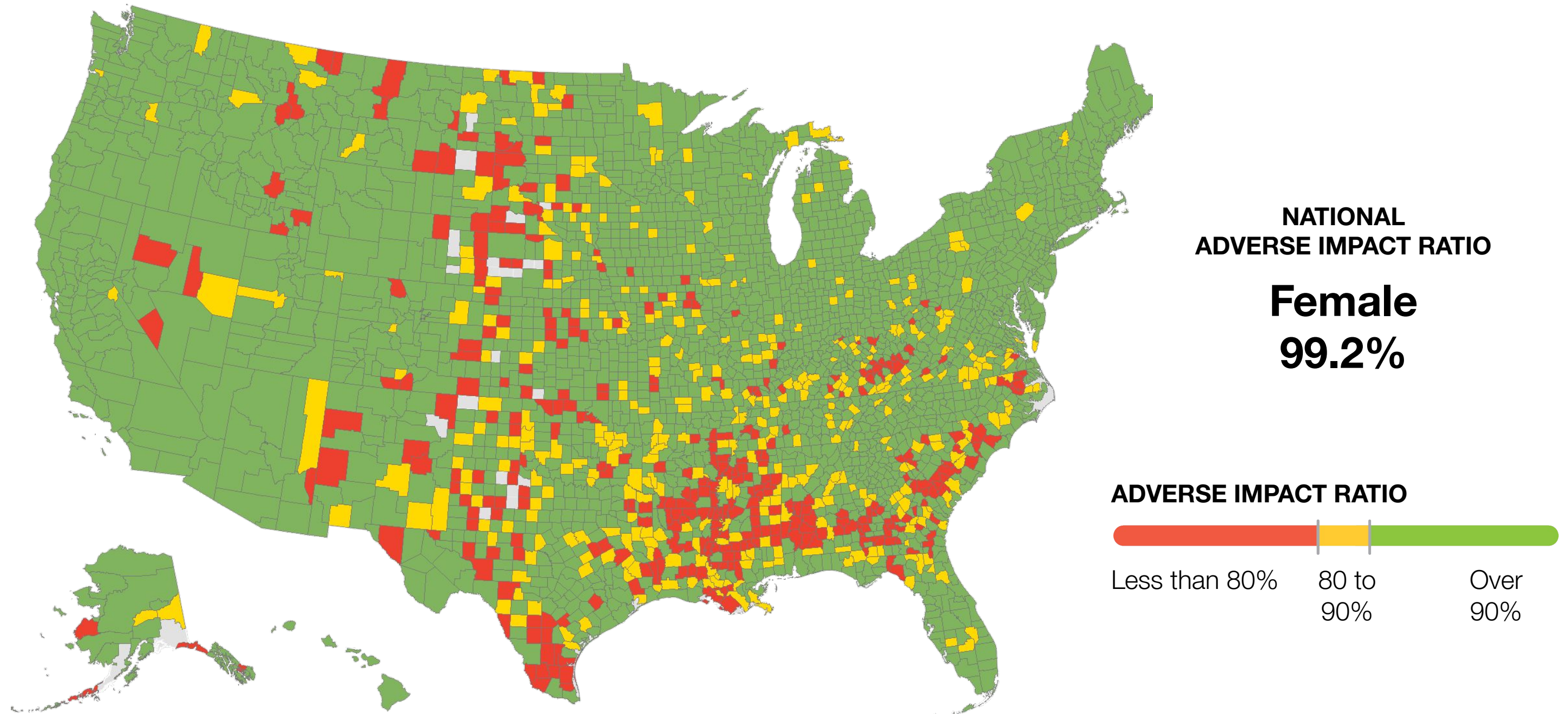
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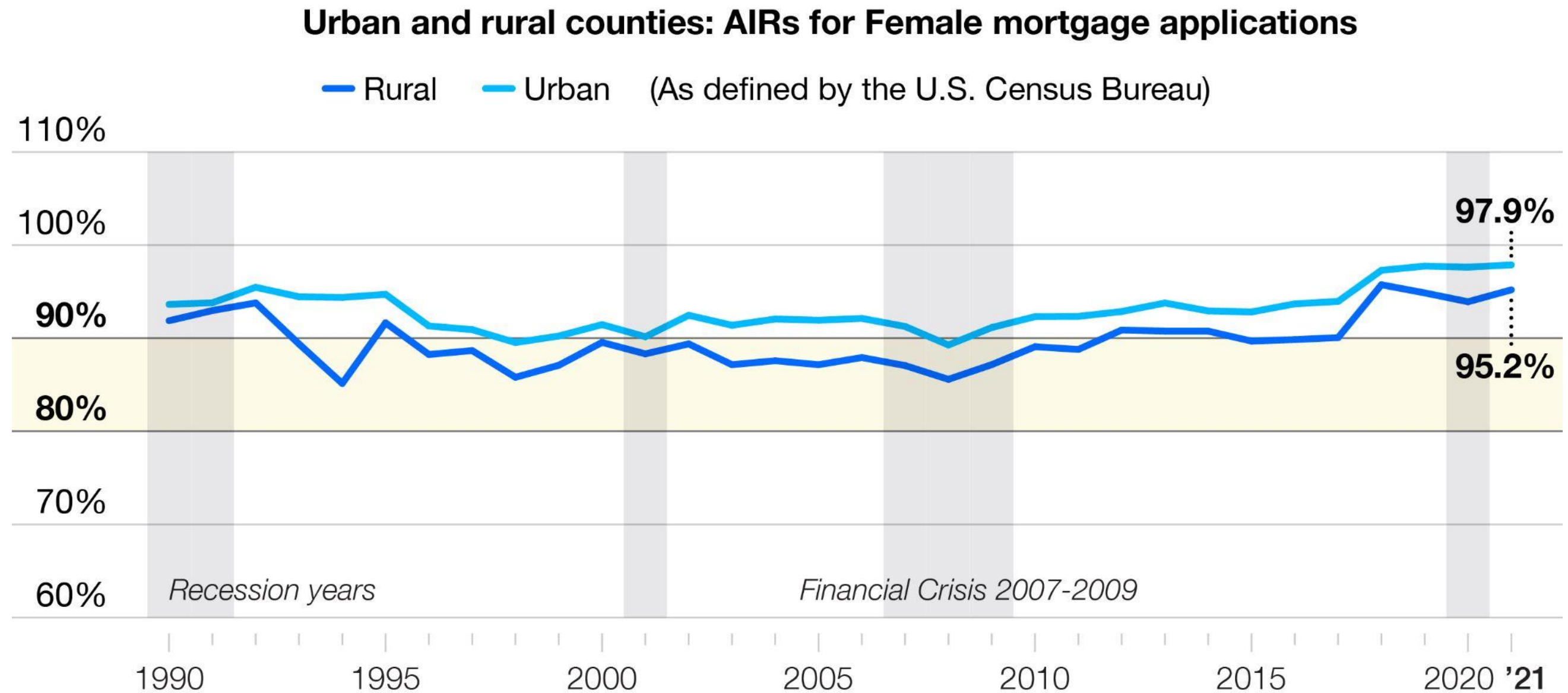# 2021 was the fairest mortgage market since the housing crisis

Adverse Impact Ratios for selected groups, U.S. mortgage applications
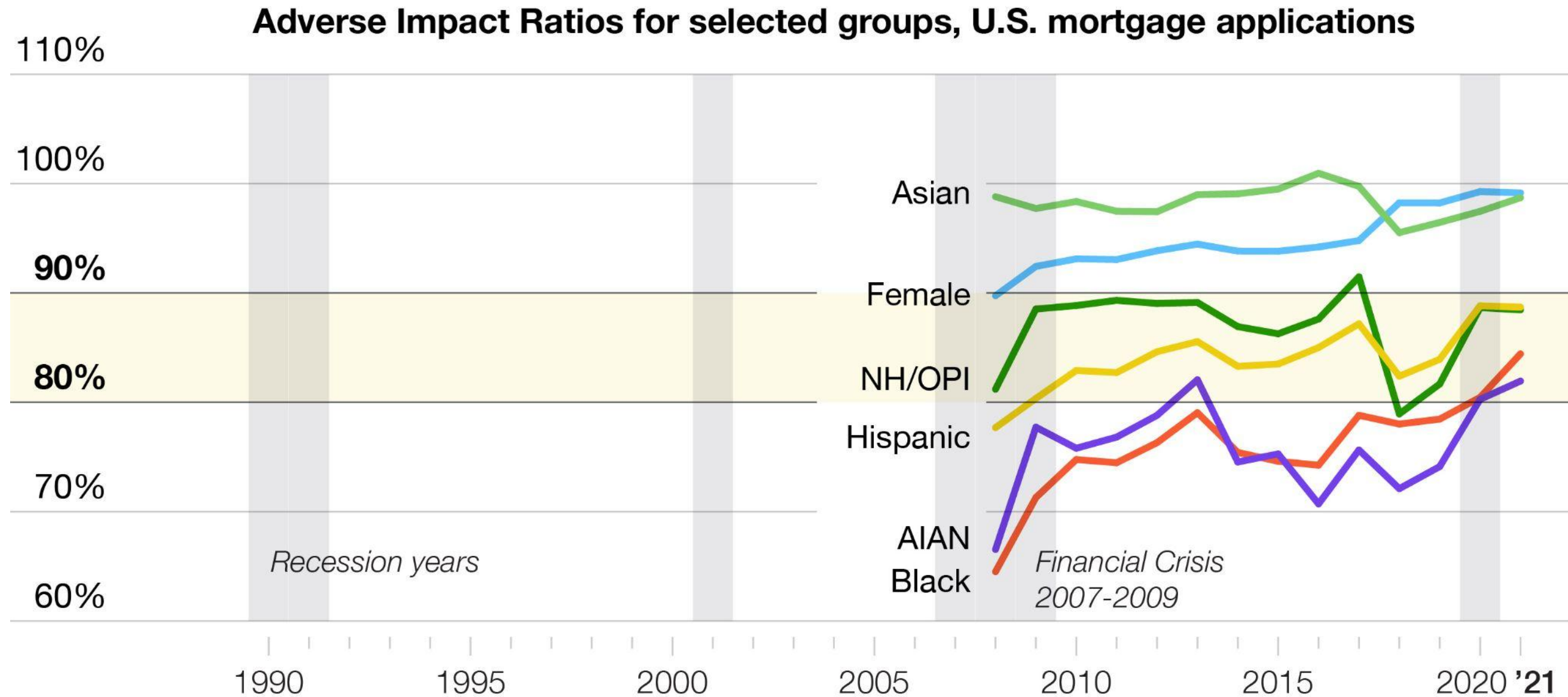
But for most groups, mortgage fairness remains stuck at 1990s levels

Adverse Impact Ratios for selected groups, U.S. mortgage applications

U.S. Mortgage Fairness in 2021: Female homebuyers

NATIONAL ADVERSE IMPACT RATIO

Female 99.2%

ADVERSE IMPACT RATIO

Less than 80%   80 to 90%   Over 90%

U.S. Mortgage Fairness in 2021: Female Urban vs Rural

Urban and rural counties: AIRs for Female mortgage applications

━ Rural   ━ Urban   (As defined by the U.S. Census Bureau)

97.9%

95.2%

Recession years   Financial Crisis 2007-2009

1990   1995   2000   2005   2010   2015   2020 '21

U.S. Mortgage Fairness in 2021: Black homebuyers

NATIONAL
ADVERSE IMPACT RATIO

**Black
84.4%**

ADVERSE IMPACT RATIO

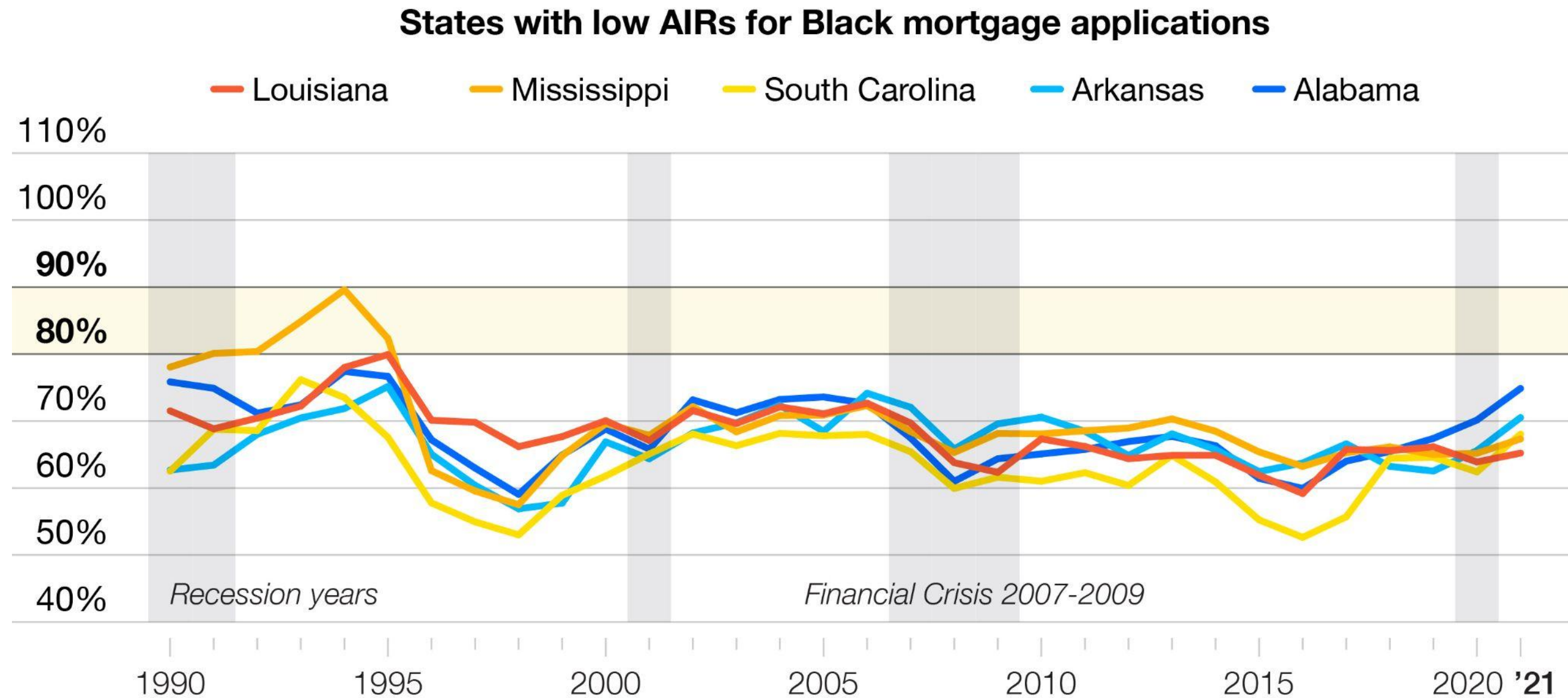Less than 80%   80 to 90%   Over 90%

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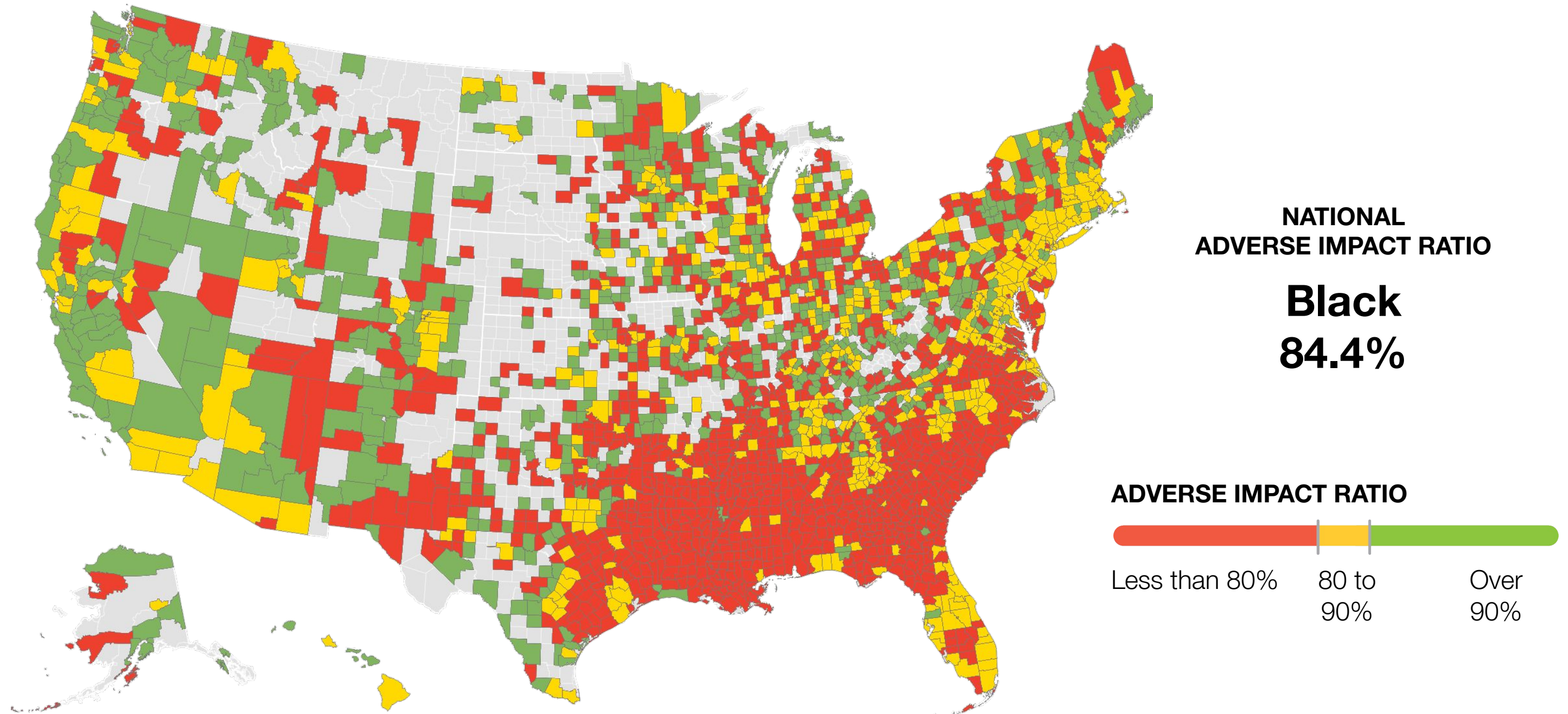
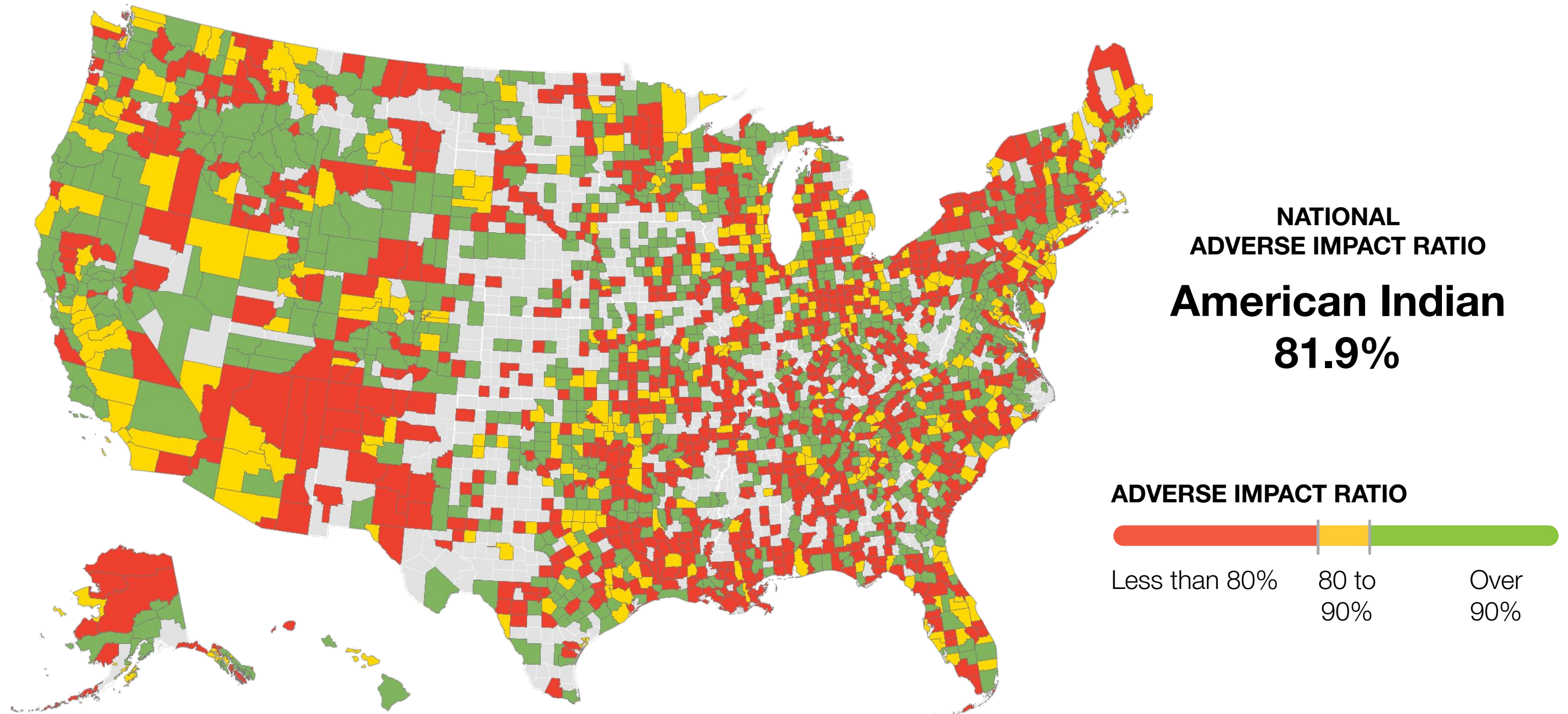# If you're a Black homebuyer, states cluster into one of three groups

BLACK ADVERSE IMPACT RATIO	STATES	2021 AIR	1990-2021 AVERAGE	DIFFERENCE	AVG. MEDIAN INDIV. INCOME	AVG. BLACK POPULATION
High trend AIR states	13	89.0%	83.1%	+5.9	$61,300	4.6%
Medium trend AIR states Includes D.C.	22	82.1%	74.2%	+7.9	$58,222	16.1%
Low trend AIR states	5	69.2%	67.3%	+1.9	$47,858	27.7%

11 other states with small Black populations had more variable trends

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Five states are persistently unfair to Black mortgage applicants

States with low AIRs for Black mortgage applications

— Louisiana — Mississippi — South Carolina — Arkansas — Alabama

Recession years

Financial Crisis 2007-2009

2021 was the fairest market for Native American home buyers since the GFC

NATIONAL ADVERSE IMPACT RATIO

American Indian 81.9%

ADVERSE IMPACT RATIO

Less than 80%   80 to 90%   Over 90%

Mortgage Fairness for Native Americans is down substantially from 1990 levels

Adverse Impact Ratios for selected groups, U.S. mortgage applications
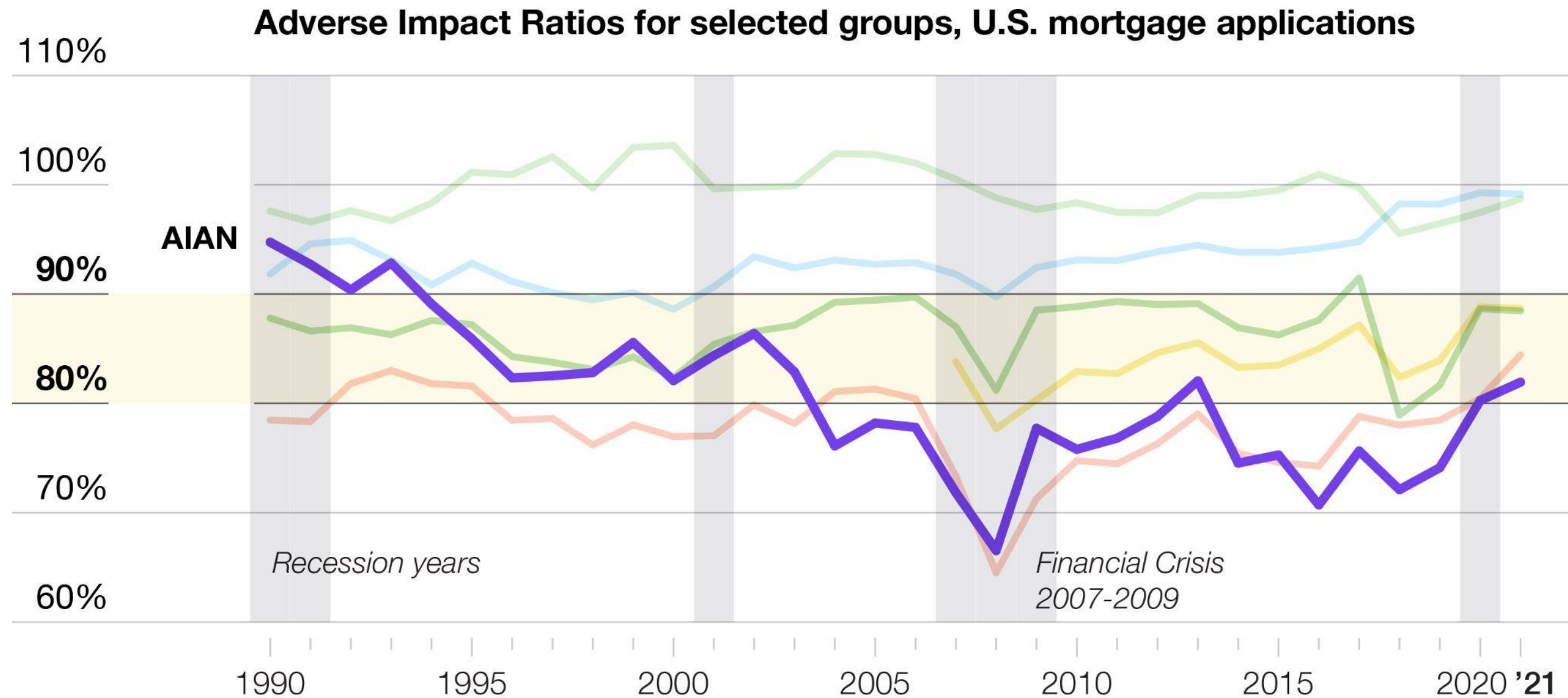
Mortgage Fairness for Native Americans: minimum 30 applications

NATIONAL ADVERSE IMPACT RATIO

American Indian 81.9%

ADVERSE IMPACT RATIO:

Less than 80%   80 to 90%   Over 90%
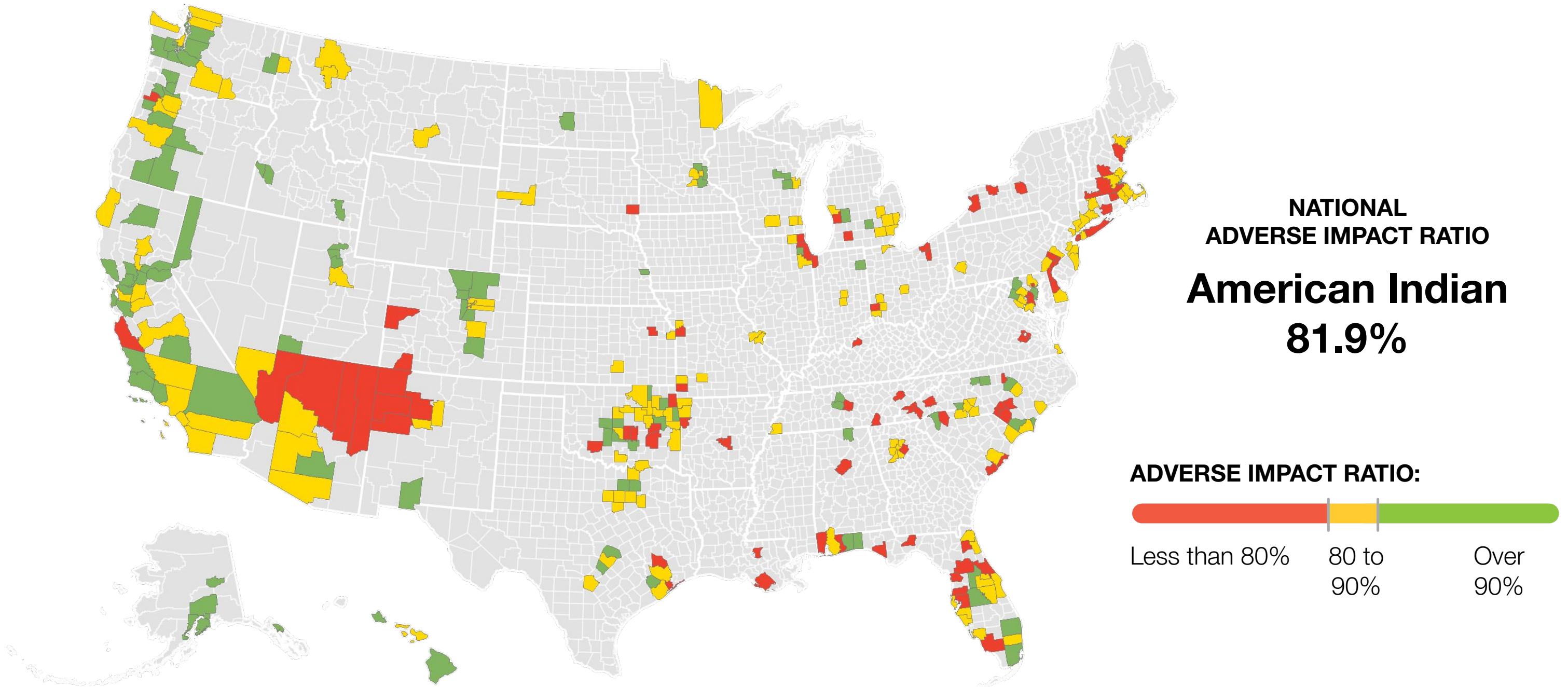
States that are particularly unfair to Native American Applicants

States with low AIRs for American Indian / Alaska Native mortgage applications

Legend: — New Mexico — Mississippi — Louisiana — North Carolina — Arizona

Recession years

Financial Crisis 2007-2009

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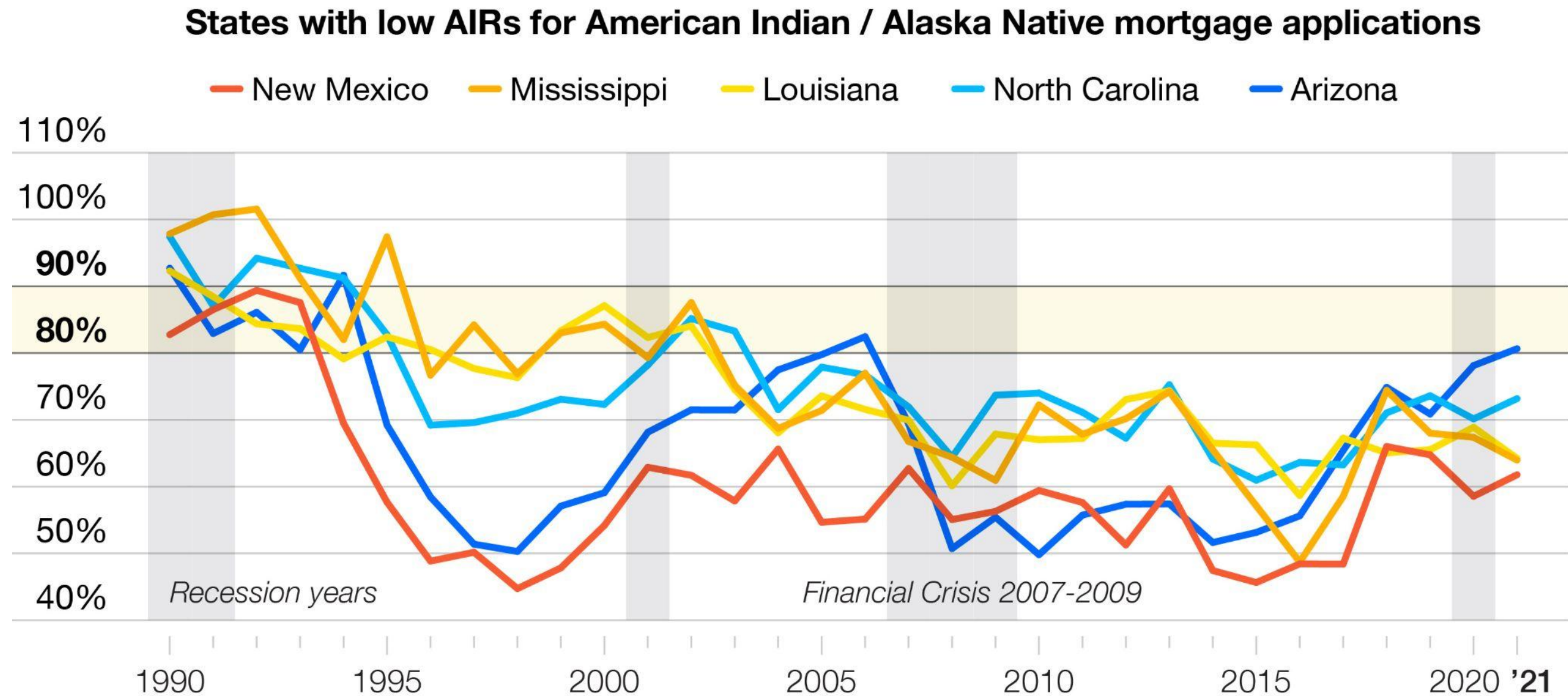
U.S. Mortgage Fairness in 2021: Hispanic

**NATIONAL
ADVERSE IMPACT RATIO**

Hispanic
88.7%

ADVERSE IMPACT RATIO:

Less than 80%   80 to 90%   Over 90%

U.S. Mortgage Fairness in 2021: Asian

NATIONAL ADVERSE IMPACT RATIO

Asian
98.7%

ADVERSE IMPACT RATIO:

Less than 80%   80 to 90%   Over 90%

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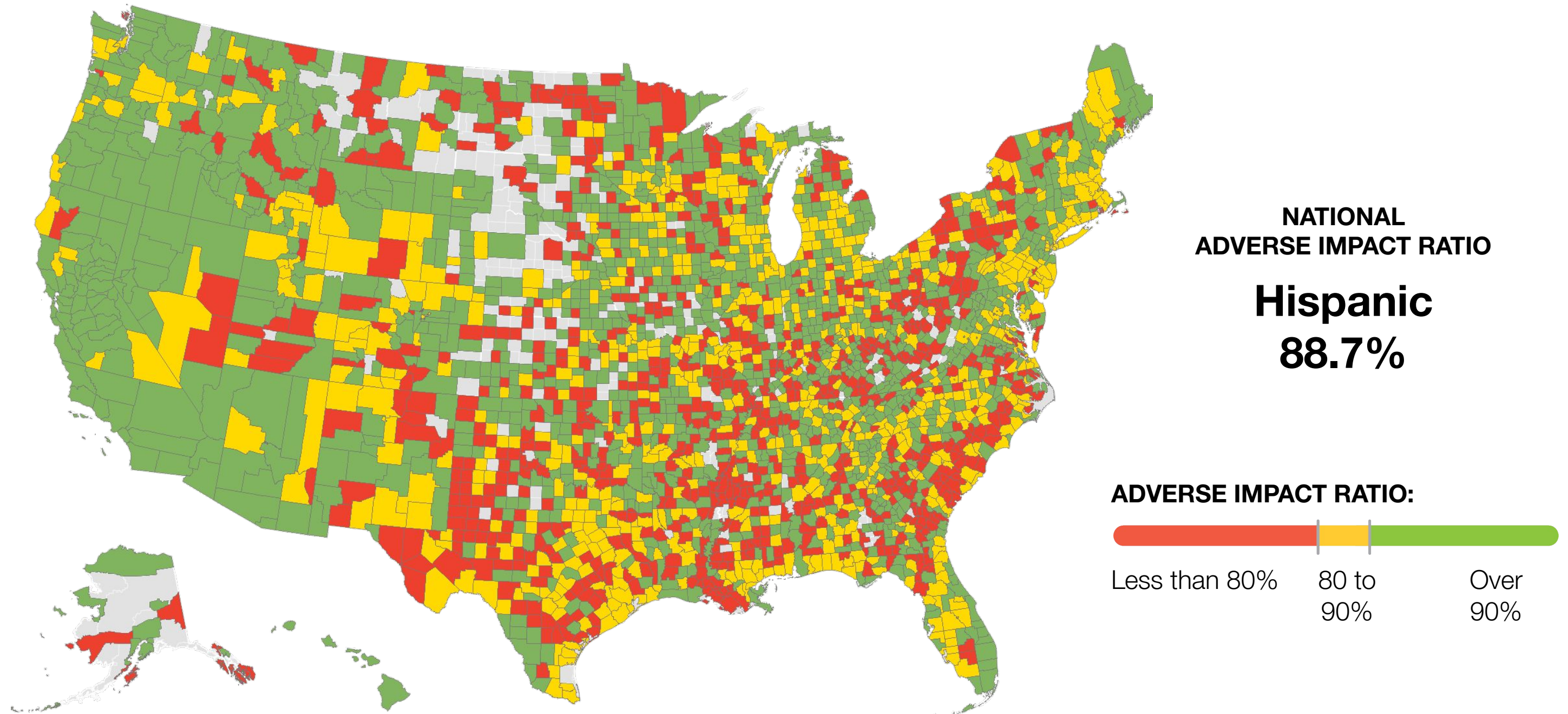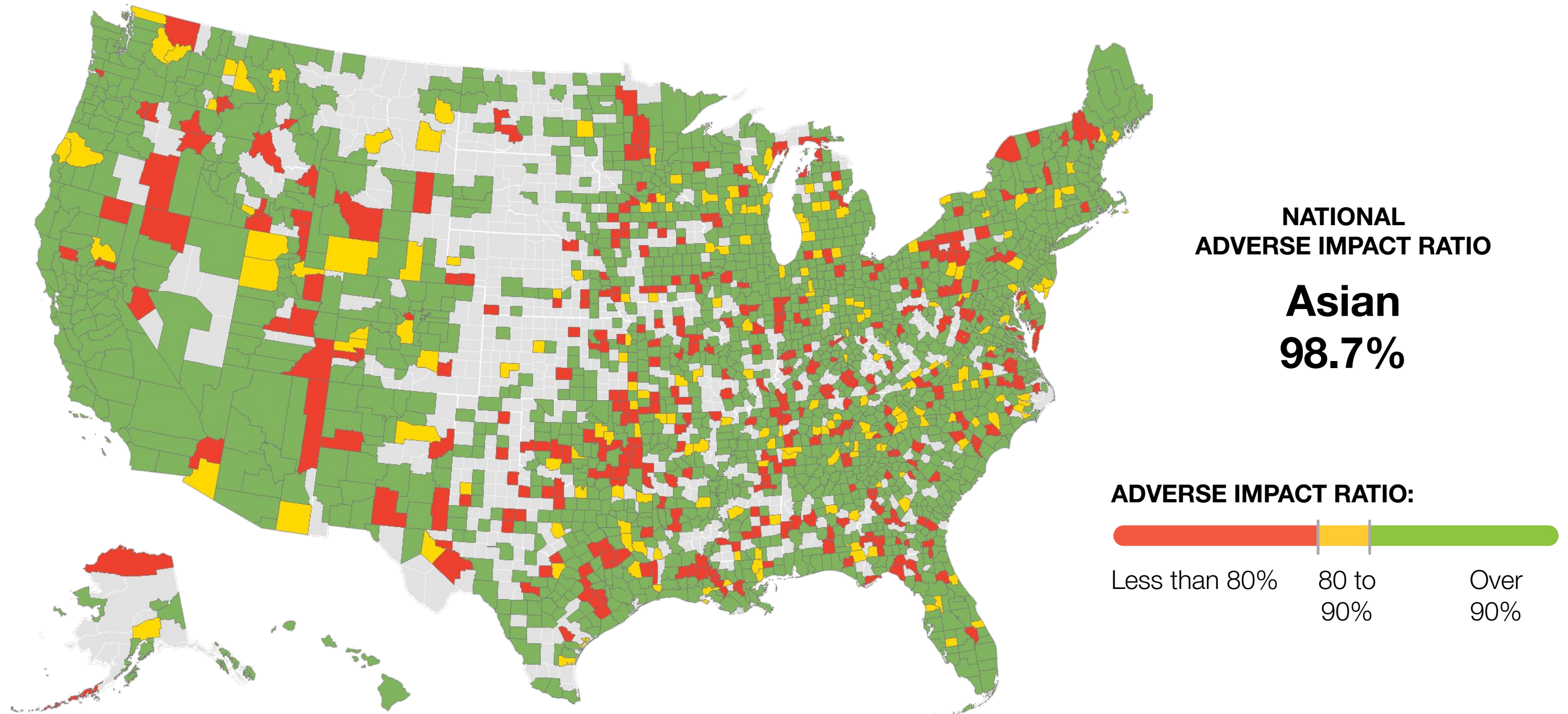
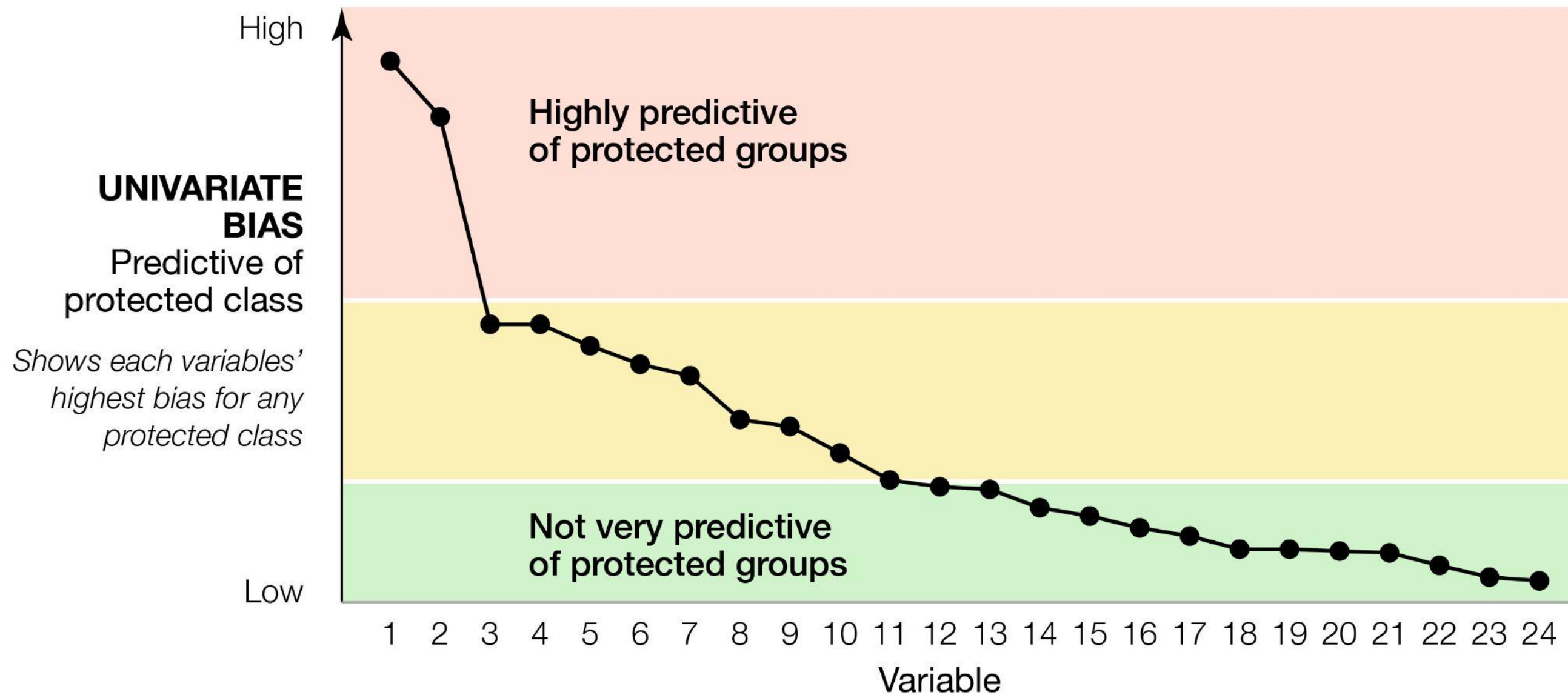# The State of Mortgage Fairness in 2021

+ For most groups, mortgage fairness is no higher today than it was in 1990

+ Mortgage fairness for black homebuyers appears stuck in neutral

  + Urban vs Rural

  + Several persistently unfair states no matter how good the macroeconomic environment is

+ Alarming drop in mortgage fairness for Native Americans going back to 1990

+ Mortgage fairness for women has improved somewhat in the last 30 years.

# Variables that appear objective often aren't
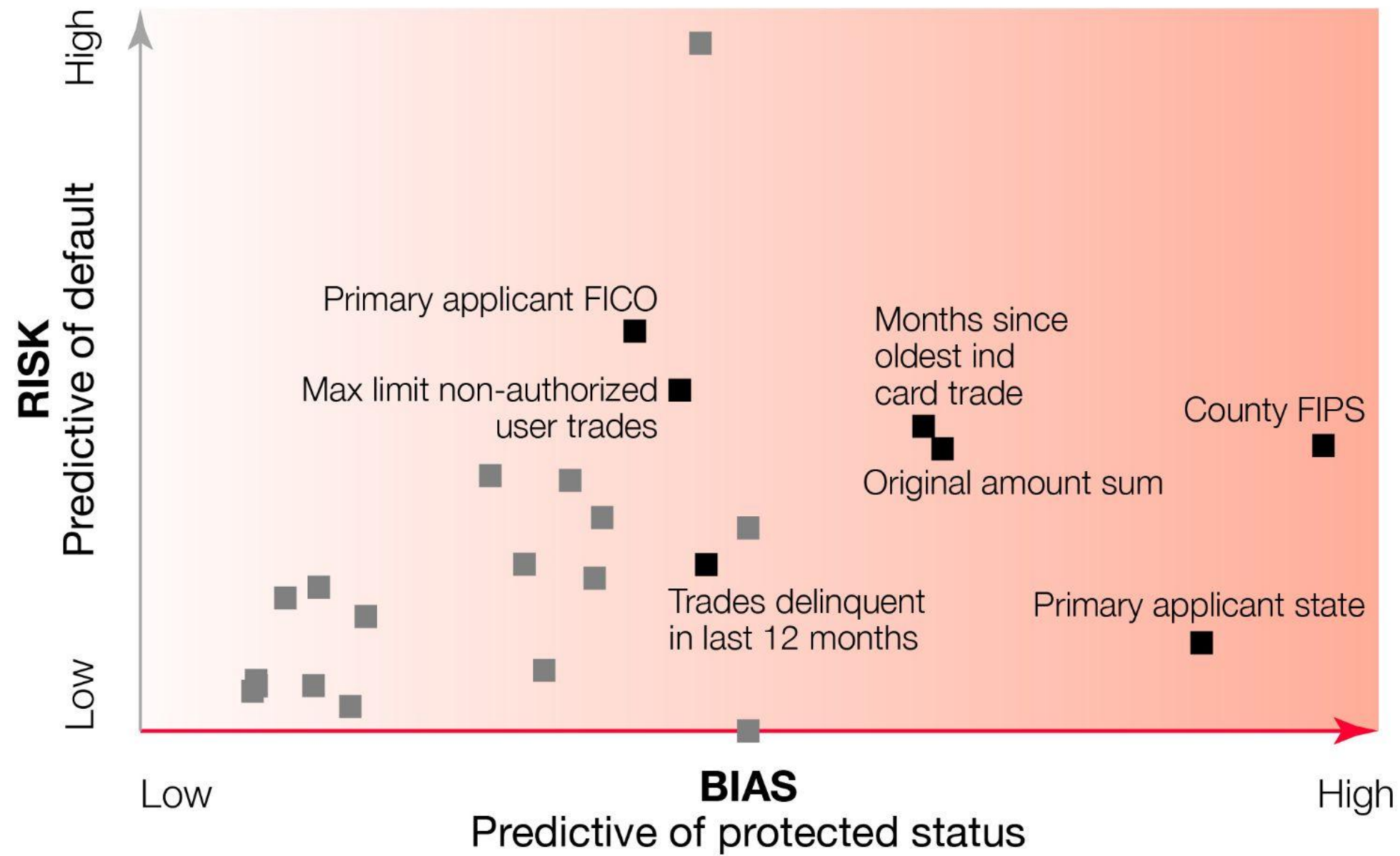
Univariate Bias: potential bias of each variable in a 24-variable model

UNIVARIATE BIAS
Predictive of protected class

Shows each variables' highest bias for any protected class

High

Highly predictive of protected groups

Not very predictive of protected groups

Low

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Variable

Multivariate Bias: model bias persists even after progressive elimination of most biased variables
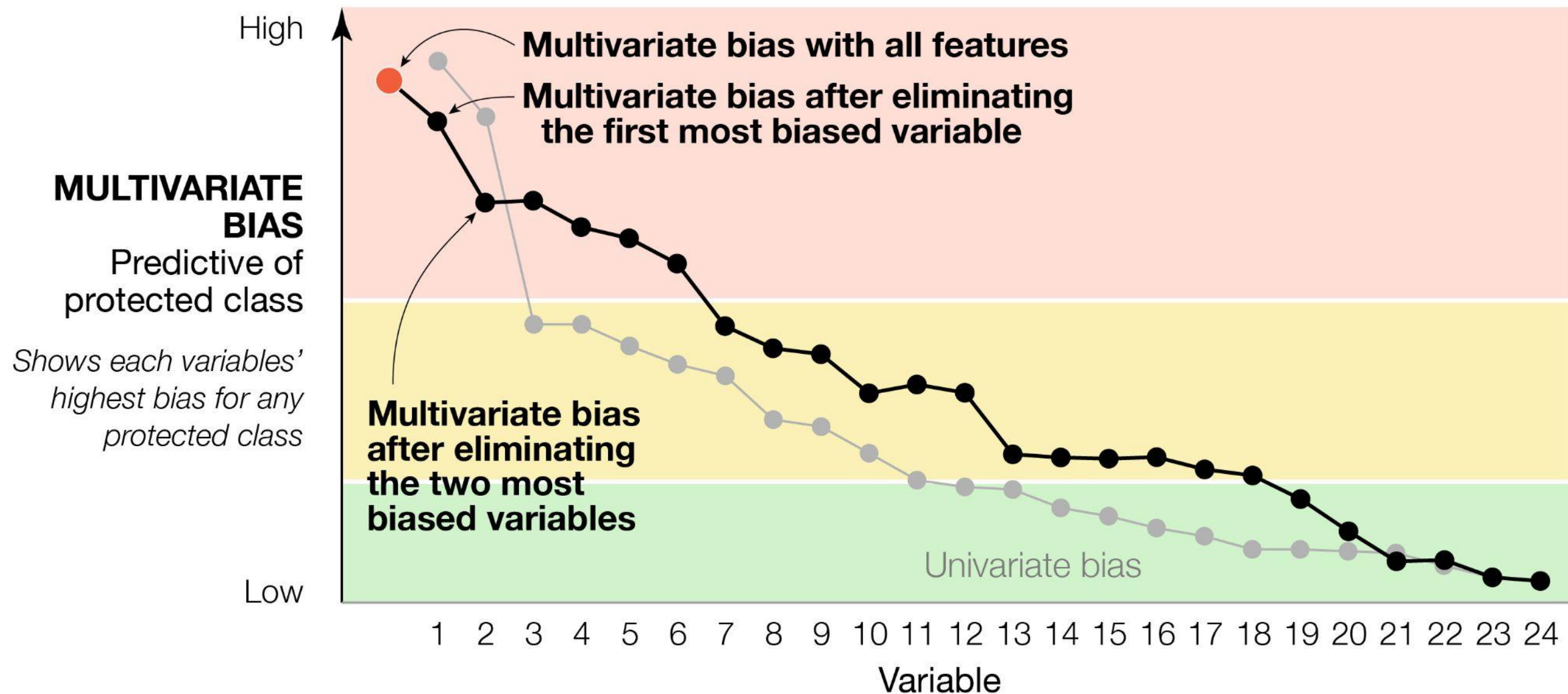
Neutrality is a Fallacy

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Could Fairness Through Awareness do better?

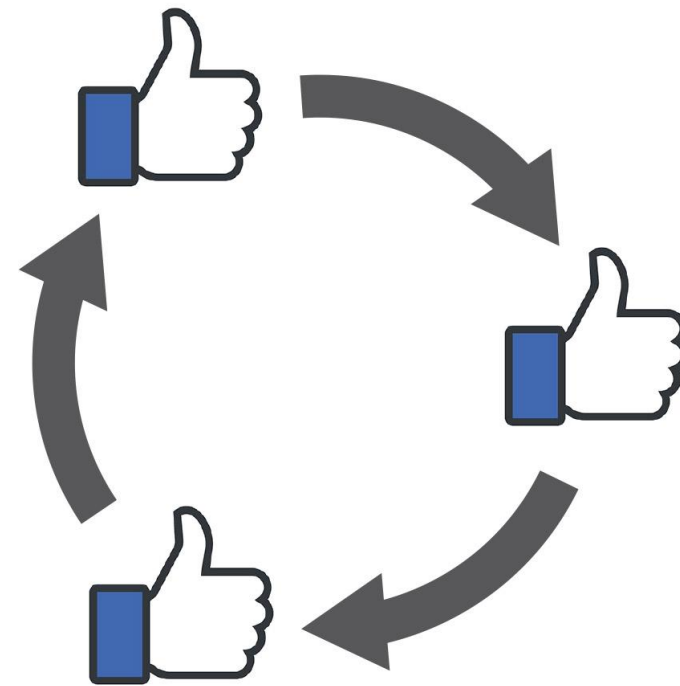# ML algorithms relentlessly pursue their target to achieve the most accurate outcome

**Every algorithm must
be given a target**

Social media algorithms seek to maximize their target: engagement
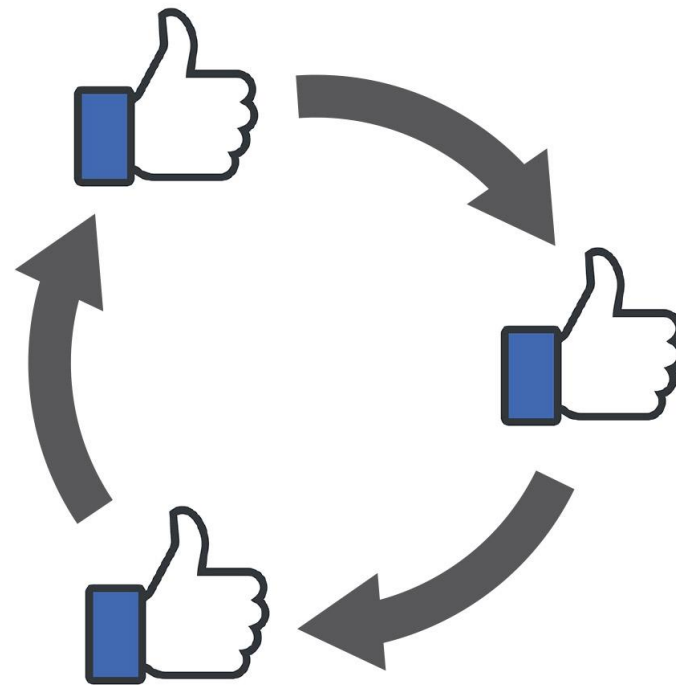
Every algorithm must be given a target

Social media target: Maximize engagement

The algorithm single mindedly focuses on engagement regardless of whether it's good for your health or good for society

Every algorithm must be given a target

Social media target: Maximize engagement

Without regard for societal harm

Giving an algorithm one target is problematic: imagine a self-driving car whose only target was to get you from point (a) to point (b)

Target: Get from point (a) to point (b)

Self-driving cars have a second target: Safety

Target: Get from point (a) to point (b)

Second Target: Safety (obey traffic laws; avoid accidents with cars, pedestrians, cyclists, etc)

We can do this in financial services: Target a low risk of default . . .

Target: Low risk of default

We can do this in financial services: Target a low risk of default . . . while also targeting fairness

Target: Low risk of default

Second Target: Fairness
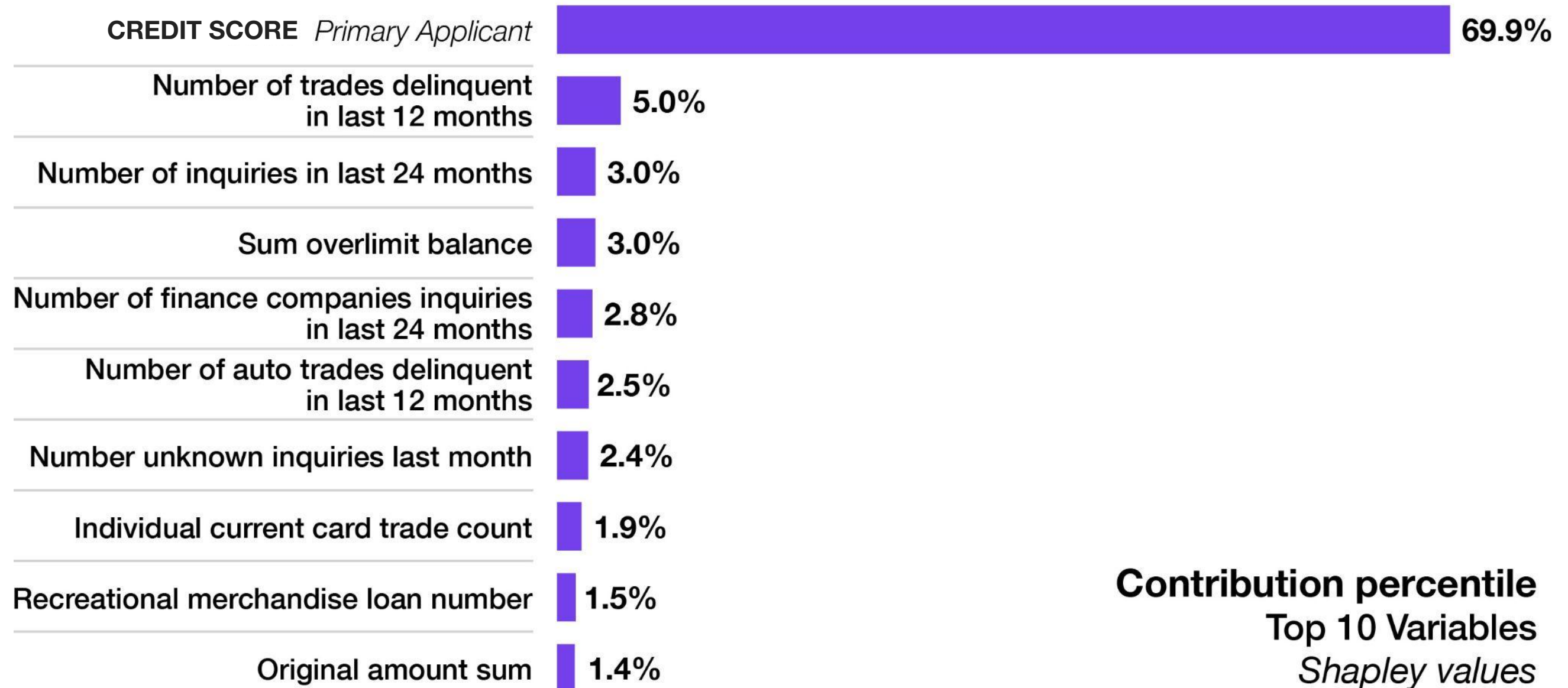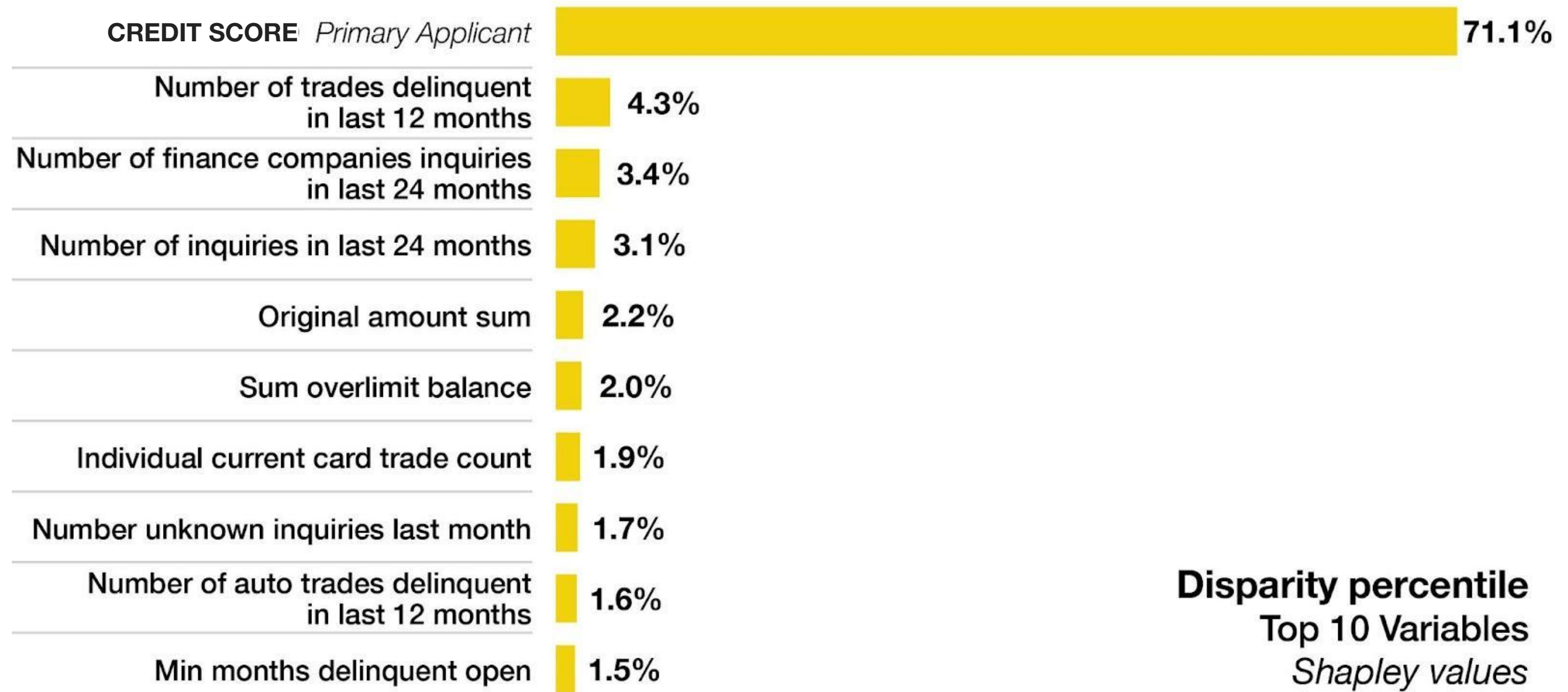
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Could AI Fairness Techniques Do Better?

		Lender's Model
Accuracy		95.63%
Black	AIR	75%
Hispanic	AIR	103%
API	AIR	108%
Female	AIR	92%
Age 62+	AIR	117%

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10 variables drove 93.4% of [Lender] model's predictive power

Variable	Contribution
CREDIT SCORE *Primary Applicant*	69.9%
Number of trades delinquent in last 12 months	5.0%
Number of inquiries in last 24 months	3.0%
Sum overlimit balance	3.0%
Number of finance companies inquiries in last 24 months	2.8%
Number of auto trades delinquent in last 12 months	2.5%
Number unknown inquiries last month	2.4%
Individual current card trade count	1.9%
Recreational merchandise loan number	1.5%
Original amount sum	1.4%

Contribution percentile
Top 10 Variables
Shapley values

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Credit Scores drive most of the disparity for protected applicants

CREDIT SCORE *Primary Applicant*	71.1%
Number of trades delinquent in last 12 months	4.3%
Number of finance companies inquiries in last 24 months	3.4%
Number of inquiries in last 24 months	3.1%
Original amount sum	2.2%
Sum overlimit balance	2.0%
Individual current card trade count	1.9%
Number unknown inquiries last month	1.7%
Number of auto trades delinquent in last 12 months	1.6%
Min months delinquent open	1.5%

Disparity percentile
Top 10 Variables
Shapley values

FairPlay identified 7 Second Look models as accurate as [Lender's] . . .

	Lender's Model	FairPlay Models						
		1	2	3	4	5	6	7
Accuracy	95.63%	95.97%	95.93%	95.91%	95.91%	95.90%	95.90%	95.81%
Black AIR	75%							
Hispanic AIR	103%							
API AIR	108%							
Female AIR	92%							
Age 62+ AIR	117%							

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. . . that significantly improved fairness for Black and Female applicants

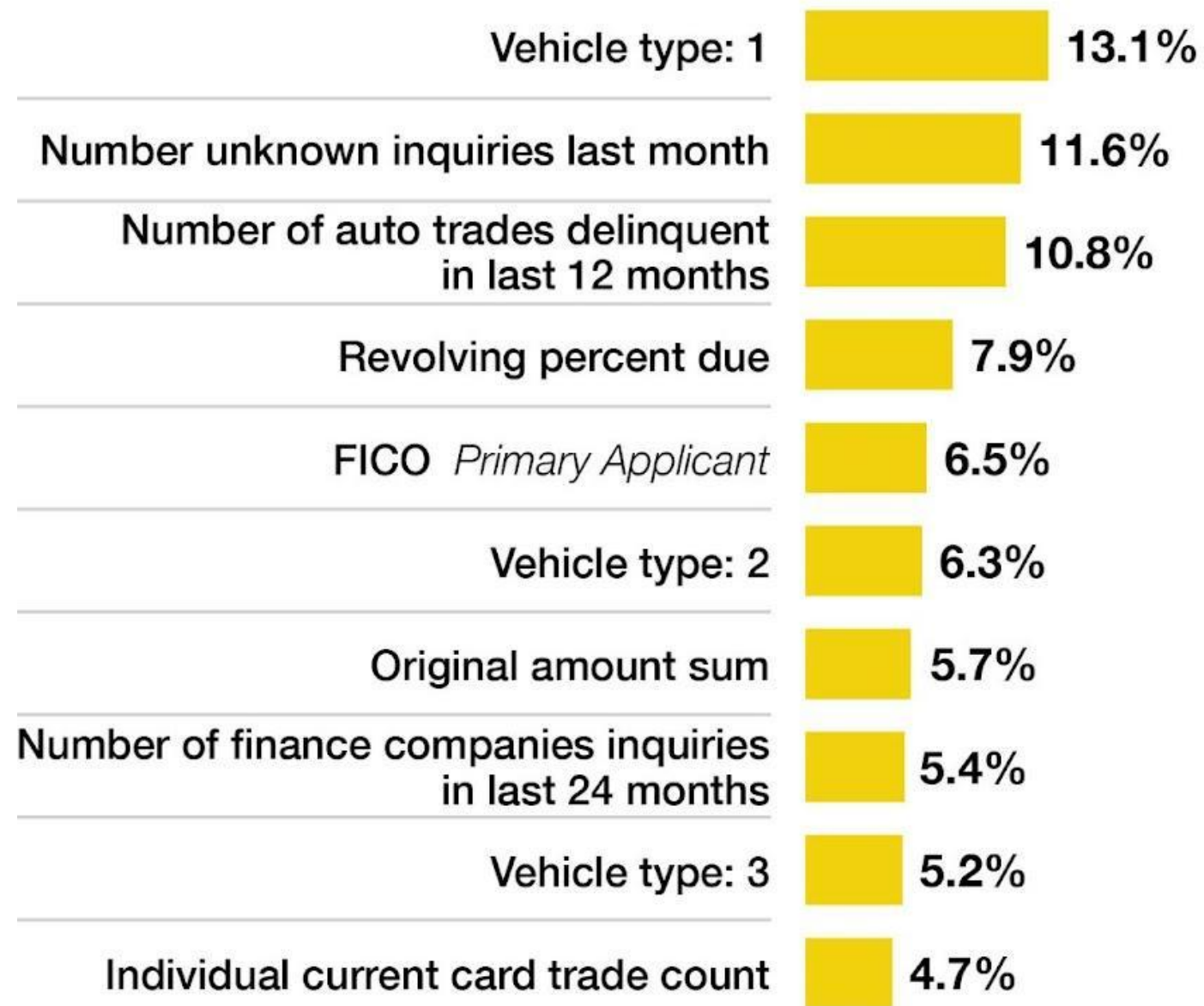|	Lender's Model	FairPlay Models						
		1	2	3	4	5	6	7
Accuracy	95.63%	95.97%	95.93%	95.91%	95.91%	95.90%	95.90%	95.81%
Black AIR	75%	87%	85%	84%	82%	85%	82%	83%
Hispanic AIR	103%	101%	101%	101%	101%	101%	101%	101%
API AIR	108%	106%	105%	107%	107%	106%	105%	108%
Female AIR	92%	99%	99%	99%	99%	99%	99%	99%
Age 62+ AIR	117%	113%	114%	114%	114%	114%	113%	114%

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. . . and produced between 3,700 and 5,200 new loans for approval

	Lender's Model	FairPlay Models						
		1	2	3	4	5	6	7
Accuracy	95.63%	95.97%	95.93%	95.91%	95.91%	95.90%	95.90%	95.81%
Black AIR	75%	87%	85%	84%	82%	85%	82%	83%
Hispanic AIR	103%	101%	101%	101%	101%	101%	101%	101%
API AIR	108%	106%	105%	107%	107%	106%	105%	108%
Female AIR	92%	99%	99%	99%	99%	99%	99%	99%
Age 62+ AIR	117%	113%	114%	114%	114%	114%	113%	114%
New Loans		5,199	3,714	4,085	3,714	3,714	3,714	3,714

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	Lender's Model	FairPlay Models						
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New Loans		5,199	3,714	4,085	3,714	3,714	3,714	3,714

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The Second Look Models Make Use of More Variables

| Variable	Value
Vehicle type: 1	13.1%
Number unknown inquiries last month	11.6%
Number of auto trades delinquent in last 12 months	10.8%
Revolving percent due	7.9%
FICO *Primary Applicant*	6.5%
Vehicle type: 2	6.3%
Original amount sum	5.7%
Number of finance companies inquiries in last 24 months	5.4%
Vehicle type: 3	5.2%
Individual current card trade count	4.7%

**Second Look
Drivers of Difference**
Top 10 Variables
Shapley values

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Increasing approvals for protected groups ≠ increased risk

Protected Class	Success Ratio
Female	99.92
Black	99.91
Hispanic	99.93
API	100.03
AIAN	99.98
2+ races	99.89
Under age 25	100.05
Over age 62	99.96

95% 96% 97% 98% 99% **100%** 101% 102% 103%

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Is mortgage fairness about to get worse?

National Mean AIRs vs 30-Year Mortgage Rate, 2007-2021
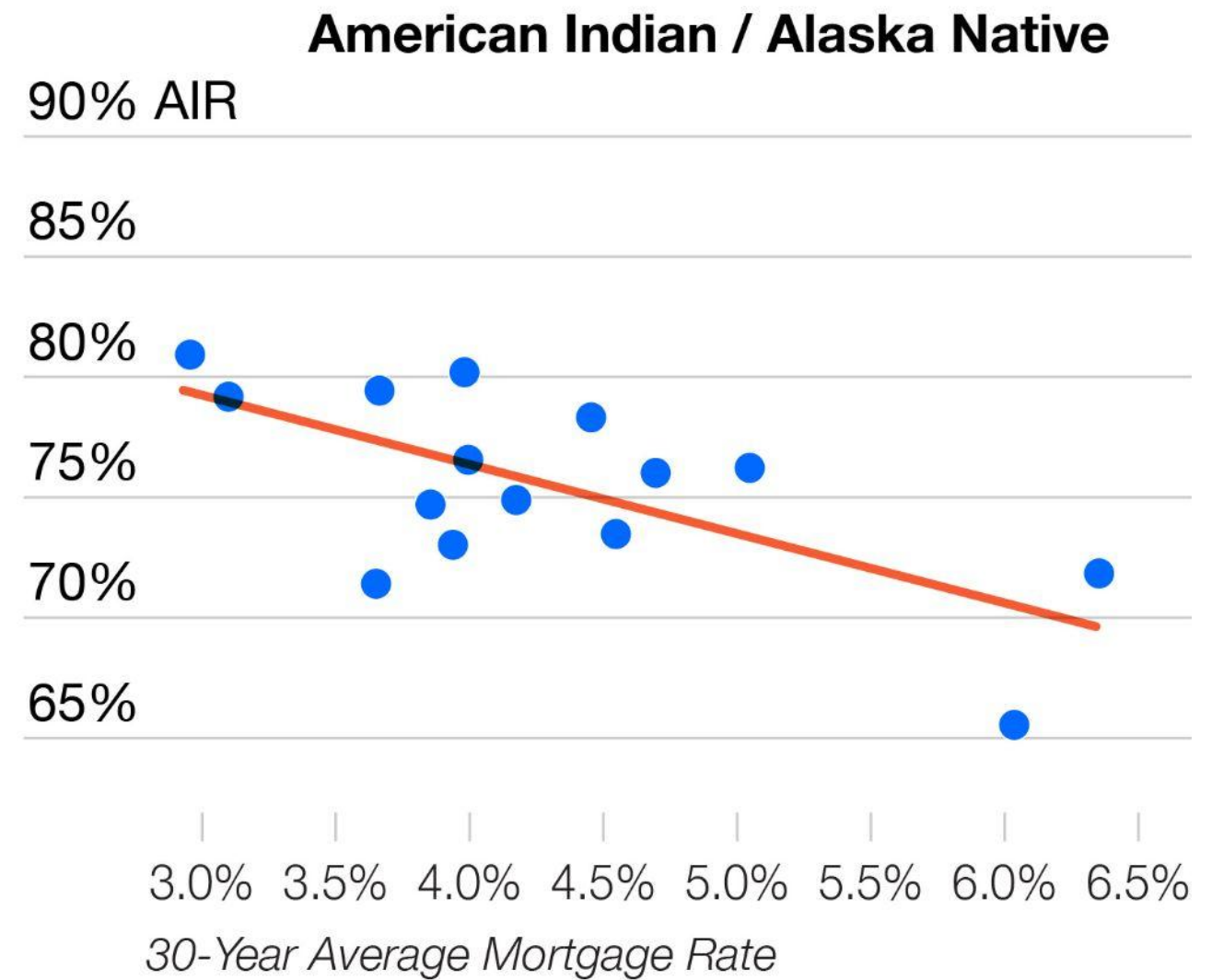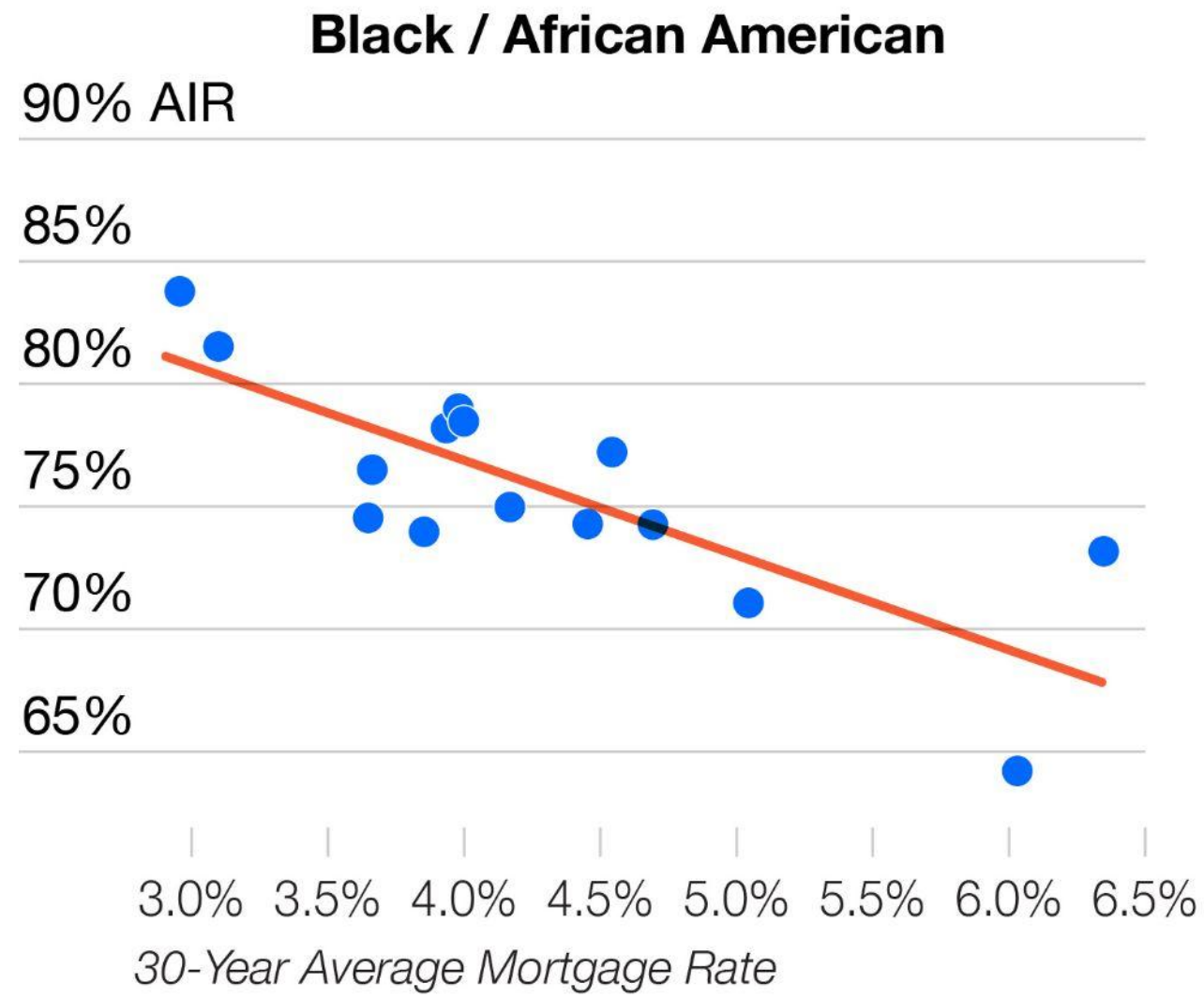
"Changing algorithms is easier than changing people"

University of Chicago economist, Sendhil Mullainathan

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