Mortgage Prepayment, Race, and Monetary Policy

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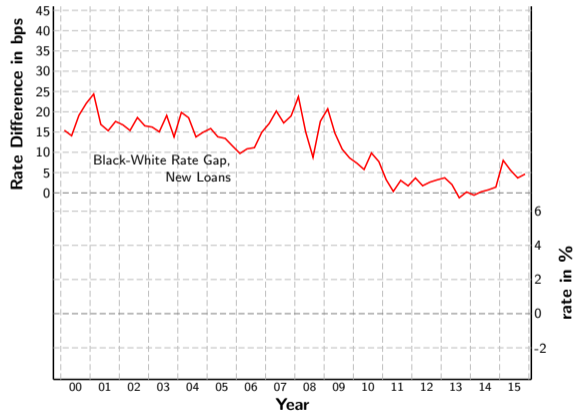[2]Federal Reserve Bank of Boston
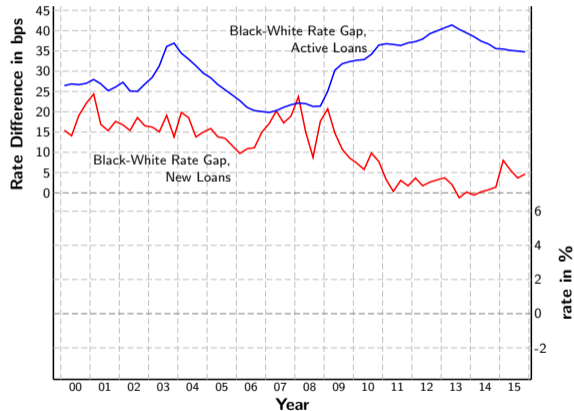
[3]Harvard University

CFPB Conference
May 6, 2021

Introduction

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- Why? Differences in refinance speeds
  - FICO LTV
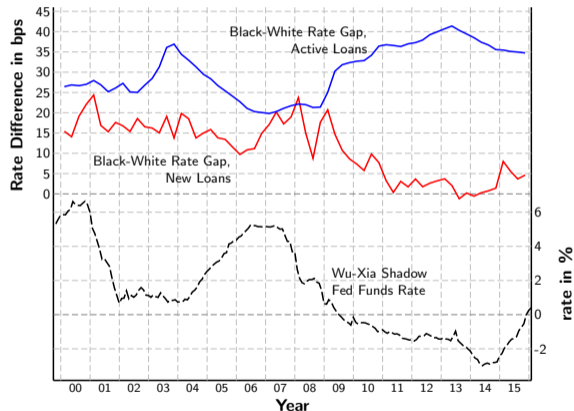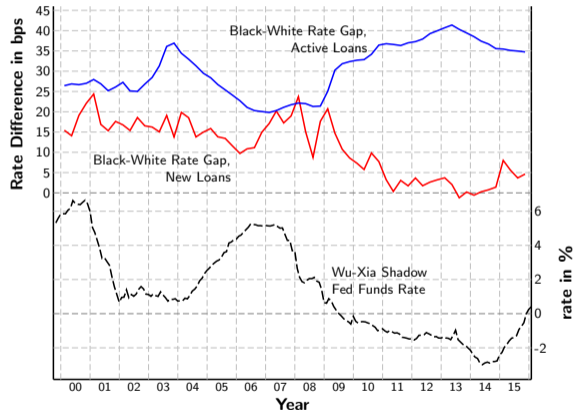 - Difference in sensitivity to refi option

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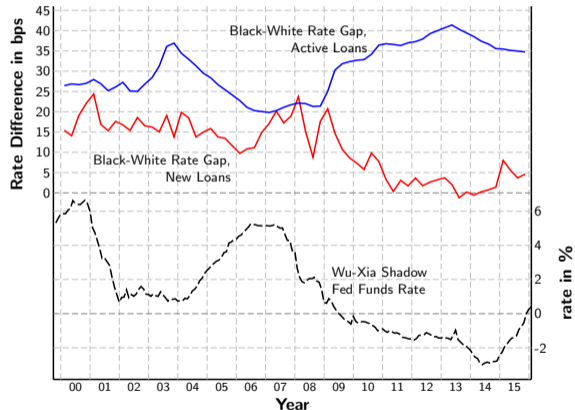
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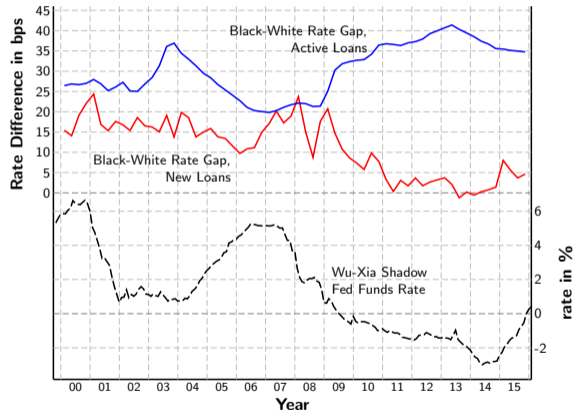 - QE: Refinances, Home buying

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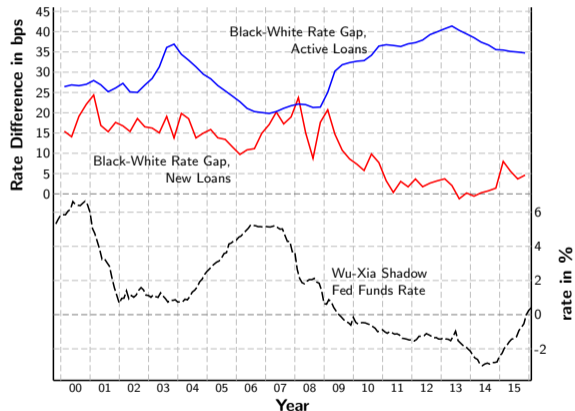
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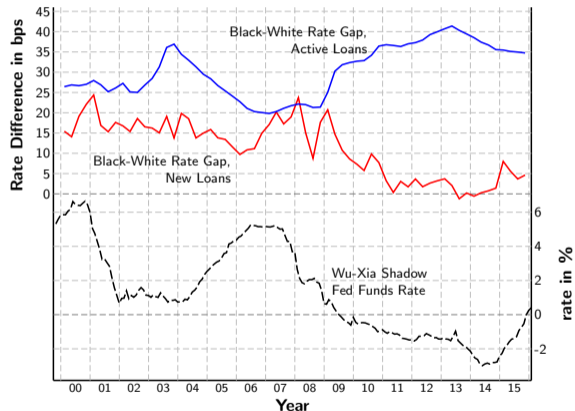 - FICO LTV
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- Monetary Policy
  - QE: Refinances, Home buying
  - Disparate impact across races

Rates in the Stock and the Flow

- Main sample is merged sample of fixed-rate mortgages:

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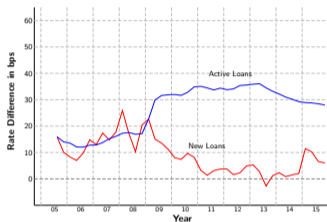
All Loans

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Fannie and Freddie Only

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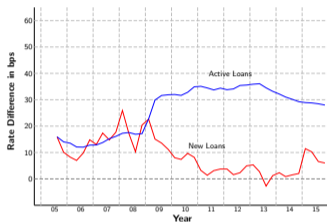

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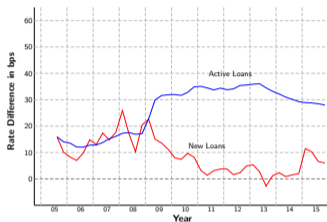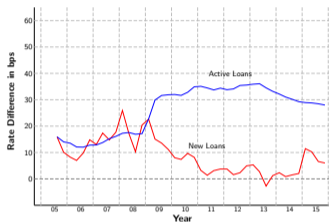# Rates in the Stock and the Flow

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QE and Rates

- QE1 furnishes test _{Beraja et al. (2018)}

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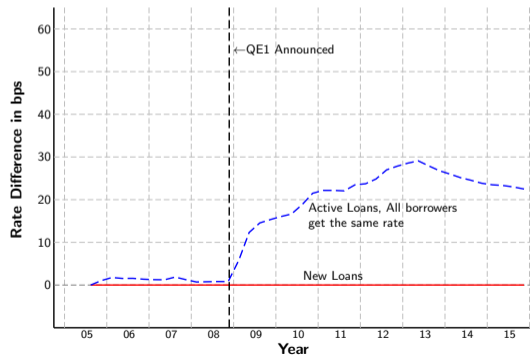
- Regression
    - Post-period: 6 months before QE1 announcement

	(1)	(2)
Black (d)	0.232***	0.202***
	(0.016)	(0.015)
Hispanic White (d)	0.134***	0.110***
	(0.019)	(0.016)
postQE1 (d)	-0.220***	-0.002***
	(0.004)	(0.000)
Black * postQE1	0.120***	-0.007***
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Hispanic White * postQE1	0.118***	0.003**
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Constant	6.239***	6.135***
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Vintage Year-Qtr FE		X

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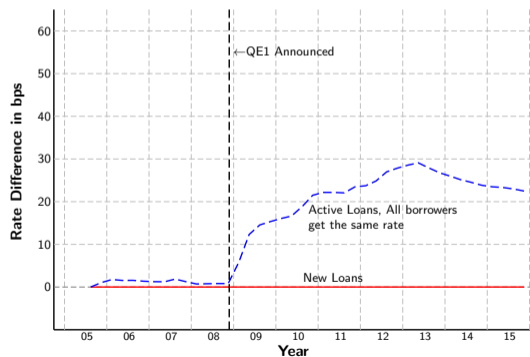
- Regression
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- Vintage effects wipe out effect of QE
  - Borrowers who got mortgages after QE got the same rates

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Differences in Refinancing Behavior

Dependent Variable: Prepay Refinance (d)	GSE Loans					
	(1)	(2)	(3)	(4)	(5)	(6)
Black (d)	-0.746***	-0.380***	-0.330***	-0.255***	-0.148***	-0.149***
	(0.086)	(0.049)	(0.038)	(0.032)	(0.025)	(0.025)
Hispanic White (d)	-0.687***	-0.454***	-0.462***	-0.421***	-0.278***	-0.289***
	(0.118)	(0.066)	(0.064)	(0.057)	(0.038)	(0.036)
Asian (d)	0.436***	0.258***	0.268***	0.256***	0.180***	0.176**
	(0.143)	(0.093)	(0.097)	(0.098)	(0.068)	(0.068)
LTV Change		-0.001	-0.050***	-0.046***	-0.045***	-0.038***
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Female (d)			-0.061***	-0.060***	-0.078***	-0.079***
			(0.012)	(0.012)	(0.013)	(0.014)
Call Option			0.308***	0.315***	0.316***	0.721***
			(0.021)	(0.021)	(0.021)	(0.061)
SATO			-1.597***	-1.549***	-1.518***	-4.560***
			(0.128)	(0.122)	(0.123)	(0.427)
Risk Score Change				0.775***	0.764***	0.778***
				(0.085)	(0.084)	(0.077)
Loan Age	X	X	X	X	X	X
Underwriting Vars		X	X	X	X	X
HMDA Vars			X	X	X	X
Vintage Year-Qtr FE	X	X	X	X	X	X
State FE		X	X	X		
Zip Code FE					X	
Zip Code-by-Year-Qtr FE						X
# Observations	15,460,588	11,983,398	11,547,035	11,469,141	11,469,141	11,318,445
# Loans	792,823	622,936	601,094	601,028	601,028	590,643
R²	0.008	0.012	0.019	0.020	0.022	0.079

- Underwriting controls explain ∼ 50%.

- Controlling for socio-demographics, risk score change, refi incentive, ZIP code FEs explains additional ∼ 30%.

- Altogether explain almost 80% of difference between Black and White borrowers.

- Can explain about 60% of difference between Hispanic and White borrowers.

▸ FHA Results

Refi Incentive

- Bin scatter plot of *Call Option* and refi propensity by race/ethnicity:
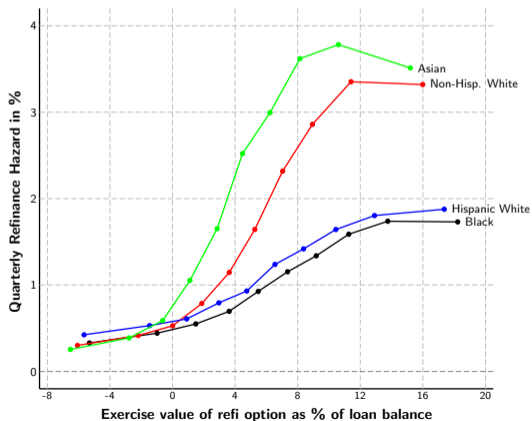
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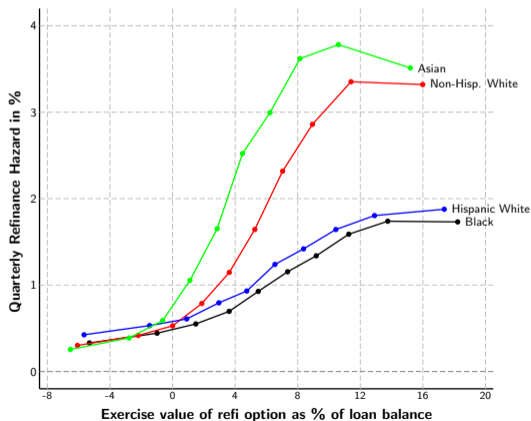
Dependent Variable: Prepay Refinance (d)	GSE Loans		FHA Loans	
	(1)	(2)	(5)	(6)
Black (d)	-0.178***	**0.465*****	-0.158***	**0.233****
	(0.027)	(0.073)	(0.025)	(0.100)
Hispanic White (d)	-0.293***	0.284***	-0.297***	0.062
	(0.038)	(0.065)	(0.040)	(0.081)
Call Option	0.310***	0.320***	0.193***	0.209***
	(0.021)	(0.022)	(0.020)	(0.021)
Black * Call Option		-0.100***		-0.068***
		(0.007)		(0.009)
Hispanic White * Call Option		-0.097***		-0.068***
		(0.007)		(0.008)
Loan Age	X	X	X	X
Underwriting Vars	X	X	X	X
HMDA Vars	X	X	X	X
Vintage Year-Qtr FE	X	X	X	X
Zip Code FE	X	X	X	X
# Observations	10,816,263	10,816,263	3,636,573	3,636,573
# Loans	563,001	563,001	177,437	177,437
R^2	0.022	0.022	0.023	0.023

- 1 std. dev. ↑ in *Call Option*:
  - White: 2.1 ppts ↑
  - Black: 1.4 ppts ↑

- Agarwal et al. (2013): ▶ ADL Details

QE and Prepayment

- Event Study
  - QE Announced on 11/25/2008

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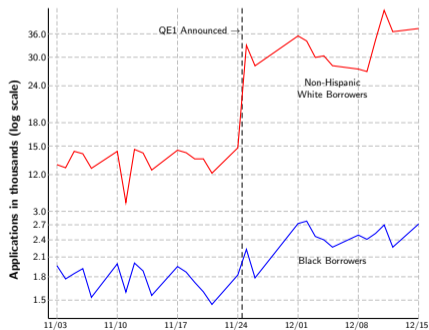
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  - 5× for Black
  - 2× for Non-Hisp. White

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- Additional Findings

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- Additional Findings
- (1) Default ⟦↦ Details⟧
    - Observable differences (Credit Score, etc.) explain *all* the difference in foreclosures but not 90-day delinquencies

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- Additional Findings

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- Investors pay more for loans from black borrowers
- Lower prepayment speeds imply that black borrowers should pay *lower* rates

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- Future Directions
- (1) Explanations of Refi Differences
  - DiD study using FHA streamline requirements
  - Decomposition into time and state dependence based on Andersen et al. (2020).

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SUPPLEMENTAL SLIDES

HMDA-McDash Match Rate and McDash Coverage

Origination Year	McDash Loans Matched	Only 1 HMDA Candidate	McDash Loans Uniquely Matched	McDash Coverage
1992	51%	48%	20%	58%
1993	55%	50%	19%	70%
1994	58%	53%	24%	52%
1995	61%	57%	29%	46%
1996	63%	58%	33%	42%
1997	62%	58%	35%	39%
1998	65%	60%	36%	52%
1999	65%	60%	35%	46%
2000	64%	61%	50%	31%
2001	64%	60%	49%	44%
2002	65%	59%	50%	50%
2003	71%	64%	53%	67%
2004	69%	64%	55%	65%
2005	**67%**	**61%**	**51%**	**73%**
2006	**63%**	**59%**	**49%**	**81%**
2007	**63%**	**59%**	**50%**	**87%**
2008	**65%**	**62%**	**54%**	**79%**
2009	**67%**	**64%**	**59%**	**79%**
2010	**69%**	**67%**	**61%**	**77%**
2011	**69%**	**67%**	**61%**	**73%**
2012	**73%**	**71%**	**64%**	**67%**
2013	**75%**	**74%**	**67%**	**62%**
2014	**77%**	**76%**	**71%**	**48%**
2015	**79%**	**78%**	**75%**	**45%**
Total	66%	62%	49%	61%

Sample Restrictions

Sample Restriction:	# Loans Lost	# Loans Remaining
Originations between 01/2005 and 12/2015		
Loans with "conf" ≥ 0.80		
Fixed Rate Loans		
First Liens		
Fully Amortizing Loans No Prepayment Penalty		
$20 \leq$ LTV ≤ 100		
Occupancy Non-missing		
Loan Amount $\leq$ \$1m		
Income $\leq$ \$500k		
Term $=$ 30 years		
No Home Improvement Loans		1,681,252
Seasoning ≤ 6 Months	193,898	1,487,354
Black, Hispanic White, Asian, and White Borrowers	208,817	1,278,537
GSE and FHA Loans	179,810	1,098,727
$3\% \leq$ Mortgage Rate $\leq 8\%$	2,434	1,096,293

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Rate Gap in SCF

- Difference in average mortgage rates for Black and Non-Hispanic White borrowers based on data from the SCF (1992–2019).

Data: Summary Statistics

	All		Black		Hispanic White		Non-Hispanic White	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
FHA Sample: Fixed Characteristics								
Equifax Risk Score (100s points)	6.84	0.67	6.53	0.71	6.77	0.64	6.89	0.66
LTV (%)	93.6	7.5	93.1	8.2	94.1	7.2	93.5	7.4
Loan Amount ($100k)	1.73	0.91	1.68	0.90	1.67	0.88	1.72	0.89
Interest Rate (ppts)	4.93	1.00	5.10	1.05	4.87	0.98	4.92	0.99
Income ($1k)	65.8	37.5	61.0	33.3	56.2	30.3	67.6	38.5
Borrower Age (years)	38.5	11.9	41.9	12.1	37.8	11.2	38.2	11.9
Refinance (d)	0.294	0.456	0.310	0.462	0.181	0.385	0.312	0.463
Condo (d)	0.115	0.318	0.155	0.362	0.110	0.312	0.106	0.308
2-4 Family (d)	0.014	0.119	0.024	0.154	0.031	0.174	0.010	0.101
Low Documentation (d)	0.190	0.393	0.207	0.405	0.164	0.370	0.192	0.394
Non-Occupant Owner (d)	0.033	0.178	0.033	0.179	0.026	0.158	0.034	0.181
Female (d)	0.353	0.478	0.530	0.499	0.318	0.466	0.333	0.471
Co-applicant (d)	0.414	0.493	0.248	0.432	0.367	0.482	0.445	0.497
# Loans	295,487		31,764		33,717		222,236	

Data: Summary Statistics

FHA Sample: Time-Varying Characteristics								
	All		**Black**		**Hispanic White**		**Non-Hispanic White**	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Qtrs since Orig	13.3	10.2	15.0	11.1	13.7	10.3	12.9	10.0
Call Option (ppts)	4.77	6.53	5.68	6.68	4.88	6.50	4.64	6.50
SATO (ppts)	0.116	0.346	0.165	0.376	0.158	0.356	0.104	0.338
Equity (%)	-9.25	14.85	-8.84	16.42	-12.38	16.86	-8.70	14.10
Negative Equity (d)	0.117	0.322	0.146	0.353	0.105	0.307	0.115	0.319
Risk Score Change (100s points)	0.016	0.697	-0.109	0.778	0.002	0.727	0.036	0.676
Prepay Refinance (ppts)	1.33	11.47	0.89	9.40	1.03	10.10	1.44	11.93
Prepay Sale (ppts)	0.94	9.67	0.47	6.87	0.62	7.86	1.08	10.33
Default (ppts)	0.89	9.41	1.58	12.47	0.90	9.42	0.81	8.94
# Loan-quarters	6,184,502		765,502		749,691		4,518,876	

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FHA Refinance Results

Dependent Variable: Prepay Refinance (d)

	FHA Loans			
	(7)	(8)	(9)	(10)
Black (d)	-0.600***	-0.364***	-0.235***	-0.163***
	(0.053)	(0.031)	(0.028)	(0.028)
Hispanic White (d)	-0.401***	-0.384***	-0.400***	-0.315***
	(0.076)	(0.042)	(0.047)	(0.041)
Asian (d)	0.417***	-0.020	0.071	0.034
	(0.088)	(0.059)	(0.073)	(0.073)
LTV Change		-0.015***	-0.038***	-0.014***
		(0.003)	(0.003)	(0.002)
Female (d)			-0.082***	-0.101***
			(0.016)	(0.017)
Call Option			0.194***	0.595***
			(0.020)	(0.081)
SATO			-0.293**	-3.302***
			(0.122)	(0.509)
Risk Score Change			0.843***	0.836***
			(0.084)	(0.083)
Loan Age	X	X	X	X
Underwriting Vars		X	X	X
HMDA Vars			X	X
Vintage Year-Qtr FE	X	X	X	X
State FE		X		
Zip Code FE			X	
Zip Code-by-Year-Qtr FE				X
# Observations	6,184,502	4,316,733	3,732,349	3,559,947
# Loans	291,587	209,827	182,517	170,234
R²	0.004	0.012	0.017	0.145

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Logit Refinance Results

• Average marginal effects:

Dependent Variable: Prepay Refinance (d)	GSE Loans				FHA Loans	
	(1)	(2)	(3)	(4)	(7)	(8)
Black (d)	-0.686***	-0.421***	-0.353***	-0.282***	-0.585***	-0.419***
	(0.033)	(0.030)	(0.029)	(0.030)	(0.037)	(0.024)
Hispanic (d)	-0.654***	-0.475***	-0.489***	-0.449***	-0.405***	-0.389***
	(0.057)	(0.024)	(0.030)	(0.031)	(0.059)	(0.028)
Asian (d)	0.466***	0.275***	0.259***	0.247***	0.455***	-0.030
	(0.132)	(0.070)	(0.070)	(0.070)	(0.088)	(0.043)
Loan Age	X	X	X	X	X	X
Underwriting Vars		X	X	X		X
HMDA Vars			X	X		X
Vintage Year-Qtr FE	X	X	X	X	X	X
State FE		X	X	X		X
# Observations	15,460,588	11,983,398	11,547,035	11,469,141	6,184,502	4,316,733

Option Value (Deng et al. 2000)

- Prepayment option value given by:

$$Call\ Option_{i,k} = \frac{V_{i,m} - V_{i,r}}{V_{i,m}}$$

where

$$V_{i,m} = \sum_{s=1}^{TM_i - k_i} \frac{P_i}{(1 + m_t)^s} \qquad V_{i,r} = \sum_{s=1}^{TM_i - k_i} \frac{P_i}{(1 + r_i)^s}$$

- r_i – borrower i's mortgage rate
- TM_i – mortgage term
- k_i – age/seasoning of the mortgage
- m_i – prevailing market rate (the FHLMC PMMS index)
- P_i – mortgage payment
- The larger the value of $Call\ Option_{i,k}$, the more the borrower would benefit from refinancing into a new loan with a lower rate and payment.

Agarwal et al. (2013) Optimal Refi Formula

- A borrower should refinance when current market rate falls below the original rate by at least:

$$\frac{1}{\psi}\left[\phi + W(-exp(-\phi))\right]$$

where W is the Lambert W-function and

$$\psi = \frac{\sqrt{2\rho+\lambda}}{\sigma}$$

$$\phi = 1 + \psi(\rho+\lambda)\frac{\kappa/M}{(1-\tau)} \qquad (1)$$

$$\lambda = \mu + \frac{i_0}{exp[i_0\Gamma]-1} + \pi \qquad (2)$$

$$(3)$$

- ρ – discount rate
- μ – expected probability of moving
- σ – std. dev. of mortgage rate
- $\frac{\kappa/M}{1-\tau}$ – ratio of the tax-adjusted refinancing cost and the remaining mortgage value
- Γ – remaining maturity of the mortgage
- i_0 – original mortgage rate

Agarwal et al. (2013) Optimal Refi Formula

- Two variables:

  - *ADL Dummy* – 1 if the difference between the borrower's current interest rate and the market rate (PMMS survey) is greater than the ADL threshold.

  - *ADL* – continuous variable that measures how much higher/lower the difference between the current rate and market rate is from the ADL threshold.

Dependent Variable: Prepay Refinance (d)						
	GSE Loans					
	(1)	(2)	(3)	(4)	(5)	(6)
Black (d)	-0.118***	0.309***	-0.136***	0.065**	-0.149***	0.044
	(0.021)	(0.048)	(0.021)	(0.029)	(0.020)	(0.028)
Hispanic White (d)	-0.197***	0.172***	-0.224***	-0.019	-0.234***	-0.049*
	(0.025)	(0.045)	(0.026)	(0.026)	(0.025)	(0.025)
Call Option	0.225***	0.232***				
	(0.016)	(0.016)				
Black * Call Option		-0.068***				
		(0.005)				
Hispanic White * Call Option		-0.064***				
		(0.005)				
ADL Dummy			0.525***	0.605***		
			(0.079)	(0.086)		
Black * ADL Dummy				-0.572***		
				(0.061)		
Hispanic White * ADL Dummy				-0.625***		
				(0.067)		
ADL					0.530***	0.560***
					(0.049)	(0.049)
Black * ADL						-0.550***
						(0.054)
Hispanic White * ADL						-0.564***
						(0.059)
Loan Age	X	X	X	X	X	X
Underwriting Vars	X	X	X	X	X	X
HMDA Vars	X	X	X	X	X	X
Vintage Year-Qtr FE	X	X	X	X	X	X
Zip Code FE	X	X	X	X	X	X
# Observations	10,544,968	10,544,968	10,544,968	10,544,968	10,544,968	10,544,968
# Loans	557,848	557,848	557,848	557,848	557,848	557,848
R^2	0.016	0.016	0.011	0.011	0.012	0.012

Sale Results

Dependent Variable: Prepay Sale (d)

	GSE Loans						FHA Loans			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Black (d)	-0.524***	-0.424***	-0.385***	-0.383***	-0.346***	-0.346***	-0.644***	-0.554***	-0.449***	-0.425***
	(0.019)	(0.018)	(0.017)	(0.019)	(0.022)	(0.023)	(0.030)	(0.036)	(0.035)	(0.033)
Hispanic White (d)	-0.430***	-0.338***	-0.329***	-0.328***	-0.273***	-0.273***	-0.515***	-0.559***	-0.522***	-0.472***
	(0.028)	(0.020)	(0.021)	(0.021)	(0.018)	(0.018)	(0.029)	(0.035)	(0.035)	(0.035)
Asian (d)	-0.185***	-0.196***	-0.219***	-0.220***	-0.215***	-0.211***	-0.233***	-0.357***	-0.336***	-0.343***
	(0.031)	(0.027)	(0.029)	(0.029)	(0.030)	(0.031)	(0.041)	(0.033)	(0.038)	(0.036)
LTV Change		-0.016***	-0.023***	-0.023***	-0.023***	-0.024***		-0.026***	-0.027***	-0.017***
		(0.001)	(0.001)	(0.001)	(0.001)	(0.002)		(0.002)	(0.002)	(0.002)
Female (d)			0.026***	0.024***	0.019**	0.016			0.023**	0.011
			(0.008)	(0.008)	(0.009)	(0.010)			(0.011)	(0.012)
Risk Score Change				0.030	0.020	0.031			0.277***	0.260***
				(0.033)	(0.033)	(0.030)			(0.015)	(0.015)
Loan Age	X	X	X	X	X	X	X	X	X	X
Underwriting Vars		X	X	X	X	X		X	X	X
HMDA Vars			X	X	X	X			X	X
Vintage Year-Qtr FE	X	X	X	X	X	X	X	X	X	X
State FE		X	X	X				X		
Zip Code FE					X				X	
Zip Code-by-Year-Qtr FE						X				X
# Observations	15,460,588	11,983,398	11,547,035	11,469,141	11,469,141	11,318,445	6,184,502	4,316,733	3,732,349	3,559,947
# Loans	792,823	622,936	601,094	601,028	601,028	590,643	291,587	209,827	182,517	170,234
R^2	0.002	0.003	0.004	0.004	0.006	0.062	0.003	0.005	0.006	0.131

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Default Results

Dependent Variable: Default (d)									
			GSE Loans					FHA Loans	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Black (d)	0.443***	0.285***	0.223***	0.146***	0.135***	0.733***	0.466***	0.421***	0.318***
	(0.076)	(0.053)	(0.043)	(0.030)	(0.029)	(0.057)	(0.038)	(0.033)	(0.033)
Hispanic White (d)	0.422***	0.274***	0.235***	0.194***	0.188***	0.165***	0.155***	0.085*	0.071
	(0.097)	(0.066)	(0.061)	(0.049)	(0.049)	(0.044)	(0.047)	(0.046)	(0.044)
Asian (d)	0.026	0.028**	0.048***	0.027**	0.021*	-0.125***	-0.052**	-0.041	-0.052
	(0.018)	(0.012)	(0.014)	(0.012)	(0.012)	(0.023)	(0.024)	(0.026)	(0.039)
Equifax Risk Score		-0.449***					-0.894***		
		(0.062)					(0.075)		
LTV Origination		0.010***					0.014***		
		(0.001)					(0.001)		
LTV Change		0.034***	0.036***	0.037***	0.039***		0.036***	0.037***	0.051***
		(0.003)	(0.004)	(0.004)	(0.004)		(0.004)	(0.004)	(0.006)
Female (d)			-0.017***	-0.016***	-0.015***			-0.027*	-0.025
			(0.005)	(0.005)	(0.005)			(0.014)	(0.015)
Loan Age	X	X	X	X	X	X	X	X	X
Underwriting Vars		X	X	X	X		X	X	X
HMDA Vars			X	X	X			X	X
Vintage Year-Qtr FE	X	X	X	X	X	X	X	X	X
State FE		X	X				X		
Zip Code FE				X				X	
Zip Code-by-Year-Qtr FE					X				X
# Observations	14,883,532	11,555,401	11,135,402	11,135,402	10,983,861	5,484,924	3,840,247	3,328,566	3,154,707
# Loans	792,823	622,936	601,094	601,094	590,534	291,587	209,827	182,527	169,608
R²	0.006	0.012	0.013	0.016	0.084	0.006	0.011	0.012	0.146

Pricing Implications

1. What if any pricing implications are there?

   - Lower minority prepayment speeds (refi + sale) $\Rightarrow$ Black/Hispanic loans are more valuable to lenders/investors.

     - $\Rightarrow$ Equilibrium interest rates should be lower at origination for minority borrowers (all else equal).

   - Conduct a back-of-the-envelope calculation using low balance "spec pools" to try to determine how much more valuable securities with minority loans are to investors.

     - 50–100 bps increase in "gain-on-sale".

     - Assuming full pass-through of MBS prices to borrowers $\Rightarrow$ 5–15 bps lower rates.

Do Investors Price Racial Differences in Prepayment?

2. Do investors actually price prepayment differences between minority and White borrowers?

- Need data on MBS prices to answer this question.

- Construct a TRACE-eMBS-HMDA matched dataset.
    - Match public 2018–2019 HMDA data to eMBS loan level collateral data for conforming mortgages – unique match rate of $\sim 45\%$.
    - Keep pools in which we can identify at least 60% of mortgages.

- TRACE contains all MBS transactions prices involving dealers.

- Estimate regressions of prepayment speeds and prices on race – measured at both tract-level and loan-level.
    - Evidence that pools with more Black borrowers are significantly less likely to prepay.
      ▸ Details
    - Evidence of higher MBS prices for pools with higher fraction of minority borrowers at the tract-level. ▸ Details

Do Investors Price Racial Differences in Prepayment?

- Estimate pool-month regressions of
  $factor_t$ (percent of original balance
  remaining in the pool in month t), on
  average census tract composition of
  race in the pool.

  - Include controls, including time since
    origination, avgloan size, avg credit
    score, avg LTV, etc.

- Consistent with loan-level results,
  pools with more Black borrowers are
  significantly less likely to prepay and
  end up with higher factors.

	(1)
	factor
(mean) tract_black	0.149***
Loan size	
under 85k	0
85-110k	-0.00411***
110-125k	-0.00544***
125-150k	-0.0114***
150-175k	-0.0175***
175-200k	-0.0275***
over 200k	-0.0436***
Constant	1.037***
FICO controls	Yes
LTV controls	Yes
Time controls	Yes
SATO controls	Yes
couponXmon FE	Yes
seller FE	Yes
Observations	248516
R^2	0.561

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Do Investors Price Racial Differences in Prepayment?

- Estimate regressions of "payuyps" on census tract composition of race for newly issued, 30 year MBS pools.

  - MBS prices typically quoted in units of \$ per \$100 balance and in terms of "pay-ups" to the To-Be-Announced (TBA) price for a given coupon.

  $$Payup_{i,t,t',c} = p_{i,t,t',c} - p_{t,t',c}^{TBA} \quad (4)$$

- $p_{t,t',c}^{TBA}$ – TBA price at time t for settlement time t' for coupon c.

- For t' outside of standard TBA settlement dates (once a month), we use a linear interpolation.

	(1)	(2)
	≥\$85k trades	≥\$1mil trades
(mean) tract_black	0.998***	1.411***
Loan size		
under 85k	0	0
85-110k	-0.376***	-0.369***
110-125k	-0.609***	-0.591***
125-150k	-0.715***	-0.687***
150-175k	-0.927***	-0.907***
175-200k	-1.147***	-1.132***
over 200k	-1.244***	-1.251***
Constant	-30.61***	-16.09**
FICO/LTV controls	Yes	Yes
Refi incentive controls	Yes	Yes
Trade size controls	Yes	Yes
seller FE	Yes	Yes
couponXweek	Yes	Yes
Observations	14374	13570
R^2	0.731	0.754

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$