Complex Mortgages

Gene Amromin
Federal Reserve Bank of Chicago

Jennifer Huang
University of Texas at Austin and Cheung Kong GSB

Clemens Sialm
University of Texas at Austin and NBER

Edward Zhong
University of Wisconsin-Madison

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Motivation

- Over the last decade the residential mortgage market has experienced a significant increase in product complexity.
- Most of the product innovation focused on products with deferred amortization schedules.
- Whereas mortgage securitization and the extension of credit to subprime borrowers have received a lot of attention recently, the contract design of mortgages remains largely unexplored.

Mortgage Types

- Fixed Rate Mortgages (FRM)
- Adjustable Rate Mortgages (ARM)
- Complex Mortgages (CM)

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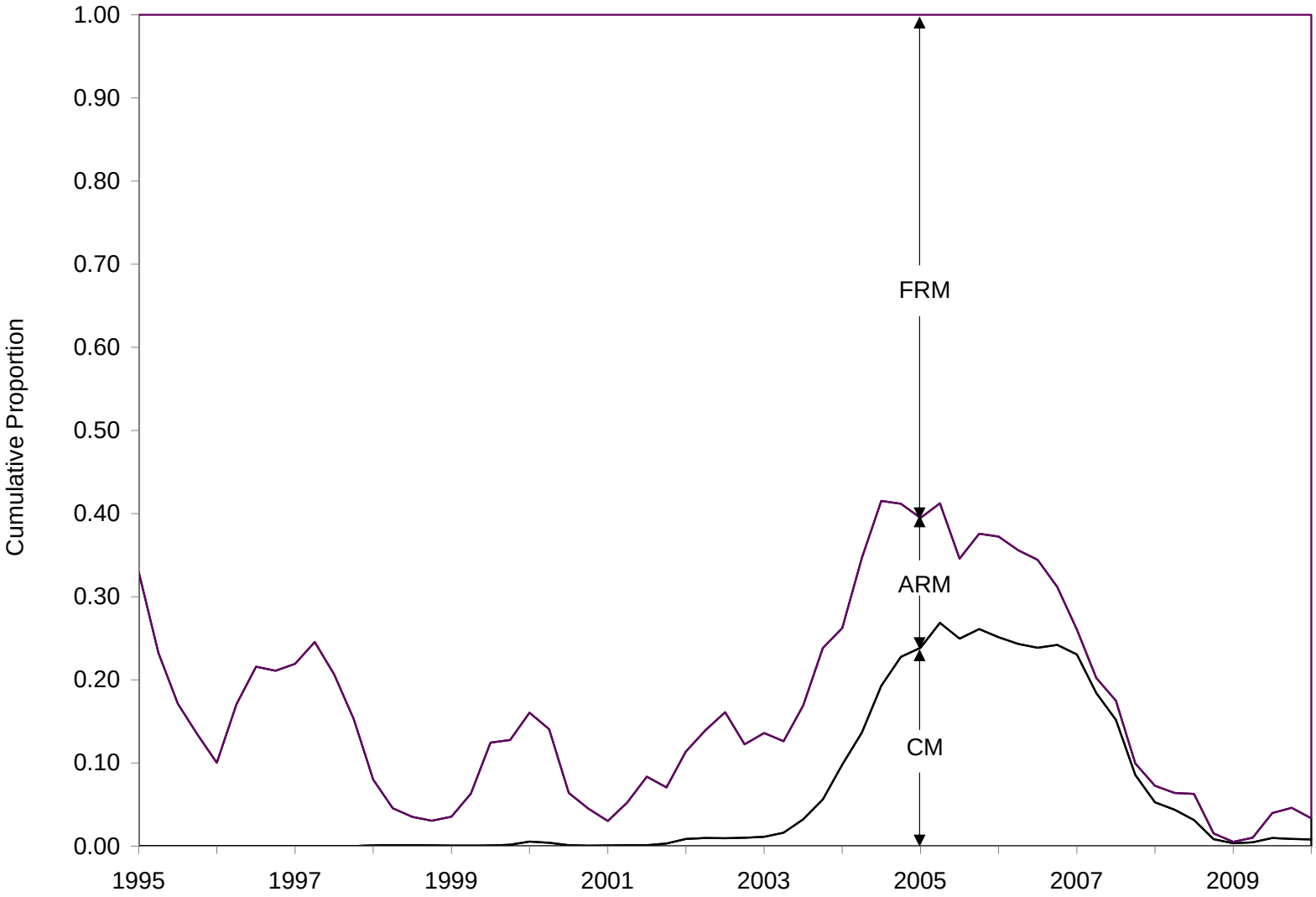
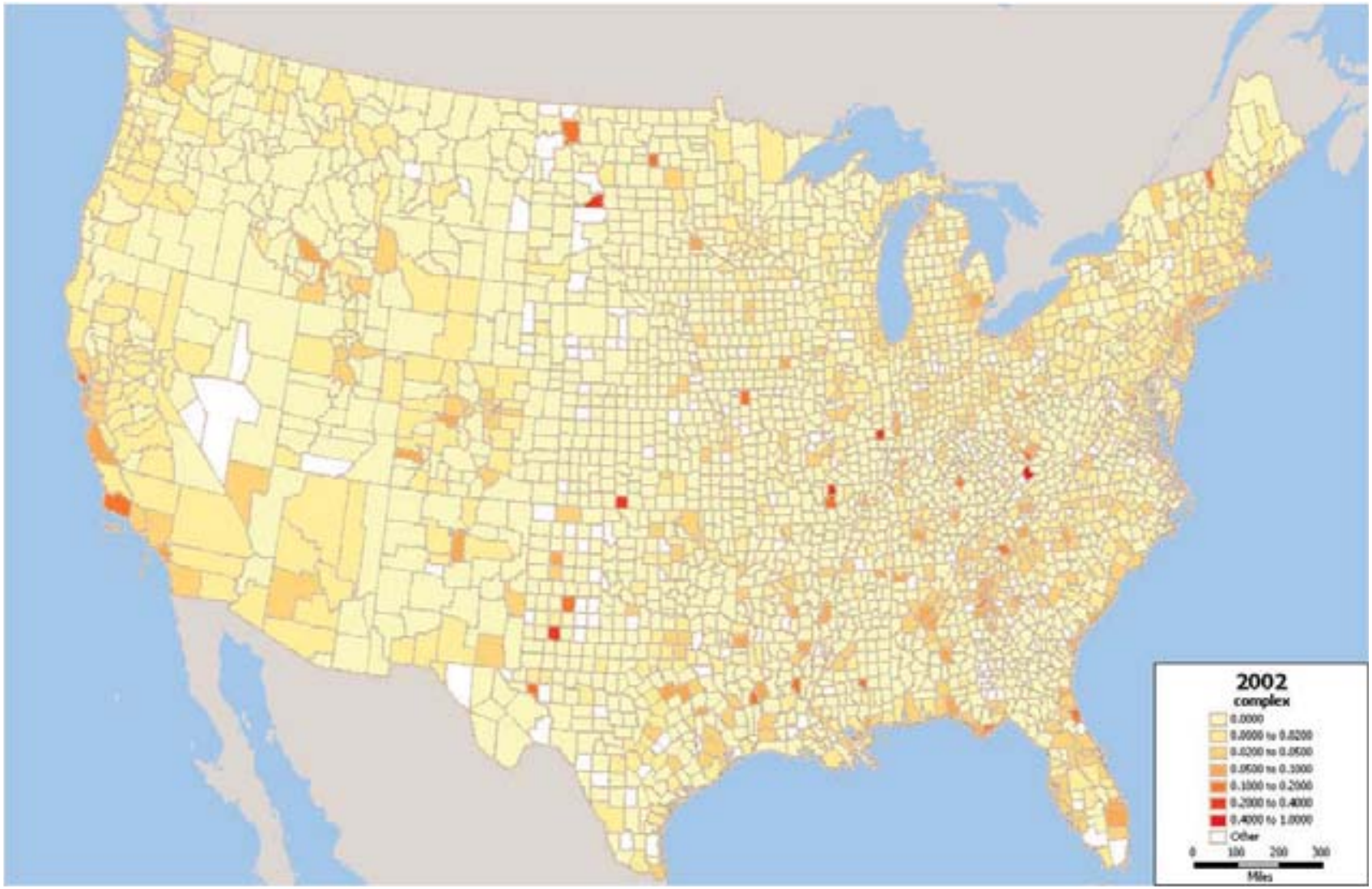
- Adjustable Rate Mortgages (ARM)
- Complex Mortgages (CM)
  - Interest Only Mortgages (IO)
  - Option ARMs and Negative Amortization Mortgages (NEGAM)

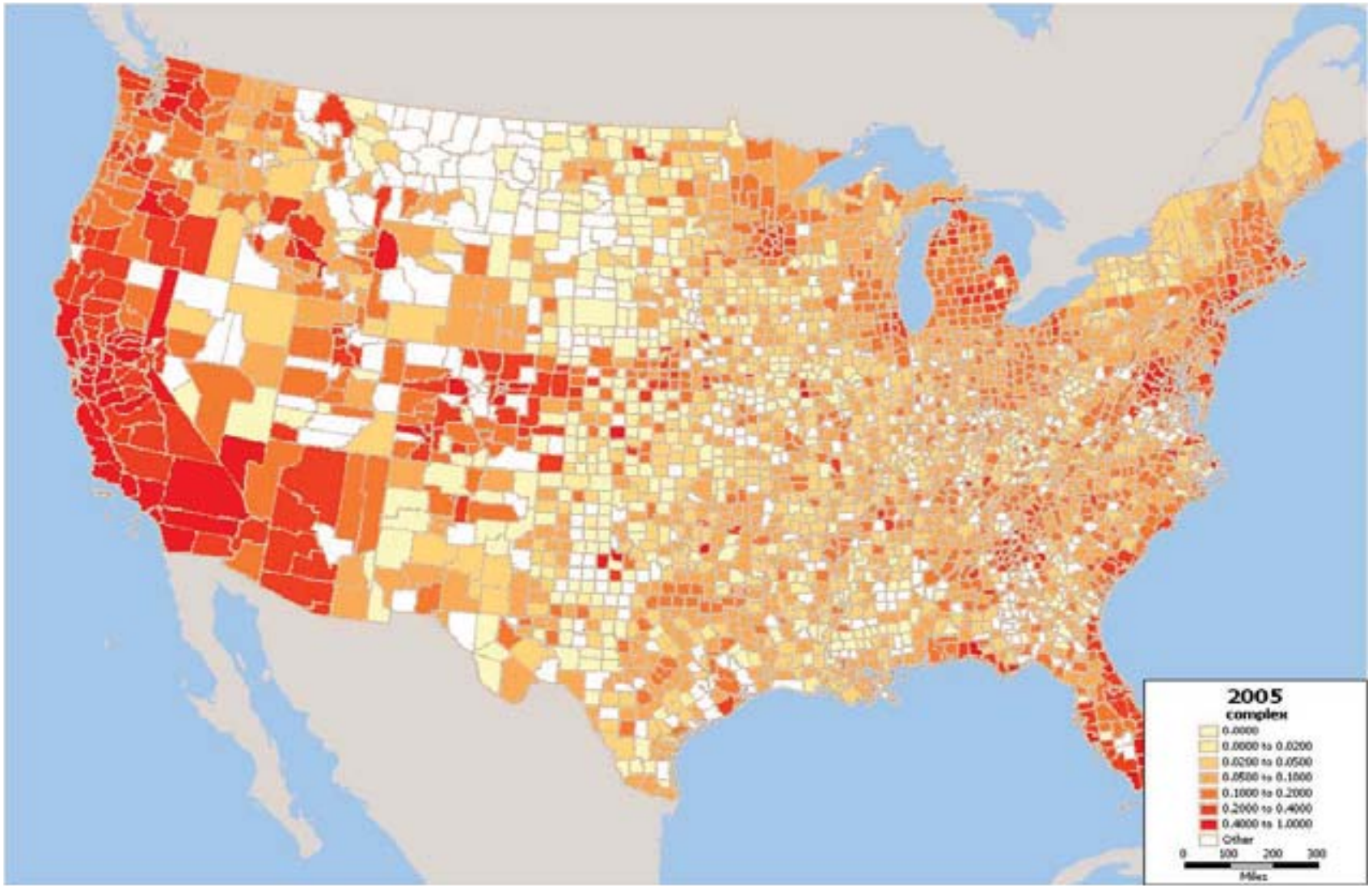
Composition of Mortgages over Time



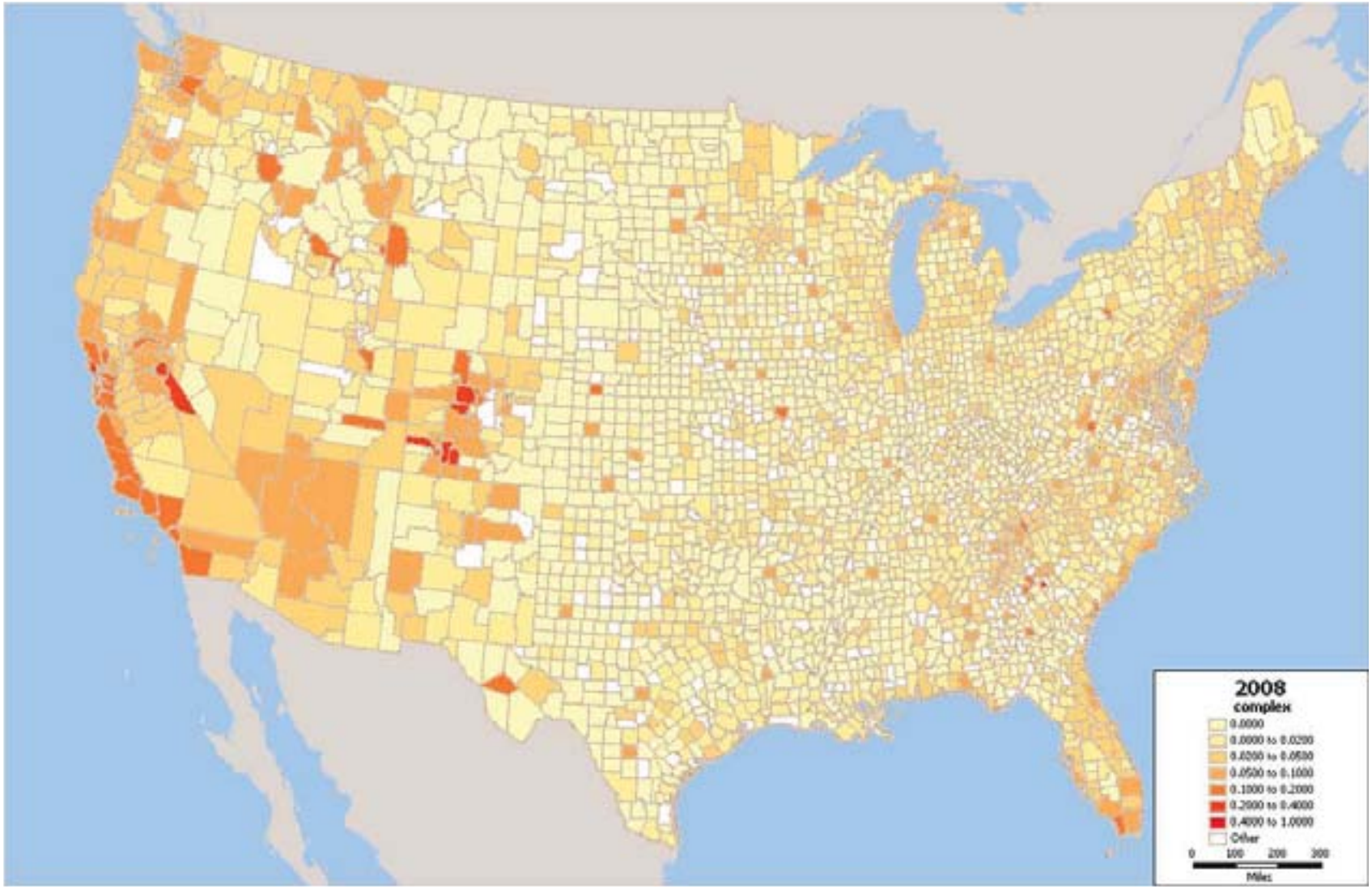
Complex Mortgages in 2002



Complex Mortgages in 2005



Complex Mortgages in 2008



Related Literature on Recent Mortgage Crisis

- Extension of Credit to Subprime Borrowers
  - Mian and Sufi (2010); Goetzmann, Peng, and Yen (2010)
- Mortgage Securitization
  - Keys, Mukherjee, Seru, and Vig (2010); Jiang, Nelson, and Vytlacil (2010a, 2010b); Purnanandam (2011)
- Agency Problems
  - Berndt, Hollifield, Sandas (2010); Woodward and Hall (2010)
- Regulation
  - Li, White, and Zhu (2010); Favilukis, Ludvigson, and Van Nieuwerburgh (2011)

Rationales for Complex Mortgages

- Obfuscation:
  - Gabaix and Laibson (2006); Carlin (2009); Carlin and Manso (2009)

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- Option to Default:
  - Amromin, Huang, and Sialm (2007); Guiso, Sapienza, and Zingales (2009)

Main Results

- Obfuscation:
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- Consumption Smoothing:
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- Option to Default:
  - Complex mortgages are more prevalent in non-recourse states.
  - The difference in the delinquency rates between complex and traditional borrowers increases both with measures of financial sophistication (like income or credit scores) and measures of strategic default (like the LTV ratio).
  - Complex borrowers exhibit a smaller increase in the probability of declaring bankruptcy after defaulting on their mortgages than traditional borrowers.

Data

- Sample of more than 10 million mortgage loans originated in the U.S. from 2003 to 2007 from LPS Analytics.
- MSA-level data on house price appreciation from the Federal Housing Finance Agency (FHFA).
- Local macro-economic variables from HMDA, U.S. Census, the BLS, and the BEA.

Summary Statistics

	FRM	ARM	CM
Income	87,835	99,816	133,581
Income with Full Documentation	85,302	95,572	117,895
FICO	710	681	713
FICO less than 620	0.10	0.24	0.06
First Lien Loan to Value (LTV)	0.74	0.77	0.73
Value to Income (VTI)	3.47	3.52	4.15
Investment Property	0.09	0.10	0.12
Low Documentation	0.11	0.12	0.25
Government Securitized	0.79	0.40	0.26
Private Securitized	0.15	0.42	0.53
Above Conforming Limit	0.05	0.14	0.33
College or More	0.33	0.36	0.38
House Price Change Prior 5 Years	0.50	0.56	0.74
Non-Recourse Mortgage	0.16	0.21	0.27
Number of Observations	7,077,626	1,284,132	1,773,843

Dynamic Changes in Mortgage Payments

- Payments on complex mortgages are on average about 20% lower than the payments on fully amortizing fixed rate mortgages during the first five years after origination. ▸ Fig 3

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- Due to the deferred amortization, debt levels remain high for an extended time period. Borrowers of complex loans amortize on average only 4% of their loan balance after five years, whereas borrowers of fixed rate loans amortize on average 9%. ▸ Fig 5

Multinomial Logit Regressions

	Individual-level Covariates		MSA-Level Covariates	
	ARM	CM	ARM	CM
Log(Income)	0.326**	0.640**	0.224**	0.484**
FICO	−0.522**	−0.043**	−0.512**	−0.020*
LTV	0.195**	0.317**	0.214**	0.344**
VTI	0.304**	0.542**	0.185**	0.351**
Low Documentation	0.092*	0.783**	0.141**	0.823**
Above Loan Limit	0.706**	1.275**	0.658**	1.170**
Condo	0.594**	0.704**	0.424**	0.460**
Investment Property	0.293**	0.213**	0.353**	0.208**
Refinance	−0.262**	0.219**	−0.222**	0.287**
College or More			0.114**	0.040*
Young			0.092**	0.099**
House Price Change			0.080**	0.364**
Population Growth			0.021	0.120**
Log(BEA Income)			0.100**	0.149**
Non-Recourse States			0.344**	0.625**
Observations	10,135,601		8,914,795	

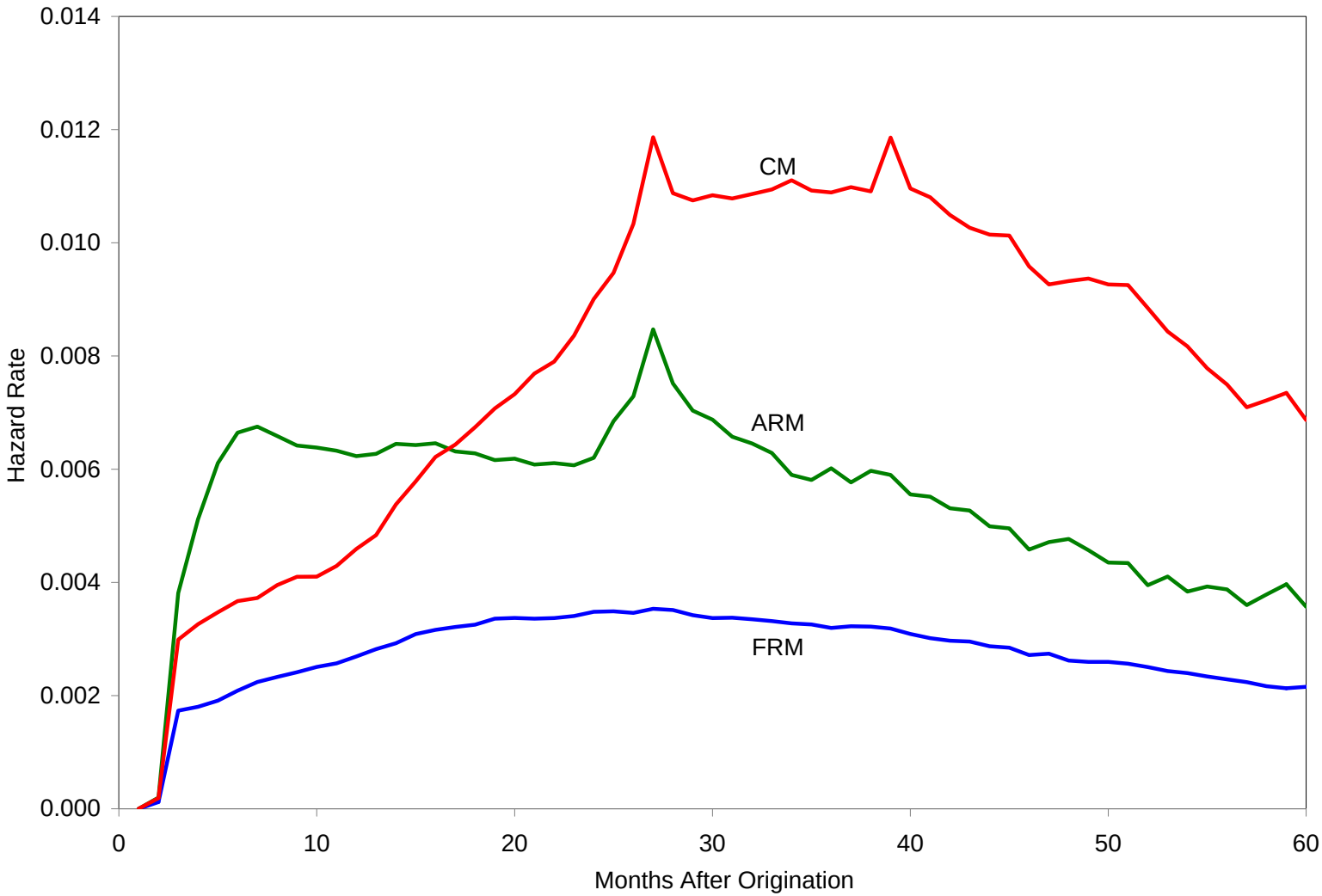
Robustness Tests

- The results remain robust using alternative samples or specifications.
  - Inclusion of state and lender fixed effects. ▸ Fixed Effects
  - Decomposition of complex loans into Interest-Only (IO) and Negative Amortization Mortgages (NEGAM). ▸ Contract Detail
  - Subsamples of full-documentation loans, purchases, non-California loans, non-securitized loans, and loans on investment properties. ▸ Subsamples
  - Year-by-year multinomial logit estimation. ▸ Year-by-Year

Reasons for Mortgage Delinquency

- Cash Flow Default
  - Complex mortgages exhibit increasing payments over time, as the payments reset when the loans become fully amortizing.
- Strategic Default
  - Complex mortgages have higher loan-to-value ratios, increasing the option value to default.
  - Complex borrowers exhibit different characteristics or preferences (e.g., risk aversion, income risk, ethical norms).

Mortgage Complexity and Delinquency



Hazard Models of Mortgage Delinquency

CM	0.736**	0.709**	0.540**
ARM	0.481**	0.490**	0.315**
Log(Income)	−0.126**	−0.074**	−0.075**
FICO	−0.673**	−0.664**	−0.635**
LTV	0.515**	0.494**	0.509**
VTI	0.040**	0.045**	0.048**
Low Documentation	0.028*	0.036**	0.089**
Above Loan Limit	0.215**	0.315**	0.141**
Condo	−0.163**	−0.078**	−0.069**
Investment Property	0.392**	0.364**	0.321**
Refinance	0.088**	0.038**	0.004
College or More		−0.214**	−0.205**
Young		0.019*	0.017*
Log(BEA Income)		0.045**	0.046**
Increase in House Value		−0.428**	−0.431**
Increase in Loan Balance		0.038**	0.039**
Payment Resets		0.030**	0.028**
Unemployment Rate		0.021	0.022
Income Growth since Origination		−0.160**	−0.154**
Government Securitized			−0.207**
Private Securitized			0.263**
Observations	32,590,515	25,619,647	25,619,647

Hazard Models of Delinquency with Interaction Effects

CM	0.700**	0.751**	0.673**	0.692**
CM x Log(Income)	0.083**			0.080**
CM x FICO		0.061**		0.060**
CM x LTV			0.097**	0.133**
ARM	0.494**	0.484**	0.490**	0.488**
Log(Income)	−0.095**	−0.074**	−0.074**	−0.093**
FICO	−0.663**	−0.677**	−0.664**	−0.676**
LTV	0.495**	0.494**	0.476**	0.470**
VTI	0.048**	0.045**	0.046**	0.049**
Low Documentation	0.033**	0.033**	0.043**	0.040**
Above Loan Limit	0.280**	0.309**	0.316**	0.276**
Condo	−0.078**	−0.078**	−0.080**	−0.082**
Investment Property	0.357**	0.361**	0.364**	0.355**
Refinance	0.041**	0.041**	0.036**	0.041**
College or More	−0.214**	−0.214**	−0.213**	−0.213**
Young	0.020**	0.019**	0.018*	0.020**
Log(BEA Income)	0.045**	0.044*	0.045**	0.044**
Increase in House Value	−0.429**	−0.428**	−0.428**	−0.428**
Increase in Loan Balance	0.034**	0.035**	0.040**	0.036**
Payment Resets	0.030**	0.030**	0.030**	0.030**
Observations	25,619,647	25,619,647	25,619,647	25,619,647

▸ Interpretation

Hazard Models for Personal Bankruptcy

CM	0.649**	0.618**	0.477**	0.621**
Delinquency			1.299**	1.366**
CM x Delinquency				−0.276**
ARM	0.316**	0.335**	0.320**	0.317**
Log(Income)	−0.168**	−0.110**	−0.099**	−0.099**
FICO	−0.465**	−0.461**	−0.372**	−0.369**
LTV	0.584**	0.550**	0.454**	0.453**
VTI	−0.222**	−0.194**	−0.235**	−0.236**
Low Documentation	0.001	0.007	0.001	−0.000
Above Loan Limit	0.195**	0.299**	0.257**	0.255**
Condo	−0.288**	−0.144**	−0.145**	−0.146**
Investment Property	0.046	0.006	−0.100**	−0.101**
Refinance	0.409**	0.370**	0.336**	0.337**
College or More		−0.205**	−0.162**	−0.163**
Young		−0.064**	−0.067**	−0.067**
Log(BEA Income)		−0.023	−0.041*	−0.041*
Increase in House Value		−0.351**	−0.311**	−0.311**
Increase in Loan Balance		0.097**	0.095**	0.095**
Observations	34,252,339	26,778,403	26,778,403	26,778,403

Robustness Tests

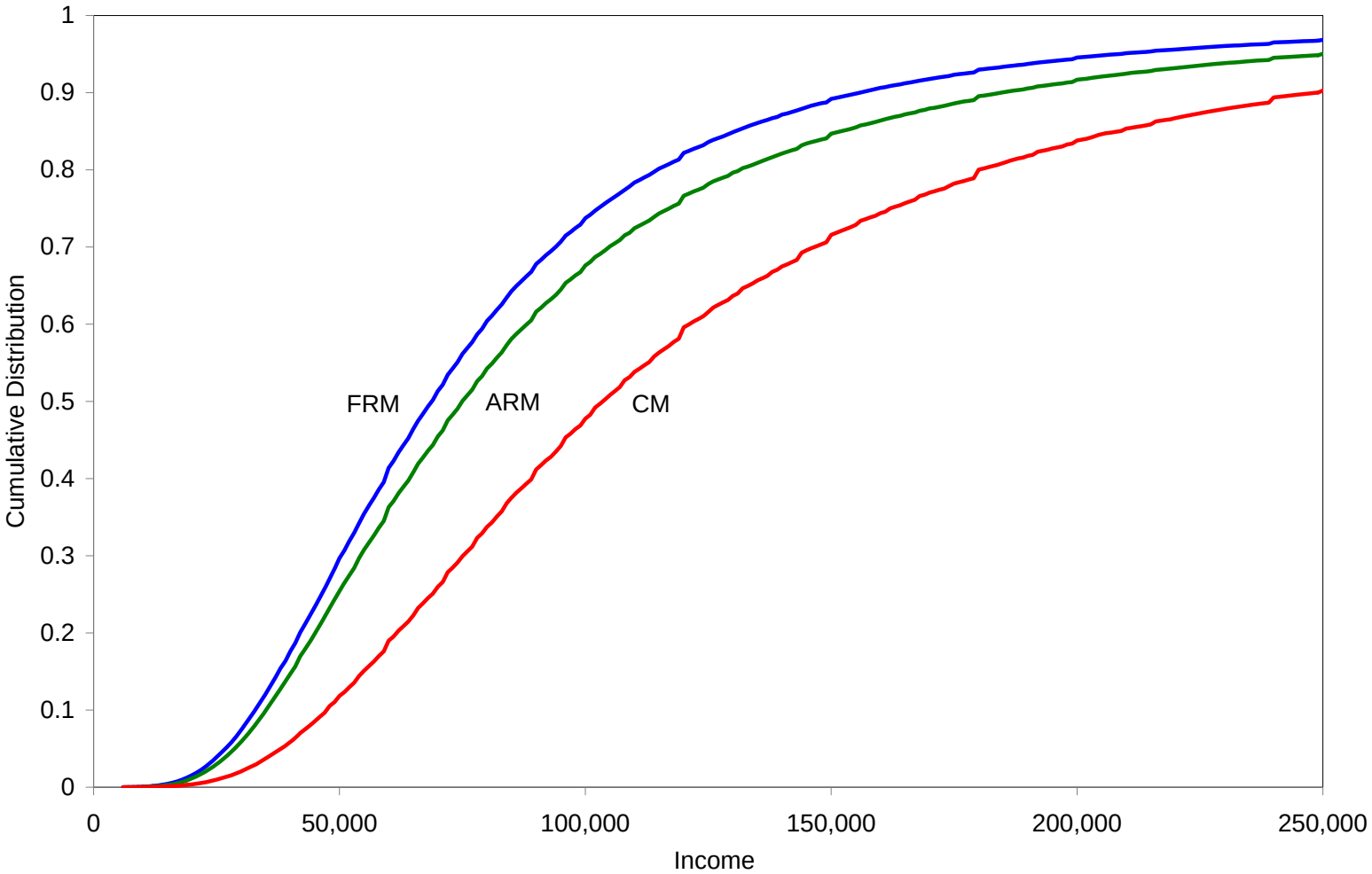
- The results remain robust using alternative samples or specifications.
  - Use of alternative baseline hazard rates (common, state, year, state-year, lender, lender-year). ▸ Fixed Effects
  - Decomposition of complex loans into Interest-Only (IO) and Negative Amortization Mortgages (NEGAM). ▸ Detailed Contract
  - Subsamples of purchases, full-documentation, non-California loans, investment properties, and securitized loans. ▸ Subsample
  - Year-by-year hazard model. ▸ Year-by-Year

Conclusions

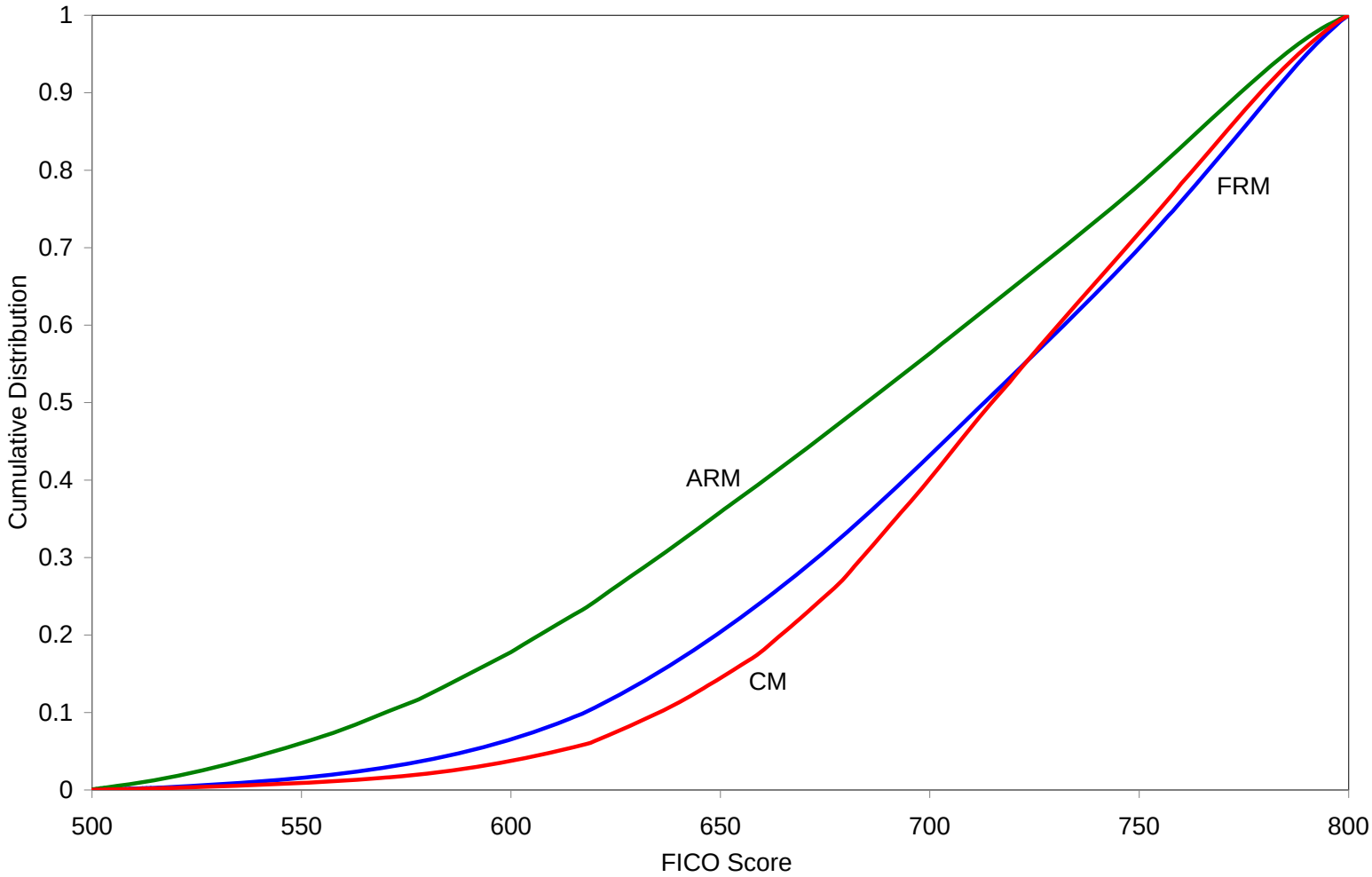
- Complex mortgages are chosen by relatively high-credit-quality households seeking to purchase more expensive houses relative to their incomes.
- Borrowers using complex mortgages experience substantially higher ex post default rates after controlling for their credit score and other household and neighborhood characteristics.
- The results indicate that the strategic default option is an important consideration for complex mortgages.

Additional Results

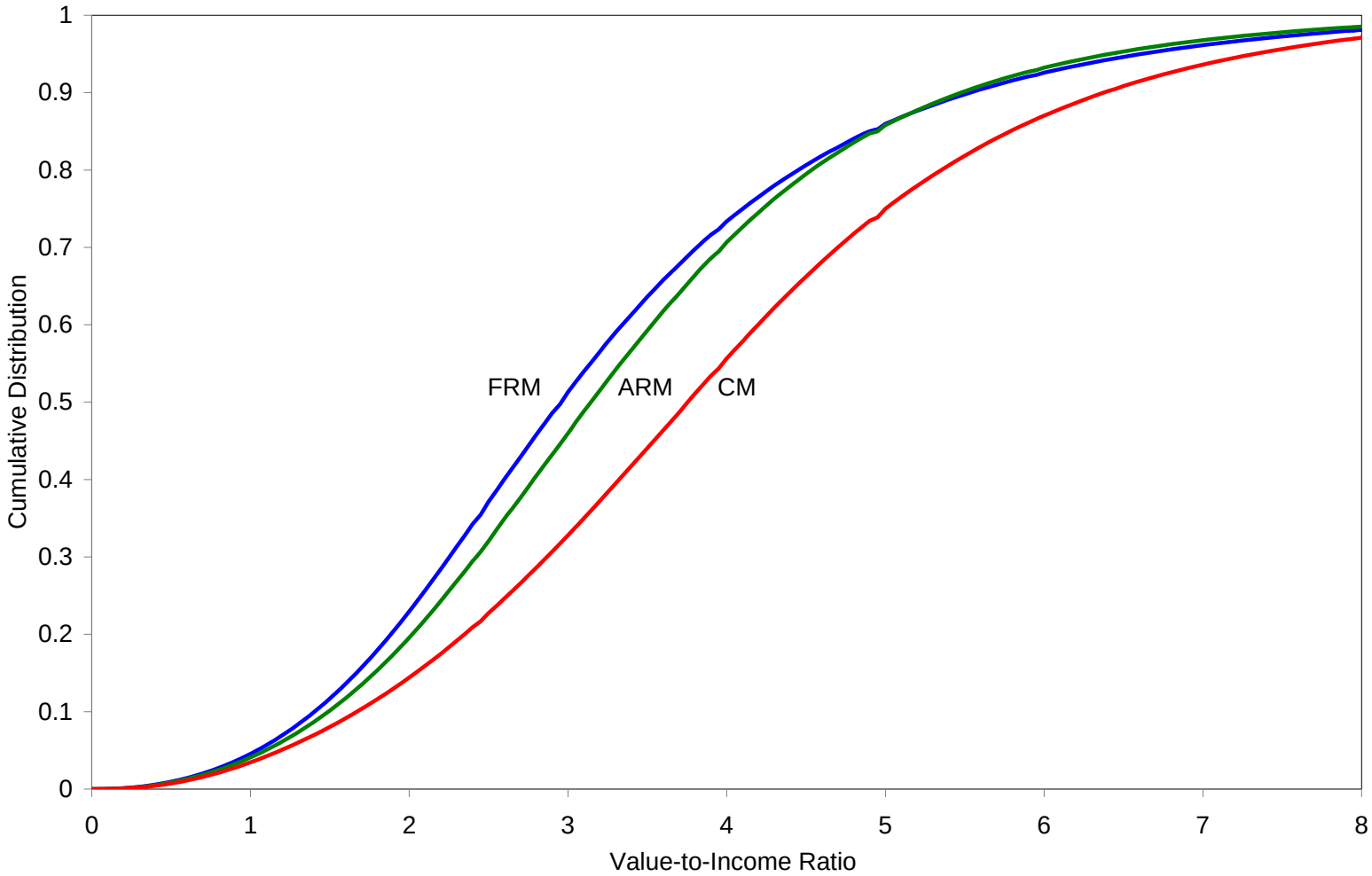
Income Level by Mortgage Type



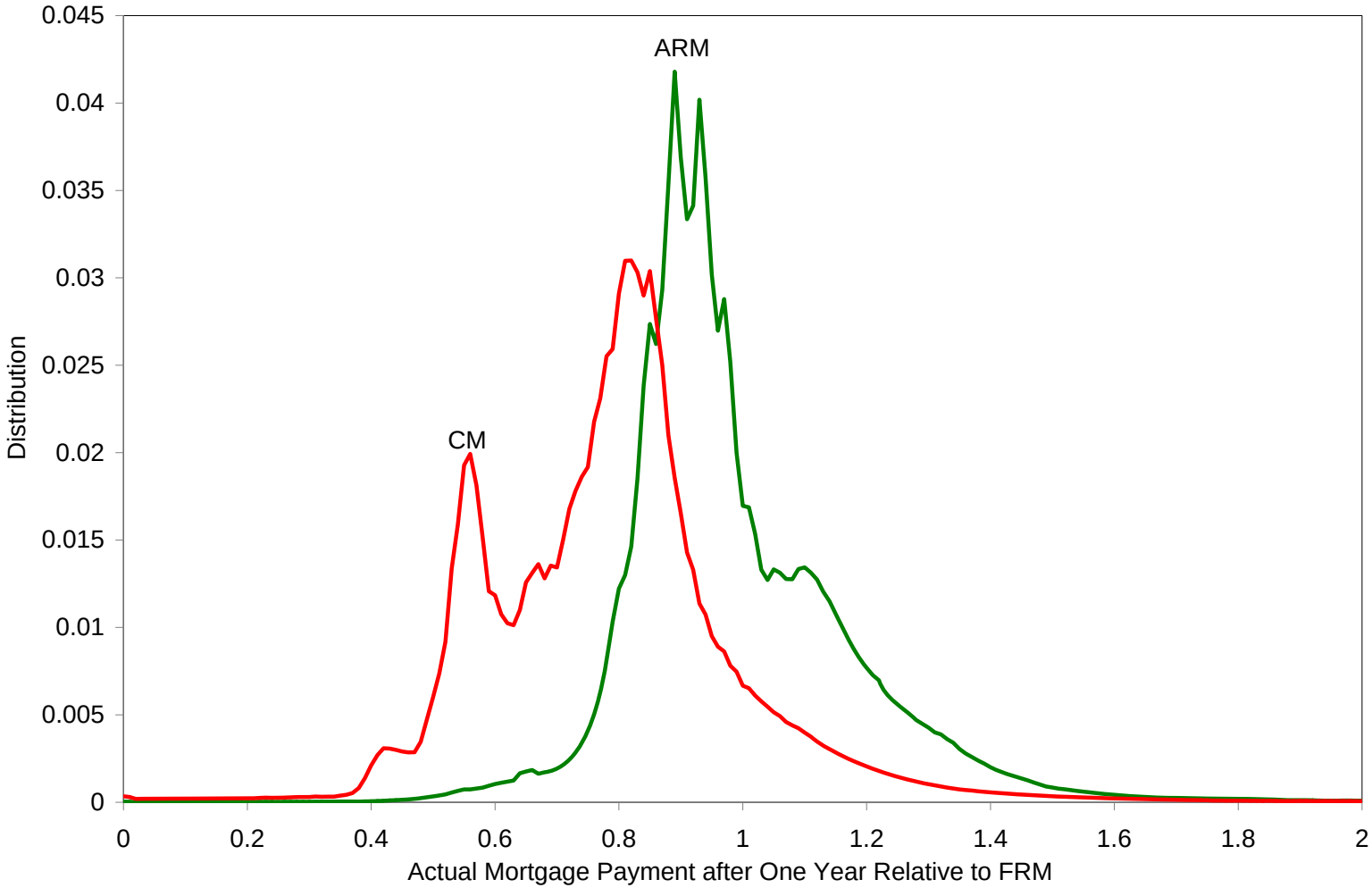
FICO Credit Score by Mortgage Type



Value to Income (VTI) Ratio by Mortgage Type



Mortgage Payment Relative to FRM After 1 Year



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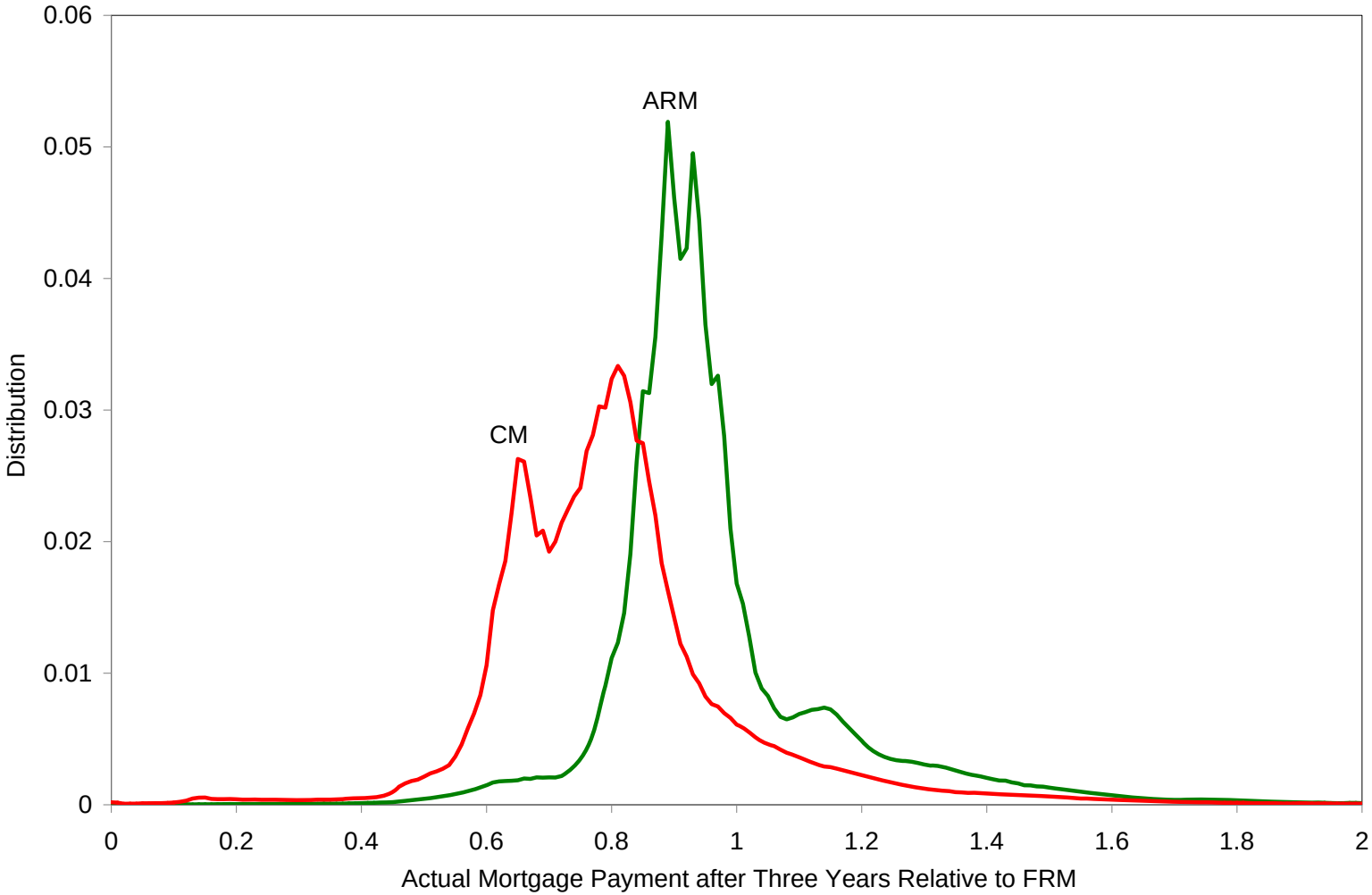
Mortgage Payment Relative to FRM After 3 Years



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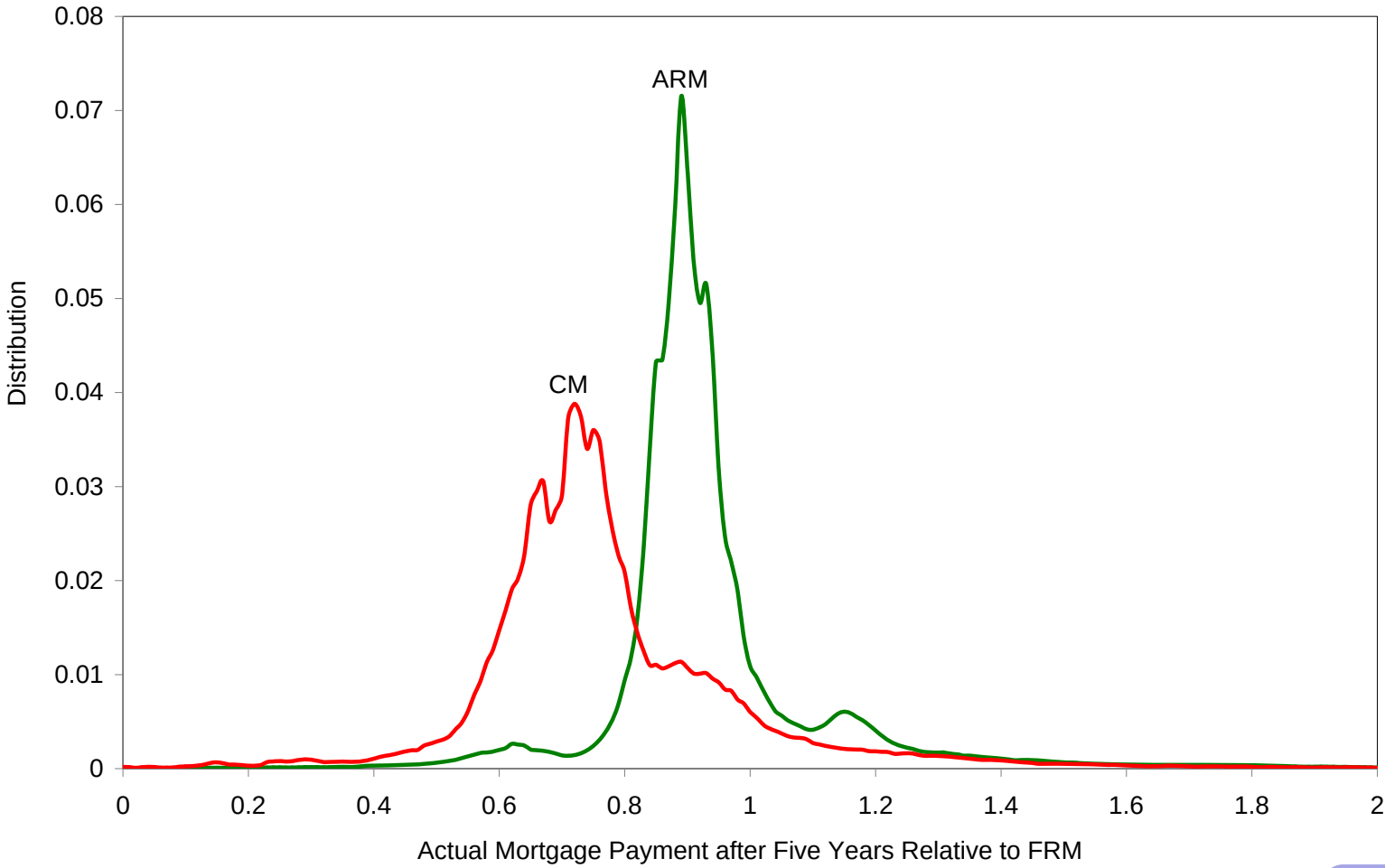
Mortgage Payment Relative to FRM After 5 Years



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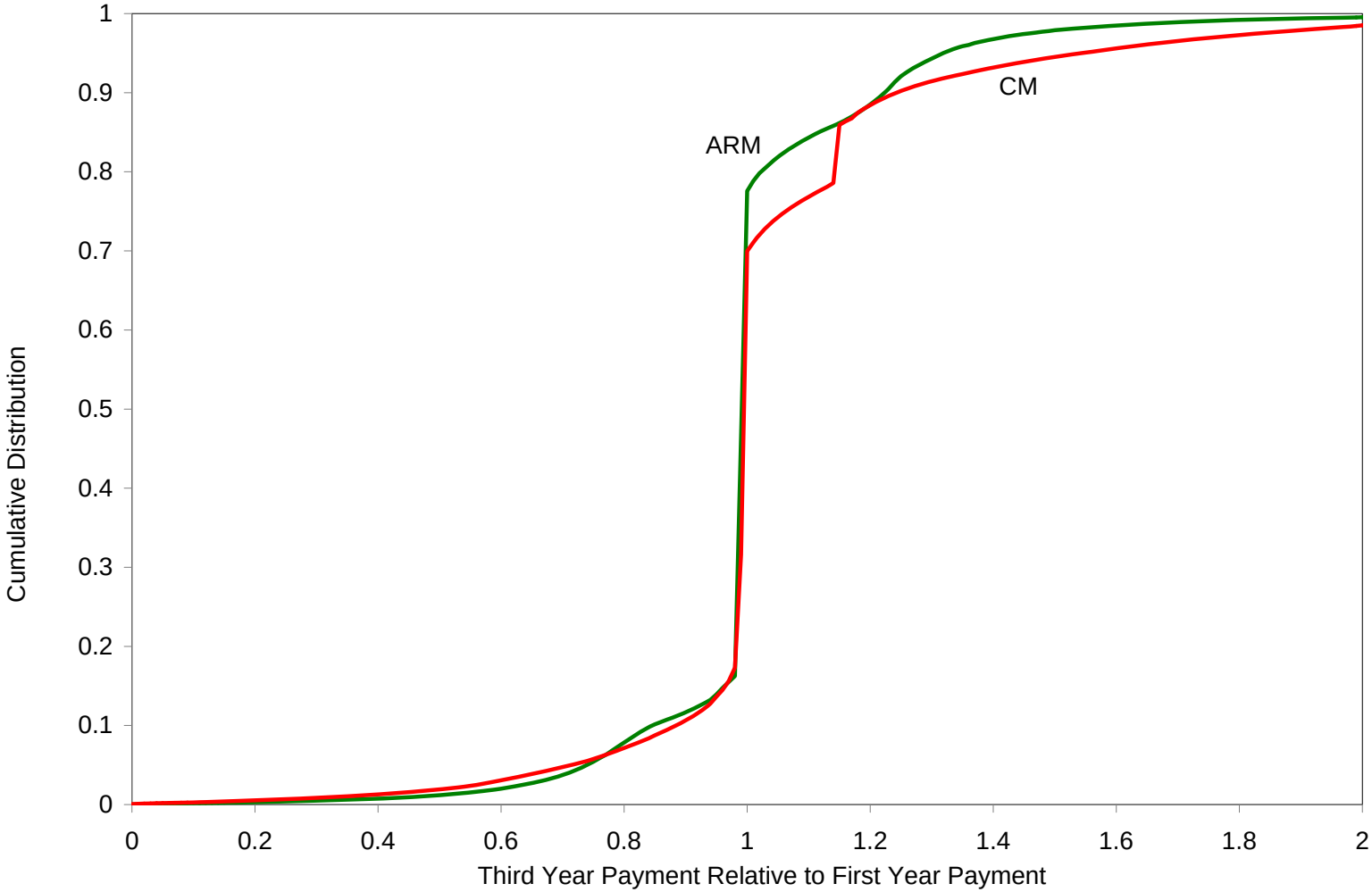
Relative Mortgage Payment After 3 Years



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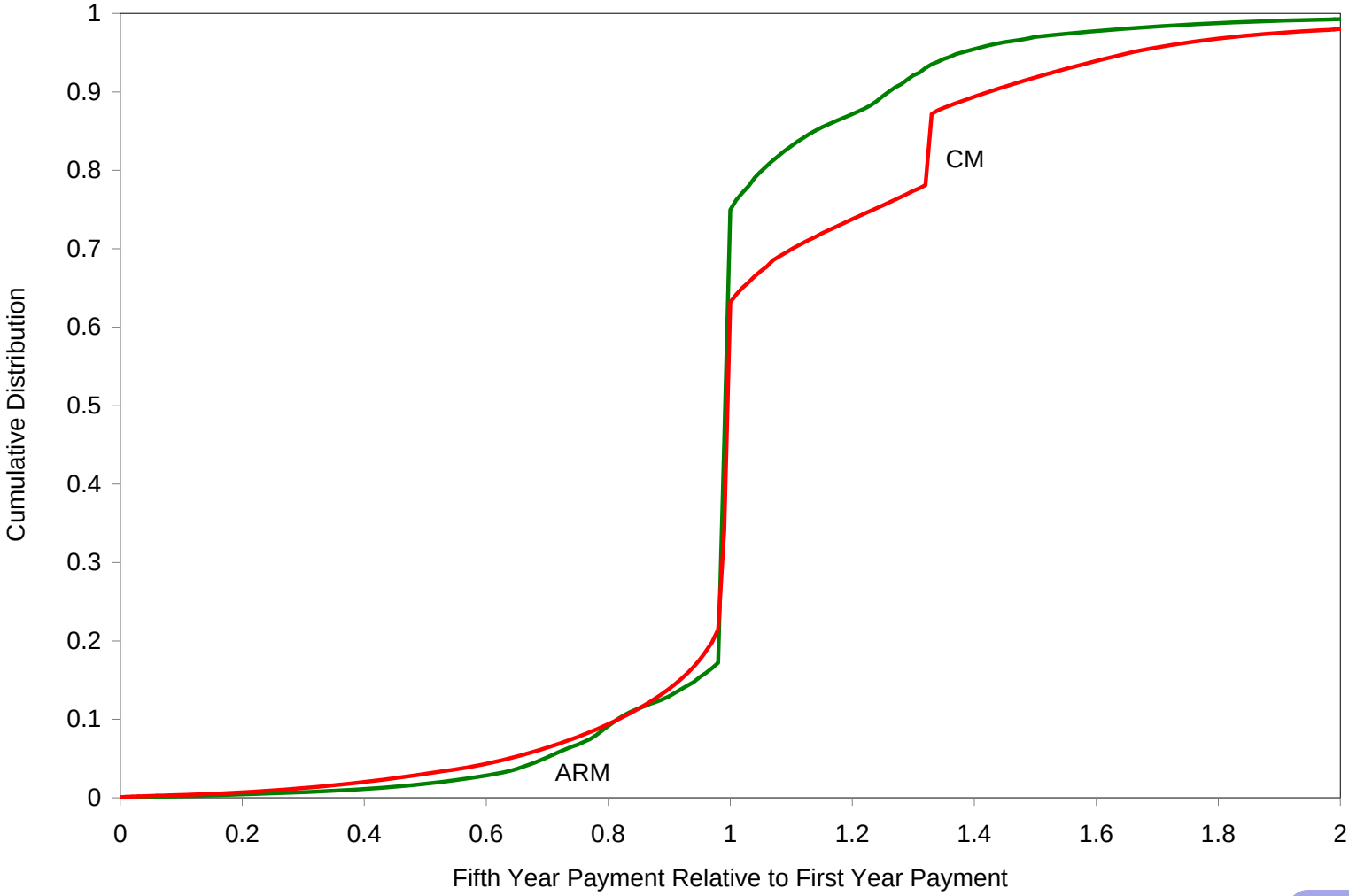
Relative Mortgage Payment After 5 Years



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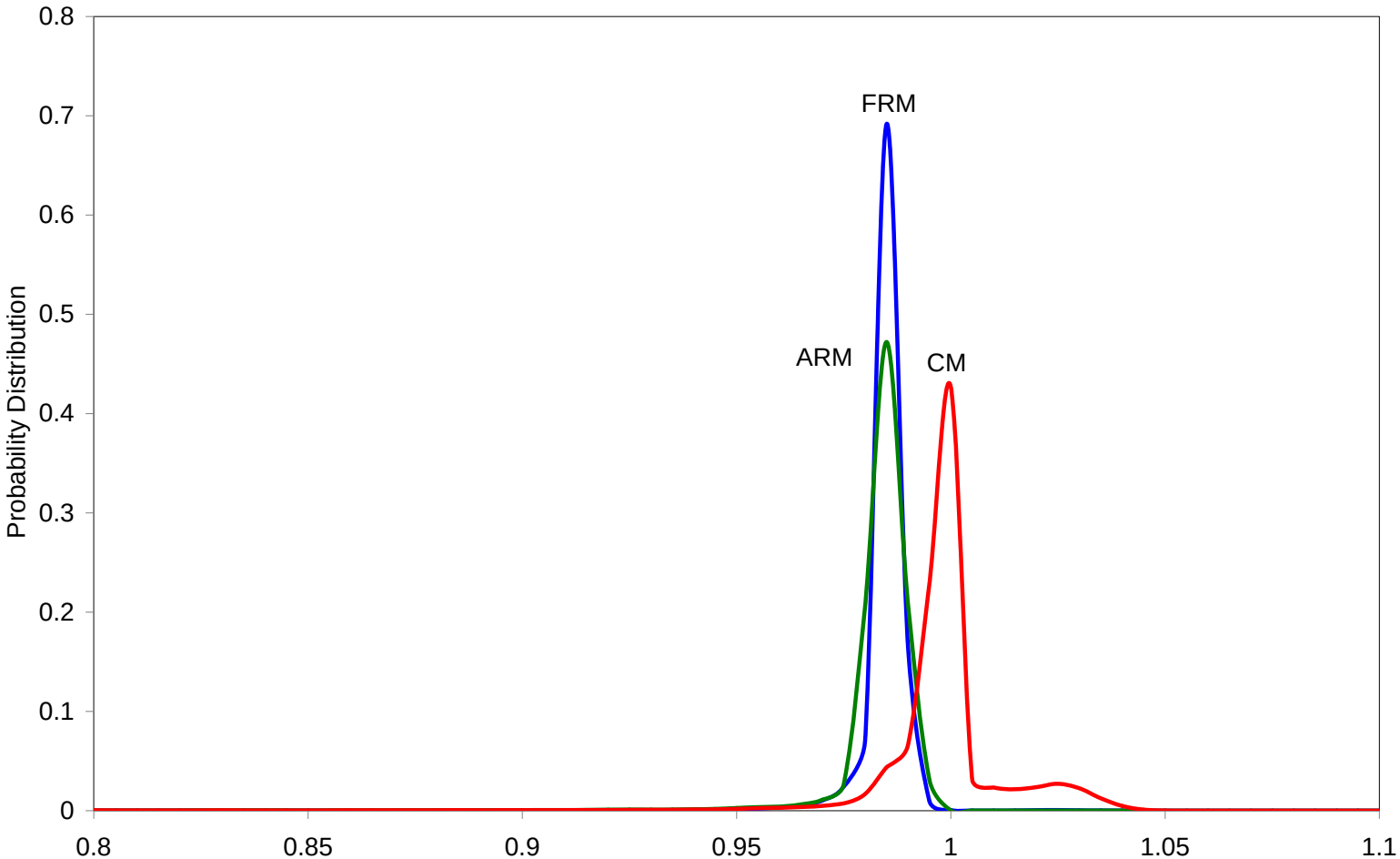
Remaining Mortgage Balance After 1 Year



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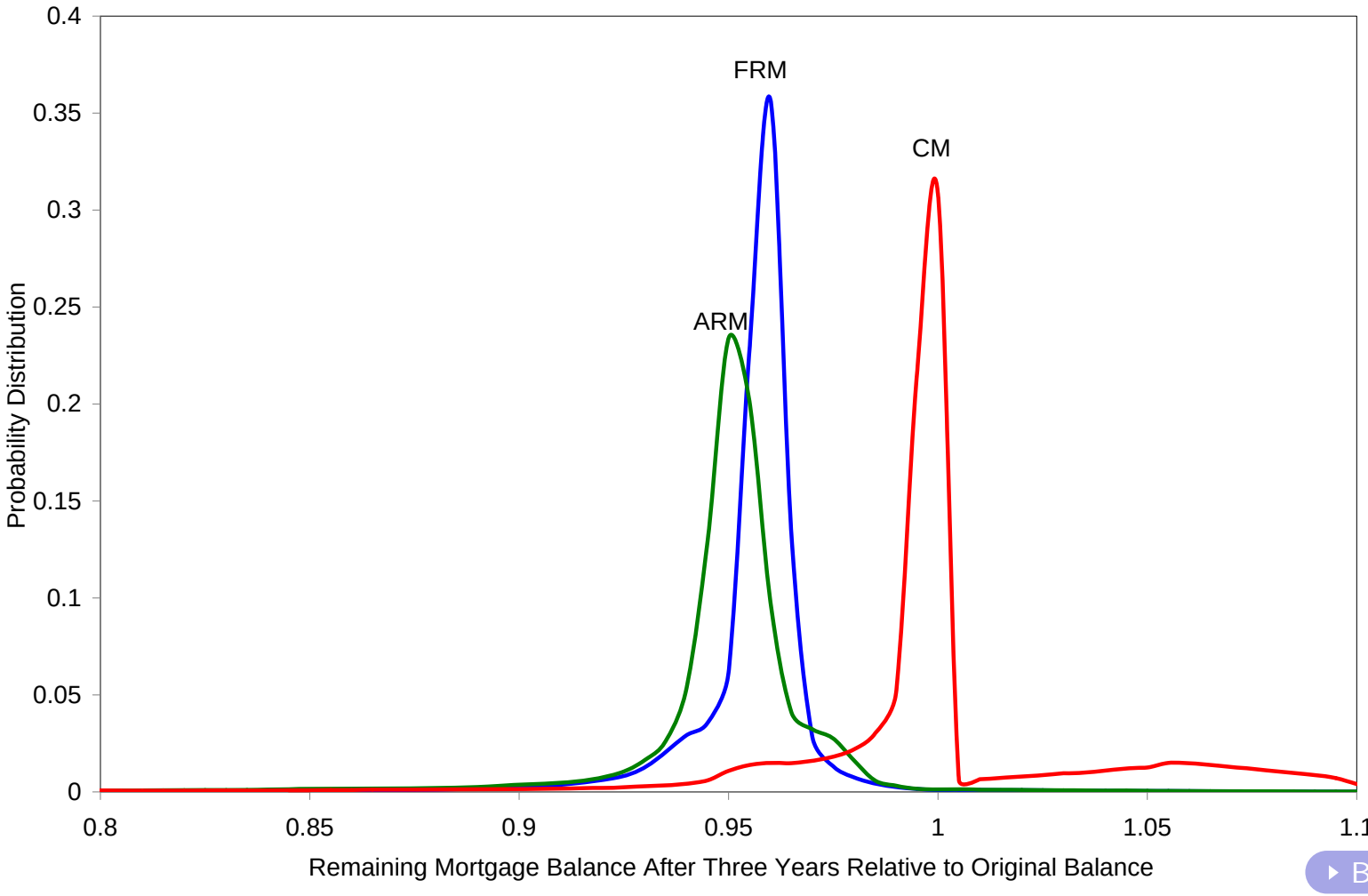
Remaining Mortgage Balance After 3 Years



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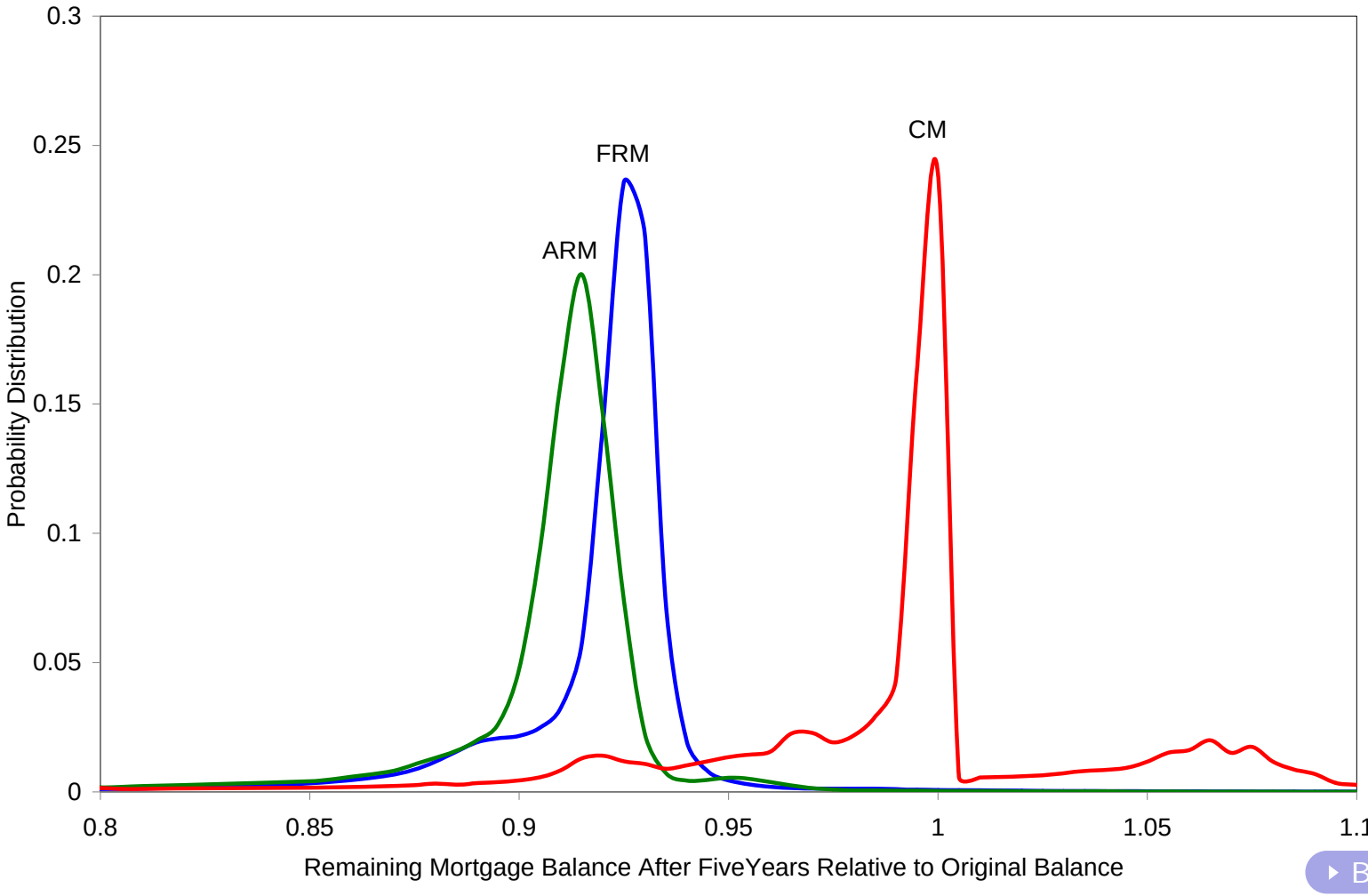

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Multinomial Logit Regressions: Fixed Effects

	State Fixed Effects		Lender Fixed Effects	
	ARM	CM	ARM	CM
Log(Income)	0.215**	0.444**	0.262**	0.467**
FICO	−0.521**	−0.035**	−0.403**	0.044**
LTV	0.206**	0.349**	0.329**	0.439**
VTI	0.154**	0.278**	0.256**	0.404**
Low Documentation	0.143**	0.815**	0.156**	0.599**
Above Loan Limit	0.697**	1.129**	0.549**	1.111**
Condo	0.389**	0.415**	0.488**	0.523**
Investment Property	0.328**	0.167**	0.282**	0.314**
Refinance	−0.302**	0.094*	−0.191**	0.018
College or More	0.117**	0.052**	0.137**	0.090**
Young	0.088**	0.062**	0.073**	0.081**
House Price Change	0.151**	0.278**	0.024	0.301**
Population Growth	0.026	0.068**	0.034	0.136**
Log(BEA Income)	0.140**	0.234**	0.092**	0.142**
Non-Recourse States			0.236**	0.486**
Observations	8,914,795		6,719,987	

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Multinomial Logit: Detailed Mortgage Contracts

	Individual-level Covariates			MSA-level Covariates		
	ARM	IO	NEGAM	ARM	IO	NEGAM
Log(Income)	0.328**	0.590**	0.862**	0.227**	0.434**	0.717**
FICO	−0.522**	−0.031**	−0.091**	−0.512**	−0.015	−0.043**
LTV	0.197**	0.281**	0.495**	0.216**	0.302**	0.557**
VTI	0.304**	0.530**	0.607**	0.186**	0.344**	0.396**
Low Documentation	0.114**	0.529**	1.596**	0.164**	0.572**	1.636**
Above Loan Limit	0.709**	1.273**	1.262**	0.661**	1.180**	1.096**
Condo	0.591**	0.725**	0.592**	0.421**	0.486**	0.340**
Investment Property	0.294**	0.196**	0.326**	0.355**	0.188**	0.351**
Refinance	−0.249**	0.018	1.065**	−0.209**	0.084	1.207**
College or More				0.112**	0.061**	−0.066**
Young				0.092**	0.102**	0.067**
House Price Change				0.081**	0.319**	0.562**
Population Growth				0.021	0.126**	0.072
Log(BEA Income)				0.100**	0.142**	0.192**
Non-Recourse States				0.344**	0.604**	0.825**
Observations		10,135,601			8,914,795	

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Multinomial Logit (CM Equation): Subsamples

	Full Documentation	Purchases Only	Exclude California	Not Securitized	Investment Properties
Log(Income)	0.420**	0.431**	0.458**	0.700**	0.410**
FICO	−0.147**	−0.086**	−0.020	−0.086**	−0.097**
LTV	0.369**	0.162**	0.250**	0.381**	0.429**
VTI	0.341**	0.336**	0.356**	0.418**	0.346**
Low Documentation		0.580**	0.666**	2.143**	−0.152**
Above Loan Limit	1.055**	1.183**	1.034**	0.731**	0.973**
Condo	0.450**	0.459**	0.436**	0.350**	0.173**
Investment Property	0.042	0.294**	0.289**	0.033	
Refinance	0.093*		0.247**	0.423**	0.030
College or More	0.051*	0.040*	0.073**	0.062**	0.062**
Young	0.086**	0.119**	0.076**	0.042*	0.072**
House Price Change	0.218**	0.439**	0.280**	0.308**	0.368**
Population Growth	0.127**	0.166**	0.180**	0.046	0.166**
Log(BEA Income)	0.114**	0.175**	0.142**	0.023	0.124**
Non-Recourse States	0.626**	0.712**	0.361**	0.858**	0.450**
Observations	3,279,098	5,214,519	7,545,202	929,429	826,569

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Multinomial Logit (CM Equation): Year-by-Year

	2003	2004	2005	2006	2007
Log(Income)	0.332**	0.453**	0.431**	0.535**	0.552**
FICO	0.122**	−0.090**	−0.190**	0.022*	0.193**
LTV	0.124**	0.365**	0.394**	0.341**	0.353**
VTI	0.229**	0.379**	0.325**	0.358**	0.441**
Low Documentation	0.772**	1.186**	0.788**	0.613**	0.724**
Above Loan Limit	1.531**	1.264**	1.143**	1.055**	1.114**
Condo	0.460**	0.482**	0.503**	0.400**	0.421**
Investment Property	−0.159**	−0.126**	0.405**	0.332**	0.125**
Refinance	0.533**	0.421**	0.127*	0.262**	0.255**
College or More	0.152**	0.102**	−0.000	0.006	0.002
Young	0.021	0.079**	0.129**	0.109**	0.090**
House Price Change	−0.019	0.332**	0.329**	0.406**	0.438**
Population Growth	0.112	0.244**	0.128**	0.094*	0.064
Log(BEA Income)	−0.060	0.133**	0.185**	0.186**	0.196**
Non-Recourse States	0.313**	0.718**	0.650**	0.602**	0.637**
Observations	1,420,293	2,244,082	1,651,865	2,272,016	1,326,539

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Interpretation of Interaction Effects

- It is important to be careful when interpreting interaction effects in non-linear models (Ai and Norton 2003).
- The interaction effect in our hazard model can be interpreted as a semi-elasticity of the hazard function:

$$\lambda(i,t) = \lambda(t)e^{(\beta_0+\beta_1\times CM+\beta_2\times FICO+\beta_3\times CM\times FICO+\epsilon)}$$

- Taking logs and the derivative derivative gives:

$$\frac{\partial log(\lambda(i,t))}{\partial FICO} = \beta_2 + \beta_3 \times CM.$$

- Since CM is binary, β_3 gives:

$$\left.\frac{\partial log(\lambda(i,t))}{\partial FICO}\right|_{CM=1} - \left.\frac{\partial log(\lambda(i,t))}{\partial FICO}\right|_{CM=0} = \beta_3.$$

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Hazard Models: Lender-Year Baselines

CM	0.669**	0.680**
CM x Log(Income)		0.107**
CM x FICO		0.093**
CM x LTV		0.127**
ARM	0.434**	0.422**
Log(Income)	−0.051**	−0.074**
FICO	−0.628**	−0.650**
LTV	0.472**	0.450**
VTI	0.055**	0.057**
Low Documentation	0.007	0.006
Above Loan Limit	0.325**	0.277**
Condo	−0.006	−0.010
Investment Property	0.331**	0.321**
Refinance	−0.012	−0.006
College or More	−0.211**	−0.210**
Young	−0.007	−0.006
Log(BEA Income)	0.043*	0.043*
Increase in House Value	−0.471**	−0.469**
	(0.016)	(0.016)
Increase in Loan Balance	0.059**	0.056**
	(0.010)	(0.010)
Payment Resets	0.031**	0.031**
	(0.001)	(0.001)
Observations	25,619,718	25,619,718

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Hazard Models: Detailed Contract Specification

IO	0.676**	0.676**	0.705**	0.643**	0.662**
NEGAM	0.888**	0.826**	0.987**	0.829**	0.858**
IO x Log(Income)		0.060**			0.060**
NEGAM x Log(Income)		0.132**			0.125**
IO x FICO			0.037**		0.038**
NEGAM x FICO			0.205**		0.199**
IO x LTV				0.085**	0.110**
NEGAM x LTV				0.222**	0.252**
ARM	0.492**	0.496**	0.486**	0.492**	0.489**
Log(Income)	−0.077**	−0.096**	−0.076**	−0.077**	−0.093**
FICO	−0.664**	−0.663**	−0.678**	−0.665**	−0.678**
LTV	0.494**	0.495**	0.493**	0.474**	0.469**
VTI	0.046**	0.048**	0.046**	0.047**	0.049**
Low Documentation	0.025*	0.023	0.023	0.034**	0.031**
Above Loan Limit	0.309**	0.278**	0.304**	0.308**	0.273**
Condo	−0.076**	−0.077**	−0.075**	−0.079**	−0.079**
Investment Property	0.363**	0.357**	0.359**	0.364**	0.354**
Refinance	0.030*	0.035**	0.033**	0.028*	0.034**
College or More	−0.212**	−0.212**	−0.212**	−0.211**	−0.211**
Young	0.019**	0.020**	0.019**	0.018*	0.020**
Log(BEA Income)	0.044**	0.044**	0.043*	0.044**	0.044**
Increase in House Value	−0.429**	−0.430**	−0.428**	−0.428**	−0.428**
Increase in Loan Balance	0.023	0.021	0.021	0.025*	0.022
Payment Resets	0.029**	0.029**	0.029**	0.029**	0.029**
Unemployment Rate	0.022	0.023	0.022	0.021	0.022
Income Growth since Origination	−0.162**	−0.162**	−0.161**	−0.161**	−0.159**
Observations	25,619,647	25,619,647	25,619,647	25,619,647	25,619,647

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Hazard Models: Subsamples

	Full Documentation	Purchases Only	Exclude California	Not Securitized	Investment Properties
CM	0.597**	0.847**	0.691**	0.536**	0.645**
CM x Log(Income)	0.072**	0.062**	0.097**	0.042**	0.038**
CM x FICO	0.028**	0.024	0.032*	0.185**	0.103**
CM x LTV	0.010	−0.086**	0.077**	−0.040	−0.087**
ARM	0.450**	0.547**	0.468**	0.105**	0.371**
Log(Income)	−0.143**	−0.121**	−0.110**	−0.069**	0.017*
FICO	−0.711**	−0.681**	−0.686**	−0.768**	−0.692**
LTV	0.476**	0.444**	0.454**	0.506**	0.674**
VTI	0.049**	0.048**	0.077**	0.042**	0.077**
Low Documentation		0.060**	0.034**	0.231**	−0.063**
Above Loan Limit	0.263**	0.236**	0.320**	0.313**	0.033
Condo	−0.064**	−0.091**	−0.096**	−0.113**	−0.164**
Investment Property	0.365**	0.290**	0.437**	0.390**	
Refinance	0.003		0.062**	0.038	0.242**
College or More	−0.188**	−0.255**	−0.197**	−0.225**	−0.228**
Young	0.015	0.030**	0.017*	0.003	0.055**
Log(BEA Income)	0.053**	0.055**	0.078**	−0.006	0.028
Increase in House Value	−0.436**	−0.434**	−0.418**	−0.438**	−0.392**
Increase in Loan Balance	−0.014	−0.015	0.057**	0.028	0.113**
Payment Resets	0.033**	0.030**	0.027**	0.024**	0.004
Unemployment Rate	0.028*	0.027	0.041*	−0.031*	−0.006
Income Growth since Origination	−0.149**	−0.167**	−0.137**	−0.149**	−0.152**
Observations	9,345,354	15,116,355	21,713,131	2,330,799	2,443,944

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Hazard Model: Year-by-Year

	2003	2004	2005	2006	2007
CM	0.170**	0.638**	0.780**	0.705**	0.513**
CM x Log(Income)	0.135**	0.074**	0.070**	0.055**	0.064**
CM x FICO	−0.052	0.058**	0.008	0.045**	0.117**
CM x LTV	−0.068	0.139**	0.230**	0.164**	0.071**
ARM	0.131**	0.305**	0.640**	0.615**	0.360**
Log(Income)	−0.310**	−0.218**	−0.133**	−0.008	−0.020
FICO	−0.815**	−0.767**	−0.683**	−0.620**	−0.619**
LTV	0.473**	0.456**	0.456**	0.465**	0.510**
VTI	0.036**	0.059**	0.029**	0.051**	0.086**
Low Documentation	−0.079**	0.062**	0.117**	0.012	−0.008
Above Loan Limit	0.345**	0.327**	0.271**	0.207**	0.314**
Condo	−0.076**	−0.036	−0.085**	−0.089**	−0.121**
Investment Property	0.461**	0.391**	0.361**	0.290**	0.341**
Refinance	0.070**	0.074**	−0.035*	0.039**	0.194**
College or More	−0.192**	−0.191**	−0.224**	−0.199**	−0.223**
Young	−0.029**	−0.002	−0.001	0.036**	0.024**
Log(BEA Income)	0.088**	0.045*	0.049**	0.021	0.045
Increase in House Value	−0.263**	−0.435**	−0.483**	−0.372**	−0.396**
Increase in Loan Balance	0.102**	0.113**	−0.017	−0.028**	0.057**
Payment Resets	0.043**	0.054**	0.042**	0.017**	−0.003
Unemployment Rate	0.053**	0.038*	0.010	0.028	0.029*
Income Growth since Origination	−0.064**	−0.035	−0.135**	−0.227**	−0.307**
Observations	5,482,921	7,174,441	4,895,836	5,549,944	2,516,505

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