Mispricing Mortgage Credit Risk: Evidence from Insurance Premiums, 1999-2016

James Kahn(james.kahn@yu.edu) and Benjamin Kay (benjamin.s.kay@frb.gov). We thank Robert Garrison II and Jared Rutner for excellent research assistance, and the Office of Financial Research for support of this work.

Did Supply or Demand Drive the Mortgage Credit Boom?

- Lax residential mortgage lending standards have been implicated as a key contributing factor to the financial crisis (Financial Crisis Inquiry Commission (2010))
- But were they? Both a credit supply and/or a demand shift could generate the large increase in lending before the crisis
- Most analysis focuses on quantities of risky mortgages, not rates
- Mortgage interest rates could help disentangle supply and demand channels. However:
  - Rates comprise more than just default risk
  - Term premiums, prepayment risk, inflation risk factor in
- Mortgage insurance premiums reflect only default risk
- Yet mortgage insurance during the period leading up to 2008 has been surprisingly neglected

Our Contributions

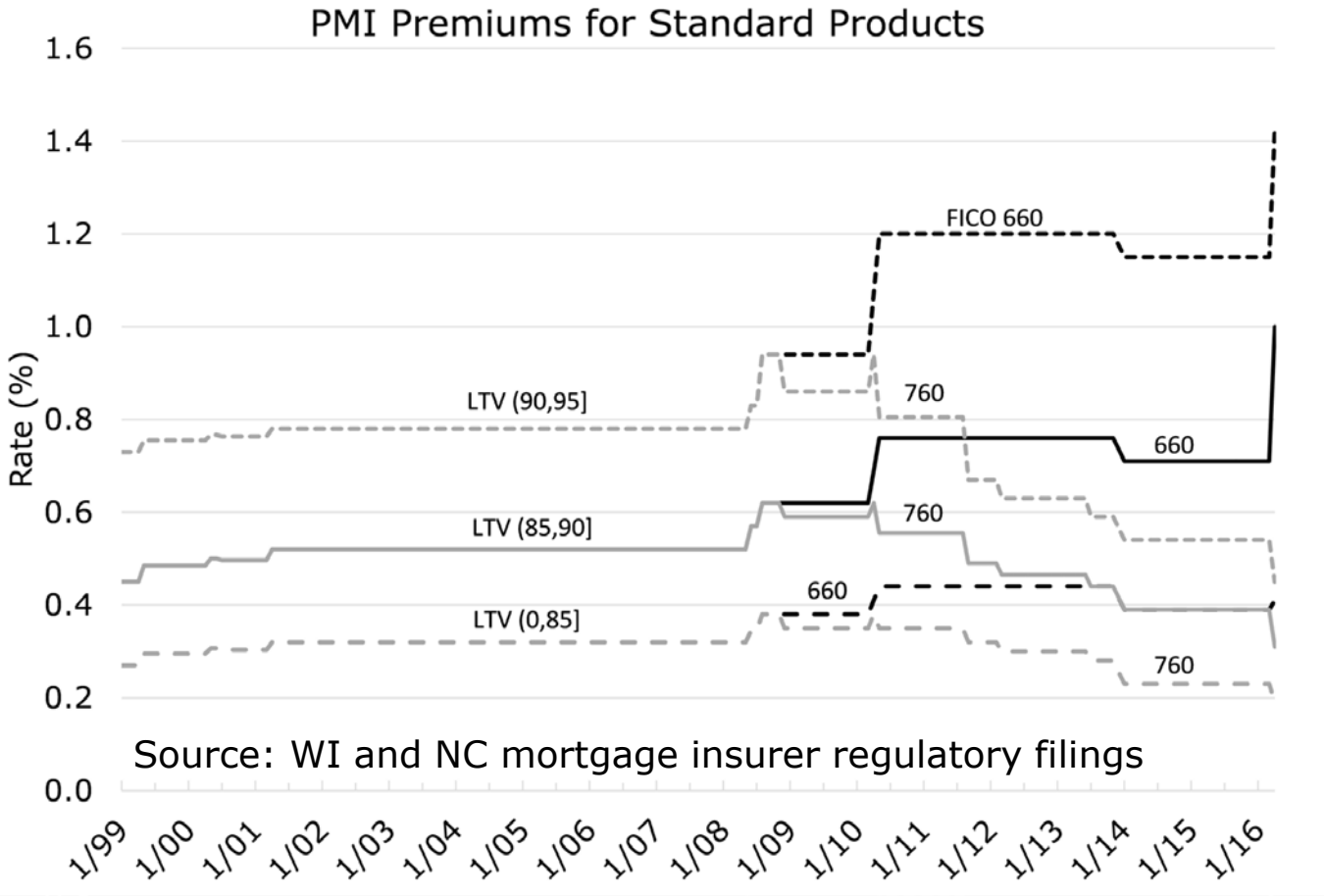
- To fill the data gap, we collect original data on private mortgage insurance (PMI) premiums from 1999-2016, and supplement these with pricing of government insurance (FHA).
- We construct price indices for mortgage insurance in four risk categories (based on FICO, LTV, documentation)
- Using post-crisis (2013) pricing as benchmark, we:
  - infer default risks by FICO, LTV
  - find the pattern of insurance mispricing pre-crisis (2005)—even allowing for higher demand-- that strongly correlates with shifts in product market shares in a manner consistent with the supply shift hypothesis

Introduction to Private Mortgage Insurance

What is PMI? PMI Protects Mortgage Investors from Losses from Mortgage Default

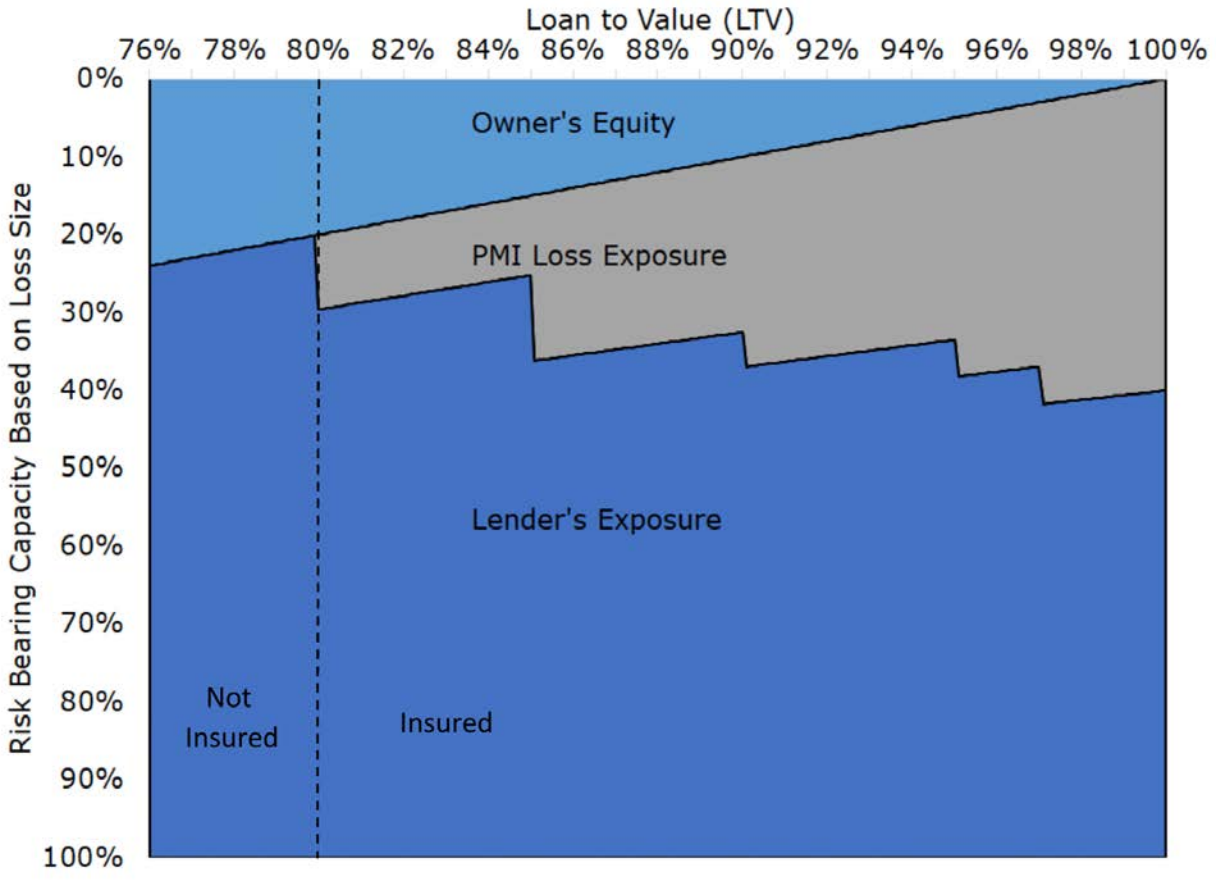
1. The primary focus of this paper is on private insurance because the pricing of PMI is a market price and therefore an informative equilibrium outcome
2. Insurers take the first hit on losses, not lenders
3. Most commonly found on mortgages with down payments of 20 percent or less (loan to value (LTV) of 80+)
4. $500+ billion in outstanding PMI insured mortgages (US Mortgage Insurers)
5. Mortgage insurers have paid out about $65 billion since the 1980's (Avery and Kull [2011])

Was Risk Properly priced? Until 2008 PMI Rates were Generally Homogeneous Across Prime FICO Scores



1. Pre-08 there was no pricing of credit risk for FICO scores 640 and higher
2. This figure shows representative case of PMI premiums on mortgages with ≤ 90 LTVs, ≥ 660 FICO scores, and full documentation for 99-16
3. These products were insurable 99-16. No so for low documentation and FICO scores or higher LTV products

Standard PMI Coverage Rates on 30 Year Mortgages



Sources: MGIC [2017] and author's calculations

1. Mortgage insurance is primarily a product for loans with $LTV \geq 80\%$
2. Coverage is the insured fraction of the loan balance
3. Exposure is the effective LTV of the GSE owning the mortgage, reflecting the insurance and the owner's equity
   A. Vast majority of high LTV GSE loans are insured
   B. Insurance available outside of GSEs
4. PMI is most commonly a fixed payment, made monthly, in the same format as mortgage interest rates

A New Mortgage Insurance Database

A New Database of PMI Premiums

- We digitize and combine sources of rate sheet and regulatory data from three private mortgage insurers (MGIC, United Guaranty, and Triad)
- These sources are publicly available but not machine readable
- We focus on fully refundable, borrower-paid, monthly premium PMI at standard coverage rates on 30 year fixed rate mortgages
- Rates are recorded in regulatory filings, conditional on borrower and loan attributes, and fixed until the next filing
- Dataset covers PMI rates from 1999 – 2016
- We construct our (product-time) panel out of the average of all prices quoted in a given month, though price differences across providers are small
- Data available to other researchers on publication

Sample PMI Rates on Higher-Risk Products

		Minimum FICO Score					
	LTV	660	640	620	600	575	550
1999	(95,97]	1.04	1.04	-	-	-	-
	(90,95]	0.75	0.75	-	-	-	-
	(85,90]	0.47	0.47	-	-	-	-
2001	(95,97]	0.99	0.99	1.33	1.48	1.70	1.70
	(90,95]	0.78	0.78	0.99	0.99	1.30	1.30
	(85,90]	0.51	0.51	0.62	0.62	0.73	0.74
2004	(95,97]	0.96	0.96	1.42	1.88	2.57	4.18
	(90,95]	0.78	0.78	1.00	1.32	1.80	2.92
	(85,90]	0.52	0.52	0.68	0.90	1.22	1.97
2006	(95,97]	0.96	0.96	1.54	2.05	2.97	4.18
	(90,95]	0.78	0.78	1.08	1.44	2.08	2.92
	(85,90]	0.52	0.52	0.74	0.98	1.41	1.97
2011	(95,97]	1.64	2.34	-	-	-	-
	(90,95]	1.20	1.36	-	-	-	-
	(85,90]	0.76	0.90	-	-	-	-
2013	(95,97]	1.53	1.53	-	-	-	-
	(90,95]	1.20	1.20	-	-	-	-
	(85,90]	0.76	0.76	-	-	-	-

* Units are in percentage points per year paid monthly.

Rates shown are those that prevailed for a majority of the year indicated.

Source: WI and NC mortgage insurer regulatory filings

1. Substantial variation in the scope of products available and the level of premiums over the 17+ years
2. First consider just the riskiest Full Doc products (FICO scores ≤ 660 and LTV ≥ 90) where some of the biggest changes in both rates and availability occurred
3. More risky products became available, first at a relatively low price. Then a steeper price gradient emerged, and the riskiest products disappeared post-2008.
4. In the documentation dimension a similar but more extreme pattern occurred

We also Gather Data on FHA Premiums

Table 3: FHA Premiums on Fixed-Rate Mortgages*

				Annual Equivalent	
	LTV	Upfront	Recurring	T=7	T=3
1999	>95	2.25	0.50	0.90	1.33
	≦95	2.25	0.50	0.90	1.33
2001	>95	1.50	0.50	0.77	1.06
	≦95	1.50	0.50	0.77	1.06
2004	>95	1.50	0.50	0.76	1.05
	≦95	1.50	0.50	0.76	1.05
2006	>95	1.50	0.50	0.76	1.05
	≦95	1.50	0.50	0.76	1.05
2011	>95	1.00	1.15	1.32	1.51
	≦95	1.00	1.10	1.27	1.51
2013	>95	1.75	1.35	1.64	1.97
	≦95	1.75	1.30	1.59	1.97

* Units are in percentage points per year paid monthly.

Rates are those that prevailed for a majority of the year indicated.

Source:Mortgage Banker's Association, authors' calculations

1. Over the whole period, a major alternative to PMI is government supplied mortgage insurance, most commonly Federal Housing Authority (FHA) insured mortgages
2. Since the 1960s these loans have allowed relatively high LTVs, typically 95+ percent plus closing costs and low minimum FICO scores.
3. They have never priced FICO scores (just set minimum requirements)
4. FHA insurance is structured to have an upfront fee plus a monthly premium
5. To make FHA rates comparable to PMI, we convert assume a mortgage life and find the NPV equivalent PMI

Credit Conditions Index

Using Premium Data to Price Risk over Time

1. We construct annual Fisher price indexes for four sub-aggregates of products by risk category
2. These indices require price and quantity data
    - Premium data as published and supplemented with imputed prices where products have disappeared
    - Quantities are dollars of originated 30 year fixed-rate home purchase loans for each product type in each year from CoreLogic's loan level mortgage origination data (LLMA 2.0)
        - Quantity data less reliable pre-2004
3. We construct indexes for PMI only, and for composite PMI-FHA prices

We Assign Products to Risk Categories by their Stressed Default Rate

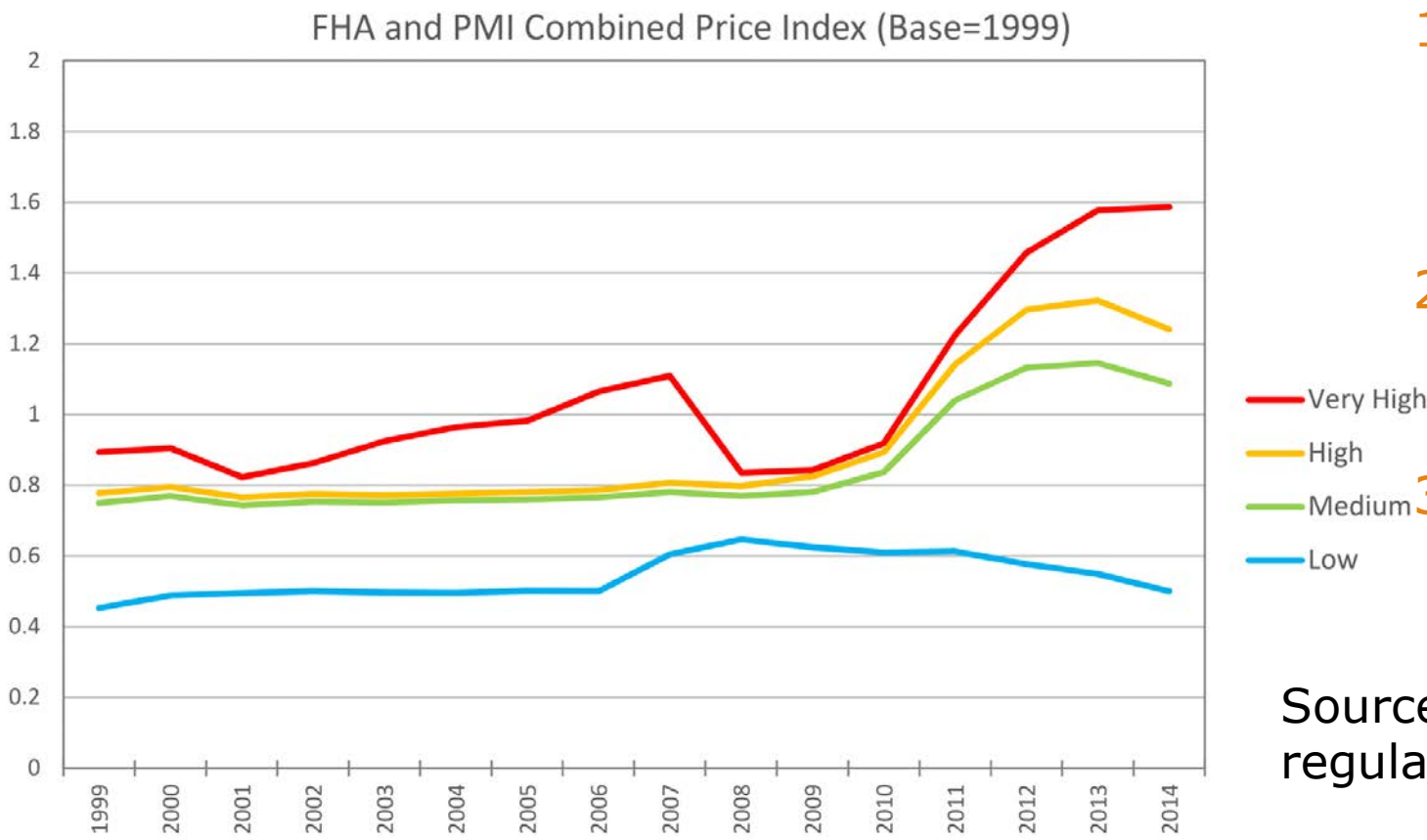
Min FICO Score

Max LTV (%)	760	740	720	700	680	660	640	620	600
103	*4.98*	6.43	*8.30*	10.16	*11.84*	13.51	*16.64*	19.77	23.49
100	4.48	5.80	*7.52*	9.24	10.77	12.30	15.23	18.16	21.66
97	*3.97*	5.17	*6.74*	8.31	*9.70*	11.08	*13.82*	16.55	19.83
95	*3.22*	4.20	*5.49*	6.77	*7.91*	9.05	*11.36*	13.66	16.43
90	*2.64*	3.44	*4.49*	5.53	*6.47*	7.41	*9.32*	11.22	13.51
85	*2.20*	2.85	*3.70*	4.54	*5.32*	6.10	*7.65*	9.20	11.06
80	*1.39*	1.79	*2.30*	2.81	*3.30*	3.79	*4.72*	5.65	6.76

Very High Risk
High
Medium
Low Risk

- The risk category of a mortgage is determined by the cumulative average five-year default rate of the 2007 vintage as measured by Lam et al. [2013]
- For some mortgages this is an ex-post characterization
- Even if the ex-ante and ex-post assessments differed, it is reasonable to assume that the ranking was similar
  - Year 2000 cohort mortgages defaulted by 2005 with a similar pattern but at a lower level

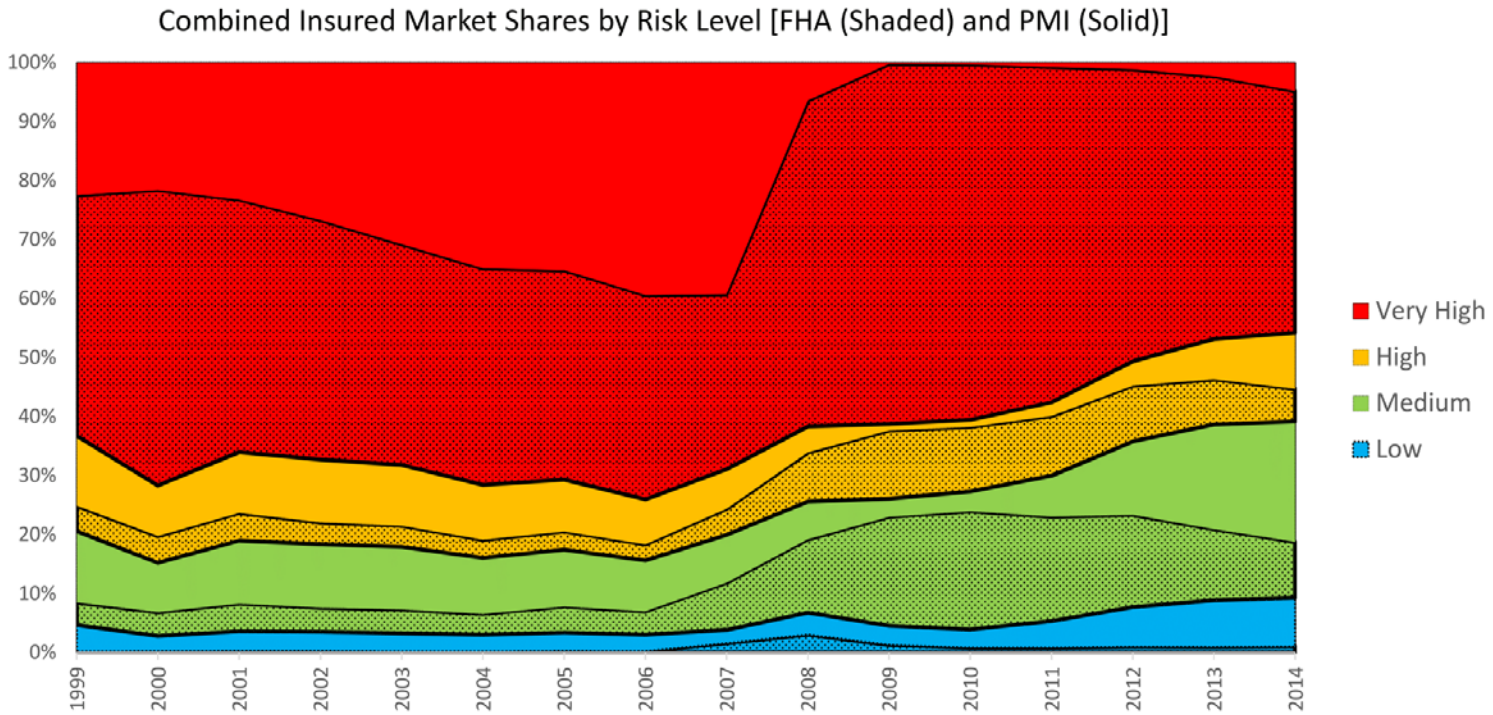
Chain Weighted FHA-PMI Price Indexes by Risk Category



1. Now highest risk products get cheaper in 2008 due to FHA rates remaining low, huge jump in FHA share
2. Spreads actually narrowed before eventually getting permanently wider
3. The "Very High Risk" index ends up about 60bp higher in 2014 than in 2005

Sources: CoreLogic LLMA 2.0, WI and NC regulators, FHA, and authors' calculations

Incorporating FHA and PMI Market Share Shows no Collapse of High and Very High Risk Mortgages



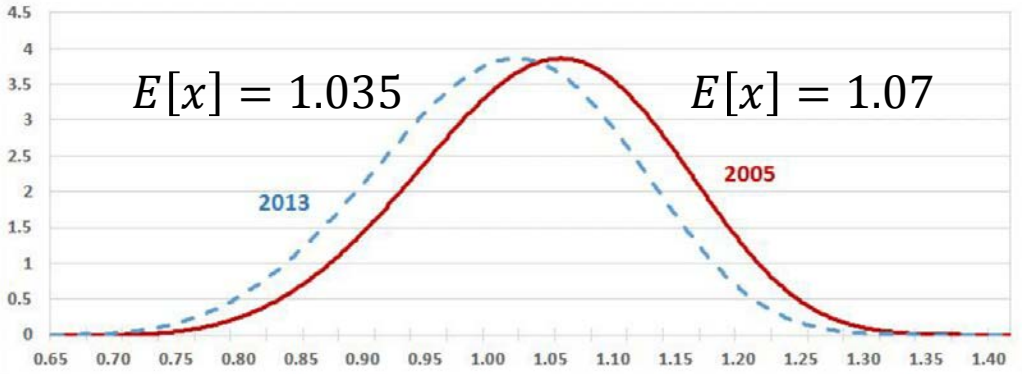
- Apparent drop in riskiest PMI mortgages 2008-2010 was really a shift from PMI to FHA

Quantifying the Mispricing of Risk

A Two-Period Model of Lending

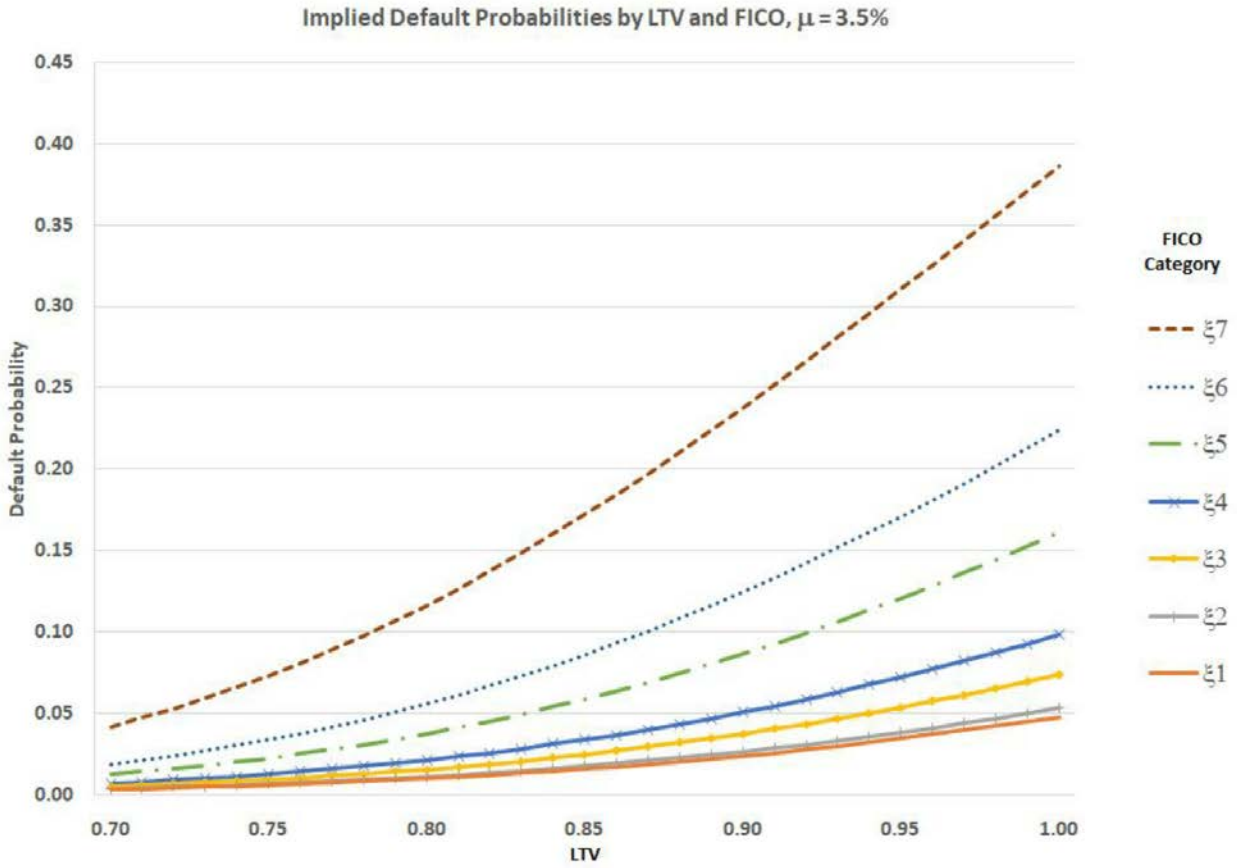
- $t = 0$: Consumer of type x gets mortgage with LTV z, PMI with coverage c, with premium $p(z; x, c)$
- $t = 1$: house value shock $x \sim G(x)$
  - borrowers repay z with probability $H(x, z; \xi)$
  - In default lender recovers $\min\{z, x - k\}$
  - PMI restores the first $c \cdot z$ of lender's shortfall
  - 'Fair' pricing implies $p^*(z; x, c)$

Time Varying House Price Appreciation Expectations



- We allow expectations of house price appreciation (distribution of x shock) to vary over time (based on Case-Shiller (2013))

Empirically Price Calibrated Default as a Function of FICO Score, LTV, and Price Shock



- ξ_1 is a 760-900 FICO score borrower and ξ_7 is 575-599
- Assume *H* is logistic: $e^{\psi\frac{x}{z}-\xi_i}/\left(1+e^{\psi\frac{x}{z}-\xi_i}\right)$
- Assume 2013 PMI premiums are "correct"
- Infer parameters of *H*:
  - Estimate $\psi, \{\xi_i\}$ by $\min \sum_{i,j}\left(p^*\left(z_j;\xi_i,\psi\right)-\right.$

Mortgage Insurance Premiums in 2005

Premiums, 2005 (percent monthly at annualized rate or equivalent)

		Minimum FICO								
		FHA (T=7)	FHA (T=3)	760	720	680	PMI 640	620	600	575
Maximum LTV	85	0.76	1.09	0.32	0.32	0.32	0.32	0.41	0.53	0.72
	90	0.76	1.09	0.52	0.52	0.52	0.52	0.68	0.90	1.22
	95	0.76	1.09	0.78	0.78	0.78	0.78	1.00	1.32	1.80
	97	0.76	1.09	0.96	0.96	0.96	0.96	1.42	1.88	2.57
	100	0.76	1.09	1.09	1.09	1.09	1.34	1.58	2.10	2.87

- Premium structure is flat over wide range of FICO scores
- FHA premium: 1.50 up front, 0.50 annual for all FICO-LTV groups

Volume Weighted Composite FHA and PMI Mortgage Insurance Premiums in 2005

Composite Premiums, 2005 (percent monthly annualized rate)

		Minimum FICO						
		760	720	680	640	620	600	575
Maximum LTV	85	0.32	0.32	0.33	0.33	0.42	0.56	0.77
	90	0.52	0.52	0.52	0.52	0.69	0.92	1.13
	95	0.79	0.79	0.79	0.79	1.01	1.18	1.14
	97	0.98	0.98	0.98	0.98	1.15	1.12	1.10
	100	1.07	1.07	1.07	1.12	1.12	1.09	1.07

- Premiums of highest risk products truncated at ~1.15 percent

"Correct" Premiums Based on 2013 Parameters, with Optimistic Beliefs in 2005

"Correct" Premiums, 2005 (percent monthly annualized rate)

		Minimum FICO						
		760	720	680	640	620	600	575
Maximum LTV	85	0.34	0.34	0.37	0.39	0.46	0.53	0.71
	90	0.42	0.44	0.51	0.58	0.77	0.96	1.40
	95	0.57	0.60	0.73	0.89	1.27	1.63	2.46
	97	0.65	0.70	0.87	1.08	1.57	2.02	3.08
	100	0.82	0.89	1.13	1.42	2.11	2.75	4.19

- No truncation in "correct" prices, only in observed ones suggests substantial mispricing

Mispricing Implied by Optimism Corrected Pricing

Composite Premiums, 2005

		Minimum FICO						
		760	720	680	640	620	600	575
Maximum LTV	85	0.32	0.32	0.33	0.33	0.42	0.56	0.77
	90	0.52	0.52	0.52	0.52	0.69	0.92	1.13
	95	0.79	0.79	0.79	0.79	1.01	1.18	1.14
	97	0.98	0.98	0.98	0.98	1.15	1.12	1.10
	100	1.07	1.07	1.07	1.12	1.12	1.09	1.07

Overpriced at least 10bp Underpriced at least 10bp Underpriced at least 100bp

- No truncation in "correct" prices, only in observed ones suggests substantial mispricing

The Consequences of Mispricing

The Consequences of Mispricing

1. Would expect "too much" of underpriced products, too little of overpriced products (adverse selection from pooling).
2. But how much? Perhaps rationing limited the impact.
3. How to judge misallocation? We look at difference in differences: change in product shares 2013 vs. 2005 against change in mispricing 2013 vs 2005.
4. Misallocation across FICO: Mainly extensive margin
   Misallocation across LTV: Mainly intensive margin

Product Share Regression are Sensitive to Pricing, Mispricing, and Rationing

variable	Model I	Model II	Model III
constant	0.952	0.523	0.426
	(0.293)	(0.186)	(0.167)
$\Delta(p_j - p_j^*)$	−1.703	−0.985	—
	(0.767)	(0.477)	
Δp_j^*	−5.176	−1.626	—
	(0.690)	(0.582)	
Δp_j	—	—	−1.189
			(0.445)
FICO < 640	—	−2.774	−2.983
		(0.312)	(0.256)
R^2	0.557	0.837	0.832

†The dependent variable is $\ln(y/(1-y))$, where $y \in [0,1] \equiv 1 + \Delta\hat{s}_j/2$ is the transformed change in product share. Standard errors are in parentheses.

Source: CoreLogic, WI and NC mortgage insurer regulatory filings, and authors' calculations.

- Observations are the changes from 2005 to 2013 at the LTV-FICO product level
- Model I results suggest that the mortgages with FICO ≤ 640 were priced attractively in 2005, and their near disappearance by 2013 is partly attributable to the increase premiums
- Model II tests the rationing hypothesis by including include non-price criteria: $FICO < 640$ similar to 200 bp premium increase
- Model III constrains pricing and mispricing to have the same effect
- While our analysis has focused on the effects of mispricing, the variation in premiums matters most

Multiple Regressions Suggest Important Role for Optimism and Mispricing

- To gauge the impact of mispricing, beliefs, and 'rationing', we focus on the share of higher-risk insured mortgages, which we take to be those in the "high" and "very high" categories
- The dollar-weighted share of these mortgages was 81 percent in 2005, compared with 58 percent in 2013
- To get some idea of the quantitative contribution of each of the effects to that change, we alternately zero out the variables in the regressions
  - Regression is non-linear: therefore effects interact and therefore answer is sensitive to ordering

The "FICO<640" or "rationing" effect is a combination of correcting mispricing and changes in beliefs, not an independent effect:

- If only under high appreciation expectations were these products viable then part of optimism
- If only mistaken beliefs could justify these products viable then part of mispricing effect

- 2005 "mispricing" contributed in the vicinity of 2 to 5 percentage points (if the FICO<640 effect were purely optimism) to as much as 15 percentage points (if the FICO<640 effect were purely correcting mispricing) of the 24 percentage point difference in the share of high-risk mortgages in 2005 versus 2013

Conclusion

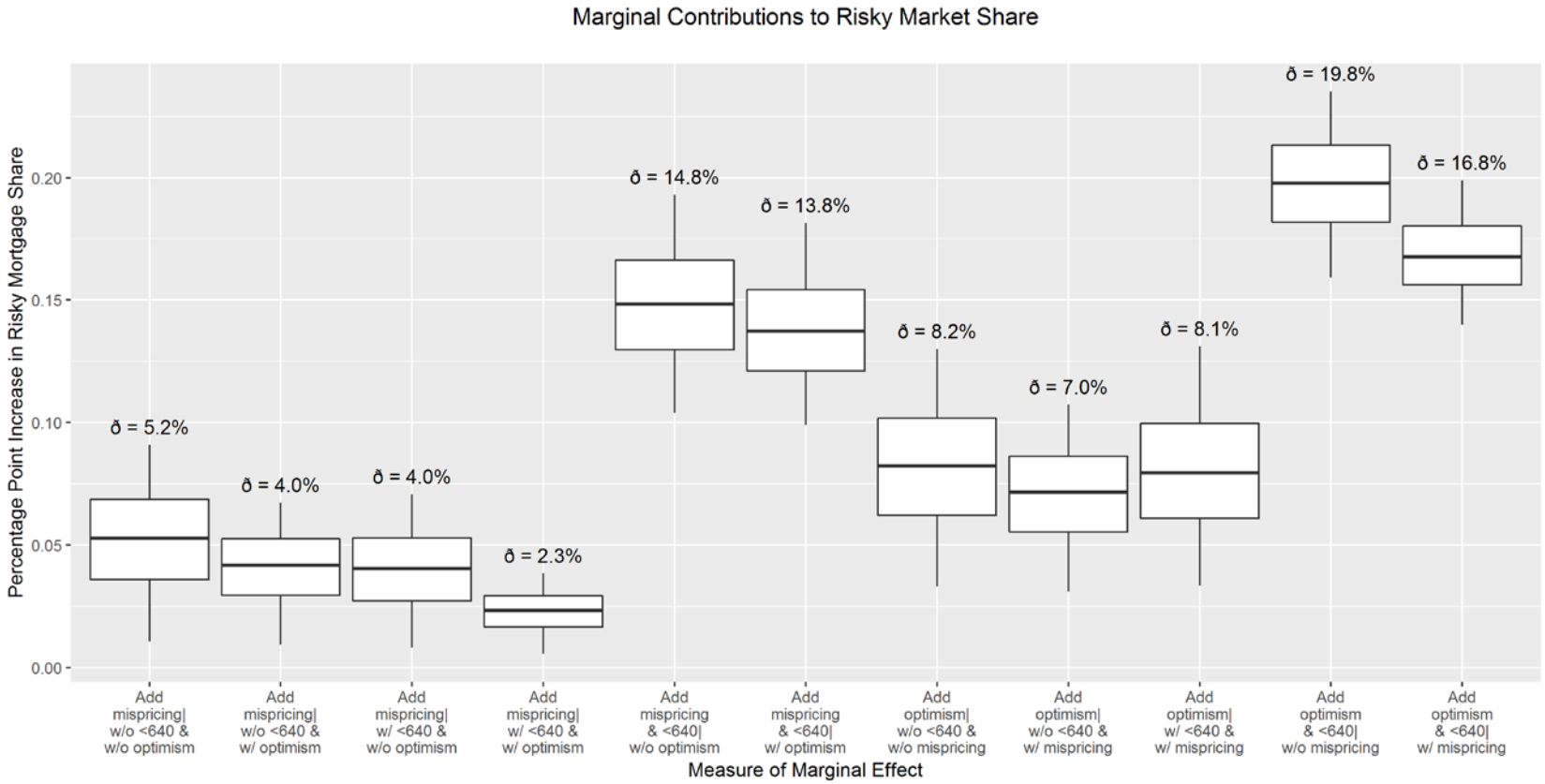
Conclusions

1. The negative correlation of product market shares and their mispricing is consistent with the price mechanism reshaping the mortgage market ("supply shift")
2. We calibrate the model to fit observed 2013 PMI premiums, where differences in optimism can justify sizable pricing differences between 2005 and 2013
3. However, optimism cannot rationalize observed 2005 premiums
4. Differences in Product shares 2005 vs 2013 shifted in response to mispricing, with pooling resulting in adverse selection
5. Mortgage insurance may have exacerbated the housing crisis by mispricing insurance

Thank you!

Appendix Slides

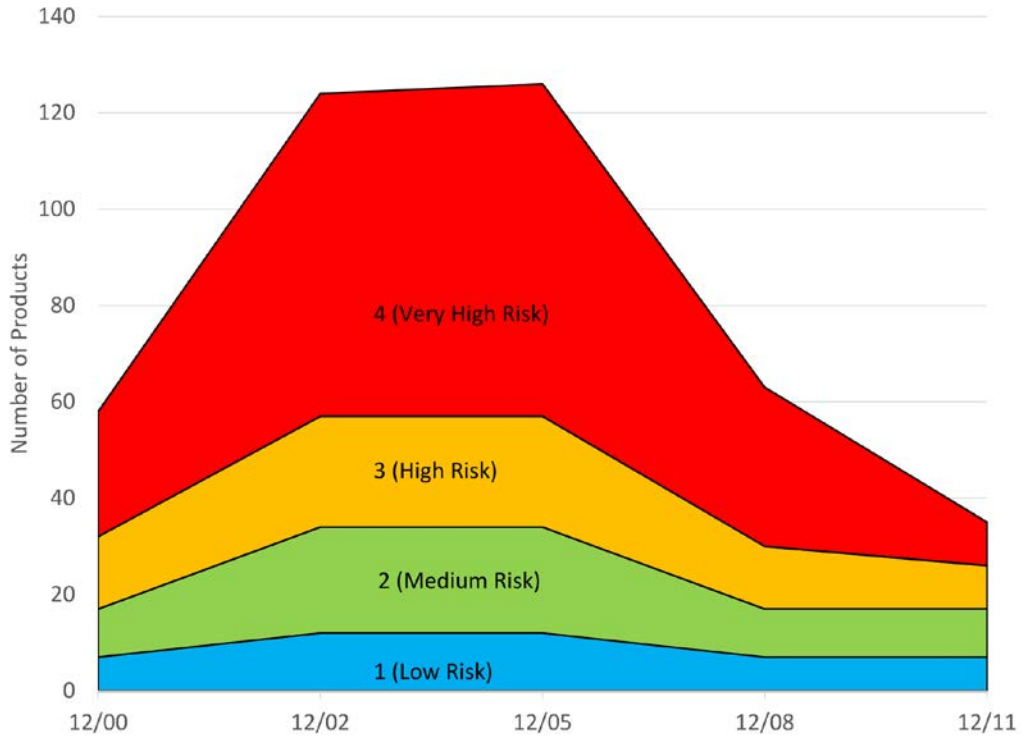
Multiple Regressions Suggest Important Role for Optimism and Mispricing



There is a Limited Academic Literature on Mortgage Insurance

1. Clauretie (1989) shows that negative amortizing ARMs, investment properties, and high LTV loans were known to be high risk decades ago. Foreclosure costs a key driver of PMI losses.
2. Clauretie and Herzog (1990) looks at PMI losses as a measure of the varying cost of foreclosure by state.
3. Rossa and Tootell (2004) document that PMI is a critical mechanism for encouraging racial minority and low income borrowing.
4. Swan (1982) details the early history of PMI and provides basic pricing models. He raises the prospect of future research on option based pricing.
5. Kau, Keenan, Muller (1993) price PMI as an option with a model of stochastic house prices and interest rates. They get close to prevailing prices but have no FICO or other borrower attributes.
6. Bhutta and Keys (2018) argue that insurers accommodated lenders and GSEs who wanted to expand share and scope of products.

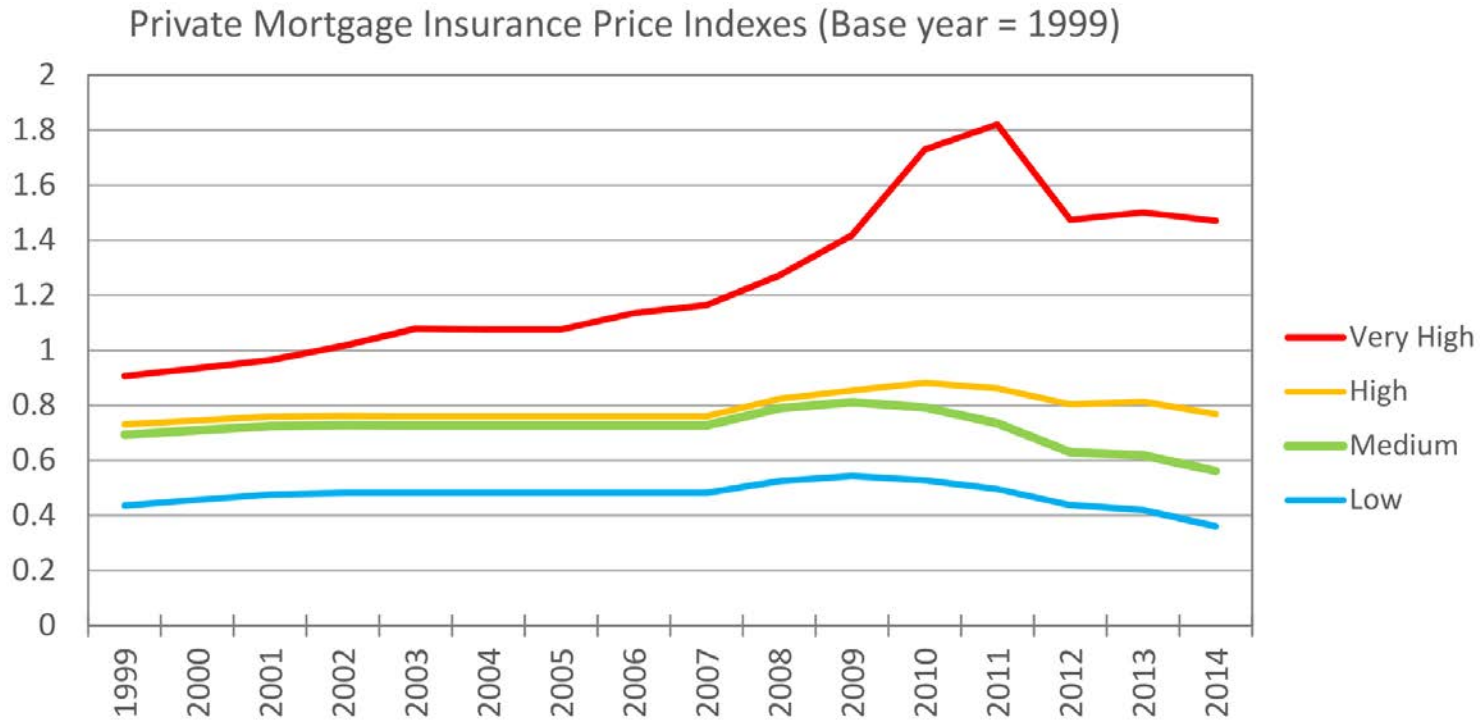
Was Risk Properly Priced? From 99-16 there were Big Changes in Product Availability



1. From 2000 to 2005 mortgage insurers nearly doubled their product offerings
2. Almost all the new products were higher risk
3. Post-crisis fewer products are available than in 2000, and almost all the eliminated products were higher risk

Sources: Lam et al. [2013] and author's analysis.

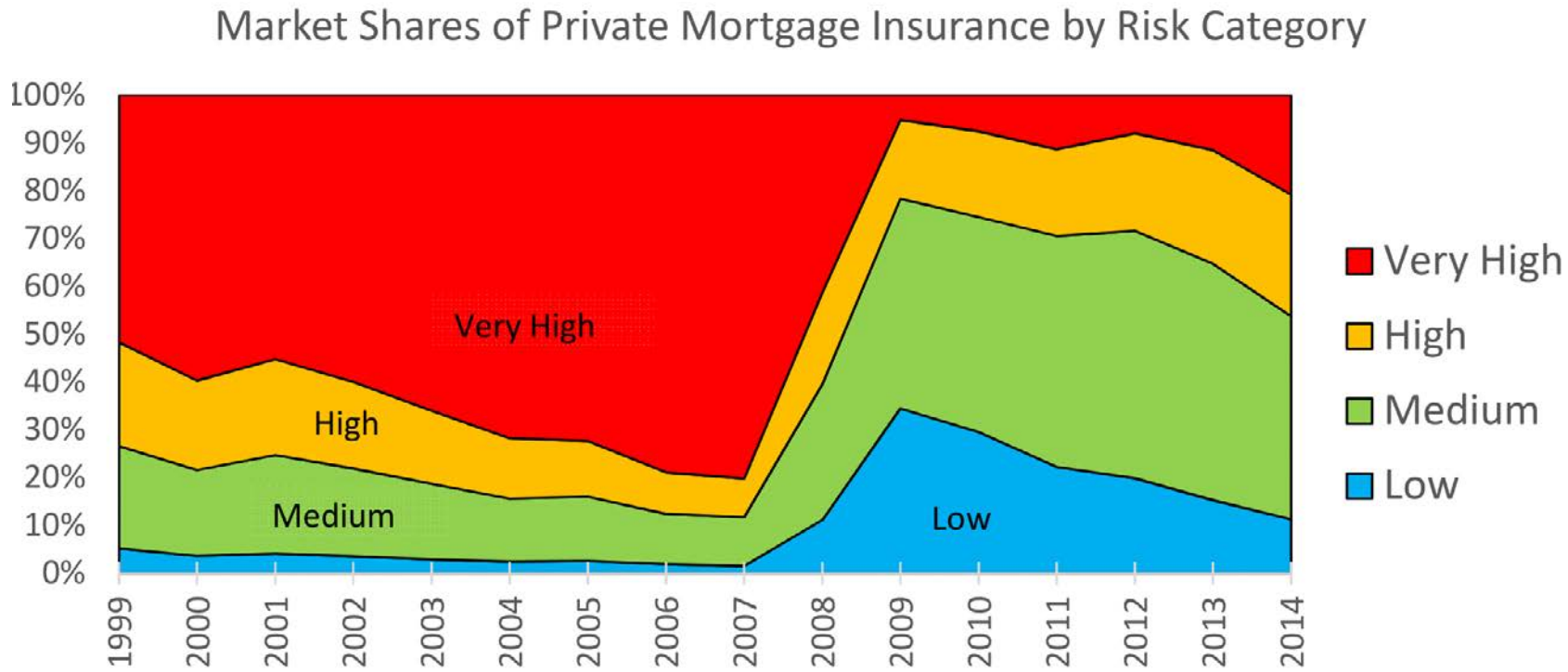
Chain Weighted PMI Price Indexes by Risk Category



1. "Very High Risk" price index increases ≈ 65 bp over the crisis
2. Pricing fanned out, with spreads permanently wider
3. The "Very High Risk" index remains about 40 basis points higher in 2014 than it was in 2005

Sources: CoreLogic LLMA 2.0, WI and NC regulators and authors' calculations

Changes in PMI Market Shares by Risk Level



- Changes in market shares 2013-14 vs 2005-6 are strongly negatively related to change in relative prices, consistent with supply shift story

Very Little Price Dispersion Among PM Insurers

1. "Last year we submitted a special rating plan with your department and consequently received the approval for its use with an effective date of July 20, 2010. This rate plan was intended to accommodate lenders who prefer a pricing system that is similar to the Borrower-Paid Monthly Rate Plan offered by Mortgage Guaranty Insurance Corporation (MGIC). There was, unfortunately, **an error in the creation of the rate plan which caused most of rates to be one basis point higher than MGIC's, and therefore the rates have not been requested by many of our customers.**" Source: UG 2011 regulatory filing
2. **In response to recent rate actions taken by PMI Mortgage Insurance (10/2007) and Mortgage Guaranty Insurance Corporation (12/2007), we are submitting for your review rate revisions that are similar to those filed by our competitors.** – Source: UG 2008 regulatory filing

- The strong price co-movement is consistent with both high levels of competition or collusion but these comments are more consistent with competition