Banking on the Edge: Liquidity Constraints and Illiquid Asset Risk

Joshua Bosshardt

Federal Housing Finance Agency

Ali Kakhbod

UC Berkeley

Farzad Saidi

University of Bonn & CEPR

April 5, 2024

Motivation

- Post-crisis liquidity regulations
  - Liquidity Coverage Ratio → short-term liquidity stress
  - Net Stable Funding Ratio → maturity mismatch

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  - Net Stable Funding Ratio → maturity mismatch

- Financial-stability implications
  - How do liquidity regulations affect bank risk taking on remaining illiquid assets?
  - How does the effect depend on funding stability?
    ⇒ Trade-off between funding resilience over the short and long run

The Liquidity Coverage Ratio in the U.S.

- Requires BHCs to hold sufficient HQLA relative to net cash outflows over a 30-day stress period

- Eligibility
  - 100% LCR: assets >$250 bn or foreign exposures >$10 bn
  - 70% LCR: assets between $50 bn and $250 bn

- Timeline
  - 2013: proposal of U.S. implementation
  - Starting January 2015: phase-in of U.S. implementation

Bank-level variation in funding stability

- Stable funding captured via investment in long-term bank bonds by insurance companies

  - Comprises $\frac{1}{6}$ of LCR banks' long-term funding   ▸ Figure

  - Non-banks should not be affected by the LCR

Bank bonds in insurance companies' portfolios
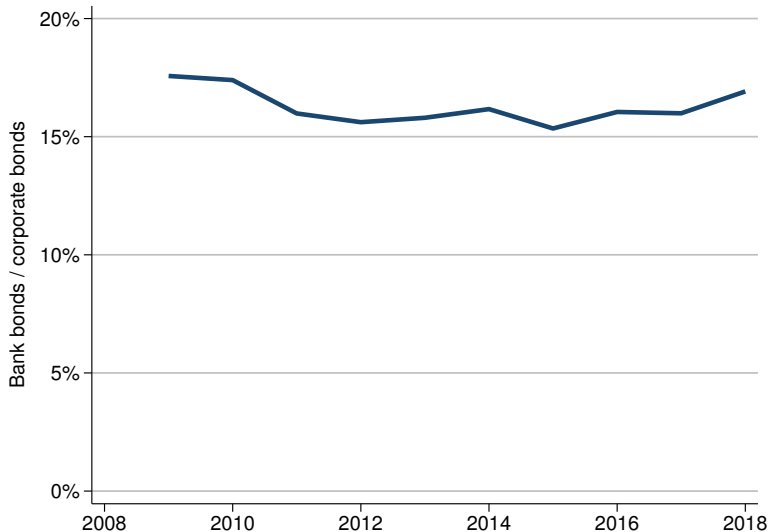
Channels by which liquidity risk interacts with credit risk

Liabilities

- Mass 1 of investors each invests 1 unit in the bank

- Deposits are insured with fixed payoff

- Fraction λ corresponds to unstable funding sources

Assets

- Liquidity regulation requires the bank to hold a fraction *l* of liquid assets

- Invest remainder in either safe *or* risky long-term assets
  - Both generate the same expected return μ
  - Risky assets are more volatile

Date *t*=1: liquidity shock

- With some probability, fraction λ of investors withdraw their 1 unit

- If the bank has insufficient liquid assets to pay the early investors, it can sell a fraction of its illiquid assets on the long-term debt market:
    - Safe assets sell at price p_s
    - Risky assets sell at a lower price $p_r < p_s$
      (Morris and Shin, 2016; Duchin et al., 2016)

Bank asset choice

- **Advantage of safe assets**: better performance in liquidity shock state because of higher liquidation price

- **Advantage of risky assets**: better performance in normal times due to limited liability

Lemma
The bank's asset choice can be summarized by a threshold μ^* such that it invests in safe assets if $\mu > \mu^*$, and it invests in risky assets if $\mu < \mu^*$.

Proposition
There exists a threshold $l^*(\lambda)$ such that μ^* is decreasing in l for $l < l^*(\lambda)$ and μ^* is increasing in l for $l > l^*(\lambda)$. The threshold $l^*(\lambda)$ corresponds to the minimum level of liquidity at which the bank can survive liquidity stress if it invests in risky assets.
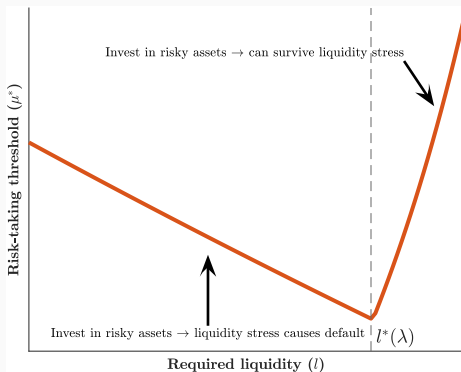
Proposition
Decreasing the fraction of unstable funding λ increases the range for l on which risk taking increases in the tightness of liquidity requirements: $\frac{dl^*(\lambda)}{d\lambda} > 0$.

▸ Robustness
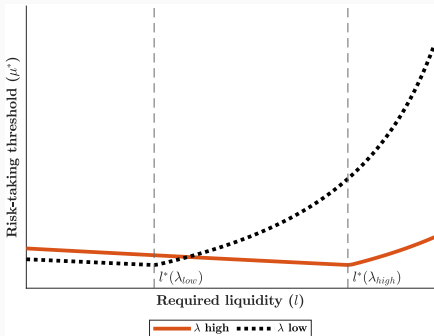
- Bank risk taking with their illiquid assets in response to tighter liquidity requirements (e.g., LCR introduction)

    - If they source more long-term funding (e.g., bank bonds)

  $\Rightarrow$ Use granular, loan-level data to test this conjecture

Evidence on liquidity regulation and risk taking

Transaction-level data

- Syndicated loans from DealScan

  - U.S. banks to U.S. non-financial companies

  - Package-lead bank observations

  - Risk measures: stock-return volatility, z-score of borrower

- HMDA mortgage applications

  - U.S. banks to U.S. households

  - Risk measure: acceptance rate for high-LTI borrowers

Bank-level data

- U.S. BHC balance sheets during 2010Q1-2019Q4 from Compustat Bank

- NAIC Schedule D Part 1: U.S. insurance company holdings of bank bonds

  - *Ins. bonds / liabilities$_{it-1y}$* $\in [0, 100]$ to capture bank i's funding stability

  - Insurers' demand relevant for pricing of banks' long-term debt and resilience during crises
    (Koijen and Yogo, 2019; Coppola, 2022)

Analysis at the level of a loan l granted by bank i to borrower f in industry $j(f)$ at date t:

$$
\begin{aligned}
y_l \quad = \quad & \beta_1 LCR_i \times Post_t + \beta_2 LCR_i \times Post_t \times Ins.bonds/liabilities_{it-1y} \\
& + \beta_3 LCR_i \times Ins.bonds/liabilities_{it-1y} + \beta_4 Post_t \times Ins.bonds/liabilities_{it-1y} \\
& + \beta_5 Ins.bonds/liabilities_{it-1y} + \psi_i + \phi_{j(f)t} + \underbrace{\gamma \mathbf{X}_{ift-1}} + \epsilon_l
\end{aligned}
$$

e.g., avg. maturity of i's bonds

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& + \beta_5 Ins.bonds/liabilities_{it-1y} + \psi_i + \phi_{j(f)t} + \underbrace{\gamma \mathbf{X}_{ift-1}}_{\text{e.g., avg. maturity of } i\text{'s bonds}} + \epsilon_l
\end{aligned}
$$

β_2 reflects insurers' demand, rather than supply:

- Need to rule out banks targeting long-term investors, e.g., <u>maturity structure</u>
- Bank bonds all carry similar capital requirements
- Insurers do not adjust portfolios based on expected bank risk taking

Bank bonds in insurance company portfolios—by LCR status
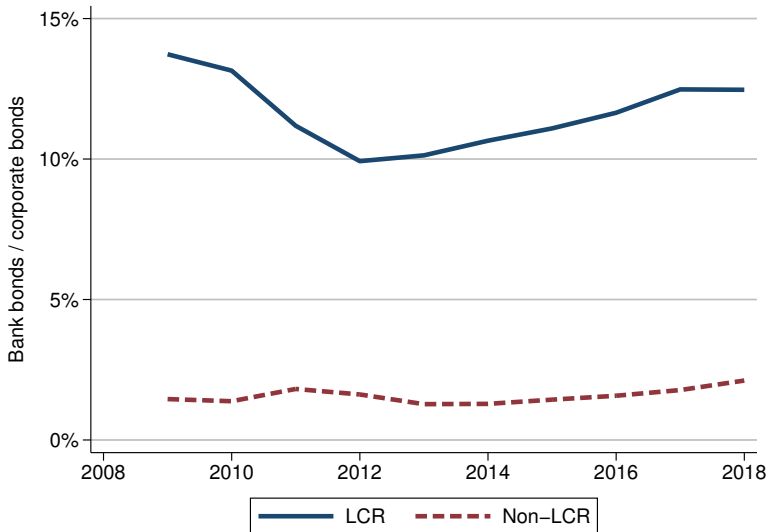
Bank risk taking in corporate lending

Effect of LCR on borrower stock-return volatility

	Baseline	+ controls	+ funding	100% LCR	Fix date
LCR × Post	0.111	0.008			
	(1.26)	(0.04)			
LCR × Post × Ins. bonds/liab.					
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Post × Ins. bonds/liab.					
Ins. bonds/liab.					
Observations	3,948	3,467			
R^2	0.550	0.632			
Controls	No	Yes			
Industry-quarter FE	Yes	Yes			
Bank FE	Yes	Yes			

Effect depends on whether banks are in the region where μ^* increases or decreases with liquidity requirements l

Effect of LCR on borrower stock-return volatility

	Baseline	+ controls	+ funding	100% LCR	Fix date
LCR × Post	0.111	0.008	-0.527		
	(1.26)	(0.04)	(-1.68)		
LCR × Post × Ins. bonds/liab.			0.440**		
			(2.49)		
LCR × Ins. bonds/liab.			-0.122		
			(-0.62)		
Post × Ins. bonds/liab.			-0.507***		
			(-3.03)		
Ins. bonds/liab.			0.212		
			(1.63)		
Observations	3,948	3,467	3,467		
R^2	0.550	0.632	0.633		
Controls	No	Yes	Yes		
Industry-quarter FE	Yes	Yes	Yes		
Bank FE	Yes	Yes	Yes		

Funding stability $\rightarrow l^*(\lambda) \Downarrow \rightarrow$ range $\Uparrow$ where tighter
liquidity requirements increase $\mu^* \rightarrow$ risk taking $\Uparrow$

Effect of LCR on borrower stock-return volatility

	Baseline	+ controls	+ funding	100% LCR	Fix date
LCR × Post	0.111	0.008	-0.527	-0.420***	
	(1.26)	(0.04)	(-1.68)	(-3.38)	
LCR × Post × Ins. bonds/liab.			0.440**	0.267***	
			(2.49)	(3.76)	
LCR × Ins. bonds/liab.			-0.122	-0.344	
			(-0.62)	(-1.41)	
Post × Ins. bonds/liab.			-0.507***	-0.233***	
			(-3.03)	(-5.11)	
Ins. bonds/liab.			0.212	0.190*	
			(1.63)	(2.07)	
Observations	3,948	3,467	3,467	3,467	
R^2	0.550	0.632	0.633	0.633	
Controls	No	Yes	Yes	Yes	
Industry-quarter FE	Yes	Yes	Yes	Yes	
Bank FE	Yes	Yes	Yes	Yes	

Holds also when restricting the LCR designation to larger banks that were subject to the strict 100% LCR

Effect of LCR on borrower stock-return volatility

	Baseline	+ controls	+ funding	100% LCR	Fix date
LCR × Post	0.111	0.008	-0.527	-0.420***	-0.128
	(1.26)	(0.04)	(-1.68)	(-3.38)	(-1.52)
LCR × Post × Ins. bonds/liab.			0.440**	0.267***	0.147**
			(2.49)	(3.76)	(2.72)
LCR × Ins. bonds/liab.			-0.122	-0.344	
			(-0.62)	(-1.41)	
Post × Ins. bonds/liab.			-0.507***	-0.233***	-0.146**
			(-3.03)	(-5.11)	(-2.70)
Ins. bonds/liab.			0.212	0.190*	
			(1.63)	(2.07)	
Observations	3,948	3,467	3,467	3,467	3,383
R^2	0.550	0.632	0.633	0.633	0.633
Controls	No	Yes	Yes	Yes	Yes
Industry-quarter FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes

Robust to using time-invariant $Ins.\,bonds\,/\,liabilities_i$ as of the end of 2012

Role of LCR banks' long-term funding for borrower stock-return volatility
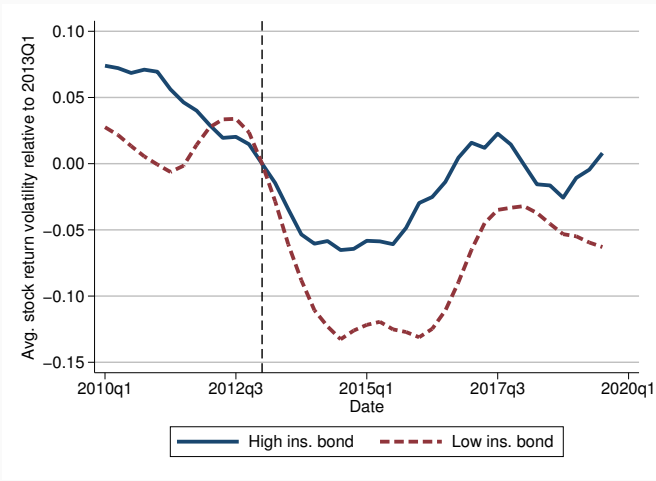
Note: series have been smoothed using a moving average

Robustness to time-invariant measure of funding stability

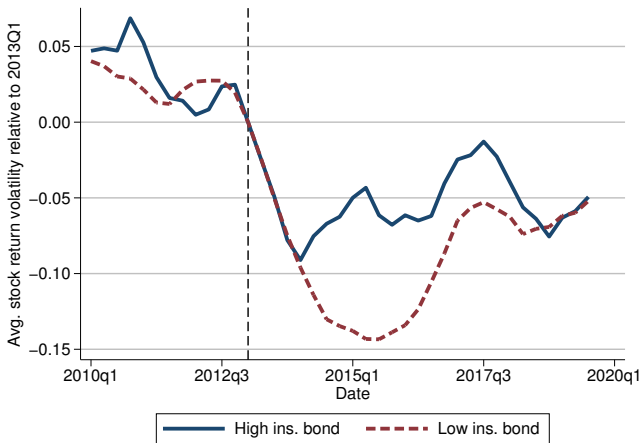Note: series have been smoothed using a moving average

Effect of LCR on borrower Altman's z-score

	Baseline	+ controls	+ funding	100% LCR	Fix date
LCR × Post	-0.491	2.771	14.556**	2.837**	2.821***
	(-0.69)	(1.66)	(2.71)	(2.63)	(3.29)
LCR × Post × Ins. bonds/liab.			-10.026**	-1.529**	-1.919**
			(-2.41)	(-2.24)	(-2.99)
LCR × Ins. bonds/liab.			3.351	-0.737	
			(1.20)	(-0.67)	
Post × Ins. bonds/liab.			10.351**	1.668***	1.736***
			(2.53)	(3.21)	(6.79)
Ins. bonds/liab.			-4.136	-0.761	
			(-1.58)	(-1.20)	
Observations	3,712	3,279	3,279	3,279	3,204
R^2	0.364	0.507	0.509	0.508	0.509
Controls	No	Yes	Yes	Yes	Yes
Industry-quarter FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes

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R^2	0.364	0.507	0.509	0.508	0.509
Controls	No	Yes	Yes	Yes	Yes
Industry-quarter FE	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes

Syndicated loans not necessarily representative of banks' total illiquid-asset positions

Bank risk taking in mortgage lending

Effect of LCR on mortgage acceptance—by borrower loan-to-income ratio

	(1) + funding	(2) 100% LCR	(3) Fix date	(4) + funding	(5) 100% LCR	(6) Fix date
LCR × Post	0.007	0.019	0.000	0.003	0.007	-0.025
	(0.25)	(0.95)	(0.00)	(0.15)	(0.46)	(-0.91)
LCR × Post × Ins. bonds/liab.	0.005	0.021	0.056	0.058	0.043*	0.118***
	(0.12)	(1.23)	(1.57)	(1.13)	(1.72)	(2.90)
LCR × Ins. bonds/liab.	0.062	0.155		0.007	0.266***	
	(1.15)	(1.29)		(0.11)	(2.81)	
Post × Ins. bonds/liab.	-0.003	-0.008	-0.012	-0.047	-0.019	-0.023
	(-0.07)	(-0.51)	(-0.70)	(-1.00)	(-1.60)	(-1.27)
Ins. bonds/liab.	-0.018	0.016		0.075	0.045***	
	(-0.39)	(1.08)		(1.24)	(3.02)	
Observations	913,249	913,249	884,602	996,904	996,904	958,554
R^2	0.051	0.051	0.051	0.061	0.062	0.061
Controls	Yes	Yes	Yes	Yes	Yes	Yes
MSA-year FE	Yes	Yes	Yes	Yes	Yes	Yes
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
LTI subsample	Low	Low	Low	High	High	High

Conclusion

- LCR associated with riskier syndicated-loan and mortgage originations for banks with greater funding stability

  $\Rightarrow$ Tensions between ensuring funding resilience over different horizons and credit risk

  - Insurers as providers of banks' long-term funding

- Calibrated model suggests modest reduction of the total surplus at the individual bank level

  $\Rightarrow$ Real effects more relevant for welfare effects of the LCR

Banks' reliance on insurance companies' investment in long-term bonds
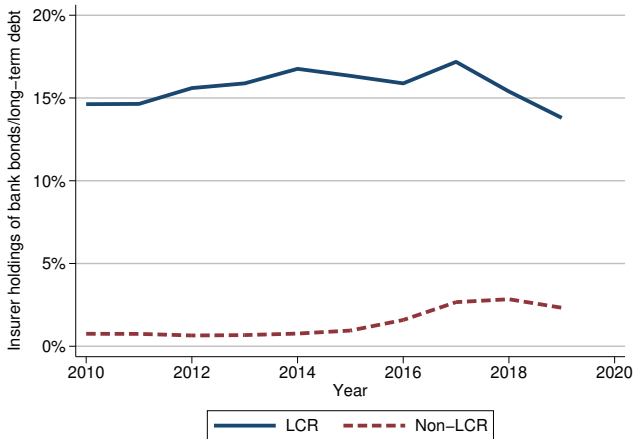
Robustness and extensions

The results are robust to:

- Requiring the bank to hold a ratio of liquid assets relative to unstable funding (l/λ)
- Allowing the bank to choose intermediate levels of risk, i.e., choose $X \in [0, 1]$ to generate a return of $\mu + X\epsilon\mu$

We derive conditions under which the results are robust to:

- Generalizing the returns on liquid assets and returns to depositors in the two periods, i.e., generalizing from $R_{l,1} = R_{d,1} = 1$ and $R_{l,2} = R_{d,2} = R$
- Imposing costs on risky assets as in risk-based capital requirements
- Allowing l to reduce liquidity shock propensity q

Bank-level summary statistics

	N	Mean	SD	Min	Max
70% LCR	23,080	0.019	0.137	0.000	1.000
100% LCR	23,080	0.016	0.124	0.000	1.000
Either LCR	23,080	0.035	0.183	0.000	1.000
Long-term debt/liabilities (%)	21,614	6.443	7.698	0.000	96.274
Ins. bonds/liabilities (%)	22,209	0.125	1.098	0.000	42.790
Ins. bonds/liabilities (cond. > 0)	2,255	1.228	3.244	0.000	42.790
Liquid assets/assets (%)	20,062	9.606	9.081	0.114	95.873
Log(liquid assets)	20,064	4.840	1.857	-1.197	13.376
Log(illiquid assets)	20,062	7.514	1.603	-4.343	14.637
Log(assets)	22,119	7.499	1.604	-1.155	14.832
Tier 1 ratio (%)	19,589	13.043	3.873	-19.650	110.620
Nonperforming assets/loans (%)	20,255	2.860	7.918	0.000	337.884
Non-interest expenses/assets (%)	21,987	0.882	13.438	0.011	1,990.476
Net income/assets (%)	22,082	0.781	4.905	-27.082	666.667
Sensitivity to market risk (%)	17,602	74.233	9.087	1.179	95.873
Average maturity (years)	23,080	1.596	5.426	0.000	49.000

Comparison of treatment and control groups

	LCR-exempt	LCR	T-statistic
Long-term debt/liabilities (%)	7.592	9.629	2.115
Ins. bonds/liabilities (%)	0.040	1.279	6.969
Ins. bonds/liabilities (cond. > 0)	1.047	1.392	1.001
Liquid assets/assets (%)	10.569	15.446	2.018
Log(liquid assets)	4.489	9.900	15.116
Log(illiquid assets)	7.033	11.949	19.508
Log(assets)	7.082	12.126	19.868
Tier 1 ratio (%)	13.128	12.463	-1.314
Non-performing assets/loans (%)	4.728	2.727	-6.84
Non-interest expense/assets (%)	1.095	0.791	-1.093
Net income/assets (%)	0.542	0.796	2.045
Sensitivity to market risk (%)	73.448	59.526	-4.045
Average maturity (years)	0.726	15.315	8.133

Summary statistics: syndicated loans

	N	Mean	SD	Min	Max
70% LCR	6,769	0.060	0.237	0.000	1.000
100% LCR	6,769	0.927	0.260	0.000	1.000
Either LCR	6,769	0.987	0.115	0.000	1.000
Long-term debt/liabilities (%)	6,769	12.929	3.300	1.285	24.262
Ins. bonds/liabilities (%)	6,769	0.583	0.479	0.085	3.396
Ins. bonds/liabilities (cond. > 0)	6,769	0.583	0.479	0.085	3.396
Bank log(assets)	6,769	14.229	0.895	9.556	14.832
Tier 1 ratio (%)	6,769	12.405	1.023	7.010	16.210
Nonperforming assets/loans (%)	6,769	1.757	1.070	0.103	6.173
Non-interest expense/assets (%)	6,769	0.730	0.135	0.443	1.163
Net income/assets (%)	6,769	0.895	0.536	-1.561	10.823
Bank liquid assets/assets (%)	6,762	18.770	6.163	0.450	45.771
Sensitivity to market risk (%)	6,134	46.997	11.292	26.559	85.323
Average maturity (years)	6,769	10.310	4.926	5.174	30.000
Stock return volatility	5,745	-2.406	0.495	-5.234	2.441
Altman z-score	5,512	1.683	131.711	-9,771.599	100.217
Borrower log(assets)	6,619	8.010	1.632	-6.908	13.498
Market-to-book ratio (%)	6,074	313.893	2,974.004	-1.420e+05	75,064.047

Summary statistics: mortgage applications

	N	Mean	SD	Min	Max
70% LCR	6,054,963	0.132	0.338	0.000	1.000
100% LCR	6,054,963	0.601	0.490	0.000	1.000
Either LCR	6,054,963	0.733	0.443	0.000	1.000
Long-term debt/liabilities (%)	6,054,963	10.248	5.808	0.000	36.232
Ins. bonds/liabilities (%)	5,937,535	0.504	0.546	0.000	3.229
Ins. bonds/liabilities (cond. > 0)	4,714,267	0.635	0.541	0.000	3.229
Average maturity (years)	6,054,963	8.132	8.460	0.000	49.000
Bank log(assets)	6,054,963	12.491	2.230	6.495	14.761
Tier 1 ratio (%)	6,054,963	11.594	1.565	4.500	18.820
Nonperforming assets/loans (%)	6,054,963	2.690	2.231	0.094	23.235
Non-interest expense/assets (%)	6,054,963	0.896	0.461	0.271	4.606
Net income/assets (%)	6,054,963	0.814	1.164	-13.744	10.823
Bank liquid assets/assets (%)	5,976,119	12.798	8.102	0.638	35.439
Sensitivity to market risk (%)	5,496,100	60.783	12.411	32.156	86.862
Acceptance	6,054,963	0.840	0.366	0.000	1.000
Conventional	6,054,963	0.657	0.475	0.000	1.000
Loan amount/income	5,913,515	2.844	6.176	0.003	3,835.000