The Importance of Technology in Banking during a Crisis

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Previously:
Tech in Fin before FinTech:
Blessing or Curse for Financial Stability?

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Information Technology and Financial Stability

IT more and more present in finance and lending, e.g FinTech

- machine learning
- more info available (e.g. digital footprint)
- enthuisiam of bank executives about technology
  - *"We see ourselves as a technology company with a banking license"* Michael Corbat (Citibank CEO, 2014)
  - *"We are a technology company"* Marianne Lake (JPMorgan Chase CFO, 2016)

Effects on financial stability? FinTech lit. cannot help too much

- FinTech not exposed yet to large shocks
- failure of predictive systems during crisis
- FinTech still small and not representative

Technology in Fin before FinTech

Financial industry very intense user of IT much before FinTech

- estimate IT Adoption across US banks *before* the GFC
- look at low- and high- IT adopters *during (and after)* the GFC
- focus on NPLs, mortgage delinquency, and lending

Pros of our approach

- look at a massive systemic shocks
- isolate technology from other factors: e.g. regulation
- capture large and representative share of lending

Cons

- need to extrapolate from pre-crisis technology

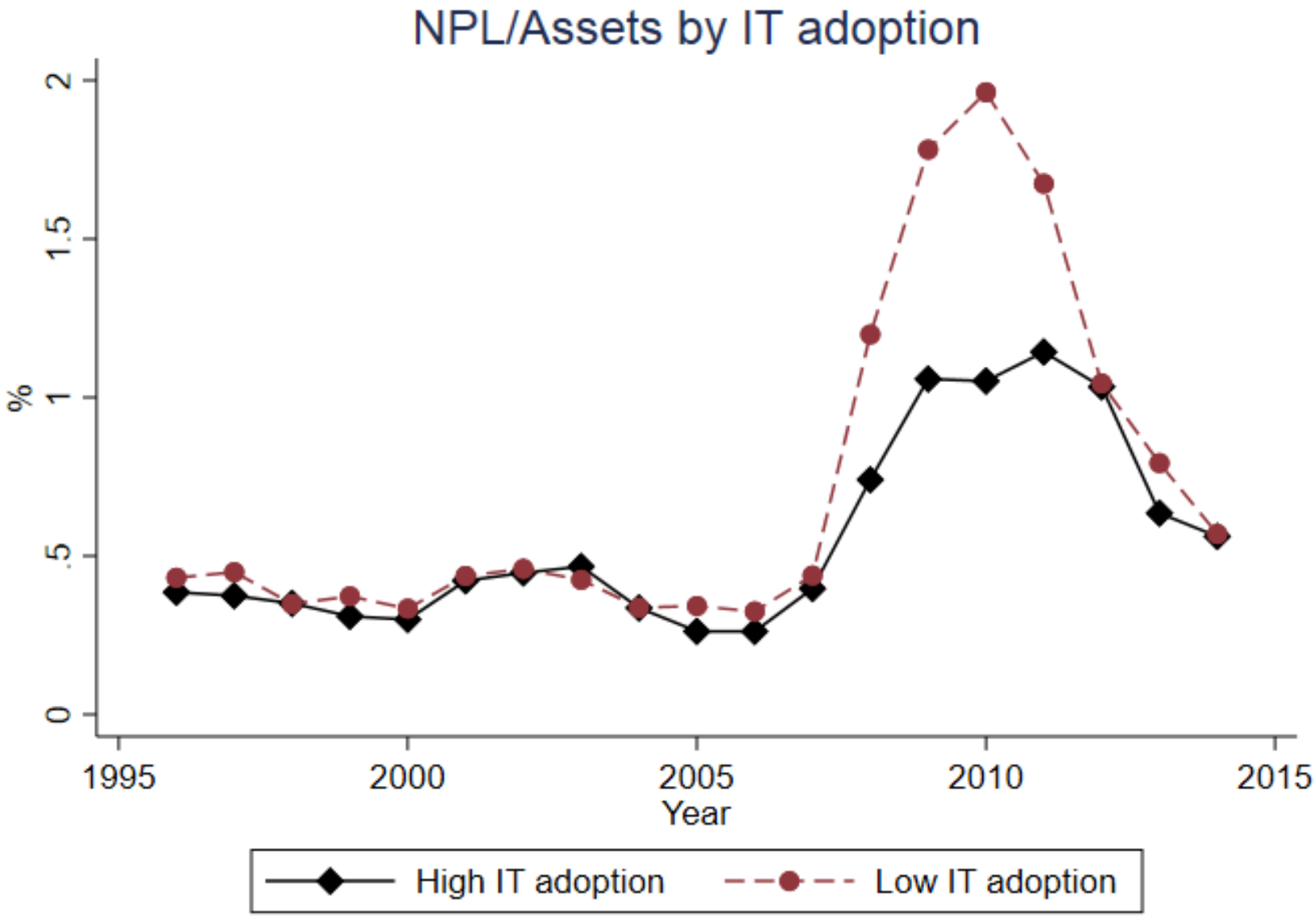
The sign of the relationship between IT and Financial Stability is ambiguous

Positive

- IT allows to gather, store, and distribute info (Petersen and Liberti, 2018)
- IT allows the use of more sophisticated statistical models
- $\Rightarrow$ better screening and monitoring

Negative

- might neglect info difficult to quantify , e.g. "soft" info (Rajan, Seru, Vig; 2015)
- statistical models trained during good times may fail during crisis
- IT may encourage moral hazard through securitization and other fin innovation


NPL/Assets by IT adoption
%
0
.5
1
1.5
2
1995
2000
2005
2010
2015
Year
High IT adoption
Low IT adoption

Preview of Results

Main Results

- 1 st.dev. $\uparrow$ IT adoption $\Rightarrow$ 15 bp $\downarrow$ NPL/Asset in the crisis (10%)
- IT uncorrelated with ex-ante bank-level exposure to the GFC

Roots

- Branch-level IT mainly driven by parent bank rather than location
- More “tech-prone" executives $\Rightarrow$ IT$\uparrow$, NPLs$\downarrow$
- Proximity to historically established technical colleges $\Rightarrow$ IT$\uparrow$, NPLs$\downarrow$

Channels

- Offloaded loans by high IT adopters less likely to be delinquent $\Rightarrow$ better screening thanks to better information management

Credit supply

- IT$\uparrow$, NPLs$\downarrow$ $\Rightarrow$ Lending $\uparrow$

Literature and Contributions

FinTech: e.g. Fuster et al. (2019); Berg et al. (2019); Di Maggio and Yao (2018) and many more...

- Impact of technology adoption on outcomes during systemic crisis

IT adoption in other industries: e.g. Beaudry et al. (2010); Bresnahan et al. (2002); Bloom et al. (2012); McElheran and Forman (2019)

- Focus on financial industry and financial stability

IT in banking before the GFC and the "profitability paradox": e.g. Beccali (2007); Berger (2003); Koetter and Noth (2013)

- Different methodology, focus on financial stability, provide explanation for "profitability paradox"

Defaults and NPLs in crises: e.g. Mian and Sufi (2009, 2011); Adelino et al. (2016)

- Role of lenders' technology

Executives and firm outcomes: e.g. Benmelech and Frydman (2015); Bertrand and Schoar (2003)

- Impact of executives' "tech-orientation" on IT and NPLs

Data

Regulatory Data on BHCs

- main variables: amount of NPLs scaled by total assets, share of loans, equity, wholesale funding, return, log of assets, and the average log wage paid to employees

Single Family Loan-Level Dataset from Freddie Mac

- postal code, credit score, LTV and DTI ratio of the borrower, origination year, seller (22 banks) and the delinquency status of the loan

Data on Biography of Executives

- bios of CEO, CFO, COO, President from S&P Global MI before 2007
- search for tech-related words to construct bank-level measure of the IT intensity of their executives
    - words are: technology, engineering, math, computer, machine, system, analytic, technique, method, process, stem, efficiency, efficient, software, hardware, data, informatic
- data on the total compensation of the executives and the non-base share of the compensation

IT Data

Survey data from Aberdeen (previously Harte Hanks)

- plant (branch) level PCs/Employee in the US in 1999, 2003, 2004, 2006, 2016
- for 2016 we have the IT budget
- used in many seminal papers on IT-adoption (non-financial)
  - e.g. Beaudry et al., 2010 JPE; Bloom et al., 2012 AER; Bresnahan et al., 2002 QJE
- highly correlated with IT budget and adoption of new technologies (Cloud Computing) for later years, 65%

Measuring IT adoption

Map bank branches to the Bank Holding Company and estimate the following equation before 2008:

$$PCs/Emp_{i,t} = \widetilde{IT}_b + \theta_c + \theta_{type} + \theta_t + \gamma \cdot Emp + \epsilon_{i,t} \quad (1)$$

- $\widetilde{IT}_b$ is BHC fixed effects
- θ_c are county FEs, θ_{type} are a branch-type FEs, θ_t are year FEs, Emp is the log number of Employees
- Standardized version of $\widetilde{IT}_b$ serves as measure of IT

Panel Regression

$$NPL_{b,t} = \alpha_b + \delta_t + \beta IT_b \cdot crisis + (X_b \cdot crisis_t)'\gamma + \epsilon_{b,t} \quad (2)$$

Table: Panel Regressions

	(1)	(2)	(3)	(4)	(5)
			NPLs		
IT-adoption	-0.0239		-0.0283		
	(0.017)		(0.018)		
crisis	0.811**	0.793**			
	(0.349)	(0.346)			
IT-adoption × crisis	-0.160**	-0.168**	-0.157**	-0.170**	-0.143**
	(0.063)	(0.065)	(0.066)	(0.068)	(0.063)
N	4608	4608	4608	4608	4608
Bank FE		×		×	×
Year FE			×	×	×
Controls					×

▸ Robustness

Magnitude

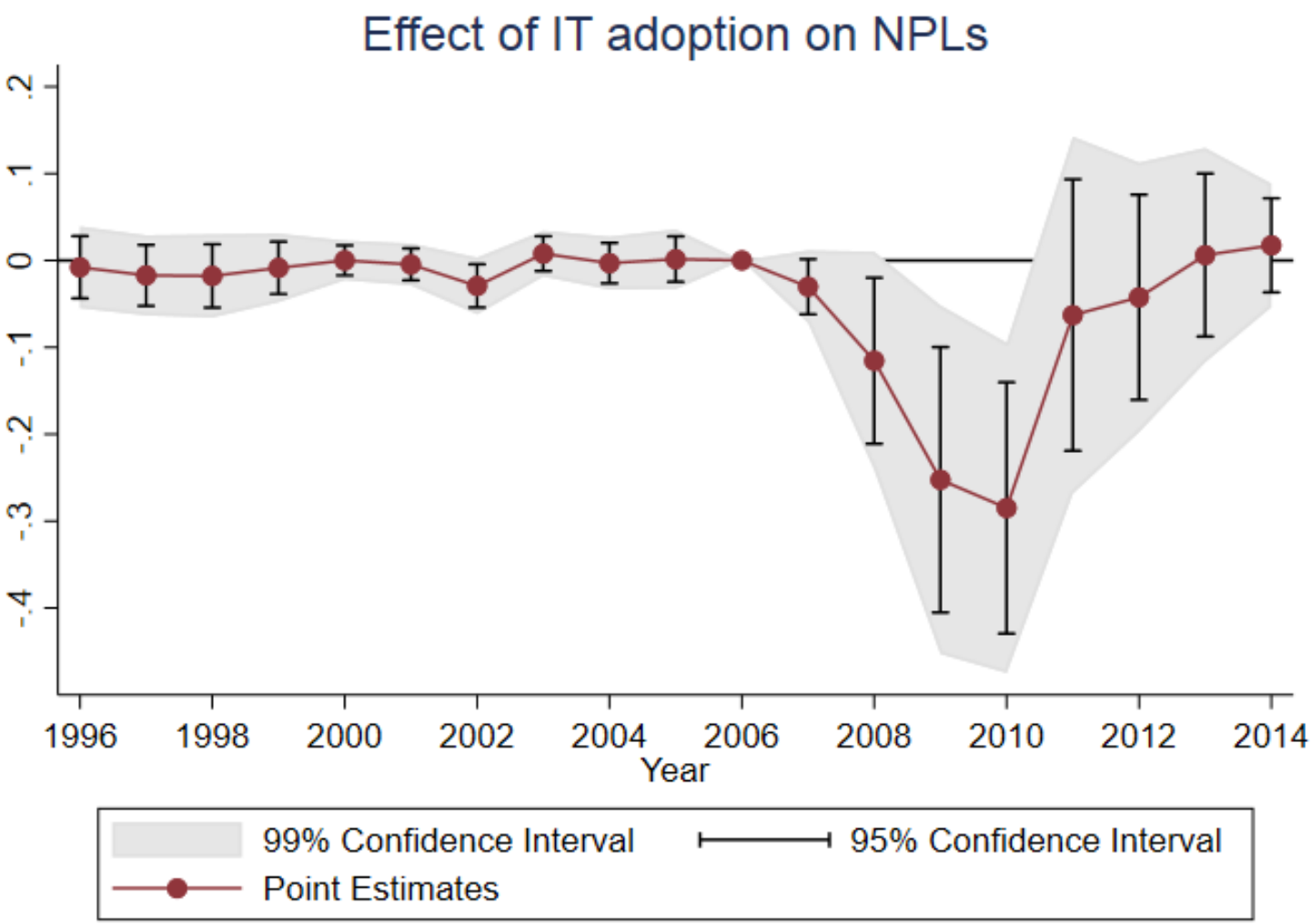
One standard deviation higher IT adoption $\Rightarrow$ 17-13 basis points less NPLs in 2007-2010

- 9 to 11% of mean NPLs (150 bp)
- 12 to 15% of std.dev. (113 bp)

If all banks were at the 75^{th} percentile of IT adoption $\Rightarrow$

- increase of NPLs lower by 6.5 to 8.5 basis points
- 6 to 8% smaller increase (actual number is 105 bp)

$$NPL_{b,t} = \alpha_b + \delta_t + \sum_{\tau \neq 2006} \beta_\tau IT_b \cdot 1[t = \tau] + \epsilon_{b,t}$$



Spurious Correlation?

IT correlated with other predictors of NPLs?

- measures of ex-ante exposure to GFC
  - pre-GFC ratios of loans, capital, and wholesale to assets, ROA, size, wages, and exposure to house-price drop
- **no correlation** with IT adoption $\Rightarrow$ unlikely to be correlated with unobservable characteristics predicting expusure to GFC
- impact of IT on NPLs unaffected by including important controls
  - $\rightarrow$ coefficient stability to formally test for bias from unobservable variables (Altonji et al.2005, Oster 2019)

Just better managed banks?

- lit find weak or no correlation with productivity or profitability in banking ("profitability paradox")
- we also find no correlation with pre-crisis ROA or wages (human capital)
- more on management to come..

Cross Sectional Results + Falsification

	NPLs during GFC (1)	Loans pre-GFC (2)	HP Exposure (3)	Size pre-GFC (4)	Capital pre-GFC (5)	Wholesale pre-GFC (6)	ROA pre-GFC (7)	Log Wage (8)
IT-adoption	-0.183***	-0.648	-0.896	-0.0931	-0.195	-0.0459	-0.0282	-0.0227
	(0.061)	(0.700)	(0.664)	(0.057)	(0.420)	(0.372)	(0.049)	(0.018)
R-squared	0.0262	0.00220	0.00550	0.00712	0.000427	0.0000383	0.00107	0.00414
N	337	337	337	337	337	337	337	337
Mean	1.54	62.69	15.83	13.9	13.02	15.92	2.55	4.84
Std.Dev.	1.13	13.8	12.06	1.1	9.43	7.41	.86	.35

Coefficient Stability

Dependent Variable:	NPLs during GFC	
	(1)	(2)
IT-adoption	-0.183***	-0.157***
	(0.061)	(0.058)
R-squared	0.0262	0.243
N	337	
Mean	1.54	
Std.Dev.	1.13	
Other Controls included		Yes

- coefficient is stable although R-squared goes up by 10 times: we perform an omitted variable bias test (Altonji et al.2005, Oster 2019) and find no bias
  - $\Rightarrow$ results point towards IT itself as the cause of the negative relationship

▸ Local Spillover (lack thereof)

Roots of IT Adoption: Executives' Backgrounds

- most of the variation in branch-level IT adoption is driven by bank characteristics (60% of explained variation)
- conjecture: Top executives with more tech-prone background
  $\Rightarrow$ Overcome frictions that prevent banks from adopting IT
- analyze bios of pre-GFC Bank Executives
- text analysis to flag "Technology" background:

$$Y_b = \alpha + \beta \cdot ExecIT_b + \epsilon_b \tag{3}$$

Table: NPLs, IT adoption, and Executives' "tech-orientation"

Dependent Variable:	NPLs during GFC (1)	NPLs during GFC (2)	IT adoption (3)
IT adoption	-0.138*		
	(0.076)		
Executives' "tech-orientation"		-0.155***	0.0900*
		(0.047)	(0.051)
R-squared	0.0141	0.0210	0.00967
N	249	249	249

▸ Robustness

Just better managers?

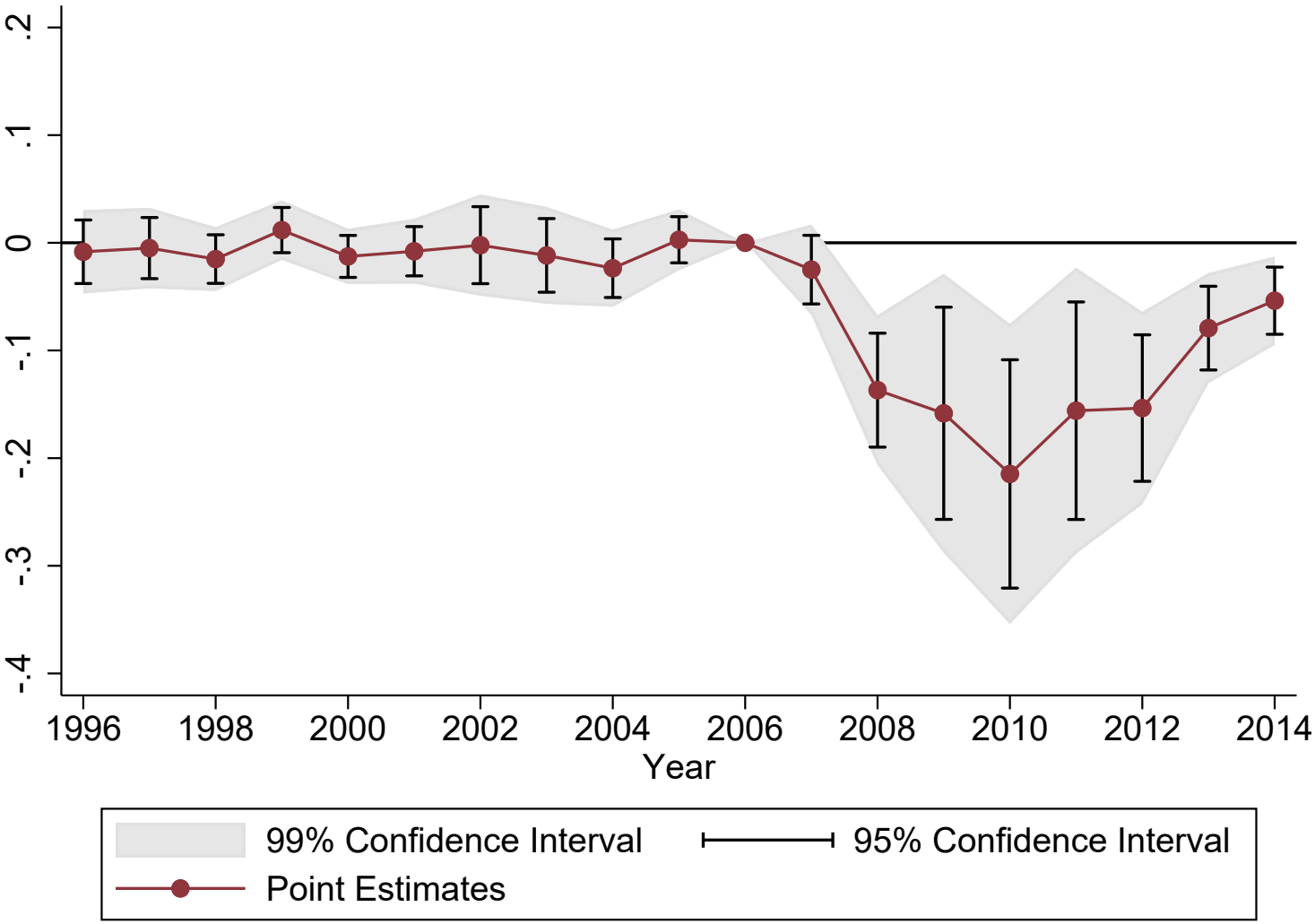
Table: Executives' "tech-orientation" and Compensation

	(1) NPLs	(2) NPLs	(3) IT-adoption	(4) IT-adoption
Executives' "tech-orientation"	-0.173***	-0.168***	0.104*	0.104*
	(0.062)	(0.062)	(0.057)	(0.057)
Log Compensation		-0.0375		-0.00208
		(0.060)		(0.053)
R-squared	0.0226	0.0244	0.0136	0.0136
N	237	237	149	149

Use compensation as proxy for human capital

- adding as control doesn't affect results
- more paid executives did not promote IT nor lowered NPLs

Figure: Time-varying Effect of tech-background of executives on NPLs



Roots of IT adoption: The Land-grant colleges

- Established in 19th century in all US States to provide technical education
  - Students more likely to major in technical subjects and less likely to major in business and management sciences
  - Location of colleges does not predict the presence of BHC headquarters in a county
- Conjecture: banks whose headquarters are closer to these colleges have generally a higher level of IT adoption
  - $\Rightarrow$ Use as IV

IV Regressions

	Dependent Variable: NPLs during GFC					
	OLS	IV	IV	IV	IV	IV
Instrument(s)		5 closest	All	LASSO	LASSO	LASSO
	(1)	(2)	(3)	(4)	(5)	(6)
IT adoption	-0.183***	-0.949*	-0.301**	-0.837**	-0.541**	-0.546**
	(0.055)	(0.489)	(0.127)	(0.350)	(0.230)	(0.241)
N	337	337	337	337	337	337
P-value: IV = OLS		0.117	0.353	0.0619*	0.118	0.132
Controls	No	No	No	No	Yes	Yes
State FEs	No	No	No	No	No	Yes
F-stat of First Stage		2.192	9.948	14.06	12.42	10.76
Cragg-Donald Wald F		1.258	1.081	22.959	17.509	5.817
Stock and Yogo's value		10.83	10.99	16.38	16.38	16.38

Channel

How did high IT adopters contain the surge in NPLs?

- loan-level Data from Freddie Mac
- performance during the crisis of mortgages issued before the crisis and securitized
- merge seller of loan with IT data (22 banks)
- detailed loan-level characteristics, such as LTV, DTI, Credit Score, postal code, and origiantion year

$$Delinquent_l = \alpha_{z(l)} + \delta_{o(l)} + \beta IT_{b(l)} + X_l'\gamma + \eta_l$$

Table: Loan-Level Regressions

Dependent Variable:	Delinquency during GFC Share of months with past due>90 days				
	(1)	(2)	(3)	(4)	(5)
IT adoption	-0.471**	-0.459**	-0.348**	-0.323**	
	(0.191)	(0.169)	(0.145)	(0.118)	
FICO score				-2.578***	-1.125***
				(0.284)	(0.181)
DTI				0.565***	0.248***
				(0.052)	(0.022)
LTV				1.075***	0.543***
				(0.129)	(0.056)
IT adoption × Low FICO					-0.198***
					(0.064)
IT adoption × High FICO					-0.00732
					(0.029)
Estimation Method	OLS	OLS	OLS	OLS	OLS
Org. Year FE		Yes	Yes	Yes	Yes
Postal Code FE			Yes	Yes	Yes
N	3,451,671	3,451,671	3,451,671	3,451,671	3,451,671
Mean	3.44	3.44	3.44	3.44	3.44
Std.Dev. of dept. var.	14.32	14.32	14.32	14.32	14.32

Loan-level Results

Even off-loaded loans from IT adopters perform better

- IT adopters produce “better" loans at origination
- IT adopters do not simply load-off “bad" loans
- effect not all due to better ability to manage crisis

Robust to controlling linearly for simple loan-level characteristics $\Rightarrow$ IT adopters either

1. able to gather, store, and use additional info
2. use the info available in a more effective way
3. or both

for financial stability not important to distinguish between (1), (2), or (3)

Lending

Does IT in finance really matter for financial stability and credit provision?

- high levels of NPLs can weigh on banks' profitability
  $\Rightarrow$ constrain lending and depress real economic activity
- IT adoption improves banks' resilience
  $\Rightarrow$ may shield their ability to provide credit to customers during financial turmoil

$$\overline{\Delta Loans_b}^{GFC} = \alpha + \beta \cdot X_b + \epsilon_b \tag{4}$$

we proxy lending with loan growth, as in Peek and Rosengreen (2000)

Figure: Loans over pre-crisis Assets by pre-GFC IT-adoption

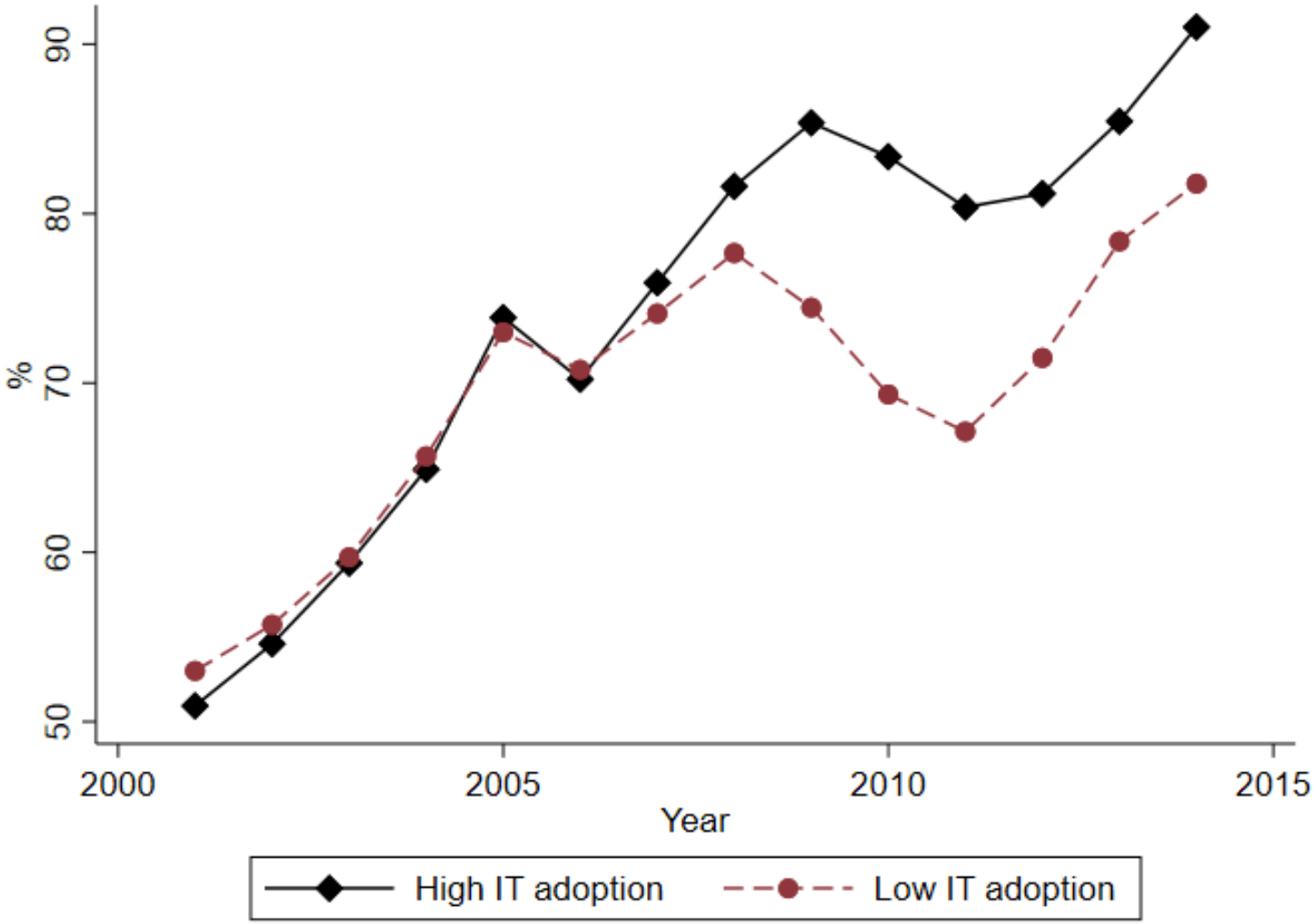


Table: Lending Regressions

Dependent Variable :	Loan Growth (crisis)			
NPLs during the GFC	-0.926***	-1.030***		
	(0.159)	(0.187)		
IT-adoption			0.378**	0.331*
			(0.182)	(0.196)
R-squared	0.0127	0.0928	0.0961	0.175
N	343	336	343	336
Controls	No	Yes	No	Yes

Summary

- we measure the heterogeneous degree of IT-adoption of US commercial banks before the GFC using a novel dataset
- high-IT-adopters experienced a significantly smaller increase in NPLs
- several pieces indicating direct role of IT adoption strengthening bank resilience
  - Coefficient stability
  - IV regressions
  - tech-background of executives
- loans originated by high-IT banks experienced lower delinquency rates, even when they were securitized and sold to Freddie Mac
  - IT-adoption helped banks to select better borrowers and produce more resilient loans

Conclusion

Financial industry becomes more and more reliant on IT

- exemplified by the surge of FinTech players
- policy-relevant to understand the consequences for financial stability

FinTech

- has not experienced yet a large systemic shock
- still tiny share of lending in most countries

So, we need to learn from the past..

- our evidence suggest that "FinTech era" likely beneficial for financial stability
  - several commonalities between the IT-intensive methods used before GFC and the most recent advancements
  - machine learning techniques are more powerful versions of the previously available statistical tools
  - our measure of IT-adoption is still informative about technological intensity more broadly defined in 2016 ($\rho = 65\%$, $R^2 = 45\%$)
- Caveat: we are silent about "institutional" features of FinTech (regulatory arbitrage, shadow banking etc)

Table: Robustness of Main Panel Regression

	Dependent Variable: NPLs							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
IT × crisis	-0.165**	-0.243*	-0.158**	-0.161**	-0.242**	-0.214**	-0.380*	-0.165***
	(0.068)	(0.120)	(0.069)	(0.063)	(0.095)	(0.080)	(0.183)	(0.051)
Exercise	Baseline	PCs per Emp	HW IT	HW NPLs	Loans	Broad def.	As of 2006	Bank Clustering
R-squared	0.00944	0.00376	0.00794	0.0108	0.00867	0.00993	0.00530	0.00944
N	4692	5035	4692	4692	4692	4692	4655	4692
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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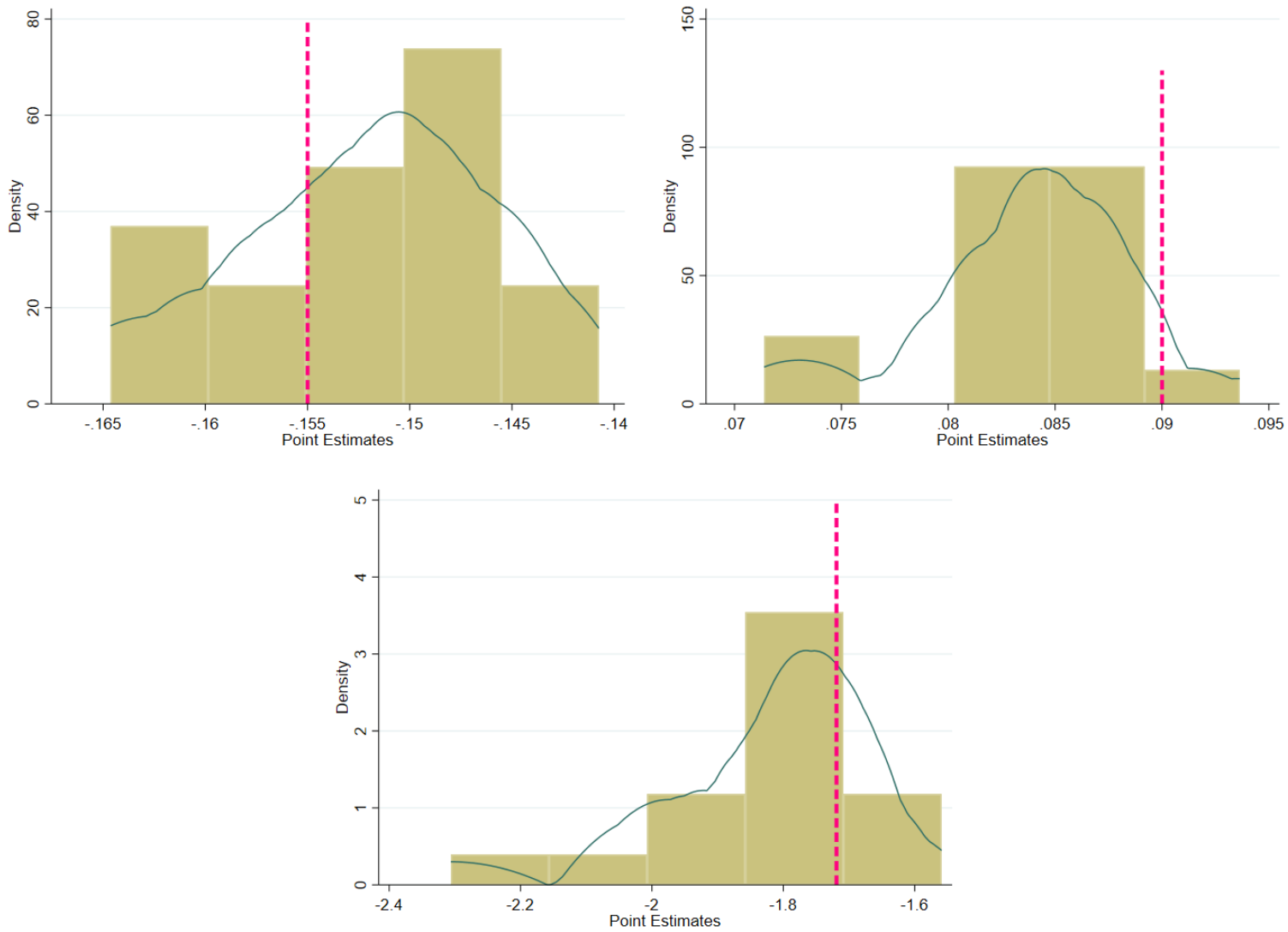
Figure: Robustness of the Executives' results to changes in the keywords list



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Cross Sectional Results + Local Spillover

Dependent Variable:	NPLs during GFC (1)	IT of local competitors (2)	NPLs during GFC (3)
IT-adoption	-0.183***	0.275***	-0.157***
	(0.061)	(0.083)	(0.058)
IT of local competitors			0.0773
			(0.047)
R-squared	0.0262	0.0750	0.243
N	337	337	337
Mean	1.54	0	1.54
Std.Dev.	1.13	1	1.13
Other Controls included			Yes

- no statistically significant local spillover

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