The Digital Banking Revolution: Effects on Competition and Stability

Naz Koont (2024)[1]

Presenter: Giselle Labrador-Badia

University of Wisconsin-Madison

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[1]Stanford University, Graduate School of Business

Introduction

- Digital banking platforms have become widespread as an alternative to traditional physical branches.
- Effects on competition are unclear:
  - size distributions of banks (scale economies, lower investment costs),
  - banking products (loans, deposits).
- Competition $\rightarrow$ stability.

Introduction

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- Effects on competition are unclear:
  - size distributions of banks (scale economies, lower investment costs),
  - banking products (loans, deposits).
- Competition $\rightarrow$ stability.
- How does the digital revolution affect competition and stability?
  - $\uparrow$ competition, $\downarrow$ stability.

Introduction

- Preview of results:
  - ↑ competition, ↓ stability.
  - After digitalization:
    - banks operate in more markets, and mid-size banks grow faster.
    - More uninsured deposits in balance sheets, and more loans to high-income borrowers.
  - Structural model of the U.S. banking industry to compare counterfactual without digitalization.
    - ↑ competition, ↓ stability.
    - ↑ consumer surplus and banks profits.

Introduction

- Contribution:
  - How digital platforms alter competition in banking. [2]
  - Effects on banks' screening and monitoring abilities by finding greater per-unit loan losses and more loans to high-income borrowers. [3]
  - Effect on digital platforms on banks' funding composition and stability. [4]
  - Banks technology adoption by endogenizing digital platform adoption. [5]

[2] Dreschsler et al. (2017), Honka et al. (2014), Hatfield and Wallen (2022), Vives and Ye (2022), Jiant et al. (2020)
[3] Fishman et al. (2017), Stein (2022), and Gornall et al. (2023), Di Maggio and Yao (2021), Liberti and Petersen (2019)
[4] Diamond and Dybvig (1983), Egan et al. (2019), Jiang et al. (2023), Drechler et al. (2023), Benmelech et al. (2023).
[5] Vives (2019), Jiang et al. (2022), Haendler (2022).

Data

- Digital platform adoption
  - Construction of data set for the universe of U.S. banks.
  - Release date of each bank's mobile application on Apple and Android App Stores, banking application's features, and its rating.

  $\rightarrow$ Dummy variable of whether banks have a mobile application at the start of each year.

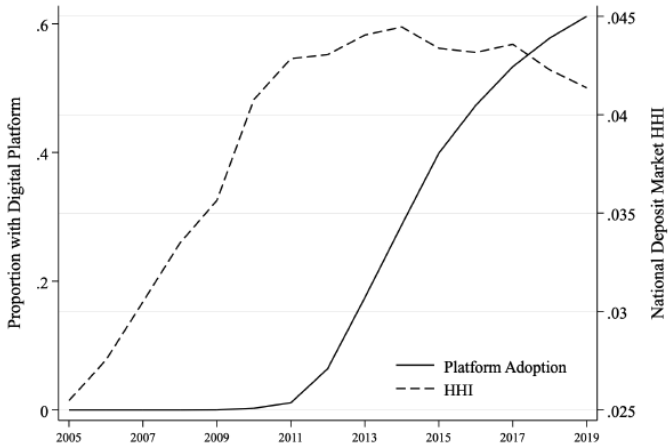
- Other data sources:
  - Call Reports, SDI, RateWatch,
  - mortgage: HMDA, small business loans: CRA, FinTech mortgage,
  - FCC census block-level data on broadband availability.

- Sample: unbalanced annual panel of U.S. commercial banks from 2010 to 2019.[6]

[6] Banks with more than 0.001% market share and at least 5 branches.

Digital Banking Platform Adoption and Market Concentration

- Digital platforms rise coincides with attenuation of market concentration.
- Suggest that digital platforms may have increased competition.

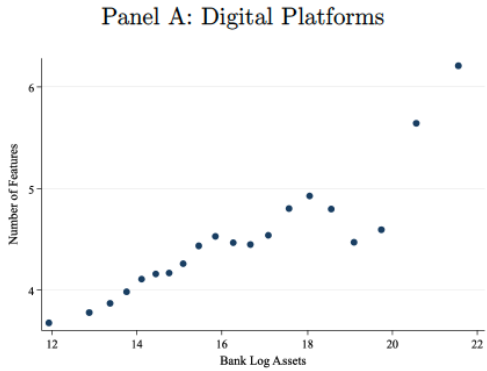


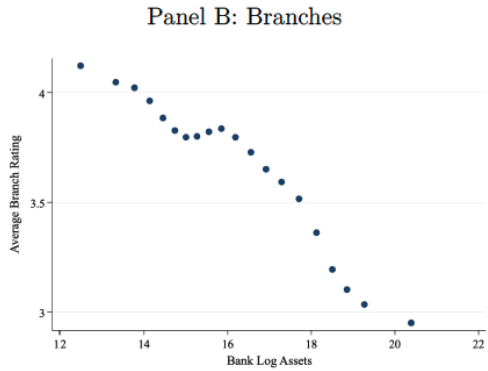
Institutional Background Main Features

- Dramatic increase in platform adoption after 2010.
- By 2019, 60% of banks will have a mobile banking application.
- Top mobile common features are access to account balances, transaction history, transfer money, find branches and ATMs, and mobile check deposits and loans.
- Most banks (60%) report getting services from third-party providers (FIS, Fiserv, Jack Henry).
- Digital platform quality varies across the bank size distribution (see next slide).

Banks' digital platform quality and branch ratings

- Larger banks have more mobile features and better app ratings.
- Smaller banks have better branch ratings.[7]





[7] Panel B includes county fixed effects.

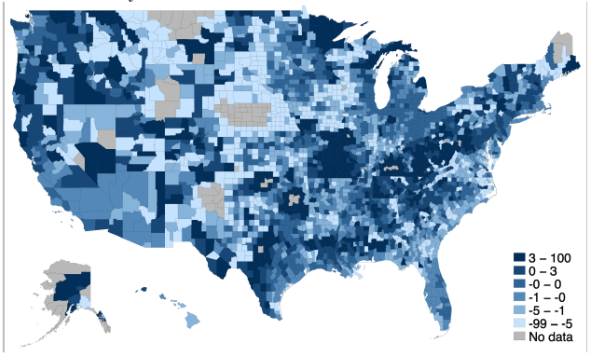
Empirical Strategy and Reduced Form Evidence

Instrument construction and identification

- Digital adoption is endogenous (omitted variable bias)
- Use banks' exposure to technology that facilitates digitalization.
- Use quasirandom availability of AT&T's coverage relative to other carriers.

Figure 4. Geographic Variation in Cellular Provider Coverage

This figure shows county-level proportional differences in AT&T and Verizon LTE coverage, defined to be $(ATT - Verizon)/Verizon \cdot 100$. Darker colors correspond to higher AT&T coverage relative to Verizon coverage. Coverage data at the provider-level come from FCC form F477 in 2015, and are averaged across census blocks within each county.



Instrument construction

- The instrument for bank adoption of mobile services is:

$$Z_b \equiv \sum_c \text{Shares}_{b,c} \cdot \text{Shocks}_c$$

$$\text{Shocks}_c \equiv \text{AT\&T}_c$$

$$\text{Shares}_{b,c} \equiv \frac{\text{Deposit Share}_{b,c} \cdot \text{Population}_c}{\sum_c \text{Deposit Share}_{b,c} \cdot \text{Population}_c}$$

Where Z_b is a shift-share instrument for technology adoption and Shocks_c is the AT&T coverage in county c (2015), deposits and population are measured in 2009.

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- Main regression specification is

$$\text{Digital}_{b,t} = \delta_1 Z_b + \delta_2 \text{Coverage}_b + \delta_3 X_{b,t} + \eta_{b,t}$$

$$Y_{b,t} = \beta_1 \widehat{\text{Digital}}_{b,t} + \beta_2 \text{Coverage}_b + \beta_3 X_{b,t} + \varepsilon_{b,t}$$

Coverage_b is similar to Z_b but with AT&T and Verizon.

ATT Coverage as instrument

Table 1 Instrument First Stage

	Digital		
	(1)	(2)	(3)
ATT Coverage	0.57***	0.57***	0.43***
	(0.11)	(0.11)	(0.11)
Overall Coverage	-0.00**	-0.00**	-0.00***
	(0.00)	(0.00)	(0.00)
Nonbank Fintech Exposure		0.08	0.15
		(0.15)	(0.15)
Prop Over 60			-0.49***
			(0.14)
Median Income			-0.03
			(0.02)
Prop Urban			0.11***
			(0.02)
Year FE	Yes	Yes	Yes
Observations	50358	50358	50358
Adjusted R^2	0.264	0.264	0.271
F	23.15	15.50	24.36

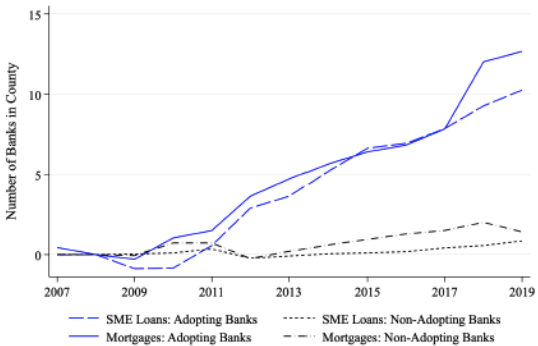
- Bank-year level observations from 2010 to 2019, year FE.
- Standard errors are clustered at the bank level.
- Validity of the instrument:
  - Relevance: increase in digital adoption with AT&T coverage.
  - Exclusion restriction: shift-share instruments if shares are exogenous.
  - Variation in AT&T coverage might be as good as random.
  - Banks' characteristics are not significantly correlated with instruments.

Evidence of spatial sorting

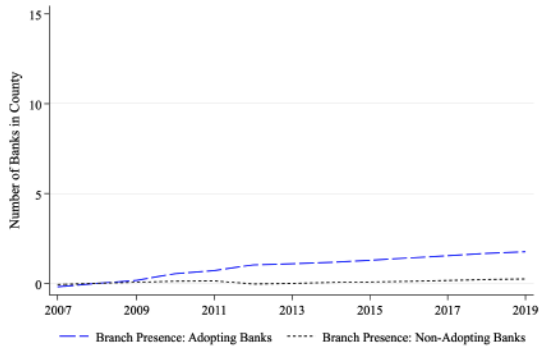
- Local banking markets increase avg. No. of banks that are originating small business loans and mortgages.

- Expansion is not accompanied by a proportional increase in bank branch presence.

Panel A: Mortgage and Business Lending



Panel B: Branch Presence



Bank Geographic expansion and digitalization

- Banks that adopt digital platforms increase the no. of counties in which they originate by 86%.

Table 2 Bank Geographic Expansion

	All		High Inc		Low Inc	
	(1)	(2)	(3)	(4)	(5)	(6)
Digital	0.99**	0.86**	1.33**	1.24**	0.70**	0.53*
	(0.42)	(0.37)	(0.56)	(0.52)	(0.32)	(0.28)
Overall Coverage	0.00**	0.00**	0.00**	0.00**	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
L.Y	0.70***	0.71***	0.65***	0.66***	0.74***	0.76***
	(0.03)	(0.03)	(0.05)	(0.05)	(0.02)	(0.02)
L.Br Num Markets	0.01**	0.02***	0.01*	0.01*	0.02***	0.02***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.00)
Nonbank Fintech Exposure	-0.42	-0.37	-0.36	-0.34	-0.50**	-0.43*
	(0.31)	(0.29)	(0.38)	(0.38)	(0.25)	(0.23)
Log Change Establishments		-0.19**		-0.21		-0.11
		(0.10)		(0.13)		(0.11)

Bank branches' response to digitalization

- Banks close branches after adopting digital platforms.
- Expand service provision.

Table 3 Bank Branch Response

	(1) Num Markets	(2) Num Markets	(3) Within-Market
Digital	-0.007	-0.008	-0.059*
	(0.024)	(0.024)	(0.032)
L.Num Markets	0.997***	0.997***	0.004
	(0.004)	(0.004)	(0.003)
L.Within-Market			0.983***
			(0.001)
Nonbank Fintech Exposure		-0.019	
		(0.023)	
Overall Coverage	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)
FE	Year	Year	County-Year
Observations	50,357	50,357	212,798
F	177.45	179.20	325.71

Banks balance sheet growth

- U-shaped across bank size, mid-size banks grew more.
- Deposit growth of mid-size banks is elevated.

Controls include establishments, employment, payroll, deposit, loan growth, and year fixed effects.

Table 4 Bank Balance Sheet Growth

	Assets			Deposits			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Digital, $100B+	-0.001	-0.002	-0.010	0.007	0.006	-0.001	0.000
	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)	(0.008)	(0.006)
Digital, $10B – $100B	0.038***	0.036***	0.034***	0.042***	0.040***	0.038***	0.025***
	(0.010)	(0.010)	(0.010)	(0.011)	(0.011)	(0.010)	(0.008)
Digital, $10B–	-0.012	-0.015	-0.009	-0.012	-0.015	-0.009	-0.018
	(0.015)	(0.015)	(0.013)	(0.017)	(0.017)	(0.014)	(0.013)
Overall Coverage	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.Y	0.464***	0.465***	0.458***	0.415***	0.416***	0.419***	0.587***
	(0.012)	(0.012)	(0.014)	(0.012)	(0.012)	(0.015)	(0.011)

Digital banking facilitates uninsured deposits

- Growth in deposits among adopters is disproportionately in uninsured deposits.
- Decrease of insured deposit for large and medium banks.

Table 5 Bank Insured Deposit Ratio

	Insured Deposit Ratio		
	(1)	(2)	(3)
Digital, $100B+	-0.017**	-0.017**	-0.012
	(0.009)	(0.009)	(0.008)
Digital, $10B – $100B	-0.024***	-0.023***	-0.016**
	(0.009)	(0.009)	(0.008)
Digital, $10B–	0.006	0.007	0.006
	(0.008)	(0.008)	(0.007)
Overall Coverage	-0.000***	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
L.Insured Deposit Ratio	0.945***	0.945***	0.971***
	(0.011)	(0.011)	(0.008)
Nonbank Fintech Exposure		0.018**	0.016*
		(0.009)	(0.009)
Log Change Establishments			0.002
			(0.005)

Corporate deposits are flowing to banks with digital platforms

Table 6 Insured Deposits and Business Payroll

	Insured Deposit Ratio	
	(1)	(2)
Payroll × Digital	-0.013***	-0.012***
	(0.004)	(0.004)
Payroll	0.003	0.001
	(0.003)	(0.003)
L.Insured Deposit Ratio	0.643***	0.644***
	(0.016)	(0.016)
Log Change Payroll		0.003
		(0.005)
Log Change Establishments		0.001
		(0.005)
Log Change Employment		-0.007
		(0.005)
Log Change Dep Growth		-0.003
		(0.005)
Year FE	Yes	Yes
Bank FE	Yes	Yes

Bank Low Income Mortgages in New Counties

- Bank expansion into new counties driven by high-income borrowers.
- Adopting banks reduce low-income mortgage origination by 27%, volume by 38%.

Table 7 Bank Low Income Mortgages in New Counties

	(1) Number	(2) Volume	(3) Avg Income Jumbo
Digital	-0.265**	-0.384**	243.518***
	(0.126)	(0.178)	(68.553)
L.Y	0.516***	0.476***	0.129***
	(0.005)	(0.005)	(0.008)
L.Br Num Markets	-0.000***	-0.000***	-0.124***
	(0.000)	(0.000)	(0.026)
Overall Coverage	0.000	0.001	-2.160***
	(0.001)	(0.001)	(0.687)
County-Year FE	Yes	Yes	Yes
Observations	58422	58422	35675
F	179.88	179.78	159.56

Loan Activity in New Counties

- Increase overall mortgage applications, fewer from low-income borrowers.
- Around 76% more rejections for low-income borrowers.

Table 8 Loan Applications and Rejections in New Counties

	(1) Applications	(2) Low Income Application Ratio	(3) Low Income Rejection Ratio
Digital	0.597***	-0.257***	0.763***
	(0.107)	(0.091)	(0.170)
L.Y	0.778***	0.499***	0.620***
	(0.004)	(0.005)	(0.009)
L.Br Num Markets	0.000**	-0.000***	-0.000***
	(0.000)	(0.000)	(0.000)
Overall Coverage	0.001	-0.000	0.001
	(0.001)	(0.001)	(0.003)
County-Year FE	Yes	Yes	Yes
Observations	164531	80331	23159
F	457.42	359.70	253.63

Model Framework

Demand for banking services: Deposits

- Each location ℓ is composed of a set households I_ℓ.
- **Heterogeneous households** choose bank j and branch $o^D_{j\ell} \in O_j$ for deposits, and bank k and branch $o^L_{k\ell}$ for loans,
- given distance to branch and rates $r^D_{j,o^D_{j\ell}}$ and $r^L_{k,o^L_{k\ell}}$,
- common taste for bank j deposit $Q^D_{j\ell}$ and loan $Q^L_{j\ell}$ in ℓ:

$$Q^D_{j\ell} = \bar{Q}^D_j J^D_{j\ell} \phi_{j\ell} \tag{1}$$

$$Q^L_{j\ell} = \bar{Q}^L_j J^L_{j\ell} \phi_{j\ell}, \tag{2}$$

  - $\bar{Q}^D_j$ and $\bar{Q}^L_j$ are common for bank j (from bank's investment decisions),
  - $J^D_{j\ell}$ and $J^L_{j\ell}$ are decreasing functions of distance to bank j 's headquarters,
  - $\left\{\phi_{j\ell}\right\}_\ell$ are idiosyncratic appeal shifters drawn from a multivariate Frechet distribution.

Demand for banking services: Deposits

- Consumers choose to deposit insured deposits in bank j and maximize utility:

$$\max_{b \in B} \quad \mu_{ib} = \underbrace{\alpha_{DI}^{R} R_b^{DI} + \alpha_{DI}^{N} N_b + \alpha_{DI}^{O,S} O_b S_b + \alpha_{DI}^{\ominus} \Theta_b + \xi_{ib}}_{\equiv \alpha_{DI} X_b} + \varepsilon_{ib}$$

  - R_b^{DI} is the interest rate on bank b for insured deposits,
  - N_b is the number of branches of bank b,
  - O_b is the dummy for the bank's digital platform,
  - S_b is the size of bank b,
  - Θ_b are other bank characteristics,
  - ξ_{ib} is the structural error term,
  - ε_{ib} is the idiosyncratic taste for bank b that distributes as a T1EV.

$$Q_b^{DI} = M^{DI} \cdot s_b^{DI} = M^{DI} \cdot \frac{\exp\left(\alpha_{DI} X_b\right)}{1 + \sum_{b' \in \mathcal{B}} \exp\left(\alpha_{DI} X_{b'}\right)},$$

- Similar demands for uninsured deposits DU.

Demand for banking services: Loans

- Consumers H choose to mortgage in bank j and maximize utility:

$$\max_{b \in B_c} \quad \mu_{ibc} = \underbrace{\alpha_H^R R_{bc}^H + \alpha_H^N N_{bc} + \alpha_H^O O_b + \alpha_H^\Theta \Theta_{bc} + \xi_{ib}}_{\equiv \alpha_H X_{bc}} + \varepsilon_{ibm}$$

  - R_{bc}^H is the interest rate on bank b for mortgage in county c,
  - N_{bc} is the number of branches of bank b in county c,
  - O_b is the dummy for the bank digital platform,
  - Θ_{bc} are other bank characteristics,
  - ξ_{ib} is the structural error term,
  - ε_{ib} is the idiosyncratic taste for bank b that distributes as a T1EV.
  - ε_{ibm} is the idiosyncratic taste for bank b that distributes as a T1EV.

$$Q_{bc}^H = M_c^H \cdot s_{bc}^H = M_c^H \cdot \frac{\exp\left(\alpha_H X_{bc}\right)}{1 + \sum_{b' \in \mathcal{B}_c} \exp\left(\alpha_H X_{b'c}\right)},$$

- Similar demands for segment L.

Banks

- Bank j is born with a headquarters location ℓ_j^{HQ}, has unit costs θ_j^D and θ_j^L for deposits and loans, and draw local fixed costs ψ_ℓ.
- Bank j choose a set of branch locations O_j and deposit and lending rates r_{jo}^D and r_{jo}^L.
- If it operates in location o, pays a local fixed cost Ψ_o.
- To operate branches O_j, it must hire $H(|O_j|)$ workers at its headquarters location.
- Bank chooses bank appeal, $\bar{Q}_j^D$ and $\bar{Q}_j^L$, by hiring $C\left(\bar{Q}_j^D, \bar{Q}_j^L\right)$ workers in its headquarters location.
- Wholesale funding then $W_j = L_j - D_j$
- The interest rate it pays on wholesale funds is $R(W_j/D_j)$.

Banks

- Bank j's problem is:

$$\max_{R^{DI},R^{DU},\left\{R_c^H\right\},\left\{R_c^L\right\}} \pi_b = \pi_b\left(R_b^{DI}, R_b^{DU}, \left\{R_{bc}^H\right\}_{c\in\mathcal{C}_b}, \left\{R_{bc}^L\right\}_{c\in\mathcal{C}_b}\right) =$$

$$\underbrace{\sum_{c\in\mathcal{C}_b}\left(R_{bc}^H - f\right)Q_{bc}^H\left(R_{bc}^H\right) + \sum_{c\in\mathcal{C}_b}\left(R_{bc}^L - f\right)Q_{bc}^L\left(R_{bc}^L\right)}_{\text{Local loan return}} +$$

$$\underbrace{\left(f - R_b^{DI}\right)Q_b^{DI}\left(R_b^{DI}\right) + \left(f - R_b^{DU}\right)Q_b^{DU}\left(R_b^{DU}\right)}_{\text{National deposit return}} - \underbrace{L_b\left(\mathcal{Q}_b\right)}_{\text{Losses}} - \underbrace{\Phi_b\left(\mathcal{Q}_b\right)}_{\text{Costs}},$$

where $\mathcal{Q}_b$ is the set of all bank's quantities, f is the federal funds rate, and Φ_b is the bank's total costs.

Banks

- The bank can of course invest in multiple branches N and moreover use both branches N and digital platforms O.

- The probability of failure becomes $p_b + \delta^O + \delta_a^O + \delta^N N + \delta_a^N N$. Thus, the expected loss L_{bc}^a for lending to borrower a for bank b in county c is given by,

$$L_{bc}^a = p_b + \delta^N N_{bc} + \delta_a^N N_{bc} + \delta^O O_b + \delta_a^O O_b$$

- Suppose that the bank makes Q_{bc}^L loans to borrowers of type $a = L$ and Q_{bc}^H loans to borrowers of type $a = H$ in a county c.

- The expected loss $L_{bc}\left(Q_{bc}^L, Q_{bc}^H\right)$ for bank b 's overall lending in county c is given by the following equation.

$$L_{bc}\left(Q_{bc}^L, Q_{bc}^H\right) = L_{bc}^L \cdot Q_{bc}^L + L_{bc}^H \cdot Q_{bc}^H$$

$$L_b\left(\mathcal{Q}_b\right) = \sum_{c \in \mathcal{C}_b} L_{bc}\left(Q_{bc}^L, Q_{bc}^H\right).$$

Banks

- Marginal deposit service costs in market $j \in \{DI, DU\}$:

$$\frac{\partial \Phi_b^j}{\partial Q_b^j} = \phi_j^N N_{bt} Q_b^j + \phi_j^{Q,S} Q_b^j S_b + \phi_j^{O,S} O_b Q_b^j S_b + \phi_j^{\Theta} \Theta_b + \xi_b^j,$$

  - where Q_b^j is the quantity of j that bank b provides,
  - O_b is a variable tracking whether bank b has a digital platform,
  - N_b is bank b 's number of branches,
  - S_b is bank size,
  - Θ_b is a vector of controls capturing bank b 's baseline differences,
  - ξ_b^j is the structural disturbance to bank b 's marginal service costs in ket j.

- Banks marginal loan service costs in market $j \in \{H, L\}$ and county $c \in \mathcal{C}_b$:

$$\frac{\partial \Phi_{bc}^j}{\partial Q_{bc}^j} = \phi_j^N N_{bc} + \phi_j^O O_b + \phi_j^{\Theta} \Theta_{bc} + \xi_{bc}^j,$$

- Costs are additive across segments so we can build total cost function $\Phi_b(\mathcal{Q}_b)$.

Banks

- The bank's problem in $t = 0$ is:

$$\max_{O_b, \boldsymbol{N}_b, \mathcal{C}_b} \Pi_b = \underbrace{\pi_b \left[O_b, \boldsymbol{N}_b, \mathcal{C}_b \right]}_{t=1 \text{ Profits}} - \underbrace{F_O \left(O_b \right)}_{\text{Adoption Cost}} - \underbrace{F_N \left(\boldsymbol{N}_b \right)}_{\text{Branch Maintenance}} - \underbrace{F_C \left(\mathcal{C}_b \right)}_{\text{Entry Cost}}$$

- Adoption costs:

$$F_O \left(O_b \right) = \left(f_O + \xi_b^O \right) \cdot O_b \sqrt{\text{Assets}_b}$$

- Branch maintenance costs:

$$F_N \left(\boldsymbol{N}_b \right) = \sum_{c \in \mathcal{C}_b} \left(f_N + \xi_b^N \right) \cdot N_{bc}$$

- Maintenance costs:

$$F_C \left(\mathcal{C}_b \right) = \sum_{c \in \mathcal{C}_b} f_C \cdot \left(D_{bc} + \xi_b^C \right) \cdot \text{ Non-Local }_{bc}.$$

Estimation

- Market size:
  - Deposits markets include money market mutual funds and deposits by wealth.
  - Low/High-income borrowers in HMDA scale by 1.2.

- Estimation equations:

$$\log s_b^j - \log s_0^j = \alpha_j^R R_b^j + \alpha_j^N N_b + \alpha_j^{O,S} O_b S_b + \alpha_j^{\Theta} \Theta_b + \xi_b$$

$$\log s_{bc}^j - \log s_{0c}^j = \alpha_j^R R_{bc}^j + \alpha_j^N N_{bc} + \alpha_j^O O_{bc} + \alpha_j^{\Theta} \Theta_{bc} + \xi_{bc}.$$

Estimation

- Loan loss estimation:

$$\text{Per Unit Loss}_{b,t} = \underbrace{\delta^O O_{bt} \frac{\left(Q^L_{bct} + Q^H_{bct}\right)}{Q^{Bal}_{bt}} + \delta^O_L O_{bt} \frac{Q^L_{bt}}{Q^{Bal}_{bt}} + \delta^O_H O_{bt} \frac{Q^H_{bt}}{Q^{Bal}_{bt}}}_{\text{Effect of Digital Platforms}}$$

$$+ \underbrace{\delta^N \frac{\sum_{cc\mathcal{C}} N_{bc} \left(Q^L_{bct} + Q^H_{bct}\right)}{Q^{Bal}_{bt}} + \delta^N_L \frac{\sum_{c\in\mathcal{C}} N_{bc} Q^L_{bct}}{Q^{Bal}_{bt}} + \delta^N_H \frac{\sum_{c\in\mathcal{C}} N_{bc} Q^H_{bct}}{Q^{Bal}_{bt}}}_{\text{Effect of Branches}}$$

$$\underbrace{+\delta_U \text{ Per Unit Loss}_{b,t-1} + \delta_C \text{ Coverage }_b + \delta_t + \xi_{bt}}_{\text{Baseline per-unit loss}}.$$

Estimation: Service Provision Costs

- To estimate the parameters that appear in banks' service provision costs, take FOC:

$$FOC_{R^j}: \underbrace{f - R^j - Q^j \left(\frac{\partial Q^j}{\partial R^j}\right)^{-1}}_{\text{Spread}^{\ j}_{\ b}} = \frac{\partial \Phi^j_b}{\partial Q^j} \quad \text{for } j \in \{DI, DU\}$$

$$FOC_{R^j_c}: \underbrace{R^j_c - f + Q^j_c \left(\frac{\partial Q^j_c}{\partial R^j_c}\right)^{-1} - \frac{\partial L}{\partial Q^j_c}}_{\text{Spread}^{\ j}_{\ b,c}} = \frac{\partial \Phi^j_{bc}}{\partial Q^j_c} \quad \text{for } j \in \{H, L\}, c \in C_b.$$

- Combined with banks' first order conditions to arrive at the following expressions.

$$\text{Spread}^j_b = \phi^N_j N_{bc} Q^j_b + \phi^{Q,S}_j Q^j_b S_b + \phi^{O,S}_j O_b Q^j_b S_b + \phi^{\Theta}_j \Theta_b + \xi^j_b \quad \text{for } j \in \{DI, DU\}$$

$$\text{Spread}^j_{b,c} = \phi^N_j N_{bc} + \phi^O_j O_b + \phi^{\Theta}_j \Theta_{bc} + \xi^j_{bc} \quad \text{for } j \in \{H, L\}, c \in C_b$$

Estimation: Service Provision Costs

- Adoption costs: parameter f_0.
- Identification: Banks' AT&T exposure is orthogonal unobservable cost.

$$\frac{1}{B}\sum_b \left[Z_b^- \left(\Delta\hat{\pi}\left(1, d_{-b}, r_b\right) - \Delta\hat{\pi}\left(0, d_{-b}, r_b\right) \right) \cdot \text{Assets}_b^{-1/2} \mid O_b^* = 0 \right] \leq f_O$$

$$\frac{1}{B}\sum_b \left[Z_b^+ \left(\Delta\hat{\pi}\left(1, d_{-b}, r_b\right) - \Delta\hat{\pi}\left(0, d_{-b}, r_b\right) \right) \cdot \text{Assets}_b^{-1/2} \mid O_b^* = 1 \right] \geq f_O$$

- Similar identification for branch maintenance and entry costs.
- Consumer Surplus $E[CS] = \frac{1}{\hat{\alpha}} \log\left(\sum_{j=0}^{J} \exp\left(\alpha_j X_b\right)\right)$,
- Per Unit Loss$^L_{b,t} = \left(\delta^O + \delta^O_L\right) \frac{O_{b,t} Q^L_{bt}}{Q^{Bal}_{bt}} + \left(\delta^B + \delta^B_L\right) \frac{\sum_c B_{bc} Q^L_{bct}}{Q^{Bal}_{bt}} + \delta_U$ Per Unit Loss $_{b,t-1} + \delta_C$ Coverage $_b + \delta_t + \xi_{bt}$.

Demand results

- AT&T exposure as an instrument for digital platforms.
- Expenses on fixed assets in deposit markets as instruments for rates.
- Hausman instruments in mortgage markets for rates.
- Deposits use bank-year panel from 2012 to 2019.
- Bank-county-year from 2018 and 2019.
- Finds that if banks increase deposit rates by 10 bp, their market shares increase by 14%.
- For mortgage rates decrease in 6.6%.
- Mid-size banks have higher demand estimates for digital platforms.

Demand estimation results

Table 9 Deposit Market Estimates

Panel A: Demands

Parameter	Symbol	j = Insured		j = Uninsured	
Deposit Rate	α_j^R	1.393**	(0.667)	2.259***	(0.628)
Digital Platforms, Banks above \$100B	$\alpha_j^{O,100B+}$	-0.060	(0.088)	0.670**	(0.283)
Digital Platforms, Banks \$10B – \$100B	$\alpha_j^{O,10B-100B}$	0.214***	(0.071)	0.710***	(0.259)
Digital Platforms, Banks below \$10B	$\alpha_j^{O,10B-}$	0.172***	(0.057)	0.490**	(0.205)
Branches	α_j^N	0.086***	(0.033)	0.383***	(0.094)
Lag Loan Losses	α_j^{Losses}	-0.629	(0.449)	-3.223*	(1.890)
Overall Coverage	$\alpha_j^{Coverage}$	0.001**	(0.000)	0.001	(0.001)
Lag Assets	α_j^{Assets}	0.970***	(0.009)	0.935***	(0.027)
Lag Insured Ratio	$\alpha_j^{Insured}$	1.158***	(0.028)	-5.296***	(0.108)
Local Population	$\alpha_j^{Population}$	-0.000	(0.000)	-0.000***	(0.000)

Deposits Cost estimation results

Panel B: Service Costs

Parameter	Symbol	j = Insured		j = Uninsured	
Baseline, Banks above \$100B	$\phi_j^{Q,100B+}$	0.14	(0.24)	1.40	(3.10)
Baseline, Banks \$10B – \$100B	$\phi_j^{Q,10B-100B}$	0.85***	(0.31)	2.63	(2.32)
Baseline, Banks below \$10B	$\phi_j^{Q,10B+}$	5.28**	(2.63)	-4.56	(17.40)
Digital Platforms, Banks above \$100B	$\phi_j^{O,100B+}$	-0.06	(0.26)	-1.36	(3.18)
Digital Platforms, Banks \$10B – \$100B	$\phi_j^{O,10B-100B}$	-0.66*	(0.40)	-3.49	(3.19)
Digital Platforms, Banks below \$10B	$\phi_j^{O,10B-}$	-6.51*	(3.73)	4.93	(29.76)
Branches	ϕ_j^N	-0.02***	(0.01)	0.00	(0.01)

Demand and cost for loans results

Panel A: Demands

Parameter	Symbol	j = High Income		j = Low Income	
Mortgage Rate	α_j^R	-0.66***	(0.04)	-0.56***	(0.04)
Digital	α_j^O	2.27**	(1.05)	1.73	(1.34)
Branches	α_j^N	0.04***	(0.00)	0.03***	(0.00)
Local Market	α_j^{Local}	1.89***	(0.03)	1.17***	(0.03)
Overall Coverage	$\alpha_j^{Coverage}$	0.00	(0.00)	-0.00	(0.00)

Panel B: Service Costs

Parameter	Symbol	j = High Income		j = Low Income	
Digital	ϕ_j^O	-1.93***	(0.25)	-1.30***	(0.18)
Branches	ϕ_j^N	-0.01***	(0.00)	-0.00***	(0.00)
County Income	ϕ_j^{Income}	-0.00***	(0.00)	-0.00***	(0.00)

Loan losses estimation results

Panel C: Loan Losses

Parameter	Symbol	Estimate	S.E.
Digital, Overall	δ_O	-0.033	(0.118)
Digital, Low Income	δ_L^O	0.836*	(0.444)
Digital, High Income	δ_H^O	-0.526***	(0.196)
Branches, Overall	δ^N	-0.261*	(0.150)
Branches, Low Income	δ_L^N	0.214	(0.167)
Branches, High Income	δ_H^N	0.212	(0.153)
Lag Losses	δ_U	85.124***	(0.419)
Overall Coverage	δ_C	-0.000*	(0.000)

Banks fixed costs estimation results

- Bounds for fixed costs are:
- E.g. entry cost between mile distance to headquarter range from 10$ to 318$.

Table 11 Bank Fixed Investment Costs

	Adoption f_O	Branch f_N	Entry f_C
Estimate	407,700	25,640	164.4
Bounds (L, U)	(398,800 , 416,600)	(25,270 , 26,010)	(10.8 , 318.0)

Aggregate Effects on Competition

- Concentration decreases with digital platforms.

Table 12 Aggregate Effect of Digital Platforms on Competition

Panel A: Consolidation and Integration

	Non-Digital Equilibrium	Digital Equilibrium	Change
HHI	0.177	0.164	-6.9%
Top Share	0.909	0.894	-1.7%
Banks in County	27.59	29.83	8.2%
Bank Branches	56.43	53.15	-5.8%

Competition Implications

Panel B: Markups, Quantities, and Expected Consumer Surplus

	Change Adj. Markup	Change Q	Change E[CS]
Deposits	-0.3%	6.3%	15.1%
Insured	-1.0%	0%	0%
Uninsured	0.4%	15.3%	32.1%
Mortgages	-7.7%	60.3%	239.6%
High Income	-5.7%	63.3%	307.2%
Low Income	-14.2%	18.8%	26.0%
Overall			26.6%

Panel C: Bank Profits

	Change Profit
Aggregate	0%
Average, $100B+	4.0%
Average, $10B–$100B	15.0%
Average, $10B–	-44.2%

Financial Stability implications

Midsize banks provide more services and serve more markets. Avg. expected loan losses decrease.

Table 13 Financial Stability Implications of Digital Platforms

Panel A: Systemic Importance

	Sum	Insured	Uninsured	High Income	Low Income	Counties
Digital, $100B+	4.0%	-1.4%	12.5%	44.2%	7.0%	5.1%
Digital, $10B–$100B	29.0%	29.1%	25.2%	60.0%	16.2%	6.9%
Digital, $10B–	17.1%	22.3%	0.8%	70.1%	19.1%	5.3%
Non-Digital	-20.7%	0%	-38.3%	-92.4%	-47.2%	0.1%

Panel C: Funding Risk

Uninsured Ratio	Non-Digital Equilibrium	Digital Equilibrium	Change
Aggregate	0.41	0.45	8.5%
Digital, $100B+	0.38	0.44	17.6%
Digital, $10B–$100B	0.29	0.31	7.7%
Digital, $10B–	0.20	0.19	-3.6%
Non-Digital	0.22	0.17	-22.5%

Conclusion

- Documents Digital platforms increase competition and pose risks to financial stability.
- Midsize banks benefit from the adoption of digital platforms.
- Likely to have implications for monetary policy and financial regulation.

Thank you!