Bank Technology: Productivity and Employment

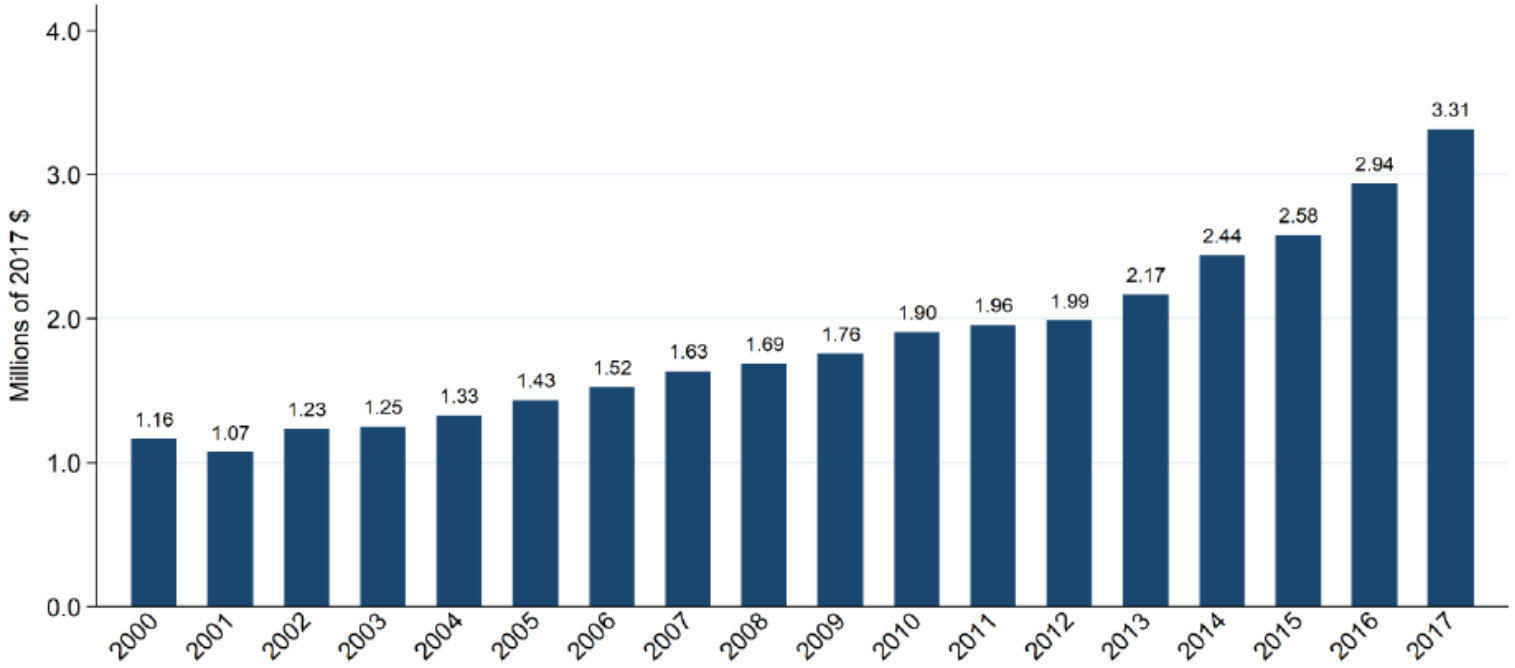
Zifeng Feng, Frostburg State University

Zhonghua Wu, Florida International University

Importance of Technology to Banking

- The banking industry has been one of the most technology-intensive industries in the U.S.
- More recently, technologies have become a critical component in bank operation
  - E.g., annual reports of the listed commercial banks
- Fresh evidence: only 7% of banks consider technology is slightly important or not important, based on the 2018 CSBS National Survey

Technology Spending Trend of U.S. Listed Commercial Banks



The trend is based on the median spending and adjusted in 2017 dollars

Prior Research on Bank Technology – What We Know

- Berger (2003): the effects of technological progress on productivity growth at the industry level & the impact on market structure.
- DeYoung (2010) : large banks are quicker than smaller community banks to adopt new technologies, so bank size matters.
- Recent research focuses on the impacts of FinTech companies on banks (e.g., Philippon, 2016).
- There is limited research on benefits of technology capital to the net output of banks at the firm level.

Prior Research on Bank Technology

- Another important issue is about the effect on bank employment.
  - ✓ A 2016 Citibank study: about 30% of banking jobs may be lost from 2015 to 2025.
  - ✓ Martin-Oliver et al. (2008): an additional 1 million Euro IT investment in Spanish banks may replace 25 bank employees.
  - ✓ However, Bessen (2015) shows use of ATMs do not eliminate bank teller jobs.

Broader Literature in Economics

- Technology investment can make labor redundant, impede employment through its **displacement effect** (e.g., Keynes, 1930) .

- Yet, others argue technology can enhance employment through its **productivity effect**.

- Acemoglu and Restrepo (2018) suggest technology adoption can *increase firm productivity and generate new tasks*, so it can increase employment

Motivation and Research Questions

Given the limited & mixed evidence, we examine two questions:

1. Bright side question: does technology adoption increase the net output of banks ***at the firm level***, if so, to which extent, given use of technology is costly? For banks with different size? Rural vs. Urban?

2. Dark-side question: does use of technology destroy banking jobs? Or, which effect plays a dominating role: the displacement effect or the productivity effect? If not, why?

These questions are important to community banks as they need to adapt, and remain competitive by adopting technology.

Data Sources

- Technology spending data: S&P Global Market Intelligence
  - US Listed Commercial banks from 2000-2017
  - Reliable data on bank technology spending and bank M&A activities
  - It includes data processing, Internet banking, ATM expenses, technology advices, software, and cloud-based services, etc.
  - We construct the annual technology capital measures using two different methods
- Firm-level financial data: Compustat database

Bank Production Function Estimation

Bank's net output ($Y_{i,t}$) is a function of its technology capital ($TK_{i,t}$), conventional capital ($CK_{i,t}$), and labor ($L_{i,t}$), in a Cobb-Douglas form.

$$y_{i,t} = \beta_{tk} tk_{i,t} + \beta_{ck} ck_{i,t} + \beta_l l_{i,t} + \upsilon_{i,t}$$

The variable of interest: β_{tk}, which measures the contribution of technology capital to the net output of banks.

Variables	(1) OP	(2) DPD	(3) FE	(4) OLS
Technology Capital, t_t	0.085***	0.112***	0.065***	0.067***
	(0.030)	(0.032)	(0.009)	(0.007)
	[2.78]	[3.44]	[7.25]	[9.63]
Conventional Capital, k_t	0.621***	0.452***	0.371***	0.449***
	(0.038)	(0.025)	(0.011)	(0.010)
	[16.25]	[17.71]	[34.39]	[42.90]
Labor, l_t	0.253***	0.428***	0.424***	0.435***
	(0.026)	(0.033)	(0.011)	(0.011)
	[9.74]	[12.90]	[37.32]	[41.13]
ρ	-	0.873***	0.630***	0.926***
	-	(0.024)	(0.009)	(0.005)
	-	[37.04]	[69.06]	[200.59]
Common factor	-	0.000	0.000	0.000
p-value: $\beta_{tk} + \beta_{ck} + \beta_l = 1$	0.285	0.812	0.000	0.000
Observations	6,149	7,151	7,151	7,151
Firms	770	781	781	781

Bank Production Function Estimation Results

Models:

- OP = Olley And Pakes (1996)
- DPD = Dynamic Panel Data
- FE = Fixed Effect
- OLS = Ordinary Least Squares

- **Technology capital makes an important contribution to bank productivity.**

Bank Production Function Results – Rural and Urban Banks

	Panel A. Rural Banks				*Panel B. Urban Banks*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**DPD**	**FE**	**OLS**	**OP**	**DPD**	**FE**	**OLS**	**OP**
Technology Capital, t_t	0.078***	0.062***	0.042***	0.024	0.021	0.087***	0.046***	0.097**
	(0.026)	(0.016)	(0.013)	(0.046)	(0.025)	(0.019)	(0.015)	(0.039)
	[3.04]	[3.79]	[3.36]	[0.53]	[0.86]	[4.52]	[3.08]	[2.50]
Conventional Capital, k_t	0.431***	0.391***	0.431***	0.512***	0.525***	0.372***	0.529***	0.588***
	(0.041)	(0.023)	(0.022)	(0.094)	(0.044)	(0.023)	(0.021)	(0.068)
	[10.46]	[16.65]	[19.19]	[5.45]	[11.96]	[16.41]	[24.83]	[8.62]
Labor, l_t	0.455***	0.461***	0.459***	0.264***	0.311***	0.290***	0.297***	0.297***
	(0.058)	(0.025)	(0.023)	(0.048)	(0.042)	(0.022)	(0.020)	(0.049)
	[7.83]	[18.18]	[20.31]	[5.51]	[7.45]	[13.48]	[14.80]	[6.12]
ρ	0.840***	0.639***	0.904***	-	0.898***	0.635***	0.939***	-
	(0.020)	(0.020)	(0.010)	-	(0.019)	(0.017)	(0.008)	-
	[41.66]	[31.95]	[88.20]	-	[46.33]	[36.33]	[110.72]	-
Common factor	0.000	0.195	0.000	-	0.002	0.007	0.000	-
p-value: $\beta_{tk} + \beta_{ck} + \beta_l = 1$	0.552	0.002	0.003	0.065	0.002	0.000	0.000	0.839
Observations	1,886	1,886	1,886	1,665	1,662	1,662	1,662	1,439
Firms	212	212	212	207	198	198	198	149

Technology investment benefits both rural and urban banks.

Bank Production Function Results – Post Financial Crisis Period

Panel A. Post Financial Crisis Period (2010-2017)								
	Tech Capital - Perpetual Inventory Model				*Tech Capital - Linear Depreciation Schedule*			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variables	**DPD**	**FE**	**OLS**	**OP**	**DPD**	**FE**	**OLS**	**OP**
Technology Capital, t_t	0.239***	0.133***	0.107***	0.131***	0.189***	0.103***	0.085***	0.127***
	(0.060)	(0.014)	(0.010)	(0.044)	(0.050)	(0.012)	(0.009)	(0.040)
	[4.00]	[9.73]	[11.00]	[2.96]	[3.79]	[8.36]	[9.81]	[3.14]
Conventional Capital, k_t	0.357***	0.307***	0.422***	0.631***	0.359***	0.310***	0.424***	0.681***
	(0.042)	(0.015)	(0.014)	(0.051)	(0.042)	(0.015)	(0.014)	(0.050)
	[8.45]	[20.80]	[29.99]	[12.33]	[8.47]	[20.92]	[30.04]	[13.64]
Labor, l_t	0.461***	0.394***	0.463***	0.194***	0.478***	0.404***	0.473***	0.193***
	(0.060)	(0.017)	(0.015)	(0.030)	(0.061)	(0.017)	(0.015)	(0.030)
	[7.69]	[23.10]	[29.92]	[6.50]	[7.85]	[23.78]	[30.63]	[6.51]
ρ	0.863***	0.458***	0.926***	-	0.850***	0.451***	0.926***	-
	(0.053)	(0.014)	(0.006)	-	(0.053)	(0.014)	(0.006)	-
	[16.41]	[32.13]	[151.80]	-	[16.13]	[31.63]	[150.75]	-
Common factor	0.000	0.000	0.000	-	0.000	0.000	0.000	-
p-value: $\beta_{tk} + \beta_{ck} + \beta_l = 1$	0.394	0.000	0.593	0.358	0.665	0.000	0.198	0.979
Observations	3,326	3,326	3,326	3,711	3,326	3,326	3,326	6,013
Firms	582	582	582	595	758	758	758	595

Technology plays a more important role in bank productivity in recent years.

Bank Technology and Employment

1. Obtain Residual Technology Spending (or Employment) using observations in each year

$$LnTechSpending_i = \beta_0 + \beta_1 Firm\ Size_i + \varepsilon_i$$

- Need to control for firm size - the most important determinant

2. Regress **Residual Employment** on **Residual Technology Spending**

$$ResEmployment_{i,t} = \beta_0 + \beta_1 ResTechSpending_{i,t-1} + \beta_2 MTB_{i,t-1} + \beta_3 Leverage_{i,t-1} + \beta_4 ROA_{i,t-1} + \beta_5 NonIntIncome_{i,t-1} + \beta_6 Tier1Capital\ Ratio_{i,t-1} + \eta_i + \alpha_t + \varepsilon_{i,t}$$

Bank Technology and Employment

Banks **investing more in technology** have **higher employment growth**

Controlling for firm size, growth strategy, financing, performance, fee income ratio, and financial strength.

Variables	(1) Number of Employees	(2) Staff Expense	(3) Number of Employees	(4) Staff Expense
Technology Spending, *t-1*	0.348***	0.380***	0.196***	0.202***
	(0.017)	(0.018)	(0.023)	(0.021)
	[19.93]	[21.28]	[8.49]	[9.65]
Market to Book, *t-1*			-0.196***	-0.227***
			(0.022)	(0.021)
			[-9.00]	[-10.73]
Leverage, *t-1*			0.015***	0.019***
			(0.004)	(0.003)
			[4.19]	[5.70]
Return on Assets, *t-1*			-6.813***	-7.910***
			(1.180)	(1.212)
			[-5.77]	[-6.53]
Non-Interest Income, *t-1*			0.499***	0.636***
			(0.108)	(0.107)
			[4.63]	[5.94]
Tier 1 Capital Ratio, *t-1*			-0.536*	-0.267
			(0.310)	(0.287)
			[-1.73]	[-0.93]
Constant	-0.036*	-0.029	0.095	0.042
	(0.022)	(0.021)	(0.072)	(0.069)
	[-1.65]	[-1.42]	[1.31]	[0.61]
Observations	6,302	6,892	5,570	6,078
Firms	742	780	708	743
R-squared	0.233	0.253	0.318	0.364
Size *t* Effects	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES
Year FE	YES	YES	YES	YES

Technology and Tasks

Bank tasks are ***positively*** associated with the lagged technology spending

It shows technology helps banks expand their business.

Variables	(1) Loans & Deposits	(2) Net Output	(3) # of Branches	(4) Loans & Deposits	(5) Net Output	(6) # of Branches
Technology Spending, *t-1*	0.308***	0.301***	0.324***	0.137***	0.161***	0.191***
	(0.016)	(0.016)	(0.017)	(0.019)	(0.020)	(0.022)
	[19.77]	[18.90]	[18.74]	[7.19]	[7.92]	[8.56]
Market to Book, *t-1*				-0.230***	-0.199***	-0.171***
				(0.019)	(0.019)	(0.021)
				[-12.40]	[-10.30]	[-8.04]
Leverage, *t-1*				0.020***	0.019***	0.014***
				(0.003)	(0.004)	(0.003)
				[5.83]	[5.12]	[4.96]
Return on Assets, *t-1*				-5.412***	-3.430***	-6.028***
				(1.105)	(1.153)	(1.084)
				[-4.90]	[-2.97]	[-5.56]
Non-Interest Income, *t-1*				-0.208**	-0.307***	-0.046
				(0.087)	(0.090)	(0.100)
				[-2.39]	[-3.40]	[-0.46]
Tier 1 Capital Ratio, *t-1*				-1.313***	-1.054***	-0.337
				(0.277)	(0.303)	(0.285)
				[-4.75]	[-3.48]	[-1.18]
Constant	-0.034*	-0.023	-0.023	0.284***	0.243***	0.134**
	(0.018)	(0.017)	(0.022)	(0.069)	(0.072)	(0.061)
	[-1.87]	[-1.35]	[-1.04]	[4.11]	[3.37]	[2.19]
Observations	6,903	6,903	6,753	6,086	6,086	5,974
Firms	780	780	774	743	743	737
R-squared	0.203	0.196	0.228	0.323	0.287	0.303
Size *t* Effects	YES	YES	YES	YES	YES	YES
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	YES	YES	YES	YES	YES	YES

Technology, Employment & Tasks – Rural and Urban Banks

Panel A. Employment and Technology Spending

	Rural Banks		*Urban Banks*	
Variables	(1) **Number of Employees**	(2) **Staff Expense**	(3) **Number of Employees**	(4) **Staff Expense**
Technology Spending, *t-1*	0.169***	0.163***	0.219***	0.231***
	(0.032)	(0.028)	(0.038)	(0.039)
	[5.27]	[5.87]	[5.79]	[5.97]

Panel B. Task and Technology Spending

	Rural Banks			*Urban Banks*		
Variables	(1) **Loans & Deposits**	(2) **Net Output**	(3) **Number of Branches**	(4) **Loans & Deposits**	(5) **Net Output**	(6) **Number of Branches**
Technology Spending, *t-1*	0.118***	0.138***	0.127***	0.152***	0.183***	0.223***
	(0.029)	(0.029)	(0.031)	(0.040)	(0.042)	(0.040)
	[4.13]	[4.70]	[4.10]	[3.82]	[4.34]	[5.52]

Robustness Checks: The Main Results Still Hold

- Use data from banks that are not involved with mergers and acquisitions activities (Non-M&A banks)
- Too-Big-To-Fail (TBTF) banks are excluded from the sample, size effect
- Banks recorded technology and communication expense in each year during 2000-2017
- Total income (net-interest income plus non-interest income) of banks as net output

Conclusions

- Technology capital contributes to the net output of banks based on a firm-level production function estimation, for rural and urban banks.
- A strong cross-sectional relation between bank employment/tasks and bank technology spending.
- These findings have potential policy implications:
  - Even if technologies are expensive, banks of all size and rural & urban banks should embrace technology, be adaptive as technology became more important after the financial crisis
  - Use of technology may not destroy bank employment as it can create new tasks