

Internet Appendix

IA1 Validation of the FinTech Score

IA1.1 Random Forest Model

In this section, we utilize classification algorithms in Machine Learning (ML) to validate the FinTech score calculated based on the two-stage algorithm. Unlike the two-stage algorithm, an ML algorithm is not susceptible to empirical difficulties caused by large numbers of independent observables. Neither does it impose a structural assumption about the relation between the dependent variable (i.e., the *FINTECH* dummy) and the independent variables. Rather, an ML algorithm can extract the target-oriented features embedded in a large set of observables through a nonlinear learning process. However, we should note several drawbacks of ML. It is challenging to determine which characteristics are most important in determining a bank's FinTech exposure. Furthermore, we lose most of the data in the training stage, which can substantially impact the analysis of operational efficiency. Given these considerable disadvantages, we consider ML an auxiliary method to validate the FinTech score estimated from the two-stage algorithm.

We focus on the Random Forest model, the most widely used classifier in ML. The Random Forest model can be understood as a collection of many random trees. Specifically, we randomly divide banks in our sample into a training sample and a test sample, with the former accounting for 75% of the banks and the latter consisting of the remaining 25%.¹ For each firm-quarter observation in the test sample, we calculate the probability of its involvement in FinTech operations, denoted *ML-RF*. We should note that, in contrast to a probability in the traditional sense, a probability given by the Random Forest model is an out-of-bag estimate. That is, it is defined as the proportion of the trees that vote for each class (i.e., the *FINTECH* dummy equal to either one or zero). If no tree shows that a bank is engaged in FinTech operations, then the probability is zero. Conversely, if every tree points to the bank's involvement in FinTech operations, then the probability is one. As such, a bank's FinTech score increases with the proportion of the trees pointing to its engagement in FinTech operations.

We examine whether the FinTech scores generated by the Random Forest model yield results consistent with those calculated using the two-stage algorithm. We compare the balance sheet attributes for the group of banks with a positive *ML-RF* as distinguished from those with a zero *ML-RF*. Table IA7 of the Internet Appendix shows that positive *ML-RF* banks have more broker-like activities (e.g., non-interest income, trading assets, securitization, brokered deposits) than banks with zero *ML-RF* (who dominate dealer-type activities such as small business lending and core deposits). Thus, the FinTech score independently estimated using a Random Forest approach displays the same distinctions between broker and dealer operations as those found using the FinTech scores obtained from the two-stage algorithm.

¹To avoid data snooping, we use the hyperparameters provided by the algorithm package in Python.

IA1.2 K-means Clustering

In this section, we employ an unsupervised clustering algorithm as another validation of our FinTech score. In unsupervised learning, the algorithms are not provided with any pre-assigned labels or scores for the training data. Therefore, this analysis clusters using our 85 financial variables and accounting ratios, excluding our FinTech score dummy variable. Among alternative clustering algorithms, we utilize K-means clustering as this model is scalable to large sample sizes. In K-means clustering, each cluster is defined by creating a centroid for each cluster. The centroids capture the closest points and add them to the cluster using an iterative clustering algorithm. The K-means algorithm aims to select centroids that minimize the within-cluster sum-of-squares criterion, also known as inertia, by utilizing the distances between data points. The output of the algorithm is a group of labels.

While unsupervised ML models help identify various structures or patterns in a collection of uncategorized data without supervision, their biggest drawback is that we cannot obtain precise information regarding data sorting. This suggests that clusters are not information. Due to this limitation, we restrict the number of clusters that the algorithm can identify to two. This allows us to compare the Call Report variables of banks clustered into two groups (a cluster of zeros and a cluster of ones).

We denote the FinTech score obtained using the K-means algorithm as *ML-UN*. Following the analysis presented in Panel A of Table 2, we provide results using *ML-UN* in Table IA8 of the Internet Appendix. In particular, we performed univariate analysis using quarterly observations in clusters of ones and zeros as defined by the K-means algorithm. We then compare the characteristics of these two bank clusters. The results are highly consistent with those of the FinTech score estimated from the two-stage algorithm presented in Table 2, Panel A, and the Random Forest model in Table IA7 of the Internet Appendix. For example, banks with higher *ML-UN* have significantly higher FinTech scores estimated from the baseline model, higher proportions of non-interest income, trading assets and brokered deposits, and lower proportions of small business loans and core deposits. Thus, the results of the K-means algorithm also provide methodological validation for the baseline algorithm.

IA1.3 Textual Analysis of SEC Filings

Banks may identify themselves as having FinTech operations in their public disclosure. We utilize a list of FinTech-related keywords based on the classifications of FinTech activities by [Chen et al. \(2019\)](#), and perform a textual analysis of traditional bank SEC filings (10-Q, 10-K, etc.) to detect each bank's self-identified integration with FinTech operations.² The number of keywords found in bank disclosures ranges between 0 and 306, with a mean of 1.42 and a standard deviation of 4.39. The keyword search results are skewed, as demonstrated by the sample median of 0.

²Since our keyword search relies on Edgar's SEC filings, we were limited to publicly traded banks to perform the validation exercise described in this subsection. If financial reports for publicly traded bank holding companies were not available on Edgar, we downloaded them manually using S&P's Capital IQ.

Table [IA9](#) of the Internet Appendix presents the quarterly univariate characteristics of banks with FinTech-related keywords in their SEC filings, compared to those without such keywords. The results are highly consistent with those of the FinTech score estimated from the two-stage algorithm, the Random Forest model, and the K-means algorithm. As an independent validation of the approach, the keyword search results indicate that banks that self-identify as FinTech have higher FinTech scores and more broker-like activities compared to the on-balance sheet activities of dealer banks with lower FinTech scores.

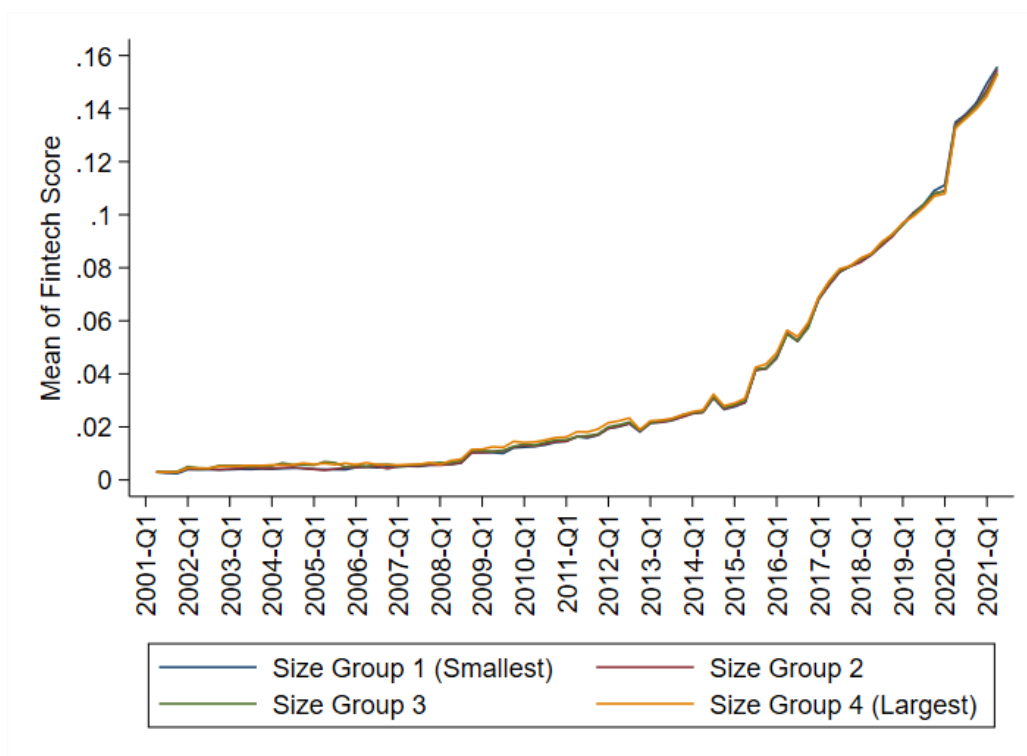


Fig. IA1. The Evolution of the FinTech Score by Size Group. This figure shows the evolution of the FinTech Score by asset size group. In each quarter, banks are divided into four size groups: total domestic assets below \$100 million (Size Group 1), between \$100 million and \$1 billion (Size Group 2), between \$1 billion and \$10 billion (Size Group 3), and higher than \$10 billion (Size Group 4).

Table IA1. List of Financial Variables Used in the Principal Component Analysis. This table lists the Call Report financial variables and accounting ratios used in the principal component analysis.

Item Number	Item Name
Balance Sheet Variables	
RCON2170	TOTAL ASSETS
RCON1763	COMMERCIAL AND INDUSTRIAL LOANS TO U.S. ADDRESSEES
RCON1480 ^a	REAL ESTATE LOANS SECURED BY NONFARM NONRESIDENTIAL PROPERTIES
RCONB538	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES (I.E.; CONSUMER LOANS)(INCLUDES PURCHASED PAPER); CREDIT CARDS
RCONB539	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES (I.E.; CONSUMER LOANS)(INCLUDES PURCHASED PAPER); OTHER REVOLVING CREDIT PLANS
RCON2011 ^b	OTHER LOANS
RCON1773	AVAILABLE-FOR-SALE DEBT SECURITIES (FROM SCHEDULE RC-B; COLUMN D)
RCON5366	LOANS AND LEASES HELD FOR SALE
RCONB528	LOANS AND LEASES, NET OF UNEARNED INCOME - TOTALS
RCON3123	ALLOWANCE FOR LOAN AND LEASE LOSSES
RCON3645	TRADING ASSETS; TOTAL
RCON3648	TRADING LIABILITIES; TOTAL
RCON3210	TOTAL EQUITY CAPITAL
RCON3945	LOANS FOR PURCHASING OR CARRYING SECURITIES
RCON3387	QUARTERLY AVERAGE OF COMMERCIAL AND INDUSTRIAL LOANS
RCONB561	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: CREDIT CARDS
RCONB562	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: OTHER
RCON1766	COMMERCIAL AND INDUSTRIAL LOANS
RCONB529	LOANS AND LEASES; NET OF UNEARNED INCOME AND ALLOWANCE
RCONA591	OUTSTANDING PRINCIPAL BALANCE OF LOANS OTHER THAN 1-4 FAMILY RESIDENTIAL MORTGAGE LOANS THAT ARE SERVICED FOR OTHERS
Income Variables	
RIAD4010	INTEREST AND FEE INCOME ON LOANS; TOTAL
RIAD4012	INTEREST AND FEE INCOME ON COMMERCIAL AND INDUSTRIAL LOANS
RIADB485	LOANS TO INDIVIDUALS FOR HOUSEHOLDS; FAMILY; AND OTHER PERSONAL EXPENDITURES: CREDIT CARDS
RIADB486	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES; OTHER (INCLUDES SINGLE PAYMENT; INSTALLMENT; ALL STUDENT LOANS; AND REVOLVING CREDIT PLANS OTHER THAN CREDIT CARDS)
RIADA220	TRADING REVENUE
RIAD4107	TOTAL INTEREST INCOME
RIAD4185	INTEREST ON TRADING LIABILITIES AND OTHER BORROWED MONEY
RIAD4073	TOTAL INTEREST EXPENSE
RIADB493	NET SECURITIZATION INCOME
RIAD5416	NET GAINS (LOSSES) ON SALES OF LOANS
RIAD4079	TOTAL NONINTEREST INCOME
RIAD3196	REALIZED GAINS (LOSSES) ON AVAILABLE-FOR-SALE DEBT SECURITIES
Pass Due Variables	
RCONB575	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: CREDIT CARDS - PAST DUE 30 THROUGH 89 DAYS AND STILL ACCRUING
RCONB576	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: CREDIT CARDS - PAST DUE 90 DAYS OR MORE AND STILL ACCRUING
RCONB577	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: CREDIT CARDS - NONACCRUAL
RCONB578 ^c	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: OTHER - PAST DUE 30 THROUGH 89 DAYS AND STILL ACCRUING
RCONB579 ^d	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: OTHER - PAST DUE 90 DAYS OR MORE AND STILL ACCRUING
RCONB580 ^e	LOANS TO INDIVIDUALS FOR HOUSEHOLD; FAMILY; AND OTHER PERSONAL EXPENDITURES: OTHER - NONACCRUAL
RCON5459	ALL OTHER LOANS - PAST DUE 30 THROUGH 89 DAYS AND STILL ACCRUING
RCON5460	ALL OTHER LOANS - PAST DUE 90 DAYS OR MORE AND STILL ACCRUING
RCON5461	ALL OTHER LOANS - NONACCRUAL
RCONB711	OUTSTANDING PRINCIPAL BALANCE OF ASSETS SOLD AND SECURITIZED WITH RECOURSE OR OTHER SELLER-PROVIDED CREDIT ENHANCEMENTS - ALL OTHER LOANS
RCONB557	ALLOWANCE FOR CREDIT LOSSES ON OFF-BALANCE SHEET CREDIT EXPOSURES
RCON3123/	ALLOWANCE FOR LOAN AND LEASE LOSSES/(LOANS AND LEASES HELD FOR SALE+LOANS AND LEASES; NET OF UNEARNED INCOME - TOTALS)
RCON5369+RCONB528)	LOANS AND LEASES HELD FOR SALE/(LOANS AND LEASES; NET OF UNEARNED INCOME - TOTALS
RCON5369/RCONB528	

^aRCON1480 until 2006Q4; Starting from 2007Q1: RCONF160+RCONF161.

^bRCON2011 until 2010Q4; Starting from 2011Q1: RCONK137+RCONK207.

^cRCONB578 until 2010Q4; Starting from 2011Q1: RCONK213+RCONK216.

^dRCONB579 until 2010Q4; Starting from 2011Q1: RCONKk214+RCONK217.

^eRCONB580 until 2010Q4; Starting from 2011Q1: RCONKk215+RCONK218.

Item Number	Item Name
Brokered Source of Funds Variables	
RCON2365/RCON2200	TOTAL BROKERED DEPOSITS/TOTAL ASSETS
Charge-offs Variables	
RIADB514	CHARGE-OFFS ON LOANS TO CREDIT CARDS
RIADB515	RECOVERIES ON LOANS TO CREDIT CARDS
RIADB516 ^f	CHARGE-OFF ON LOANS - OTHER
RIADB517 ^g	RECOVERIES ON LOANS - OTHER
RIADB522	BALANCE MOST RECENTLY REPORTED FOR THE DECEMBER 31, 2000; REPORTS OF CONDITION AND INCOME(1.E.; AFTER ADJUST-MENTS FROM AMENDED REPORT OF INCOME)
RIAD4605	RECOVERIES ON ALLOWANCE FOR LOAN AND LEASE LOSSES
RIADC079	CHARGE-OFFS ON ALLOWANCE FOR LOAN AND LEASE LOSSES
RIAD5523	WRITE DOWNS ARISING FROM TRANSFER TO HFS
RIAD4230	PROVISION FOR LOAN AND LEASE LOSSES
Capital Variables	
RCON7205	TOTAL RISK-BASED CAPITAL RATIO
Deposit Variables	
RCON2365	TOTAL BROKERED DEPOSITS
RCON2343+RCON2344 ^h	TOTAL BROKERED RETAIL DEPOSITS ISSUED IN DENOMINATIONS OF \$100,000 OR IN DENOMINATIONS GREATER THAN \$100,000 AND PARTICIPATED OUT BY THE ISSUED EITHER IN DENOMINATIONS OF \$100,000 OR LESS
RCON2200	BROKER IN SHARES OF \$100,000 OR LESS
RCONB550	TOTAL DEPOSITS
RCONB552	TOTAL NONTRANSACTION ACCOUNTS DEPOSITS OF INDIVIDUALS; PARTNERSHIPS; AND CORPORATIONS
RCONB549	TOTAL TRANSACTIONS ACCOUNTS - DEPOSITS OF INDIVIDUALS; PARTNERSHIPS; AND CORPORATION
RCONB551	TOTAL NONTRANSACTION ACCOUNTS - DEPOSITS OF COMMERCIAL BANKS AND OTHER DEPOSITORY INSTITUTIONS IN THE U.S.
RCON2385	TOTAL TRANSACTIONS ACCOUNTS (INCLUDING MMDA'S)
RCON2215	TOTAL NONTRANSACTION ACCOUNTS
RCONB550/RCON2385	TOTAL NONTRANSACTION ACCOUNTS DEPOSITS OF INDIVIDUALS; PARTNERSHIPS; AND CORPORATIONS/TOTAL NONTRANSACTION ACCOUNTS (INCLUDING MMDA'S)
RCONB551/RCON2385	TOTAL TRANSACTIONS ACCOUNTS - DEPOSITS OF COMMERCIAL BANKS AND OTHER DEPOSITORY INSTITUTIONS IN THE U.S./TOTAL NONTRANSACTION ACCOUNTS (INCLUDING MMDA'S)
RCONB552/RCON2385	TOTAL TRANSACTIONS ACCOUNTS - DEPOSITS OF COMMERCIAL BANKS AND OTHER DEPOSITORY INSTITUTIONS IN THE U.S./TOTAL NONTRANSACTION ACCOUNTS (INCLUDING MMDA'S)
RCON2365/RCON2385	TOTAL BROKERED DEPOSITS/TOTAL NONTRANSACTION ACCOUNTS (INCLUDING MMDA'S)
Quarterly Average Variables	
RCON3360	QUARTERLY AVERAGE OF TOTAL LOANS
RCON3368	QUARTERLY AVERAGE OF TOTAL ASSETS
RCON3485	TRANSACTION ACCOUNTS (IN DOMESTIC OFFICES) (NOW ACCOUNTS; ATS ACCOUNTS; AND TELEPHONE AND PREAUTHORIZED TRANSFER ACCOUNTS) - QUARTERLY AVERAGE
Real Estate Variables	
RCON5367	ALL OTHER LOANS SECURED BY 1-4 FAMILY RESIDENTIAL PROPERTIES: SECURED BY FIRST LIENS
RCON5368	ALL OTHER LOANS SECURED BY 1-4 FAMILY RESIDENTIAL PROPERTIES: SECURED BY JUNIOR LIENS
RCON1460	REAL ESTATE LOANS SECURED BY MULTI-FAMILY (5 OR MORE) RESIDENTIAL PROPERTIES
Securitization Variables	
RCON3818 ⁱ	UNUSED COMMITMENTS - OTHER
OBS Variables	
RCONJ457/RCON1766	OTHER UNUSED COMMITMENTS: COMMERCIAL AND INDUSTRIAL LOANS/COMMERCIAL AND INDUSTRIAL LOANS
RCONJ459/RCONK207	OTHER UNUSED COMMITMENTS: ALL OTHER UNUSED COMMITMENTS/OTHER CONSUMER LOANS TO INDIVIDUALS FOR HOUSEHOLD, FAMILY, AND OTHER PERSONAL EXPENDITURES (INCLUDES SINGLE PAYMENT, INSTALLMENT, AND ALL STUDENT LOANS)
RCONA591/RCON2170	OUTSTANDING PRINCIPAL BALANCE OF LOANS OTHER THAN 1-4 FAMILY RESIDENTIAL MORTGAGE LOANS THAT ARE SERVICED FOR OTHERS/TOTAL ASSETS
RCONB557/ (RCONJ457+RCONJ459)	ALLOWANCE FOR CREDIT LOSSES ON OFF-BALANCE SHEET CREDIT EXPOSURES/(OTHER UNUSED COMMITMENTS: COMMERCIAL AND INDUSTRIAL LOANS+OTHER UNUSED COMMITMENTS)
RCONB557/RCON2170	ALLOWANCE FOR CREDIT LOSSES ON OFF-BALANCE SHEET CREDIT EXPOSURES/TOTAL ASSETS
RCONB550/RCON2200	TOTAL NONTRANSACTION ACCOUNTS DEPOSITS OF INDIVIDUALS; PARTNERSHIPS; AND CORPORATIONS/TOTAL DEPOSITS
RCONB549/RCONB550	TOTAL TRANSACTIONS ACCOUNTS - DEPOSITS OF INDIVIDUALS; PARTNERSHIPS; AND CORPORATION/TOTAL NONTRANSACTION ACCOUNTS DEPOSITS OF INDIVIDUALS; PARTNERSHIPS; AND CORPORATIONS
RCONB552/RCON2200	TOTAL NONTRANSACTION ACCOUNTS OF COMMERCIAL BANKS AND OTHER DEPOSITORY INSTITUTIONS IN THE U.S./TOTAL DEPOSITS
RCONB551/RCON2200	TOTAL TRANSACTIONS ACCOUNTS - DEPOSITS OF COMMERCIAL BANKS AND OTHER DEPOSITORY INSTITUTIONS IN THE U.S./TOTAL DEPOSITS

^fRIADB516 until 2010Q4; Starting from 2011Q1: RIADK129+RIADK205.

^gRIADB517 until 2010Q4; Starting from 2011Q1: RIADK133+RIADK206.

^hRCON2343+RCON2344 until 2009Q4; Between 2010Q1-2016Q4: RCON2343+RCONJ472; Starting from 2017Q1: RCONHK05.

ⁱRCON3818 until 2009Q4; Since 2010Q1: RCONJ457+RCONJ458+RCONJ459.

Table IA2. Principal Component Analysis. This table presents the results of the principal component analysis for each size group. The principal component analysis is conducted for each year-quarter and each size group. For each of the listed principal components, the table presents the average proportion of variance explained by the principal component, and the cumulative proportion of variance explained. The financial variables and accounting ratios used in the principal component analysis are listed in Table IA1 of the Internet Appendix.

Size Group 1			Size Group 2			Subsample - Size 3			Subsample - Size 4		
Total Assets ≤ \$100 Mil			Total Assets ∈ (\$100 Mil, \$1 Bil]			Total Assets ∈ (\$1 Bil, \$10 Bil]			Total Assets > \$10 Bil		
PC	Prop.	Cum.	PC	Prop.	Cum.	PC	Prop.	Cum.	PC	Prop.	Cum.
1	0.175	0.175	1	0.202	0.202	1	0.215	0.215	1	0.382	0.382
2	0.080	0.254	2	0.098	0.300	2	0.118	0.334	2	0.139	0.521
3	0.063	0.317	3	0.063	0.363	3	0.064	0.398	3	0.071	0.592
4	0.053	0.370	4	0.051	0.413	4	0.055	0.452	4	0.056	0.648
5	0.043	0.413	5	0.039	0.452	5	0.044	0.496	5	0.045	0.693
6	0.037	0.449	6	0.034	0.486	6	0.038	0.535	6	0.037	0.730
7	0.032	0.482	7	0.031	0.517	7	0.033	0.568	7	0.032	0.762
8	0.029	0.511	8	0.028	0.545	8	0.030	0.598	8	0.028	0.790
9	0.027	0.538	9	0.025	0.571	9	0.027	0.624	9	0.025	0.815
10	0.025	0.563	10	0.024	0.594	10	0.025	0.649	10	0.022	0.837
11	0.023	0.587	11	0.022	0.616	11	0.023	0.672	11	0.019	0.856
12	0.022	0.608	12	0.020	0.636	12	0.021	0.693	12	0.017	0.873
13	0.020	0.628	13	0.018	0.654	13	0.019	0.712	13	0.015	0.888
14	0.019	0.647	14	0.017	0.671	14	0.018	0.730	14	0.014	0.901
15	0.017	0.664	15	0.016	0.687	15	0.017	0.747	15	0.012	0.913
16	0.016	0.680	16	0.015	0.701	16	0.016	0.763	16	0.011	0.924
17	0.015	0.695	17	0.014	0.715	17	0.015	0.777	17	0.010	0.934
18	0.014	0.709	18	0.013	0.729	18	0.014	0.791	18	0.009	0.943
19	0.013	0.723	19	0.013	0.742	19	0.013	0.805	19	0.008	0.950
20	0.013	0.736	20	0.012	0.754	20	0.013	0.817	20	0.007	0.957

Table IA3. Probit Estimation of the FinTech Score. This table presents the results of the quarterly probit regressions of the *FINTECH* dummy on the first 16 principal components estimated from the principal component analysis. The *FINTECH* dummy equals one starting from the quarter when a bank started its first FinTech integration, and zero before. Given space constraints, only the coefficients for the first principal component are reported. The complete regression results are available upon request. *t*-stats are in parentheses.

<i>FINTECH</i>									
	2001Q2	2001Q3	2001Q4	2002Q1	2002Q2	2002Q3	2002Q4	2003Q1	2003Q2
Prin1	0.089 (1.63)	0.105* (1.89)	0.047 (0.80)	0.105** (2.05)	0.132*** (2.85)	0.121*** (2.94)	0.145*** (2.91)	0.174*** (3.86)	0.156*** (3.42)
Obs.	8,685	8,654	8,589	8,511	8,469	8,430	8,377	8,351	8,319
Pesudo R^2	0.067	0.083	0.083	0.112	0.118	0.109	0.142	0.148	0.122
<i>FINTECH</i>									
	2003Q3	2003Q4	2004Q1	2004Q2	2004Q3	2004Q4	2005Q1	2005Q2	2005Q3
Prin1	0.139*** (2.90)	0.167*** (3.72)	0.133*** (2.62)	0.134*** (2.67)	0.077 (1.27)	0.170*** (4.26)	0.169*** (3.46)	0.165*** (3.40)	0.129*** (3.85)
Obs.	8,298	8,248	8,190	8,164	8,122	8,087	8,048	7,995	7,987
Pesudo R^2	0.113	0.118	0.121	0.130	0.117	0.131	0.123	0.191	0.125
<i>FINTECH</i>									
	2005Q4	2006Q1	2006Q2	2006Q3	2006Q4	2007Q1	2007Q2	2007Q3	2007Q4
Prin1	0.184*** (3.89)	0.149*** (3.14)	0.149*** (3.43)	0.122*** (2.53)	0.138*** (2.94)	0.130*** (3.00)	0.134*** (2.97)	0.123*** (2.77)	0.129*** (3.01)
Obs.	7,967	7,931	7,919	7,887	7,833	7,812	7,778	7,728	7,706
Pesudo R^2	0.107	0.109	0.075	0.096	0.141	0.095	0.102	0.068	0.074
<i>FINTECH</i>									
	2008Q1	2008Q2	2008Q3	2008Q4	2009Q1	2009Q2	2009Q3	2009Q4	2010Q1
Prin1	0.098** (2.12)	0.150*** (3.54)	0.137*** (3.30)	0.116*** (2.57)	0.122*** (3.49)	0.149*** (4.37)	0.136*** (3.82)	0.145*** (4.49)	0.098*** (2.85)
Obs.	7,659	7,622	7,564	7,495	7,448	7,403	7,319	7,247	7,177
Pesudo R^2	0.097	0.069	0.069	0.051	0.052	0.050	0.069	0.046	0.050
<i>FINTECH</i>									
	2010Q2	2010Q3	2010Q4	2011Q1	2011Q2	2011Q3	2011Q4	2012Q1	2012Q2
Prin1	0.129*** (3.89)	0.121*** (3.68)	0.115*** (3.56)	0.130*** (3.88)	0.128*** (3.99)	0.132*** (4.16)	0.149*** (4.86)	0.141*** (4.77)	0.131*** (4.49)
Obs.	7,078	7,020	6,927	6,851	6,804	6,748	6,719	7,308	7,245
Pesudo R^2	0.057	0.054	0.047	0.062	0.047	0.046	0.047	0.037	0.031

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*, **, and *** representing 10%, 5%, and 1% respectively.

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FINTECH									
	2012Q3	2012Q4	2013Q1	2013Q2	2013Q3	2013Q4	2014Q1	2014Q2	2014Q3
Prin1	0.131*** (4.60)	0.146*** (4.62)	0.142*** (4.68)	0.114*** (3.63)	0.118*** (3.91)	0.110*** (3.57)	0.090*** (2.91)	0.118*** (3.90)	0.128*** (4.78)
Obs.	7,180	6,981	6,924	6,845	6,795	6,718	6,639	6,568	6,590
Pesudo R^2	0.038	0.028	0.032	0.031	0.029	0.032	0.031	0.031	0.027
FINTECH									
	2014Q4	2015Q1	2015Q2	2015Q3	2015Q4	2016Q1	2016Q2	2016Q3	2016Q4
Prin1	0.141*** (4.88)	0.131*** (4.62)	0.125*** (4.44)	0.102*** (3.96)	0.105*** (3.94)	0.089*** (3.40)	0.088*** (3.68)	0.105*** (4.25)	0.102*** (4.19)
Obs.	6,422	6,337	6,265	6,188	6,101	6,049	6,058	5,905	5,837
Pesudo R^2	0.035	0.035	0.042	0.021	0.030	0.026	0.021	0.021	0.024
FINTECH									
	2017Q1	2017Q2	2017Q3	2017Q4	2018Q1	2018Q2	2018Q3	2018Q4	2019Q1
Prin1	0.114*** (4.90)	0.107*** (4.68)	0.100*** (4.42)	0.105*** (4.83)	0.114*** (5.12)	0.113*** (5.07)	0.115*** (5.30)	0.114*** (5.27)	0.110*** (5.01)
Obs.	5,785	5,719	5,668	5,602	5,538	5,467	5,402	5,330	5,287
Pesudo R^2	0.021	0.021	0.024	0.020	0.022	0.019	0.017	0.018	0.019
FINTECH									
	2019Q2	2019Q3	2019Q4	2020Q1	2020Q2	2020Q3	2020Q4	2021Q1	2021Q2
Prin1	0.118*** (5.41)	0.103*** (4.72)	0.127*** (5.87)	0.128*** (5.90)	0.096*** (4.55)	0.104*** (4.92)	0.104*** (4.96)	0.114*** (5.46)	0.126*** (6.13)
Obs.	5,231	5,184	5,105	5,035	4,988	4,955	4,924	4,899	4,872
Pesudo R^2	0.017	0.015	0.019	0.022	0.015	0.015	0.015	0.022	0.015

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA4. FinTech Score and Bank Efficiency: Correlation Matrix. This table shows the correlation matrix for *FINTECH_SCORE (quarterly)*, *FINTECH_SCORE (pooled)* and operational efficiency measures. The sample spans the period from Q2 2001 to Q2 2021. The observations are at the bank-quarter level. *FINTECH_SCORE (quarterly)* is a bank's FinTech score derived using quarterly probit estimation in the second step. *FINTECH_SCORE (pooled)* is a bank's FinTech score derived using pooled probit estimation in the second step. *DEA_EFF* is the bank's operational efficiency calculated using the Data Envelopment Analysis. *SFA_EFF* is the bank's operational efficiency estimated using the Stochastic Output Distance Function.

	<i>SFA_EFF</i>	<i>DEA_EFF</i>	<i>FINTECH_SCORE (quarterly)</i>
<i>DEA_EFF</i>	0.219***		
<i>FINTECH_SCORE (quarterly)</i>	0.166***	0.187***	
<i>FINTECH_SCORE (pooled)</i>	0.168***	0.186***	0.973***

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA5. List of Banks with Highest Fintech Scores. This table presents the list of banks with the highest average FinTech scores during the sample period, including examples of their selected FinTech activities.

Bank Name	Avg. FinTech Score	Selective FinTech Activities
FIRST NB	0.61	eStore platform named Best Digital Initiative Nationally Among the first banks nationwide to integrate Zelle's real-time P2P transfers CardGuard debit-card security controls "Clicks-to-Bricks" omnichannel strategy Partnered with Fiserv to develop and enhance digital banking platform
BANKERS BK OF THE WEST	0.52	"Easier Instant Payments" advisory and funding-agent services RTP Network funding-agent partnership FedNow & RTP Settlement Solutions
WELLS FARGO FNCL BK	0.45	Collaboration with TradeSun to integrate AI into trade finance operations Partnership with Google Cloud to offer a virtual assistant Partnered with Q2 Holdings to develop new commercial banking platform Startup Accelerator: added Ascent RegTech & Motiv (AI/IoT) Startup Accelerator: added Extend & Oliver (digital payments/legal innovation)
PITNEY BOWES BK	0.42	Modernized online banking platform and mobile solutions
COMENITY CAPITAL BANK	0.42	EasyPay for bill payments without requiring a login Mobile and web channels as primary delivery Buy now pay later
HATCH BK	0.39	Initial rollout of Hatch Business Checking accounts Virtual debit cards, ACH, bill pay, and digital-check capabilities via Hatch's web & mobile dashboard
MAPLEMARK BK	0.39	First U.S. bank to integrate term-deposit technology via Raisin's SaaS Partnership with Raisin, a Berlin-based deposit marketplace, to launch customizable CDs in the U.S. Modern online banking navigation
FARM BUREAU BK FSB	0.38	Collaboration with Funding Circle to boost small business lending Partnership with FinTech lender StreeShares Utilizing Finastra's Fusion Phoenix core banking system to optimize innovation and growth strategies
LEAD BK	0.35	Implemented cloud-based API platform with Slalom Collaboration with Finzly and PointChain for BaaS Powering money movement, loans, and payments for FinTechs and crypto startups (e.g., Affirm) Partnership with Ramp for BaaS Flex loan accounts transferred to Lead Bank Featured on Forbes Fintech 50 and GGV Capital's Embedded Fintechs 50 for BaaS innovation
UNIVERSITY BK	0.34	Participating Zelle partner Partnered with ZSuite Tech to streamline commercial lending processes Selected as a top performer in bank transformation by Cornerstone Advisors
MINNESOTA B&T	0.32	Digital wallet integration, biometric security, and tokenization Part of the Minnesota Technology Network, a platform for technology professionals

Table IA6. FinTech Score Variance Decomposition. This table examines how bank *FINTECH_SCORE* is explained by time fixed effects, bank fixed effects, and bank size. Observations are at the bank-quarter level. $\ln(ASSETS)$ is the natural logarithm of bank total assets.

	<i>FINTECH_SCORE</i>				
	(1)	(2)	(3)	(4)	(5)
Year-quarter FE	+		+	+	+
Bank FE		+	+		+
$\ln(ASSETS)$				+	+
Observations	561,112	561,028	561,028	561,112	561,028
Adjusted R^2	0.879	0.135	0.912	0.883	0.914

Table IA7. Comparison of Broker vs. Dealer Variables For Banks with Zero and Positive FinTech Scores Estimated from the Random Forest Model. This table compares the broker vs. dealer characteristics across banks with different FinTech scores calculated through the Random Forest model. Quarterly observations are divided into a group with FinTech scores greater than zero (i.e., positive possibility of engaging in FinTech operations) and a group with FinTech scores equal to zero (i.e., zero possibility of engaging in FinTech operations). The difference in the means of each characteristic between the two groups is shown in the second column and the t-test statistics are shown in the third column.

Variable Description	Positive – Zero	t-stat
FinTech score from two-stage model	0.007***	50.45
Non-interest income		
Non-interest Income/Total Income (%)	1.177***	6.70
Trading Assets		
Total Held to Maturity Securities/Total Assets (%)	0.078*	1.80
Total Available for Sale Securities/Total Assets (%)	1.890***	15.60
Total Trading Assets/Total Assets (%)	0.087***	11.00
Securitization and Off-Balance Sheet Activities		
Other Assets Serviced for Others (Excl. 1-4 Family Mortgage)/Total Assets (%)	1.428***	3.95
Ownership Interest in Securitized Credit Card Loans/Total Credit Card Loans (%)	0.119***	3.15
Ownership Interest in Securitized C&I Loans/Total C&I Loans (%)	-0.006	-0.60
Unused Off-balance Sheet C&I Loan Commitments/Total C&I Loans (%)	76.930	1.30
All Other Unused OBS Commitments/Total Other Consumer Loans (%)	5,652**	1.95
Allowance for Credit Losses on OBS Exposures/Other Unused OBS Loan Commit. (%)	0.012***	8.80
On-Balance Sheet Lending		
C&I loans<\$100,000 Original Amt./Total C&I Loans (%)	-1.331***	-15.00
Average Loan Size for C&I loans<\$100,000 Original Amount (\$ k)	0.235***	5.00
Brokered Deposits		
Brokered Deposits/Total Assets (%)	0.276***	15.70
Brokered Deposits<\$100k/Total Assets (%)	0.501***	7.40
Brokered Deposits \$100k-250k & Some IRAs/Total Deposits (%)	0.201***	8.35
Non-brokered Deposits Obtained via Deposit Listing Services/Total Deposits (%)	0.131***	4.90
Core Deposits/Total Assets (%)	-0.361***	-8.05

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA8. Comparison of Broker vs. Dealer Variables Using FinTech Scores Estimated from Unsupervised Machine Learning Model. This table compares the broker vs. dealer characteristics across banks with different FinTech scores calculated from the K-means algorithm. Quarterly observations are divided into a cluster of ones and a cluster of zeros, both defined by the K-means algorithm. The difference in the means of each characteristic between the two groups is shown in the second column, and the t-test statistics are shown in the third column.

Variable Description	C1 – C0	t-stat
FinTech score from two-stage model	0.019***	39.35
Non-interest income		
Non-interest Income/Total Income (%)	38.637***	84.60
Trading Assets		
Total Held to Maturity Securities/Total Assets (%)	-0.063	-0.75
Total Available for Sale Securities/Total Assets (%)	-9.086***	-39.60
Total Trading Assets/Total Assets (%)	2.149***	153.2
Securitization and Off-Balance Sheet Activities		
Other Assets Serviced for Others (Excl. 1-4 Family Mortgage)/Total Assets (%)	-0.760	-1.2
Ownership Interest in Securitized Credit Card Loans/Total Credit Card Loans (%)	3.184***	20.95
Ownership Interest in Securitized C&I Loans/Total C&I Loans (%)	0.009	0.60
Unused Off-balance Sheet C&I Loan Commitments/Total C&I Loans (%)	-200.878*	-1.90
All Other Unused OBS Commitments/Total Other Consumer Loans (%)	-650.499	-0.15
Allowance for Credit Losses on OBS Exposures/Other Unused OBS Loan Commit. (%)	-0.075***	-31.55
On-Balance Sheet Lending		
C&I loans<\$100,000 Original Amt./Total C&I Loans (%)	-9.849***	-27.25
Average Loan Size for C&I loans<\$100,000 Original Amount (\$ k)	6.103***	29.15
Brokered Deposits		
Brokered Deposits/Total Assets (%)	0.560***	10.60
Brokered Deposits<\$100k/Total Assets (%)	-0.484**	-2.30
Brokered Deposits \$100k-250k & Some IRAs/Total Deposits (%)	2.040***	23.40
Non-brokered Deposits Obtained via Deposit Listing Services/Total Deposits (%)	13.437***	149.85
Core Deposits/Total Assets (%)	-40.294***	-326.35

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA9. Comparison of Broker vs. Dealer Variables Between Banks with Zero and Positive FinTech-Related Keywords. This table compares the characteristics across banks with different numbers of FinTech keywords in the quarterly SEC filings. Quarterly observations are divided into a group with positive numbers of FinTech keywords (i.e., positive possibility of engaging in FinTech operations) and a group with numbers of FinTech keywords equal to zero (i.e., zero possibility of engaging in FinTech operations). The difference in the means of each characteristic between the two groups is shown in the second column and the t-test statistics are shown in the third column.

Variable Description	Positive – Zero	t-stat
FinTech score from two-stage model	0.033***	84.80
Non-interest income		
Non-interest Income/Total Income (%)	6.418***	15.60
Trading Assets		
Total Held to Maturity Securities/Total Assets (%)	3.616***	15.9
Total Available for Sale Securities/Total Assets (%)	14.384***	27.55
Total Trading Assets/Total Assets (%)	0.565***	15.25
Securitization and Off-Balance Sheet Activities		
Other Assets Serviced for Others (Excl. 1-4 Family Mortgage)/Total Assets (%)	7.080***	5.85
Ownership Interest in Securitized Credit Card Loans/Total Credit Card Loans (%)	1.267***	9.80
Ownership Interest in Securitized C&I Loans/Total C&I Loans (%)	0.011	0.90
Unused Off-balance Sheet C&I Loan Commitments/Total C&I Loans (%)	-314.353	-1.15
All Other Unused OBS Commitments/Total Other Consumer Loans (%)	87,663***	3.25
Allowance for Credit Losses on OBS Exposures/Other Unused OBS Loan Commit. (%)	0.076***	-31.55
On-Balance Sheet Lending		
C&I loans<\$100,000 Original Amt./Total C&I Loans (%)	-4.638***	-25.70
Average Loan Size for C&I loans<\$100,000 Original Amount (\$ k)	-1.338***	-9.65
Brokered Deposits		
Brokered Deposits/Total Assets (%)	1.110***	17.45
Brokered Deposits<\$100k/Total Assets (%)	3.248***	14.55
Brokered Deposits \$100k-250k & Some IRAs/Total Deposits (%)	0.817***	8.55
Non-brokered Deposits Obtained via Deposit Listing Services/Total Deposits (%)	-0.122***	-2.55
Core Deposits/Total Assets (%)	-0.078	-0.40

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA10. Univariate Analysis of Survivorship Bias. This table presents the comparison of *FINTECH_SCORE* between the top and bottom quartiles of operational efficiency measures for banks that survived throughout the sample period (81 quarters). The sample spans the period from Q2 2001 to Q2 2021. The observations are at the bank-quarter level. *FINTECH_SCORE* is a bank's FinTech Score derived using the two-step non-linear estimation methodology. *DEA_EFF* is the bank's operational efficiency calculated using the Data Envelopment Analysis. *SFA_EFF* is the bank's operational efficiency estimated using the Stochastic Output Distance Function.

Variable	<i>DEA_EFF</i> 1st Quartile		<i>DEA_EFF</i> 4th Quartile		Q4-Q1	<i>t</i> -stat
	Obs.	Mean	Obs.	Mean		
<i>FINTECH_SCORE</i>	79,705	0.040	79,706	0.031	0.009***	41
Variable	<i>SFA_EFF</i> 1st Quartile		<i>SFA_EFF</i> 4th Quartile		Q4-Q1	<i>t</i> -stat
	Obs.	Mean	Obs.	Mean		
<i>FINTECH_SCORE</i>	79,136	0.038	79,383	0.032	0.007***	31.35

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA11. Regressions of Survivorship Bias. This table presents the results of a balanced analysis of bank operational efficiency for banks that survive throughout the entire sample period (81 quarters). The period of the analysis is from Q2 2001 to Q2 2021. The observations are at the bank-quarter level. *DEA_EFF* is the bank's operational efficiency calculated using the Data Envelopment Analysis. *SFA_EFF* is the bank's operational efficiency estimated using the Stochastic Output Distance Function. *FINTECH_SCORE* is a bank's FinTech Score derived using the two-step non-linear estimation methodology. *ln(ASSETS)* is the natural logarithm of total assets. *CAPITAL* is the ratio of book equity to total assets. *ASSET_QUALITY* is the ratio of non-current loans and leases that are past due for at least ninety days to total assets. *MGMT_QUALITY* is the ratio of overhead expenses to total assets. *EARNINGS* is the ratio of net income to total assets. *LIQUIDITY* is the ratio of cash to total assets. *SENSITIVITY* is the ratio of the absolute difference between short-term assets and short-term liabilities to total assets. *HHI* is the weighted-average Herfindahl-Hirschman Index of deposit market across the bank's markets, where the weight is the bank's share of deposits in each county where the bank has branches. All independent variables are lagged by one quarter. Standard errors are clustered at the bank level, and *t*-stats are shown in parentheses.

	<i>DEA_EFF</i>			<i>SFA_EFF</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Fractional Response	Fixed Effects	OLS	Fractional Response	Fixed Effects
<i>FINTECH_SCORE</i>	3.788*** (24.45)	3.807*** (22.99)	3.223*** (24.13)	0.492*** (10.58)	0.678*** (12.94)	0.236*** (7.43)
<i>ln(ASSETS)</i>	0.170*** (7.64)	0.182*** (7.62)	0.922*** (23.04)	0.175*** (17.66)	0.134*** (12.85)	0.096*** (5.88)
<i>ln(ASSETS)²</i>	-0.006*** (6.91)	-0.007*** (6.96)	-0.038*** (22.51)	-0.006*** (14.56)	-0.004*** (9.58)	-0.002*** (3.52)
<i>CAPITAL</i>	0.225*** (3.75)	0.233*** (3.63)	0.164** (2.31)	-0.062 (1.54)	-0.063 (1.44)	0.114** (2.10)
<i>ASSET_QUALITY</i>	0.173 (1.12)	0.202 (1.28)	-0.253** (2.09)	-1.219*** (14.39)	-0.984*** (13.61)	-1.682*** (23.04)
<i>MGMT_QUALITY</i>	-0.478 (0.94)	-0.456 (0.83)	-0.166 (0.56)	0.943 (1.61)	1.502* (1.80)	1.211*** (3.12)
<i>EARNING</i>	1.708*** (5.93)	1.786*** (5.92)	0.774*** (3.49)	8.597*** (30.05)	8.593*** (22.90)	6.641*** (33.90)
<i>LIQUIDITY</i>	-0.388*** (20.38)	-0.409*** (19.49)	-0.327*** (19.59)	-0.133*** (11.92)	-0.116*** (11.76)	-0.136*** (13.67)
<i>SENSITIVITY</i>	-0.107*** (7.89)	-0.107*** (7.83)	-0.071*** (5.57)	-0.019*** (2.80)	-0.022*** (3.12)	-0.029*** (5.62)
<i>HHI</i>	-0.065*** (4.62)	-0.066*** (4.58)	0.048* (1.70)	0.053*** (8.24)	0.048*** (7.67)	-0.004 (0.35)
Bank FE	-	-	+	-	-	+
Year-quarter FE	+	+	+	+	+	+
Observations	314,865	314,865	314,865	313,503	313,503	313,503
Adjusted <i>R</i> ²	0.20	.	0.22	0.47	.	0.41

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA12. FinTech Score and Bank Efficiency: Multivariate Analysis. This table presents the results of a multivariate analysis of bank operational efficiency. The period of the analysis is from Q2 2001 to Q2 2021. The observations are at the bank-quarter level. *DEA_EFF* is the bank's operational efficiency calculated using the Data Envelopment Analysis. *SFA_EFF* is the bank's operational efficiency estimated using the Stochastic Output Distance Function. *FINTECH_SCORE (pooled)* is a bank's FinTech Score derived using pooled probit estimation in the second step. *ln(ASSETS)* is the natural logarithm of total assets. *CAPITAL* is the ratio of book equity to total assets. *ASSET_QUALITY* is the ratio of non-current loans and leases that are past due to at least ninety days to total assets. *MGMT_QUALITY* is the ratio of overhead expenses to total assets. *EARNINGS* is the ratio of net income to total assets. *LIQUIDITY* is the ratio of cash to total assets. *SENSITIVITY* is the ratio of the absolute difference between short-term assets and short-term liabilities to total assets. *HHI* is the weighted-average Herfindahl-Hirschman Index of deposit market across the bank's markets, where the weight is the bank's share of deposits in each county where the bank has branches. All independent variables are lagged by one quarter. Standard errors are clustered at the bank level, and *t*-stats are shown in parentheses.

	<i>DEA_EFF</i>			<i>SFA_EFF</i>		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	Fractional Response	Fixed Effects	OLS	Fractional Response	Fixed Effects
<i>FINTECH_SCORE (pooled)</i>	4.649*** (34.11)	4.835*** (31.62)	4.553*** (35.65)	0.681*** (14.32)	0.956*** (17.58)	0.443*** (11.22)
<i>ln(ASSETS)</i>	0.041*** (3.23)	0.046*** (3.19)	0.614*** (19.31)	0.151*** (25.77)	0.124*** (22.67)	0.142*** (11.78)
<i>ln(ASSETS)²</i>	-0.000 (0.75)	-0.001 (1.04)	-0.026*** (19.17)	-0.005*** (20.67)	-0.004*** (16.83)	-0.004*** (7.64)
<i>CAPITAL</i>	0.230*** (7.90)	0.236*** (7.82)	0.115*** (3.69)	-0.182*** (7.51)	-0.164*** (6.92)	-0.013 (0.50)
<i>ASSET_QUALITY</i>	-0.377*** (4.01)	-0.363*** (3.79)	-0.687*** (9.09)	-1.130*** (19.31)	-0.924*** (18.01)	-1.626*** (31.38)
<i>MGMT_QUALITY</i>	-0.003 (0.01)	0.066 (0.22)	-0.558*** (3.18)	0.716*** (2.44)	1.332*** (3.22)	1.023*** (4.86)
<i>EARNING</i>	1.118*** (7.44)	1.187*** (7.63)	0.387*** (3.50)	8.894*** (55.70)	8.636*** (43.57)	6.213*** (51.57)
<i>LIQUIDITY</i>	-0.328*** (20.70)	-0.347*** (20.20)	-0.284*** (22.34)	-0.122*** (12.95)	-0.108*** (12.41)	-0.130*** (16.79)
<i>SENSITIVITY</i>	-0.099*** (10.74)	-0.098*** (10.61)	-0.108*** (11.06)	-0.008* (1.72)	-0.013*** (2.76)	-0.031*** (7.12)
<i>HHI</i>	-0.037*** (3.33)	-0.036*** (3.21)	0.033 (1.34)	0.075*** (14.08)	0.070*** (13.20)	0.003 (0.34)
Bank FE	-	-	+	-	-	+
Year-quarter FE	+	+	+	+	+	+
Observations	543,967	543,967	543,967	532,568	532,568	532,568
Adjusted <i>R</i> ²	0.21	.	0.21	0.46	.	0.40

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA13. The Specialness of FinTech: The Role of FinTech Beyond Other Factors of Productivity. This table examines the relation between operational efficiency and the FinTech score after controlling for the effect of other productivity factors, including labor, capital, and land. *SALARY* is the salaries of employee benefits scaled by the income before income taxes and discontinued operations. *FIXED_EXP* is the expenses of premises and fixed assets (net of rental income) scaled by income before income taxes and discontinued operations. We include the squares of *SALARY* and *FIXED_EXP* to allow a non-linear relation between these factors of productivity and operational efficiency. We include the interaction between *SALARY* and *FIXED_EXP* to allow a translog production function. All other variables are defined in Appendix Table 10. Standard errors are clustered at the bank level, and *t*-stats are shown in parentheses.

Dependent Variable:	<i>DEA_EFF</i>			<i>SFA_EFF</i>		
	OLS	Fractional Response	Fixed Effects	OLS	Fractional Response	Fixed Effects
	(1)	(2)	(3)	(4)	(5)	(6)
<i>FINTECH_SCORE</i>	3.367*** (33.23)	3.477*** (30.57)	2.946*** (32.02)	0.489*** (13.96)	0.635*** (15.10)	0.311*** (13.28)
<i>SALARY</i>	-0.018*** (-8.56)	-0.019*** (-8.50)	-0.015*** (-9.63)	-0.047*** (-46.12)	-0.041*** (-45.35)	-0.033*** (-41.23)
<i>SALARY</i> ²	0.001*** (5.48)	0.001*** (5.06)	0.001*** (8.36)	0.002*** (26.75)	0.002*** (26.57)	0.001*** (25.62)
<i>FIXED_EXP</i>	0.029*** (3.65)	0.031*** (3.74)	0.036*** (5.79)	0.084*** (22.70)	0.075*** (23.29)	0.028*** (9.61)
<i>FIXED_EXP</i> ²	-0.002 (-1.38)	-0.003 (-1.64)	-0.001 (-0.92)	-0.002** (-2.35)	-0.002** (-2.17)	0.005*** (6.55)
<i>SALARY</i> × <i>FIXED_EXP</i>	-0.000 (-0.17)	0.000 (0.19)	-0.001*** (-3.14)	-0.003*** (-6.51)	-0.003*** (-7.10)	-0.003*** (-9.48)
Other Controls	+	+	+	+	+	+
Bank FE	-	-	+	-	-	+
Year-quarter FE	+	+	+	+	+	+
Observations	494,399	494,399	494,399	494,874	494,874	494,874
Adjusted <i>R</i> ²	0.208		0.200	0.476		0.414

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA14. FinTech Score and Operational Efficiency: Propensity Score Matching. This table compares the operational efficiency of banks with and without FinTech activities using propensity score matching. *DEA_EFF* is the bank's operational efficiency calculated using the Data Envelopment Analysis. *SFA_EFF* is the bank's operational efficiency estimated using the Stochastic Output Distance Function. In each quarter, banks with FinTech activities (*FINTECH*=1, treated) are matched with banks without FinTech activities (*FINTECH*=0, controlled) by their FinTech scores. We apply a nearest-neighbor matching with common support and a caliber distance of 0.1 of the standard deviation of the probit of the propensity score. For the matched sample, we calculate the average operational efficiency of the treated and control groups and compare the statistical difference.

Variable	Treated Mean	Control Mean	Difference	<i>p</i> -value
<i>DEA_EFF</i>	0.484	0.478	0.006	0.031
<i>SFA_EFF</i>	0.809	0.806	0.003	0.060

Table IA15. The Information Friction Channel. This table examines the heterogeneous effects of the FinTech score on operational efficiency. The samples in Columns 1 and 2 include banks that remained publicly traded or privately owned throughout the sample period. The samples in Columns 3 and 4 include privately owned banks that are either owned by a BHC or stand-alone throughout the sample period and exclude the smallest size group, whose task complexity and information frictions are considered the lowest. *PRIVATE* is an indicator variable that equals one if the bank is privately owned and zero if it is publicly traded or owned by a publicly traded BHC. *STANDALONE* is an indicator variable that equals one if the bank is a standalone bank and zero if a BHC owns it. $\ln(ASSETS)$ is the natural logarithm of total assets. *CAPITAL* is the ratio of book equity to total assets. *ASSET_QUALITY* is the ratio of non-current loans and leases that are past due for at least ninety days to total assets. *MGMT_QUALITY* is the ratio of overhead expenses to total assets. *EARNINGS* is the ratio of net income to total assets. *LIQUIDITY* is the ratio of cash to total assets. *SENSITIVITY* is the ratio of the absolute difference between short-term assets and short-term liabilities to total assets. *HHI* is the weighted-average Herfindahl-Hirschman Index of deposit market across the bank's markets, where the weight is the bank's share of deposits in each county where the bank has branches. Standard errors are clustered at the bank level, and *t*-stats are shown in parentheses.

Dependent Variable:	<i>DEA_EFF</i>	<i>SFA_EFF</i>	<i>DEA_EFF</i>	<i>SFA_EFF</i>
	(1)	(2)	(3)	(4)
<i>FINTECH_SCORE</i>	1.201*** (7.28)	0.203*** (3.97)	1.759*** (15.07)	0.032 (0.97)
<i>FINTECH_SCORE</i> $\times$ <i>PRIVATE</i>	1.910*** (12.89)	0.097* (1.93)		
<i>FINTECH_SCORE</i> $\times$ <i>STANDALONE</i>			0.372*** (4.50)	0.164*** (4.66)
$\ln(ASSETS)$	0.560*** (13.39)	0.110*** (7.85)	0.931*** (10.72)	0.423*** (12.00)
$\ln(ASSETS)^2$	-0.023*** (-13.09)	-0.002*** (-4.24)	-0.035*** (-10.09)	-0.014*** (-10.41)
<i>CAPITAL</i>	0.157*** (4.69)	-0.013 (-0.46)	0.057 (0.83)	0.068** (2.24)
<i>ASSET_QUALITY</i>	-0.660*** (-8.55)	-1.584*** (-29.90)	-0.163* (-1.94)	-1.691*** (-20.57)
<i>MGMT_QUALITY</i>	-0.378* (-1.94)	1.117*** (4.94)	-0.121 (-0.36)	1.073*** (3.88)
<i>EARNING</i>	0.503*** (4.24)	6.294*** (48.91)	0.996*** (6.10)	5.532*** (32.56)
<i>LIQUIDITY</i>	-0.316*** (-24.24)	-0.133*** (-16.83)	-0.201*** (-11.69)	-0.103*** (-10.15)
<i>SENSITIVITY</i>	-0.103*** (-10.24)	-0.032*** (-7.20)	-0.057*** (-4.51)	-0.037*** (-6.46)
<i>HHI</i>	0.035 (1.38)	0.002 (0.20)	0.005 (0.14)	-0.001 (-0.11)
Bank FE	+	+	+	+
Year-quarter FE	+	+	+	+
Observations	505,337	495,541	228,054	224,619
Adjusted R^2	0.205	0.402	0.603	0.506

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA16. Competitive Pressure, FinTech Dummy, and Operational Efficiency. This table explores the impact of competitive pressure on *FINTECH* dummy and the implications on operational efficiency. Column 1 examines the impact of competitive pressure on a bank's *FINTECH* dummy. *FINTECH* is a dummy variable that equals one starting from the date when the bank established a FinTech connection, and zero otherwise. *COMP_FT* is the increase in bank competitors' average *FINTECH_SCORE* from 12 quarters before to 8 quarters before (t_8-t_{12}), where competitor banks are defined as all other banks that operate in the same state, within the same size group and year-quarter as the focal bank. Columns 2 and 3 report the results of estimating Equation 1 using the fitted value of the *FINTECH* dummy from column 1 as the main independent variable. $\ln(ASSETS)$ is the natural logarithm of total assets. *CAPITAL* is the ratio of book equity to total assets. *ASSET_QUALITY* is the ratio of non-current loans and leases that are past due for at least ninety days to total assets. *MGMT_QUALITY* is the ratio of overhead expenses to total assets. *EARNINGS* is the ratio of net income to total assets. *LIQUIDITY* is the ratio of cash to total assets. *SENSITIVITY* is the ratio of the absolute difference between short-term assets and short-term liabilities to total assets. *HHI* is the weighted-average Herfindahl-Hirschman Index of deposit market across the bank's markets, where the weight is the bank's share of deposits in each county where the bank has branches. All independent variables are lagged by one quarter. Standard errors are clustered at the bank level, and *t*-stats are shown in parentheses.

	<i>FINTECH</i>	<i>DEA_EFF</i>	<i>SFA_EFF</i>
	(1)	(2)	(3)
<i>COMP_FT</i>	13.380*** (16.50)		
$\widehat{FINTECH}$		0.021*** (2.84)	0.008* (1.84)
$\ln(ASSETS)$	0.023 (0.11)	0.448*** (14.10)	0.099*** (6.14)
$\ln(ASSETS)^2$	0.012 (1.60)	-0.018*** (14.25)	-0.002*** (3.51)
<i>CAPITAL</i>	1.707*** (6.29)	0.152*** (2.77)	0.086*** (2.58)
<i>ASSET_QUALITY</i>	-1.908*** (3.76)	-0.241*** (3.23)	-1.869*** (31.64)
<i>MGMT_QUALITY</i>	-0.224 (0.18)	-0.030 (0.18)	0.928*** (4.42)
<i>EARNINGS</i>	1.410 (0.91)	0.555*** (4.85)	5.633*** (45.67)
<i>LIQUIDITY</i>	0.551*** (4.11)	-0.380*** (26.79)	-0.151*** (18.84)
<i>SENSITIVITY</i>	1.136*** (15.81)	-0.088*** (6.44)	-0.051*** (7.18)
<i>HHI</i>	0.742*** (4.92)	-0.029 (1.03)	-0.014 (1.18)
Bank FE	+	+	+
Year-quarter FE	+	+	+
SW F-stats	272.33***	.	.
[p-value]	[0.00]	.	.
Observations	434,865	432,635	426,358
Adjusted R^2	-	0.62	0.60

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA17. Robustness Tests of Competitive Pressure. This table explores the impact of competitive pressure on *FINTECH_SCORE* in column 1 and the *FINTECH* dummy in column 4 and their implications on *DEA_EFF* in columns 2 and 5, and on *SFA_EFF* on columns 3 and 6. *COMP_FT_W* is the change in bank competitors' average *FINTECH_SCORE* from 12 quarters before to 8 quarters before (t_8-t_{12}), where competitor banks' fintech scores are defined as deposit-weighted fintech scores of all other banks that have branches in the same counties, are within the same size group and year-quarter as the focal bank. Columns 2 and 3 report the results of estimating Equation 1 using the fitted value of *FINTECH_SCORE* from column 1 as the main independent variable. Columns 5 and 6 report the results of estimating Equation 1 using the fitted value of the *FINTECH* dummy from column 4 as the main independent variable. *DEA_EFF* is the bank's operational efficiency calculated using the Data Envelopment Analysis. *SFA_EFF* is the bank's operational efficiency estimated using the Stochastic Output Distance Function. *ln(ASSETS)* is the natural logarithm of total assets. *CAPITAL* is the ratio of book equity to total assets. *ASSET_QUALITY* is the ratio of non-current loans and leases that are past due for at least ninety days to total assets. *MGMT_QUALITY* is the ratio of overhead expenses to total assets. *EARNINGS* is the ratio of net income to total assets. *LIQUIDITY* is the ratio of cash to total assets. *SENSITIVITY* is the ratio of the absolute difference between short-term assets and short-term liabilities to total assets. *HHI* is the weighted-average Herfindahl-Hirschman Index of deposit market across the bank's markets, where the weight is the bank's share of deposits in each county where the bank has branches. All independent variables are lagged by one quarter. Standard errors are clustered at the bank level, and *t*-stats are shown in parentheses.

	<i>FINTECH_SCORE</i>		<i>DEA_EFF</i>		<i>SFA_EFF</i>	<i>FINTECH</i>		<i>DEA_EFF</i>	<i>SFA_EFF</i>
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
<i>COMP_FT_W</i>	0.732*** (6.71)			0.304*** (4.40)					
<i>FINTECH_SCORE</i>									
<i>ln(ASSETS)</i>	0.009*** (3.76)	6.506*** (4.84)	1.804*** (2.84)	-0.057 (0.23)	0.157*** (4.49)	0.045*** (3.16)			
<i>ln(ASSETS)²</i>	-0.000 (0.80)	-0.019*** (13.15)	-0.003*** (4.60)	0.017* (1.86)	0.496*** (14.59)	0.126*** (7.34)			
<i>CAPITAL</i>	0.009** (2.24)	0.120* (1.79)	0.086** (2.25)	2.003*** (6.72)	-0.022*** (15.00)	-0.004*** (5.51)			
<i>ASSET_QUALITY</i>	0.007 (1.42)	-0.301*** (3.85)	-1.916*** (30.94)	-1.900*** (3.54)	-0.133 (1.44)	0.014 (0.30)			
<i>MGMT_QUALITY</i>	0.127*** (5.14)	-0.848*** (3.11)	0.652*** (2.76)	-0.983 (0.68)	0.135 (0.73)	-1.818*** (27.19)			
<i>EARNING</i>	0.025** (2.35)	0.397*** (2.91)	5.320*** (40.31)	2.099 (1.11)	0.226* (1.66)	5.285*** (40.02)			
<i>LIQUIDITY</i>	-0.006*** (4.56)	-0.319*** (17.66)	-0.137*** (14.74)	0.555*** (3.37)	-0.445*** (18.31)	-0.172*** (14.65)			
<i>SENSITIVITY</i>	0.000 (0.15)	-0.057*** (4.93)	-0.043*** (8.23)	1.491*** (19.29)	-0.291*** (5.45)	-0.110*** (5.06)			
<i>HHI</i>	0.002 (1.24)	-0.012 (0.41)	-0.009 (0.70)	0.909*** (5.48)	-0.139*** (3.17)	-0.046*** (2.60)			
Bank FE	-	-	+	-	-	+			
Year-quarter FE	+	+	+	+	+	+			
Observations	393,981	392,259	386,502	394,307	392,259	386,502			
SW F-stats	45.05***	.	.	19.32***	.	.			
[p-value]	[0.00]	.	.	[0.00]	.	.			
Adjusted R ²	0.92	0.20	0.38	.	0.52	0.60			

*, **, and *** representing 10%, 5%, and 1% respectively.

Table IA18. The Impact of Changes in FinTech Score on Efficiency. This table examines the effects of changes in *FINTECH_SCORE* on the changes in operational efficiency in Panel A and the effects of changes in *COMP_FT* on the changes in focal bank's *FINTECH_SCORE* in Panel B. *FINTECH_SCORE* is a bank's FinTech score derived using the two-step non-linear estimation methodology. *DEA_EFF* is the efficiency score calculated using the Data Envelopment Analysis. *SFA_EFF* is the efficiency score estimated using the Stochastic Output Distance Function. For each bank in each quarter, we calculate the changes in its *FINTECH_SCORE* over the past four quarters. Then banks are sorted within each size group into four equal quartiles based on their changes in *FINTECH_SCORE*. We focus on the subsamples of banks whose *FINTECH_SCORE* increased from the bottom quartile (Q1) to the top quartile (Q4) or decreased from the top quartile (Q4) to the bottom quartile (Q1), and calculate the changes in the efficiency scores. We test whether the changes in efficiency scores are statistically different from zero.

Panel A: Sorting on *FINTECH_SCORE*

	ΔDEA_EFF	<i>t</i> -stat	ΔSFA_EFF	<i>t</i> -stat
Subsample	(1)	(2)	(3)	(4)
<i>FINTECH_SCORE</i> from Q1 to Q4	0.0773***	29.23	0.0166***	7.84
<i>FINTECH_SCORE</i> from Q4 to Q1	-0.1915***	68.59	-0.0429***	25.95

Panel B: Sorting on *COMP_FT*

	$\Delta FINTECH_SCORE$	<i>t</i> -stat
Subsample	(1)	(2)
<i>COMP_FT</i> from Q1 to Q4	0.0039***	2.74
<i>COMP_FT</i> from Q4 to Q1	-0.0105***	10.37

*, **, and *** representing 10%, 5%, and 1% respectively.

References

Chen MA, Wu Q, Yang B (2019) How valuable is fintech innovation? The Review of Financial Studies 32(5):2062–2106

Table IA19. The Impact of M&As on Efficiency Scores: Univariate Analysis. This table presents the univariate tests of the impact of M&As on the acquirers' *DEA_EFF* and *SFA_EFF* scores. *FINTECH_SCORE* is a bank's FinTech score derived using the two-step non-linear estimation methodology. *DEA_EFF* is the efficiency score calculated using the Data Envelopment Analysis. *SFA_EFF* is the efficiency score estimated using the Stochastic Output Distance Function. We track the dynamics of the acquirers' *FINTECH_SCORE* for treated and control groups. The treated group consists of acquirers with a lower *FINTECH_SCORE* than the target pre-merger. The control group consists of acquirers with a higher or equal *FINTECH_SCORE* than the target pre-merger. For both groups, the acquirer must be more efficient than the target pre-merger. For each group, we compare the average efficiency of the target and acquirer bank in the pre-merger quarter to the efficiency of the acquirer bank in the post-merger quarter and test the statistical significance of the differences. Panel A (B) uses the DEA (SFA) efficiency sample.

Panel A: DEA Efficiency Sample					
Subsample	Obs.	Post-merger – Pre-merger	Difference	<i>t</i> -stat	
$FINTECH_SCORE_{Acq} < FINTECH_SCORE_{Tar}$	627	0.6224	0.1959	1.0540	
$FINTECH_SCORE_{Acq} \geq FINTECH_SCORE_{Tar}$	627	0.4265			
Panel B: SFA Efficiency Sample					
Subsample	Obs.	Post-merger – Pre-merger	Difference	<i>t</i> -stat	
$FINTECH_SCORE_{Acq} < FINTECH_SCORE_{Tar}$	608	0.0858	-0.0026	0.2283	
$FINTECH_SCORE_{Acq} \geq FINTECH_SCORE_{Tar}$	608	0.0885			

*, **, and *** representing 10%, 5%, and 1% respectively.