

The non-linear association between bank fintech and relationship lending: A panel threshold analysis of Indian banks

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ABSTRACT

Recent studies have produced mixed evidence on whether information technology benefits or hurts relationship lending. However, this study is the first to incorporate the recent advances in financial technology to estimate the relationship between bank fintech and relationship lending, emphasizing the non-linear nature of this relationship. Using a panel threshold regression with data from Indian banks, we establish the existence of a threshold beyond which the relationship changes. The empirical results indicate that greater bank fintech is associated with an increase in relationship lending only after relationship lending crosses a threshold level. Below the threshold level, more bank fintech is associated with a decline in relationship lending under certain specifications. These findings are robust under alternate measures and specifications and generate important insights about the use of fintech in the banking industry.

1. Introduction

The advent of financial technology or ‘fintech’ promises a transformative shift for the banking sector. The use of mobile banking services, digital wallets, robot advisors and blockchain technology are some of the advancements that are reshaping the financial landscape. According to BCG (2023), revenues from fintech can generate manifold benefits for emerging economies such as India. The possible benefits that fintech could bring for the banking sector along with the threat of being rendered obsolete has many banks ‘jumping into the fray’ to internalize these technological advancements. Banks are imbibing fintech either by developing inhouse products or by partnering with fintech companies. The State Bank of India (SBI) created the Fintech Incubation Program in 2018 to aid young startups in developing innovative technology solutions for the financial sector. Programs such as these provide young fintechs with an

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opportunity to scale up while giving banks access to cutting-edge ideas. These developments underscore the need for research that examines the impact that banks' incorporation of fintech has on core banking strategies or functions.

The literature on the impact of fintech on the banking sector is largely restricted to competition vs. complementarity between banks and fintech companies (Hodula, 2022; Kowalewski & Pisany, 2022; Sheng, 2021). These papers analyse how bank lending is affected when there is fintech development in a country. However, many banks themselves are internalizing advancements in financial technology either through developing their own applications or partnering with private players. The body of literature examining the impact of fintech adoption from a bank's perspective is still in its early stages but fast expanding. The focus has been mainly on the relationship between fintech adoption by banks and a bank's ability to create liquidity (Fang et al., 2023; Guo & Zhang, 2023), or reduce risk (Cheng & Qu, 2020; Fang et al., 2023) or increase performance (Bian et al., 2024; Zhao et al., 2022). However, Boot (2017) argues that information generated through big data and social media interactions which are core tenets of fintech would impact the value that relationship banking brings to a bank. However, the effect of bank fintech on relationship lending has not been empirically studied so far. There are only a couple of papers (Gangopadhyay et al., 2022; Sedunov, 2017) which study the impact of information technology on relationship banking, but they use indirect measures for relationship banking and narrow measures for a bank's technological prowess. Moreover, these two papers have found contrasting evidence for the relationship between information technology and relationship lending.

The objective of this paper is to examine the association between bank fintech and relationship lending using direct and appropriate measures for both factors. We posit that the mixed results in the literature could be due to the non-linear relationship between bank fintech and relationship lending that the existing studies have ignored. It is possible that the relationship depends upon the stage of relationship lending which a bank is at. When a bank has crossed a certain threshold level of relationship lending, bank fintech can be leveraged to further strengthen relationship lending. But below the threshold level, bank fintech may not be of use for relationship lending and may in fact be deployed for diversifying the loan portfolio. The digital footprint that fintech captures along with existing level of soft/hard information use at the bank decides whether fintech can be leveraged for strengthening relationship lending. To examine this non-linear relationship, we use the panel threshold regression model proposed by

Hansen (1999) which accounts for the heterogeneities of banks while examining the relationship. We use data from Indian banks for a time period (post 2009) when fintech usage started picking up in the banking sector with the advent of digital technologies.

This paper contributes to the literature in multiple ways. First, it contributes to an established literature on relationship lending. Within the plethora of existing studies, we contribute to the understanding of the role played by technology in relationship lending. Second, this study is the first to appropriately measure bank fintech and relationship lending and then estimate the relationship between them. Third, this paper is a novel attempt to provide greater context for the relationship by examining non-linearities i.e., by identifying a threshold which changes the nature of the relationship. Fourth, the study creates a bank level measure to capture the strength of relationship lending for Indian banks, whereas most studies have measured relationship lending at the firm level. Finally, the study is the first to develop a bank fintech score using textual analysis for Indian banks where most existing studies have used measures such as IT spending which are indirect measures of bank fintech.

The results from our analysis show that, the relationship between bank fintech and relationship lending increases after relationship lending crosses a threshold level. Below the threshold, bank fintech leads to a decrease in relationship lending. These results are robust for various specifications of relationship lending. The findings resolve the existing confusion in the empirical literature by showing that the relationship is more nuanced than has been studied before. The study suggests that all types of banks may not utilize fintech in the same manner and there are different benefits to be enjoyed from bank fintech, depending on the level of relationship lending banks are already at. The rest of the paper is organized as follows. The second section addresses the institutional context around fintech and relationship lending. The third section discusses the related literature and sets up the hypotheses. The fourth section details the data used as well as the calculation of both the bank fintech and relationship lending scores. The fifth section explains the empirical methodology used for analysis. The sixth section presents the results of the study highlighting the key findings and interpretations. The final section discusses the main findings of the paper, its implications, limitations, and future research directions.

2. Institutional Context

2.1 History of fintech

The buzz around “fintech” would have us believe that this is an entirely new phenomenon. However, technology has always been part of the banking sector. Bian et al., (2024) outlines three waves of technological advancements in finance. The first wave from 1866 to 1967 saw the introduction of wire transfers and credit cards. The second wave from 1967 to 2008 brought about SWIFT technology and saw the emergence of online banking. The third wave triggered by the 2008 financial crisis, saw the erosion of trust in traditional financial institutions and brought about the current wave of financial technology or fintech. There are two major factors which differentiate the third wave of fintech from the previous waves. One, this wave of innovations seems to be spearheaded by companies outside of the traditional financial sector such as large technology firms and startups. Second, synchronous advancement of non-financial technology such as the proliferation of mobile internet and availability of low-cost smart phones have significantly widened the reach of these financial innovations.

2.2 Defining fintech

Defining fintech is a challenge. A commonly quoted definition of fintech is the Financial Stability Board’s definition: “technologically enabled innovation in financial services that could result in new business models, applications, processes or products with an associated material effect on financial markets and institutions and the provision of financial services.” Schueffel (2016) examined over 200 articles mentioning fintech over a period of 40 years across academia and practise and arrived at “Fintech is a new financial industry that applies technology to improve financial activities”. While we broadly adhere to these definitions, our focus is on capturing fintech developments incorporated by banks and to this purpose we use textual analysis to capture what constitutes “bank fintech” similar to other papers in this area (Bian et al., 2024; Cheng & Qu, 2020; Fang et al., 2023).

2.3 Fintech development in India

India and China tie for the highest fintech adoption rate of 87% according to the 2019 EY Global Fintech Adoption report (E&Y, 2019). The fintech market in India has emerged as a

force to reckon with, with a highly efficient payment system in both volume and value. The introduction of Application Program Interfaces (APIs) and data sharing norms have aided banks in partnering with fintech companies to reap the gains that fintech provides. Applications such as Intelligent Robotic Assistant (IRA) is being used to assist bank staff for improving customer transactions in larger bank branches.

The payments ecosystem in India is a road map for emerging as well as certain developed nations (RBI, 2022). The Unified Payment Interface (UPI) developed by the National Payments Corporation of India (NPCI) has been a game changer in this field. The system which facilitates instant inter-bank transactions which initially onboarded 21 banks as part of its pilot program in 2016 is now ubiquitous with 602 banks using the system. In 2022, the RBI mandated cardless cash withdrawals with UPI acting as the authorization gateway. As a testimony to the success of the payment system, the RBI's digital payment index has seen a steady increase since 2018, with a 10% growth year over year in 2023 compared to 2022. There have been other developments in the payment infrastructure such as the introduction of interoperable bill payments with a push towards making it friendly for remittances and the tokenization of credit card data with regulations in place for safe handling and data privacy. The digital landscape which has been created eases the process for both banks and private companies to deploy fintech applications.

2.4 Relationship Banking

Through greater interaction between bank and borrower over multiple interactions, exclusive relationships and over diverse products, banks can glean soft information about the borrower (Boot, 2000). Soft information can include a bank's assessment of a firm's future performance through interacting with its suppliers, customers, or other business associations (Udell, 2008). By collecting soft information over the course of the relationship, banks can provide credit at lower interest rates (Berger & Udell, 1995; Peltoniemi, 2007; Bonini et. al, 2016) while demanding lesser collateral (Ono & Uesugi, 2009; Anderson et. al, 2023). Relationship banking has been widely considered beneficial for small firms for whom the relationship capital acts as a substitute for the hard information larger firms generate to obtain credit. Identifying relationship lending is a challenging task. However, literature has commonly captured relationship lending in the following ways:

- Length of relationship (captured by number of years of association between bank and borrower where longer association shows greater strength) (Petersen & Rajan, 1994)
- Breadth of relationship or scope (the number of products which bank and borrower interact over; greater products signify greater relationship) (Degryse & Van Cayseele, 2000)
- Number of banks a borrower banks with (where fewer number or a single bank signify greater relationship lending) (Bhardwaj et al., 2022)

India's banking sector being relationship oriented (Bhue et al., 2015) offers a suitable setting to study the association of bank fintech and relationship banking.

3. Related Literature and Hypotheses

Boot and Thakor (2000) conclude that when banks encounter competition from non-banking institutions they return to their roots and strengthen relationship lending. Thakor (2020) addresses the tension between peer-to-peer lending (P2P), a fintech representation and bank lending and posits that banks would continue to sustain an advantage in relationship lending compared to P2P businesses. However, this does not specifically address the scenario when banks themselves incorporate fintech into their business models. While literature on the subject acknowledges an impact of fintech on relationship lending (Flögel & Beckamp, 2020; Jakšič & Marinč, 2019) there are no existing studies which empirically examine the relationship between bank fintech adoption and relationship banking, a lending strategy unique to banks (Berger & Udell, 1995; Boot & Thakor, 1994).

3.1 The role of bank fintech in generating new information

As financial institutions imbibe fintech innovations, it is expected to activate economies of scale by using large data sets, aid in cheaper and efficient transmission of information while reducing verification costs (Thakor, 2020). The use of policies such as open banking and increasing integration across various banking applications through Application Program Interfaces (APIs) have helped in aggregating large amounts of data. Berg et al., (2020) shows that digital footprints which users leave such as while registering on a website, can be as effective as credit bureau scores in predicting consumer default. Advancements in fintech also help in strengthening the transmission and collection of already existing data mechanisms. He

et al., (2022) finds that when banks invest in communication information technology (IT), it aids them in transmitting and producing soft information while the investment in software IT helps facilitates the transmission of hard information. Hard information in comparison to soft information is easier to transmit across various levels of the bank (Udell, 2008).

3.2 Use of technology and relationship lending

Though there are no papers which explicitly examine the relationship of bank fintech and relationship lending, Gangopadhyay et al., (2022) and Sedunov (2017) addresses the relationship between information technology usage by banks and relationship lending. Gangopadhyay et al., (2022) finds that use of information technology leads to an increase in relationship lending and attributes the increase to IT's ability to enhance the soft information collection mechanism. They attribute a concomitant rise in profit frontiers and cost frontiers to an increase in relationship banking. The paper captures the bank technology measure as a ratio of IT expenses to non-interest expenses. Conversely, Sedunov (2017) finds the use of information technology leads to a reduction in relationship lending. The paper argues that as the technological prowess of a bank increases, the bank may prioritise lending based on hard information at the expense of soft-information lending. The paper captures relationship lending as an increase in small business loans and assumes that this increase is akin to an increase in relationship lending as relationship lending is widely perceived as beneficial to small firms. Sedunov (2017) captures back-office technology as total number of employees to total bank assets and front office technology based on having an interactive website or not. Along with a lack of consensus on the results of the two papers, the measures for relationship lending do not explicitly capture any characteristics about the nature of relationship between bank and firm and technology measures are narrow in nature and may be unable to directly capture the fintech usage by banks. We propose to address this limitation in the extant literature by employing a bank fintech measure using textual analysis which has been recently gaining prominence as it is considered an improvement in capturing bank technological capabilities in a holistic manner.

Some other papers touch upon the relationship between technology and relationship banking in a more indirect manner. Kowalewski and Pisany(2022) finds that fintech credit grows complementarily with bank lending whereas big tech credit grows at the expense of bank lending. They find that domestic and private banks face greater competition from big tech companies and interpret it to be a threat to traditional relationship banking. The paper measures

fintech development at a regional level without capturing bank level differences in technology and does not explicitly measure relationship lending. Sutherland (2018) finds that lenders who join credit reporting bureaus reduce their lending to delinquent borrowers compared to before joining the bureau. The joining of the bureau bring with it greater transparency and access to hard information about firms. These delinquent borrowers, many of whom may ultimately recover, are denied a chance of obtaining credit due to the prioritisation of hard information over soft information. DeYoung et al., (2007) suggests that as technology advances large banks will prefer to disburse loans based on hard information.

The varied results we see in literature might be due to the complexity of the relationship, and we propose that it depends on the level of relationship lending of the bank. Berger & Udell (2006) argue that various lending technologies of banks such as transactional lending based on “hard information” and relationship lending based on “soft information” can be used simultaneously and are not mutually exclusive. Information is pivotal to lending (Berger & Udell, 1995). As fintech helps banks codify information about customers that earlier could not be captured, it generates new information or a “digital footprint” (Berg et al., 2020) while strengthening existing data collection mechanisms. Moreover, specialization may depend upon what kind of information is being used in the production process (Liberti & Petersen, 2019). A bank which is a “relationship lender”, may use fintech to strengthen the existing soft information mechanism by using the new information in tandem with the soft information to do more relationship lending. Whereas “transactional lenders” may use the “digital footprint” which fintech generates to reinforce hard information lending which leads to a reduction in relationship lending. We hypothesize that the relationship between bank fintech and relationship banking depends on the threshold level of relationship lending of the bank. If a bank is above a threshold level of relationship banking, bank fintech is associated with greater relationship lending. However, if a bank is below the threshold level, increase in bank fintech is associated with lower relationship lending.

H1: There is a positive association between bank fintech and relationship lending

H2: The positive association between bank fintech and relationship lending is stronger after bank relationship lending crosses a threshold level

4. Data and Variables

Our study uses a balanced panel of 21 banks from 2009-2022. The bank fintech score is calculated using the annual reports of banks. The reports are collected manually from either the bank website or the Prowess database which maintains a repository of bank annual reports. The relationship lending variables are also calculated based on data from Prowess. Many papers (Bhardwaj et al., 2022; Vig, 2013) use this database for analyzing Indian firms and banks. The bank control variables are from the RBI Statistical Table on Banks in India. The firm control variables are calculated using data from Prowess database. The macroeconomic controls are calculated from the RBI website.

4.1 Calculating the bank fintech score

Creating the data dictionary for fintech adoption:

We follow the machine learning approach adopted by Bian et al., (2024). We train two libraries, one which is fintech related and one which is not related to fintech. Bian et al., (2024) uses the technology section of the Chinese central bank reports whereas we use fintech related documents from the Reserve Bank of India (RBI) as well as reports from the top accounting or consulting companies³. For the library which is for fintech non-related documents Bian et al., (2024) uses the commercial banking law of China, we use the banking regulation act of India 1949. Using term frequency – inverse document frequency which identifies the importance of words which appear within a document as well as across a set of connected documents (Fintech-related/Fintech non-related), we arrive at a list of 2000 words. We then manually cross check whether these words are fintech related or not and narrow down the list to 73 keywords⁴ which represent fintech developments.

Calculating the fintech score:

For calculating the score, we count the mentions of these fintech keywords in the annual reports of all the banks in the sample for each year. Then the score is scaled to fintech words per 10000 words of the annual report

³ A detailed list of the fintech related documents is provided in the appendix

⁴ The entire list of fintech keywords is provided in the appendix

4.2 Calculating the bank relationship lending measures

We follow a similar approach to Bhardwaj et al., (2022) who define relationship lending in terms of exclusive relationship between bank and firm as well as the duration of these exclusive relationships as a secondary measure. However, their aim is to perform a firm level analysis and hence captures these measures at the firm-level. However, since our objective is to capture relationship lending at the bank-level, we convert the firm level data to arrive at a bank level measure. We capture relationship lending using two specifications. The first specification is the number of exclusive relationships for a bank across all its clients for a particular year. For a secondary measure of relationship lending, we calculate the duration of these exclusive relationships.

We collect data from Prowess for bankers for each firm. When a firm lists only one banker for a specific year, we count this as one exclusive relationship for the bank (definition 1). This check is done across all the firms within the database for a specific year. Each bank in our sample gets a total of the number of exclusive relationships for a year based on the number of firms that list the bank as their sole banker. As a secondary measure, we capture the duration of all exclusive relationships of a bank for every year by calculating how long these exclusive relationships last. For robustness we calculate an alternate measure of total exclusive relationships, where we only count a relationship as exclusive when it has lasted at least a year i.e., if the bank has been listed as the sole banker at least for two consecutive years (definition 2). Additionally, we calculate total exclusive relationship to total bank relationships in a year using definition 1 and 2 of exclusive relationships.

4.3 Control Variables

Following the literature which has examined the relationship between technological development and relationship lending (Gangopadhyay et al., 2022; Sedunov, 2017), we choose certain bank controls such as total asset size, total capital, return on assets of the bank, total number of bank branches. Bank size is documented to have a significant effect on whether banks employ relationship lending as a strategy (Berger et al., 2005). Smaller banks are documented to do more of relationship lending whereas larger banks do more of transactional lending. The number of bank branches may contribute to how well banks can nurture relationships. Total capital and return on assets indicate the overall health and profitability of

the bank. Additionally, we include certain median firm level controls such as median firm size and median firm profitability which represents the exclusive clients of a bank for a year to control for any firm specific factors which may affect the strength of the relationship. We also include macroeconomic controls such as Gross Domestic Product (GDP) and Inflation. The variable definitions are provided in Table 1.

Table 1
Definition of the variables

Variable	Definitions
Dependant Variables	
Total Exclusive Relationships	Log of the total number of exclusive relationships of a bank for all its clients
Duration of Exclusive Relationships	Log of the duration of all exclusive relationships of a bank in a year
Exclusive to Total	is Total exclusive relationships/Total relationships of the bank
Independent Variables	
Bank Fintech	Count of fintech keywords per 10,000 words of the annual report
Bank Size	Log of the total assets of the bank
Bank Capital	Log of the total capital of the bank
ROA	Ratio of bank net income to total assets
Bank Branches	Total number of bank branches
Median Firm Size	Log of the Median firm assets of the exclusive clients of a bank
Median Firm Profitability	Median firm profitability of the exclusive clients of a bank
Macroeconomic variables	
GDP	Growth of Real GDP (year over year)
Inflation	Inflation %

5. Econometric Methodology

First, we study the relationship between bank fintech and relationship lending without a threshold which has the following specification:

$$\begin{aligned}
 \text{Relationship Lending}_{it} &= \alpha_0 + \alpha_1 \text{Bank Fintech}_{it} + \alpha_2 \text{Bank Controls} \\
 &+ \alpha_4 \text{Median Firm Controls} + \text{Macroeconomic Controls}_t + \text{Bank}_i \\
 &+ \text{Year}_t + \varepsilon_{it}
 \end{aligned}$$

Subscript i and t stands for bank and time. The relationship lending indicator is captured using total exclusive relationship and duration of exclusive relationships respectively. The Bank Fintech Score is captured using textual analysis using the annual reports of each bank. We have

a vector of bank controls such as bank asset size, bank capital, number of bank branches and bank return on assets. The median firm controls are median firm asset size and median firm profitability. The macroeconomic controls are GDP and inflation. We have both time and bank dummies to control for time effects as well as bank-specific effects.

We examine the non-linear association between bank fintech and relationship lending using the following specification:

$$\begin{aligned}
 \textit{Relationship Lending}_{it} &= \alpha_0 + \alpha_1 \textit{Bank Fintech}_{it} (\textit{Relationship Lending}_{it} \leq \gamma) \\
 &+ \alpha_2 \textit{Bank Fintech}_{it} (\textit{Relationship Lending}_{it} > \gamma) + \alpha_3 \textit{Bank Controls}_{it} + \alpha_4 \textit{Median Firm Controls} \\
 &+ \textit{Macroeconomic Controls}_t + \textit{Bank}_i + \varepsilon_{it}
 \end{aligned}$$

The relationship lending variable splits the sample into two thresholds, one where the relationship lending variable is below the threshold ($\textit{Relationship Lending}_{it} \leq \gamma$) and the other where the relationship lending variable is above the threshold ($\textit{Relationship Lending}_{it} > \gamma$). γ is the threshold parameter. We use (Hansen, 1999)'s threshold regression model with individual(bank) specific fixed effects to determine the existence of a threshold as well as the value of γ . The model endogenously determines the threshold by using the data provided.

In an alternate specification to control for endogeneity we use lagged values of the bank explanatory variables.

$$\begin{aligned}
 \textit{Relationship Lending}_{it} &= \alpha_0 + \alpha_1 \textit{Bank Fintech}_{it-1} (\textit{Relationship Lending}_{it} \leq \gamma) \\
 &+ \alpha_2 \textit{Bank Fintech}_{it-1} (\textit{Relationship Lending}_{it} > \gamma) + \alpha_3 \textit{Bank Controls}_{it-1} + \alpha_4 \textit{Median Firm Controls} \\
 &+ \textit{Macroeconomic Controls}_t + \textit{Bank}_i + \varepsilon_{it}
 \end{aligned}$$

6. Results

First, we discuss the results for the model without a threshold. Next, we introduce the results of the threshold regression model. Finally, to account for endogeneity, we present the results of the model with lagged variables.

Table 2
Descriptive Statistics

Variable	Observations	Mean	Std. dev	Min	Max
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Log of total exclusive relationships (Def. 1)	294	3.46	1.151	0.693	6.263
Log of total exclusive relationships (Def. 2)	294	2.911	1.163	0	5.565
Log of duration of exclusive relationships	294	4.720	1.21	1.386	7.494
Exclusive to total (Def. 1)	294	0.115	0.075	0.024	0.529
Exclusive to total (Def. 2)	294	0.07	0.053	0.009	0.438
Bank Fintech	294	1.609	0.703	0.389	4.711
Bank Size	294	14.55	1.187	11.435	17.727
Bank Capital	294	8.741	1.203	5.768	12.15
Bank Number of Branches	294	3149.918	3854.635	117	22620
Bank ROA	294	0.725	1.049	-5.39	2.92
Median Firm Assets	294	5.519	0.662	2.901	7.55
Median Firm Profitability	294	0.049	0.02	-0.004	0.112
GDP (Year over Year)	294	6.049	3.571	-5.831	9.05
Inflation	294	6.947	2.741	3.328	11.989

6.1 Model without threshold

Table 3 indicates the results of non-threshold model. The coefficient of Bank Fintech is insignificant for both specifications of relationship lending. We can conclude that bank fintech is not significantly related to relationship lending when only a single regime is considered.

Table 3

Non-threshold regression

	Model 1	Model 3
	Exclusive Relationships	Duration of Relationships
Bank Fintech	-0.025 (0.061)	0.089 (0.063)
Bank Size	1.038*** (0.164)	0.876*** (0.297)
Bank Capital	-0.039 (0.078)	0.094 (0.078)
Bank Number of Branches	-0.0001*** (0.00002)	-0.0001*** (0.00002)
Bank ROA	-0.023 (0.025)	-0.047 (0.041)

Median Firm Size	-0.205 (0.165)	-0.026 (0.046)
Median Firm Profitability	4.133 (1.86)	2.361** (0.975)
GDP	-0.013 (0.114)	0.219** (0.103)
Inflation	0.137 (0.098)	0.175 (0.102)
R squared	0.754	0.628

*Notes: We have two measures of relationship lending: log of total exclusive bank relationships (Model 1) and duration of exclusive relationships (Model 2). Here the total exclusive relationships are calculated as per Definition 1 of total exclusive relationships. We report robust standard errors. *** p value < 0.01, ** p value < 0.05, * p value < 0.1*

6.2 Model with a single threshold and two regimes

Now we examine the model with a single threshold where the threshold is the log of the total exclusive relationships in Model 1 and 2 and the log of the duration of the relationship in model 3 and 4. For Model 1 and Model 2, the null hypothesis of no threshold is rejected at the 1% level. We see that when the threshold value of the total exclusive relationships is greater than 3.663, bank fintech is positively and significantly associated with relationship lending. However, for model 1 and 2 we see a negative but insignificant relationship when the threshold of exclusive relationships is below 3.663. When the dependent variable is duration of the exclusive relationship (Model 3 and Model 4), the null hypothesis of no threshold is rejected at the 1% level. Here along with a positive and significant effect of bank fintech on relationship lending when the duration indicator crosses the threshold, we also observe a negative and significant effect below the threshold. This implies that an increase in bank fintech is positively related to an increase in relationship lending after relationship lending has crossed a threshold and below the threshold, we see a decline in relationship lending

Interestingly, we see that bank size has a significant and positive association with both specifications of relationship lending which contrasts with the idea that small banks tend to favor relationship lending (Berger et al., 2005; Berger & Udell, 2002). Median firm assets of a bank's client show a negative and significant relationship with relationship lending which is in line with the conventional idea that smaller and more opaque firms engage in greater relationship lending. The median profitability of a bank's clients is positively associated with

relationship lending indicating that profitable firms continue to engage in relationship banking. The number of bank branches is seen to have a negative relationship with relationship banking indicating that increasing the number of bank branches does not necessarily foster relationship lending.

Table 4

Panel threshold regression with total exclusive relationships and duration of exclusive relationships

		Model 1	Model 2	Model 3	Model 4
		Exclusive Relationships	Exclusive Relationships	Duration of Relationships	Duration of Relationships
Threshold		3.663	3.663	3.044	3.044
	Regime 1 ($RL \leq \gamma$)				
Bank Fintech		-0.069 (0.079)	-0.069 (0.081)	-0.361*** (0.098)	-0.352*** (0.096)
	Regime 2 ($RL > \gamma$)				
Bank Fintech		0.241*** (0.065)	0.239*** (0.065)	0.08* (0.041)	0.086** (0.039)
Bank Size		0.674*** (0.086)	0.663*** (0.084)	0.445*** (0.123)	0.494*** (.146)
Bank Capital		-0.043 (0.055)	-0.036 (0.057)	-0.017 (0.036)	-0.22 (0.036)
Bank Number of Branches		-0.0001*** (0.00002)	-0.0001*** (0.00002)	-0.00008*** (0.000002)	-0.00008 (0.00002)
Bank ROA		-0.078*** (0.036)	-0.082*** (0.031)	-0.024 (0.032)	-0.035 (0.031)
Median Firm Size		-0.182*** (0.158)	-0.18*** (0.155)	-0.032 (0.051)	-0.036 (0.053)
Median Firm Profitability		3.015** (1.311)	2.996** (1.306)	2.308 (1.169)	2.32* (1.174)
GDP			0.007 (0.004)		0.0006 (0.004)

Inflation		-0.005 (0.016)		0.144 (0.012)
R squared	0.584	0.586	0.649	0.653

Notes: We have two measures of relationship lending: log of total exclusive bank relationships (Model 1 and 2) and log of duration of exclusive relationships (Model 2 and 3). Here the total exclusive relationships is calculated as per definition 1. The threshold variables are the respective relationship lending measures. RL stands for the respective relationship lending variable. Model 2 and Model 4 do not include the macroeconomic controls. We report robust standard error. *** p value < 0.01, ** p value < 0.05, * p value < 0.1

Table 5 shows the results for the regression which incorporates lagged values of the explanatory values to account for possible endogeneity. Here we see similar results to Table 4 with the coefficients of Regime 2 in Table 5 higher in magnitude when compared to the coefficients of Regime 2 in Table 4. Bank size, number of bank branches and median firm profitability continues to have a significant relationship with measures of relationship lending.

Table 5
Panel threshold regression with lagged values of dependent variables

		Model 1	Model 2	Model 3	Model 4
		Exclusive Relationships	Exclusive Relationships	Duration of Relationships	Duration of Relationships
Threshold		4.318	4.318	3.61	3.61
	Regime 1 ($RL \leq \gamma$)				
Bank Fintech (t-1)		-0.063 (0.071)	-0.056 (0.073)	-0.139* (0.07)	-0.143** (0.062)
	Regime 2 ($RL > \gamma$)				
Bank Fintech (t-1)		0.261*** (0.085)	0.27*** (0.086)	0.141** (0.049)	0.145*** (0.048)
Bank Size (t-1)		0.882*** (0.124)	0.823*** (0.099)	0.5*** (0.111)	0.583*** (0.126)
Bank Capital (t-1)		-0.107** (0.042)	-0.097* (0.049)	-0.055 (0.048)	-0.072 (0.045)

Bank Number of Branches (t- 1)	-0.0001*** (0.00003)	-0.0001*** (0.00003)	-0.00009*** (0.00002)	-0.00009*** (0.00002)
Bank ROA (t-1)	0.002 (0.023)	0.01 (0.019)	-0.005 (0.029)	-0.02 (0.024)
Median Firm Size	-0.195 (0.164)	-0.189 (0.16)	-0.03 (0.04)	-0.039 (0.041)
Median Firm Profitability	2.664* (1.351)	2.719* (1.369)	3.36*** (0.777)	3.245*** (0.755)
GDP		0.001 (0.005)		0.005 (0.003)
Inflation		-0.015 (0.016)		0.022** (0.009)
R squared	0.60	0.604	0.652	0.664

*Notes: Here we use lagged values of all bank variables to control for endogeneity. Here the total exclusive relationships is calculated as per Definition 1 of total exclusive relationships. The threshold variables are the respective relationship lending measures. RL stands for the respective relationship lending variable. Model 1 and Model 3 do not include macroeconomic controls. We report robust standard errors. *** p value < 0.01, ** p value < 0.05, * p value < 0.1*

6.3 Robustness Tests

As a robustness measure, we modify the definition of what constitutes as an exclusive relationship, and we classify a relationship as exclusive only if a bank is listed as the sole banker for a firm for two consecutive years. In table 6 we see that the threshold results in terms of significance and direction hold when compared to the earlier specifications. When the lagged explanatory variables are used along with the Definition 2 of exclusive relationships, the coefficients of regime 2 though positive cease to be significant. As an additional robustness test, we use a different measure of relationship lending which is total exclusive relationships to total relationships of a bank which is calculated using both definitions of exclusive relationships. Here we find further support for our initial hypotheses. Bank fintech is positively associated with relationship lending after relationship lending crosses a threshold level.

Bank size continues to be positively related (Model 2) to relationship lending even after number of exclusive relationships are scaled using total bank relationships. This indicates that larger Indian banks continue to employ relationship lending as a strategy.

Table 6

Panel threshold regression with an alternate definition of exclusive relationship

	Model 1 Exclusive Relationships	Model 2 Exclusive Relationships
Threshold	1.09	1.09
Regime 1 ($RL \leq \gamma$)		
Bank Fintech	-0.577** (0.218)	-0.579** (0.216)
Regime 2 ($RL > \gamma$)		
Bank Fintech	0.129*** (0.044)	0.1333*** (0.041)
Bank Size	0.612*** (0.112)	0.648*** (.115)
Bank Capital	-0.149** (0.056)	-0.155** (.057)
Bank Number of Branches	-0.0000919*** (0.000279)	-0.00009*** (0.00003)
Bank ROA	-0.073 (0.04)	-0.079 (0.038)
Median Firm Size	-0.207 (0.131)	-0.211 -0.131
Median Firm Profitability	3.240 (2.055)	3.251 (2.079)
GDP		-0.002 (0.004)
Inflation		0.012 (0.019)
R squared	0.498	0.499

*Notes: Here a relationship is considered exclusive only if a firm reports a bank as its sole lender for two consecutive years (definition 2). The threshold variables are the respective relationship lending measures. RL stands for the respective relationship lending variable. We report robust standard errors. *** p value < 0.01, ** p value < 0.05, * p value < 0.1*

Table 7

Panel threshold regression with lagged values of bank explanatory variables

	Model 1 Exclusive Relationships	Model 2 Exclusive Relationships
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Threshold	1.09	1.09
	Regime 1 ($RL \leq \gamma$)	
Bank Fintech	-0.485*** (0.143)	-0.0495*** (0.151)
	Regime 2 ($RL > \gamma$)	
Bank Fintech	0.085 (0.162)	0.079 -0.056
Bank Size	0.691*** (0.143)	0.713*** (0.123)
Bank Capital	-0.193*** (0.043)	-0.197*** (0.046)
Bank Number of Branches	-0.00008** (0.00003)	-0.00007** (0.00003)
Bank ROA	-0.141 (0.033)	-0.016 (0.03)
Median Firm Size	-0.164 (0.146)	-0.167 (0.145)
Median Firm Profitability	3.244 (2.204)	3.218 (2.228)
GDP		-0.002 (0.004)
Inflation		0.006 (0.019)
R squared	0.503	0.504

*Notes: Here we use lagged values of all bank variables to control for endogeneity. Here the total exclusive relationships is calculated as per Definition 2 of total exclusive relationships. The threshold variables are the respective relationship lending measures. RL stands for the respective relationship lending variable. Model 1 does not include macroeconomic controls. We report robust standard errors. *** p value < 0.01, ** p value < 0.05, * p value < 0.1*

Table 8
Panel threshold with Exclusive Relationship to Total Relationships

	Model 1	Model 2	Model 3	Model 4
	Exclusive to Total	Exclusive to Total	Exclusive to Total	Exclusive to Total
Threshold	0.368	0.368	0.21	0.21
	Regime 1 ($RL \leq \gamma$)			
Bank Fintech	0.007 (0.004)	0.008* (0.087)	0.006 (0.004)	0.007 (0.004)
	Regime 2 ($RL > \gamma$)			

Bank Fintech	0.135*** (0.007)	0.138*** (0.006)	0.099*** (0.005)	0.099*** (0.005)
Bank Size	0.015 (0.009)	0.022** (0.008)	-0.003 (0.008)	0.002 (0.008)
Bank Capital	0.006 (0.007)	0.006 (0.007)	-0.002 (0.002)	-0.002 (0.002)
Bank Number of Branches	-0.000004*	-0.000004* (0.000002)	-0.000002 (0.000002)	-0.000002 (0.000001)
Bank ROA	0.001 (0.001)	-0.001 (0.002)	-0.002 (0.001)	-0.003 (0.002)
Median Firm Size	-0.015 0.011	-0.015 (0.011)	-0.008 (0.004)	-0.001 (0.004)
Median Firm Profitability	0.294** (0.134)	0.291** (0.134)	0.196* (0.096)	0.198** (0.094)
GDP		0.001** (0.0005)		-0.00001 (0.0003)
Inflation		0.002 (0.001)		0.002** (0.0007)
R squared	0.402	0.42	0.411	0.422

*Notes: Model 1 and Model 2 use definition 1 of exclusive relationship to calculate total exclusive relationships to total relationships whereas Model 2 and Model 3 use definition 2 of exclusive relationship to calculate total exclusive relationships to total relationships. RL stands for the respective relationship lending variable. Model 1 and Model 3 do not include macroeconomic controls. We report robust standard errors. *** p value < 0.01, ** p value < 0.05, * p value < 0.1*

7. Conclusion and Discussion

The empirical results in this paper indicate that when banks are at higher level of relationship lending, bank fintech development further strengthens relationship lending which is robust to various specifications of relationship lending. However, when banks are at a lower level of relationship or those who might be transaction oriented, bank fintech may promote transactional lending at the expense of relationship lending. These results provide a contrasting view to the idea that growth in fintech happens at the expense of relationship lending. The findings of this paper indicate that bank fintech can help in strengthening relationship lending depending upon the threshold level of relationship lending at the bank. Banks can reap the benefits that fintech offers without losing what makes them unique. The notion that when banks face competition from external parties such as fintech, they respond by intensifying relationship

lending can be extended. When banks themselves imbibe fintech, they can use the advances that fintech provides to intensify relationship lending.

These findings have significant implications for various stakeholders. Banks can employ fintech to gain deeper insights about their customers which helps create more personalized products with a goal of enhancing relationship lending. Also, if a bank identifies its own relationship orientation, it will help in fine-tuning the effect bank fintech has. For regulators, there is a need to support fintech growth within a strong regulatory framework. They need to ensure that the integration of fintech into a bank’s ecosystem enhances transparency while ensuring security and compliance. Policymakers need to foster an ecosystem which is both collaborative and competitive for banks and fintech companies. Creating a level playing field for innovation will go a long way in promoting greater relationship lending, which would be beneficial for small and medium firms, that form the backbones of economies like India.

While the bank fintech score is important for indicating a bank’s technological prowess especially in newer technologies, it may not be able to exactly capture adoption. Data on actual fintech investment at a bank level would highly enhance studies in this area. A possible extension to our work which could bring valuable insights is to segregate various technologies that a bank employs and understand it’s individual contribution to relationship lending.

Appendix

Table 9

Documents which make up the fintech related repository

Name of Document	Year	Source
Report on the working group of fintech and digital lending	2017	RBI
Report on the working group of digital lending including online platforms and mobile apps	2021	RBI
India Fintech Report, the winds of change	2022	Ernst & Young
Unleashing the potential of fintech in banking	2017	Ernst & Young
The Indian Payments Handbook	2023	PricewaterhouseCoopers

Exhibit A**Fintech Keywords**

'AI', 'Algorithm', 'Analytics', 'API', 'Automation', 'Bigtech', 'Biometric', 'Bitcoin', 'Blockchain', 'CBDC', 'Chatbots', 'Computing', 'Cryptocurrencies', 'Digitalisation', 'Digitisation', 'Digital', 'Fintech', 'Hackathons', 'Innovation', 'Insurtech', 'Interfaces', 'Internet', 'IOT', 'Ledger', 'Metaverse', 'mobile', 'Neobank', 'network', 'OTP', 'Paytech', 'RegTech', 'cloud', 'Robotics', 'Robot', 'Sandboxes', 'Stack', 'online', 'Technology', 'Tokenisation', 'UPI', 'Wealthtech', 'Wallet', 'account aggregator', 'artificial intelligence', 'big data', 'blockchain technology', 'cards upi', 'data analytics', 'digital adoption', 'digital banking', 'digital lending', 'digital payment', 'digital transactions', 'distributed ledger', 'emerging technologies', 'growth digital payments', 'information technology', 'innovation hub', 'interface upi', 'ledger technology', 'machine learning', 'mobile banking', 'online payments', 'open banking', 'payment infrastructure', 'regulatory sandbox', 'technological innovation', 'upi payments', 'cloud computing', 'data mining', 'cloud technology', 'data layer'

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