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Does competition affect business risk in the Indian banking system? An analysis with information and communication technology as a threshold

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ABSTRACT

This study addresses the critical but understudied intersection of business risk (BR), competition, and technological advancements in the Indian banking sector. The aim is to comprehensively examine the impact of digital transformation on the nexus between business risk and competition. The study uses panel data from 23 listed banks in India from 2012 to 2022. The study employs a threshold analysis to identify how technological development causes changes to the business risk. The outcome reveals that threshold model estimates for Models 1 and 2, considering the impact of competition (Lerner Index) on business efficiency and risk, with technology expenditure as the threshold variable. Model 1 (BRC) indicates that post-threshold regimes are statistically significant, reflecting less risk efficiency at increasing competition. Model 2 (BRV) reflects considerable positive effects of competition, though decreasing after the threshold. Control variables, including ROA, market capitalization, and capital adequacy, also significantly influence business risk outcomes. The study identifies cybersecurity problems, system functionality dependency, regulatory compliance, data privacy, etc., as critical dimensions through which technological development escalates business risk in the banking sector. The study explores business risk dimensions in banks, an area that has received scant research attention. It also pioneers in examining the impact of technological development on the interplay between business risk and competition in India. The study does not observe any paper on the technology investment threshold and its impact on business risk.

Contribution/Originality: Despite banks taking an active approach to mitigating credit and default risk, they often overlook business risk, which is increasingly significant due to heightened competition and technological advancements. This study addresses this gap by offering practical implications for designing more effective risk assessment frameworks and regulatory review processes.

1. INTRODUCTION

Business Risk (BR) is not a new risk type. In the work of Crouhy, Galai, and Mark (2006), it is rightly stated that business risk has been the core task of management for ages. According to Chaffai and Dietsch (2015), BR is described as any form of potential loss caused by adverse and unexpected changes in business volume, margin, and cost. This

could be the result of changes in customer preferences, intensified competition, or other changes in the bank's environment. It is a form of nonfinancial risk that causes uncertainty in earnings not related to financial risks like market risk, credit risk, etc. The organization needs to adapt itself and make suitable policy changes to mitigate these unexpected events and changes (Fida & Naveed, 2021; Isnurhadi, Sulastri, Saftiana, & Jie, 2023).

A pivotal transformation in the banking landscape is attributable to technological advancements, exerting a profound impact on customer preferences and competitive dynamics. The advent of disruptive innovations in cyber technologies, machine learning, artificial intelligence (AI), and big data has engendered a paradigm shift in operational frameworks, necessitating technology investment (TI). Such expenditures assume significance in the context of bolstering operational efficiency, elevating service quality, and enhancing overall performance (Joaquim, Miguel, & Silva, 2024). Therefore, banks are forced to invest strategically in and incorporate newer financial technologies to traverse and capitalize on the changing banking landscape successfully. However, the BR driven by the rise in competition and technology spending is neglected (Uddin, Mollah, Islam, & Ali, 2023).

Past research has largely discussed the correlation between financial risks and competition in the banking sector, but studies concerning this nexus with technology are scanty (Al-Shari & Lokhande, 2023). Previous research has not paid adequate attention to the dynamic nature of technological development and its influence on risk factors and competition issues in the banking sector, creating a lacuna in the understanding of the role of technology investments in forming modern banking BR (Li, Li, Xu, & Sun, 2025; Seelanatha & Natoli, 2025). This research gap identifies the need for research that explores the particular manner in which investment in technology shapes and possibly reshapes the risk profile of banks in a technological world where time is of the essence. It indicates that extant research is unable to keep up with the intense changes in technology investment and the corresponding consequences for banks (Mubarak & Hamdan, 2023; Nhat, 2025).

Banks are always being challenged to update themselves to new and innovative technology over time (Seelanatha & Natoli, 2025). Wells Fargo, Citigroup, Deutsche Bank, Credit Suisse, and so forth are some examples of banks experiencing technological problems. The Kotak Bank, based in India, met regulatory limitations imposed by the Reserve Bank of India (RBI) over fears of the bank's technology management during IT examinations (ET Bureau, 2024). Wells Fargo is one of the biggest banks in the United States, but ironically, it has found it difficult to keep pace with the rapid technological change. The bank has been criticized for its legacy IT systems, which have been rightly blamed for many outages and security breaches (Welch, 2023). Citigroup is another large bank that is facing technological challenges. The bank has been investing heavily in technology in recent years, but it is still struggling to catch up to some of its competitors. Deutsche Bank is a German bank that has been struggling financially in recent years. The bank has also been criticized for its legacy IT systems and its slow pace of technological change. The recent cybersecurity incident involving Credit Suisse serves as a pertinent illustration of how digitalization can give rise to information asymmetry and escalate BR. Credit Suisse encountered a significant data breach affecting approximately 18,000 bank accounts, laying bare concealed assets totaling 80 billion. Cybersecurity experts posit that the internal operational oversight exercised by staff members engaged with technology imparts them with a nuanced understanding that can be exploited to identify and exploit vulnerabilities in digital systems (Nhat, 2025; Uddin et al., 2023).

This study serves as a pioneering endeavor, being the first to comprehensively examine the impact of technological development on the nexus between BR and competition in an emerging economy. Consequently, this empirical study contributes significantly to the existing body of literature on commercial banking within the Indian context (Olalere, Islam, Yusoff, Ariffin, & Kamruzzaman, 2021). This is crucial for policymakers, regulators, and financial institutions to effectively manage and mitigate risks.

With the increase in the TI over a threshold level in banks, the Business Risk Reduction (BRR) efficiency increases at a slower rate (actual BR increases) with the increase in competition. This occurs both at constant and variable scales. The study is conducted on 23 scheduled banks in India over the period from 2012 to 2022 using panel

data. The findings indicate that beyond the threshold of competition, the BR increases. The rising rate of BR may be attributed to technological advancements represented by various perspectives of vital dimensions. Of primary concern are cybersecurity issues, as financial institutions become more exposed to cyber threats and attacks. Moreover, a significant concern arises from system dependence, whereby system weaknesses can lead to serious consequences, adding an unpredictable risk factor to operations. Regulatory compliance further amplifies these risks, requiring substantial TI to meet higher standards. The lack of adequate technological infrastructure not only exposes banks to regulatory fines but also increases legal risks. Additionally, managing sensitive customer data through technology systems presents a dual challenge of data privacy and reputation management. The potential fallout from data breaches or mishandling of customer information extends beyond financial implications to include reputational damage and legal consequences. Furthermore, financial risks are intensified by cost overruns in TI, which impose additional burdens on a bank's financial capacity and contribute to the overall rise in financial risk.

This research contributes to the existing body of literature by both theoretically and empirically analyzing the threshold model of the nonlinear association between competition, as represented by Lerner's Index, and business risk reduction efficiency (BRC and BRV), with technological investment (TI) as the threshold variable. The results demonstrate that the impact of competition on business risk reduction depends on the level of technological investment. Specifically, competition does not directly influence BRC under the first regime but becomes adverse at certain points, indicating higher risk resulting from increased competition as technology investment rises. For BRV, competition consistently elevates business risk, though the effect diminishes over time. The findings highlight the moderating role of technological investment in the relationship between competition and risk, emphasizing the importance of technological capability in enhancing banking efficiency. Furthermore, the statistical significance of control variables indicates their relevance in risk mitigation policies. This study offers valuable insights for policymakers and bank managers operating under competitive pressures.

Below are the arrangements of the subsequent sections of this paper: In Section 2, there is an extensive review of literature, including the development of hypotheses. This section not only provides an interesting understanding of BR but also proposes a comprehensive definition that will serve as the working platform for the rest of the paper. Section 3 delves into the theoretical background and contextual framework, providing a theoretical underpinning for the study. In Section 4, the focus shifts to the data, the variables employed, and the methodology adopted. Section 5 presents the empirical findings derived from the research. Section 6 is dedicated to the discussion of these findings, and finally, Section 7 draws conclusions based on the results obtained.

2. REVIEW OF LITERATURE AND HYPOTHESES DEVELOPMENT

The operational landscape of banks has undergone rapid transformation, introducing a spectrum of new risks alongside the industry's gains and expansion. The heightened level of banking activities and the emergence of financial technology (fintech) have prompted specific apprehensions, leading banks to strategically concentrate on safeguarding against inherent risks through various approaches and measures. Notably, recent years have witnessed a proliferation of studies delving into the components of risk in banks (Olalere, 2021).

2.1. Business Risk

Business risk encompasses the potential that operating income could be lower than planned for reasons including higher costs or lower revenues (e.g., decreased market share, lowered margins, market slump). This risk takes the form of unfavorable results from choosing poorly designed markets, products, activities, or structures, or from having a less-than-ideal competitive position. Revenue volatility, rigid cost structures, uncompetitive product or price offerings, and structural inefficiencies are the main causes of risk. It denotes an organization's exposure to factors that could diminish profits, result in failure, or introduce compliance risk. BR emerges from uncertainties, defined by instances where future events remain unknown. Examples of uncertainties impacting a business encompass shifts in

demand, changes in customer preferences, competitive dynamics, technological advancements, the broader economic landscape, and governmental regulations, among others (Doff, 2016; Isnurhadi et al., 2023).

The subprime crisis highlighted that the management of BR was lagging behind. Prior to the subprime crisis, the banking industry was in a booming phase, thus facing a low level of BR. However, the subprime crisis had a significant consequence on the banking sector. The eminent banking supervisor committees like the Basel Committee have also advised that more attention should be paid to BR. Basel III has conceded that risk is hard to measure and has encouraged banks to take a holistic look at it (Chaffai & Dietsch, 2015).

One of the theories related to BR is the *Resource-Based View (RBV) theory*. The RBV theory focuses on a firm's internal resources and capabilities as the source of its competitive advantage (Assensoh-Kodua, 2019). From an RBV perspective, BR is tied to the firm's ability to leverage its unique resources and capabilities to withstand competitive pressures and market changes (Rao & Brown, 2024). The risk arises when these resources become obsolete or lose their competitive edge (Öztürk & Akpınar, 2023).

2.2. Competition in Banks

The banking industry is facing competition among itself. To compete, banks have implemented diverse strategies. One such strategy is to diversify their product base. This helps maximize revenue production and reduce risk with non-interest products/services. Income diversification within the banking industry has the potential to mitigate income volatility and associated risks, surpassing the efficacy of solely safeguarding traditional interest income. This diversification also requires investment in new technology and processes. But it is a way to reduce the BR of banks (Isnurhadi, 2023).

In the study conducted by Uddin et al. (2023), it is posited that investments in technology and technological innovations may render banks more susceptible to risks. The rationale behind this assertion lies in the notion that while technology facilitates an increase in business volume, the concomitant exposure to risks arises from inherent factors such as system failures, internal procedural complications, and disruptions stemming from both external and internal security threats. Drawing upon a comprehensive dataset spanning a decade and encompassing 264 banks across 43 diverse countries, the findings underscore that the digitization of banking operations serves as a foundational catalyst for the risks associated with heightened business volume.

To maintain a competitive edge over rivals, enterprises consistently endeavor to augment both their internal operations and external competencies. Central to achieving their desired positioning is the imperative to unearth their intrinsic uniqueness. This discernible divergence constitutes what is commonly referred to as a competitive advantage. Such advantages encompass various facets, including but not limited to the integration of cutting-edge technologies, exploitation of economies of scale in production, adept management of supply chains, provision of premier and punctual services, and establishment of an optimal pricing framework. Although businesses may gain ascendancy over competitors through initiatives such as the early adoption of artificial intelligence within the context of Industry 4.0, they might encounter difficulties in perpetuating such advantages amid the transition to Industry 5.0. Therefore, a sustainable and long-term competitive advantage should be the target through the efficient utilization of resources.

2.3. Technological Investment in Banks – Positive and Negative Aspects

Businesses are allocating capital to technological improvements to remain relevant. In the banking sector, it improves consumer satisfaction by enhancing efficiency and convenience. Banks with legacy IT systems are facing challenges in the evolving financial sector.

With the increasing coverage of smartphones and internet usage, customers can manage their financial operations from any location.

The investment is not limited to convenience, but a significant amount is invested in cybersecurity. It is both a boon and a curse for businesses. It remains a constant battle between bank security and fraudsters. Nonetheless, it has a positive motive, but the underlying effect on the BR of Indian banks cannot be ascertained (Lu, 2018). The motivation for the research is to link the trilogy of technology, competition, and BR and highlight the benefits of banks' technological investment.

The hypothesis of this research is to find that H.A. Banks are exposed to more business risk due to the increase in competition amidst increasing technological investment.

3. DATA AND METHODOLOGY

This academic study is centered on analyzing the Indian banking sector, involving a thorough data collection process. The research focused on 23 banks, which were chosen based on data availability. There are 34 scheduled commercial banks in India, but this study only considers 23 banks, as the number of Indian banks merged in 2021 (Akther, Rahman, & Rahman, 2023; Pinto, Rastogi, & Agarwal, 2024; Rastogi, Pushp, Kanoujiya, & Agarwal, 2025) and fit for the balanced panel data. They effectively represent about two-thirds of all scheduled commercial banks in India. This sample accounts for a substantial 86% of the total assets of banks within India, as reported by data provided by the Reserve Bank of India (RBI).

It is worth mentioning that this data collection covers an impressive 93% of the assets held by all scheduled private and public commercial banks taken together (Reserve Bank of India, 2023). The duration of data collection was 2012-2022, and for the collection of data, we have used Bloomberg, RBI, and annual reports of banks (Bloomberg, 2023). This extensive dataset underpins a comprehensive analysis of the banking sector in India over the specified decade. The variables of interest used to examine the impacts of competition on BR during technological changes are presented in Table 1.

Table 1. List of variables.

SN	Variable	Type	Code	Definition	Citations
1	Business risk (Constant)	DV	DV_BR_CRS	Efficiency level of business risk is measured through Data Envelopment Analysis (DEA) at a constant rate.	Chaoqun, Shen, Huizhen, and Wei (2024) and Adusei (2016)
2	Business risk (Variable)	DV	DV_BR_VRS	Efficiency level of business risk is measured through DEA at a variable rate.	Chaoqun et al. (2024) and Lamb and Tee (2012)
3	Lerner's index	EV	IV_lindex	It is the calculation of competition and Indian Bank's market power.	Paktinat and Javid (2015) and Lerner (1934).
4	Information and communication technology	ThV	L_M_ICT	The total amount invested by Indian banks in Information and Communication Technology.	Abdolmohammadi (2005)
5	Return on asset	CV	C_roa	It is net profit by total assets.	Hamzani and Achmad (2018)
6	Market capitalization	CV	L_C_mcapcr	It is defined as the market price of the share multiplied by the number of shares outstanding.	Anam, Fatima, and Majdi (2011)
7	Capital adequacy ratio	CV	C_car	An indicator of capital within the bank that depicts the health of a bank.	Agoraki, Delis, and Pasiouras (2011)

Note: DV, EV, ThV, and CV represent the dependent variables, exogenous variables, threshold variables, and control variables.

Table 2. Summary statistics and correlation matrix.

Variable	Obs.	Mean	SD.	Min.	Max.
DV_BR_CRS	253	0.312	0.340	0.011	1
DV_BR_VRS	253	0.556	0.390	0.015	1
IV_lindex	253	0.597	0.554	-5.509	1.875
L_M_ICT	253	2.392	0.710	-0.096	4.322
C_roa	253	0.653	0.915	-6.37	2.18
L_C_mcapcr	253	4.486	0.696	3.001	5.994
C_car	253	14.384	2.541	8.5	22.69
Correlation matrix					
Variable	**IV_lindex**	**L_M_ICT**	**C_roa**	**L_C_mcapcr**	**C_car**
IV_lindex	1.0000				
L_M_ICT	-0.2238* 0.0003	1.0000			
C_roa	0.0799 0.2052	-0.1932* 0.0020	1.0000		
L_C_mcapcr	-0.1005 0.1107	0.7311* 0.0000	0.0366 0.5626	1.0000	
C_car	-0.0104 0.8691	0.1073 0.0884	0.5835* 0.0000	0.1554* 0.0133	1.0000

Note: Obs. SD, Min. and Max. are Observations, Standard deviation, minimum and maximum value, respectively.
* Shows a significant correlation coefficient at 0.05.

4. RESULTS

4.1. Descriptive Statistics and Multicollinearity

Table 2 presents a set of summary statistics for seven different variables based on a dataset with 253 observations. These statistics offer valuable insights into the characteristics of each variable. Firstly, two dependent variables are highlighted: Business Risk at Constant Return to Scale (BRC) and Variable Return to Scale (BRV). These two variables appear to vary between 0 and 1, potentially indicating a binary or scaled measure. The independent variables, Lindex values, span a wide range from -5.509 to 1.875, suggesting significant variability in the data. TI demonstrates a moderate standard deviation of 0.710.

There are three control variables used in the study: Return on Assets (ROA), Market Capitalization (MCap), and Capital Adequacy Ratio (CAR). These independent variables exhibit varying degrees of dispersion and central tendency in their distributions.

4.2. Multicollinearity

Table 2 shows the results of the correlation matrix. The correlation between TI and Lindex is weak and negatively significant. It suggests that with an increase in technological investment, the competition denoted by Lindex decreases. There is a significant negative correlation between TI and ROA. The variables TI and MCap show a positive significant correlation coefficient.

It implies that with an increase in the company's technological capacity, its market capitalization will tend to increase. The ROA and CAR have a positively significant correlation. It can be concluded that banks with greater returns on their assets are more likely to have better capital adequacy.

The correlation matrix in Table 2 also helps identify the potential problem of multicollinearity issues. These multicollinearity issues may cause unstable coefficient estimates while building the regression model. Based on the research carried out by Gujarati and Porter (2009), it is recommended that all correlation values among variables should be lower than the threshold of 0.8. In our dataset, the correlation coefficients between the variables are indeed below 0.8, indicating that there is no issue of multicollinearity in the data.

Table 3. Shapiro-Wilk W test for normality and endogeneity test.

Variable	Obs.	W	V	Z	Prob>z
DV_BR_CRS	253	0.762	43.570	8.787	0.000
DV_BR_VRS	253	0.916	15.334	6.356	0.000
Endogeneity test					
		Model 1		**Model 2**	
Durbin Chi-2		1.181 (0.277)		0.052 (0.818)	
Wu–Hausman test		1.149 (0.285)		0.050 (0.822)	

Note: p-value 0.00 signifies non-normality of data.
The value in the parenthesis represents the p-value.

4.3. Endogeneity and Robustness

Table 3 presents the outcomes of two distinct tests employed to investigate potential endogeneity issues within the specified statistical models, denoted as Model 1 and Model 2. To examine the issue of endogeneity, two tests were performed: the Durbin Chi2 test and the Wu-Hausman test (Baltagi, 2006). These p-values of the test assess the likelihood of endogeneity. Higher p-values suggest weaker evidence against the null hypothesis. The results suggest that there may not be substantial evidence of endogeneity in both models (Wooldridge, 2015). Two models were examined to ensure the robustness of the findings.

4.4. Normality Test

The normal distribution of the dependent variable is checked using the Shapiro-Wilk W test. The results are presented in Table 3. The value of W in the result column serves as an indicator of the degree of conformity between the data and a normal distribution. A value proximate to 1 signifies a stronger resemblance to a normal distribution. Representing the test statistic for the Shapiro-Wilk test, the "z" value is a pivotal metric in the evaluation of statistical significance pertaining to the deviation from normality. In both instances, the p-value closely approximates zero (0.000), signifying compelling evidence against the hypothesis of normality. In essence, the results strongly suggest that neither BRC nor BRV conforms to a normal distribution according to the Shapiro-Wilk W test (Wooldridge, 2015). BRC and BRV are taken as two dependent variables. The double threshold model (i.e., the model with two estimated threshold values of the threshold variable) can be defined in the following way, where the estimated thresholds $\gamma 1 < \gamma 2$. The paper applies the fixed panel data threshold model (Hansen, 1999). The dependent variable yit and the threshold variable qit are scalars, and the regressor xit is a vector. The panel threshold model can be expressed as:

$$y_{it} = \mu_i + \beta'_1 x_{it} I(q_{it} \leq \gamma_1) + \beta'_2 x_{it} I(\gamma_1 << q_{it} \leq \gamma_2) + \beta'_3 x_{it} I(q_{it} > \gamma_2) + e_{it} \quad (1)$$

$$y_{it} = \mu_i + \beta'_1 x_{it} I(q_{it} \leq \gamma_1) + \beta'_2 x_{it} I(\gamma_1 << q_{it} \leq \gamma_2) + \beta'_3 x_{it} I(q_{it} > \gamma_2) + e_{it} \quad (2)$$

The above equations, labeled 1 and 2, represent threshold panel data regression models. In these equations, "yit" represents the dependent variable that is aimed to understand or predict, while "xit" denotes the independent variable(s) that are believed to influence "yit." The term "μi" signifies an intercept or constant specific to each observation or group, and "eit" stands for the error term, capturing unexplained variation in "yit." Notably, the equations employ indicator functions denoted as "I" to segment the data based on conditions associated with the variable "qit,". These conditions divide the data into distinct regimes, each with its set of coefficients, "β'1," "β'2," and "β'3," which signify the relationship between the independent variables and the dependent variable (Du & Zhang, 2011).

4.5. Threshold Effect Test

It can be seen from Table 4 that, in Model 1, the single threshold hypothesis demonstrates statistical significance at a 10% significance level, as does the double threshold hypothesis at the same significance level. However, the triple

threshold hypothesis does not meet the required level of significance. Therefore, Model 1 should be estimated using a double threshold model. In examining Model 2, the single threshold hypothesis exhibits statistical significance at an even more stringent 1% significance level. The double and triple threshold hypotheses do not pass the test. Thus, Model 2 should use a single threshold model for estimation. These findings collectively suggest the presence of a nonlinear relationship between competition and BR. Furthermore, they underscore the role of TI as a threshold variable in shaping the relationship between competition and BR.

Table 4. Threshold effect type test of model 1 and model 2.

Regime-dependent variable	Counts of thresholds	F-statistic	p-value	Crit10	Crit5	Crit1
IV_lindex (Model 1)	Single	12.33*	0.100	12.417	12.417	21.271
	Double	10.27*	0.090	9.786	12.216	19.267
	Triple	7.29	0.433	16.653	19.397	24.990
IV_lindex (Model 2)	Single	27.17*	0.000	12.365	15.697	22.958
	Double	3.14	0.880	11.338	14.186	18.778
	Triple	8.92	0.173	10.883	12.978	17.246

Note: Double-threshold model; *=0.01, signifies 1% significance level.

4.6. Analysis of the Threshold Model Regression

Following the identification of the appropriate threshold models, it became imperative to estimate the threshold values for each of these models. Table 5 provides an account of the estimated threshold values along with their corresponding confidence intervals for both Model 1 and Model 2.

Table 5. Threshold model estimation (Model 1 - DV_BR_CRS).

Variables	Coefficients	P-value	SD	t
β'_1	0.115	0.700	0.297	0.39
β'_2	1.113*	0.000	0.230	4.83
β'_3	0.198*	0.001	0.059	3.35
β'_4	-0.038	0.313	0.038	-1.01
C_roa	-0.237*	0.000	0.025	-9.26
L_C_mcapcr	-0.039	0.311	0.038	-1.02
C_car	0.051*	0.000	0.011	4.45
_cons	-0.222	0.336	0.230	-0.96
Threshold model estimation (Model 2 - DV_BR_VRS)				
β'_1	0.868*	0.000	0.193	4.49
β'_2	0.355*	0.000	0.071	4.94
β'_3	-1.523	0.010	0.584	-2.61
β'_4	-0.064*	0.173	0.047	-1.37
C_roa	-0.222*	0.000	0.028	-7.79
L_C_mcapcr	-0.013*	0.771	0.044	-0.29
C_car	0.067*	0.000	0.013	5.15
_cons	-0.446**	0.081	0.254	-1.76

Note: Double-threshold model; *=0.01, indicate 1% significance level.

Table 5 presents the results of the threshold model estimation for Model 1 with the dependent variable BRC (Business Risk Reduction efficiency at Constant Return to Scale). This analysis aims to understand how various independent variables, including Lerner's Index (Lindex as a proxy for competition), relate to the Business Risk Reduction Efficiency of banks in the presence of a threshold effect. The threshold variable used here is Technology Investment (TI). The first regime, denoted by $\beta'1$, is not statistically significant (p-value = 0.700). It suggests that the initial segment of Lerner's Index does not have a significant impact on BRC before the first threshold. The second and third regimes, denoted by $\beta'2$ (p-value = 0.000) and $\beta'3$ (p-value = 0.001), are statistically significant. They indicate that the second and third regimes of Lerner's Index have a significant impact on Business Risk Reduction

efficiency after crossing their respective thresholds. This shows that after crossing a threshold level of technology investment, the business risk reduction efficiency decreases with the increase in competition, ultimately causing the BR of banks to increase. Other control variables, such as return on assets, market capitalization, and capital adequacy ratio, have statistically significant p-values and effects on business risk.

Table 5 presents the results of the threshold model estimation for Model 2 with the dependent variable BRV (Business Risk at Variable Return to Scale). As per Table 4, Model 2 has a single threshold model for the estimations. The first two regimes, denoted by $\beta'1$ (p-value = 0.000) and $\beta'2$ (p-value = 0.000), exhibit a high degree of statistical significance, signifying that the initial and second segments of Lerner's Index exert substantial positive influences on BR but at a decreasing rate. To check the robustness of results, we examine the result of BR reduction efficiency at variable return to scale. We find that the level of Business Risk reduction efficiency increases at a slower rate with an increase in competition after crossing the threshold level. Ultimately, this causes the actual BR to increase. The other control variable and constant term are statistically significant (p-values < 0.01), underscoring their significant roles in influencing BR.

5. DISCUSSION

The empirical results from this research show that with the increase in competition and after crossing a threshold level of expenditure in technology, the Business Risk Reduction Efficiency of banks is increasing at a slower rate. This indicates that it is becoming more challenging for banks to manage their business risk efficiently. Therefore, the hypothesis is accepted that banks are exposed to more business risk due to the increase in competition amidst rising technological investments. According to a similar study by Uddin et al. (2023), it was concluded that investment in technology and technological innovations expose banks to more risk. Although technology increases business volume, it can cause system failures, problems with internal processes, and disruptions from external and internal security threats inherent to technology. In the empirical research, it was found that digitalized banking operations are a key driver of risk associated with increased business volume. According to Khattak (2022), banks benefit from technological development under a moderate level of competition. However, if competition becomes severe, technological development does not provide the same advantages (Khattak, Ali, & Khan, 2022).

In the current scenario, the surge in BR can be attributed to heightened competition from fintech, introducing novel products, processes, and entities. This is accompanied by a substantial increase in technology investments aimed at offering new services to customers conveniently while also addressing cybersecurity and data privacy concerns. The rationale behind this risk escalation includes challenges such as cybersecurity issues, substantial reliance on system functionality and potential failures, adherence to regulatory compliance, exposure to legal risks, effective management of data privacy, and the reputation of banks being in jeopardy. Additionally, factors contributing to this risk amplification encompass cost overruns in technology investments, the need for skilled human resources, and challenges related to interoperability and integration (Banerjee, Pradhan, Sensoy, & Goodell, 2024; Sharma, Ali, & Khan, 2023).

Based on cyber technology advancements that increase operational hazards in tandem with business growth, baseline results often demonstrate the power of technology for quicker business growth. Therefore, even though digitalization promotes company expansion and revenue growth, ceteris paribus, institutions with more digital operations are susceptible to unknown hazards from the chance of risk occurrences (Aldasoro, Gambacorta, Giudici, & Leach, 2022; Boot, Hoffmann, Laeven, & Ratnovski, 2021; Uddin, Mollah, & Ali, 2020). Additionally, banks find it difficult to keep up with the rapid advancements in technology. As a result, bank servers and client interactions are taken over by service-providing FinTech agents (Boot et al., 2021). With the continued evolution of technology opening up new avenues for creative financial solutions, banks are left to deal with an increasingly complex set of cyber threats and attacks. The complexity of protecting sensitive financial information from nefarious actors presents

a daunting challenge, requiring ongoing investment in effective cybersecurity protocols to offset the potential consequences of cyber breaches (Bolourforoush & Jahankhani, 2023).

The other crucial aspect driving increased BR is the high reliance on system operations and vulnerability to breakdowns. In a time when smooth and consistent digital flows are critical, any system glitch or breakdown in the banking networks has profound implications. The volatile nature of such events introduces an element of operational risk, thus exponentially increasing the overall risk exposure of financial institutions (Boot et al., 2021).

Compliance with regulation constitutes another important parameter shaping the environment of technological risk in banking. Facing the need to keep up with regulatory changes as they evolve to suit developments in technology, banks are being forced to invest significant sums into TI in order to address and comply with these new standards. With the lack of implementation of necessary TI infrastructure, banks are made vulnerable to the imposition of massive regulatory fines, in addition to inherent legal risks and a complicated risk landscape requiring active risk management measures to achieve compliance. Furthermore, the risk landscape is magnified by the processing of sensitive customer data through TI systems, which combine data privacy risks with the risk of damage to reputation (Allen, 2024). Privacy is highly guarded by banks mandated to hold onto privacy for their customers and therefore operate under strict data privacy laws. When a bank experiences a breach of, or mishandling of, customer data, it exposes both a financial and a reputation threat, affecting customer trust and the institution's credibility in a very negative way (Shehab, Al Mubarak, & Dhia, 2023; Uddin et al., 2023). The excellent example in the Indian context would be Kotak Mahindra Bank, which received RBI warning for its inability to allocate regulatory requirements to onboard customers online. RBI has tightened the online onboarding process and the new credit card issuance process. As a result of non-compliance with regulations, they have experienced reputational damage (ET Bureau, 2024).

TI investments' cost overruns form yet another level of risk, since technological developments are usually at a high cost. It has also increased human resource needs, with banks requiring trained IT personnel to effectively run and maintain their TI systems. A lack of skilled professionals in this field creates a concrete threat to the smooth functioning of such systems, highlighting the importance of human capital in overcoming the challenges of changing technological environments (Borello, Pampurini, & Quaranta, 2022).

It is interesting to note that technology investment acts as a double-edged sword, promoting competition and BR. Although technology contains entry barriers, making it easier for smaller players to create, consumers get more options and better products/services; technology fuels more competition. Government regulations and antitrust regulations are key to controlling competitive behavior and maintaining fair competition in the ever-changing environment of technology markets. The confluence of greater technology integration and a burgeoning fintech sector is not only accelerating competition but also bringing about a critical need for astute management strategies to maneuver through the associated BR.

6. CONCLUSION

This study presents a new perspective to analytically explore the role of competition on BR and the effect of technological investment in Indian banks. The study employed a panel data estimate covering ten years for the period 2012 to 2022 and 23 cross-sectional commercial banks in India. We observe that the banking sector is facing multiple changes due to the emergence of new technology, newer products, and an increase in competition. However, banks are proactive in monitoring financial risks such as credit risk and default risk. Nevertheless, they fail to examine the BR and how it is being impacted by the increase in competition and technological changes. This research aims to fill the gap and provides insights for better management in the banking system.

The study shows that technological investment significantly moderates the relationship between BR and competition. We find that with the increase in competition and after crossing a threshold of technology investment, the business risk reduction efficiency increases at a slower rate. This causes a reduction in banks' efficiency in

maintaining the BR, leading to an increase in BR. The reason for such an increase in BR can be attributed to heightened competition from fintechs introducing novel products, processes, and entities. This is accompanied by a substantial increase in technology investments aimed at offering new services to customers conveniently while also addressing cybersecurity and data privacy concerns. The rationale behind this risk escalation includes challenges such as cybersecurity issues, substantial reliance on system functionality and potential failures, adherence to regulatory compliance, exposure to legal risks, effective management of data privacy, and the reputation of banks being in jeopardy. Further factors leading to this risk exaggeration include cost overruns in TI, requirements for qualified human resources, and interoperability and integration challenges.

A proper management of BR in the fast-changing environment of digital technology requires government intervention in regulating competition and continuously monitoring technological developments. Banks, on their part, should be able to navigate successfully the challenges of the new technologies as well as the spurt in transaction volumes arising from technological ease. Governments are encouraged to establish well-rounded national technological policies and pass cyber legislation that promotes the establishment of a safe digital economy and reduces BR risks. Investing in digital technology is essential in today's era, with no other option. However, a judicious approach is essential, recognizing that such investments, while unavoidable, may concurrently elevate associated risks. Therefore, the delicate balance between embracing digital advancements and exercising caution to control BR underscores the imperative for both government and financial institutions in the present day.

The study provides new insights for banks, regulators, and the Basel Committee to review their recommendations for estimating banks' risk further. Within the confines of the researchers' current knowledge, this study stands as one of the limited inquiries that contribute novel insights into the nexus between BR and competition. Furthermore, it furnishes valuable information regarding the dynamic influence of technological investment. Such findings hold considerable significance for regulatory authorities in formulating pertinent policies. The study offers practical implications by recommending that managers within the Indian banking sector concentrate on technology investments. It suggests aligning innovative capabilities with BR management policies and leveraging available financial resources to mitigate the impact of competition on BR. Notably, this study extends the existing body of knowledge, as previous research has predominantly focused on financial risk rather than BR. Further research can explore the points drawn from this study more deeply to obtain new insights and guide financial institutions' risk management practices in the future as technological innovations continue to evolve.

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