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EFFECT OF RISK AND MARKET COMPETITION ON EFFICIENCY OF COMMERCIAL BANKS: DOES OWNERSHIP MATTER?

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ABSTRACT

Purpose– This study aims to investigates the impact of risk and market competition on the efficiency of Bangladeshi commercial banks, having an special effect of ownership.

Methodology– We select 43 commercial banks out of 61, adjusting outliers and missing data from 2000-2019. The two-step Generalize Methods of Momemts (GMM) opt for to investigate unbalanced dynamic panel data of 666 obsevations. Unit root, multicolinerity, and other prediagnostic tests support our selected method of investigation.

Findings– The two-step Generalize Methods of Moments (GMM) reveals that the impact of risk, stability, and market competition has a homogeneous effect on cost and human capital efficiency in Aggregate industry, Conventional, and Private banks' data. With the increase of risk (stability), the efficiency of banks increases (decreases); having an exception, the human capital efficiency of private banks decreases with risk-taking. However, market competition depicts the inverse association with the efficiency of Commercial banks, Conventional banks, and Private banks.

Conclusion– The nonlinear and quadratic effect of risk and market competition on different ownership of banks is also found valid in the Bangladeshi banking industry. Finally, the reaction of Islamic and Public banks asserts the opposite response to Conventional and Private banks, respectively.

Keywords: Efficiency, ownership, market competition, GMM estimators.
JEL Codes: D61, G21, C20

1. INTRODUCTION

The aftermath of the financial crisis through policy and regulatory change has shaken the global market also wave most institutions and markets. As a participant in the Global market, Bangladesh is not exceptional. The banking industry of Bangladesh is bank-based, and like most countries, the banking industry of Bangladesh is dominated by commercial banks. Moreover, the new entrance of commercial banks in regular intervals expands the market's total size and competition (Das Gupta, Sarker, & Rifat Rahman, 2021). The growing number of banks and increased competitive situations make the commercial banks shrink their profitability target and concentrate more on the customer base to hold on and grow. However, competition increases the diversity in banking and increases the risk-taking tendency of commercial banks (Zheng, Gupta, & Moudud-Ul-Huq, 2017). Regulatory changes and emphasis on its implementation pinpoint the concern of regulators and policymakers regarding risk-taking in the competitive market. As capital is the costly source of finance, so regulatory capital affects banks' cost efficiency. Thus regulatory changes raise the tension of banks in risk-taking and efficiency balance(Y. Altunbas, S. Carbo, E. P. Gardener, & P. Molyneux, 2007). Again shortage of capital and regulatory compliance failure threaten depositors' and other stakeholders' positions (Gupta, 2018).

In the efficiency concern, Cost and Human capital are increasingly crucial in the performance measure of banks. Cost efficiency is inversely proxied the profit efficiency; on the other hand, human capital efficiency becomes a sensation in the

banking industry due to bankers' rapid job switching tendency (Zheng, Gupta, & Moudud-Ul-Huq, 2018b). Therefore, concern regarding the profit portfolio and retention of efficient employees is increasingly recognized as a severe issue to delve into the impact of risk and market competition on the efficiency of banks.

The efficiency of banks addresses the cost and human capital efficiencies in this study. Unlike previous studies, we incorporate aggregate industry and different ownership concerns for in-depth evaluation of efficiency. The extended nonlinear and quadratic model of the empirical research also addresses how the efficiency pattern of different ownership commercial banks changes with risk-taking, stability, and competitive market situation. Moreover, the joint effect of risk and market competition examination reinforces nonlinear and quadratic prescription findings. Amidu and Wolfe (2013) point out six reasons behind the importance of competition as a worth considering factor of the financial market in a literature review survey. These reasons are, first, to have more access to households and organizations to financial services; second, to ensure activities of financial sectors; third stability; fourth, efficiency; fifth resilence market rate and sustainable monetary policy; and finally, playing a role in industrial development and economic growth. Therefore there is an apparent significant association between bank efficiency and competition (Gupta, Sultana, & Das, 2021).

This study addresses a few significant insights. Firstly, intense market competition significantly impacts cost-efficiency deterioration and enhancement of human capital efficiency(HCE). Secondly, the risk-taking of commercial banks of Bangladesh increases the cost and human capital efficiency and decreases with incremental stability. However, the impact risk and stability do not hold the same over time. Finally, the quadratic effect of risk and competition on different efficiency is observed heterogeneous across ownership changes. Thus, from the finding of the study and evaluation of literature, it is apparent that risk, stability, market competition, and other industry level and macroeconomic factors significantly affect the efficiency of different commercial banks of Bangladesh. Moreover, increased market competition and growth of financial institutions reduce the information cost that raises concern of efficiency evaluation of financial institutions (Hauswald & Marquez, 2006). Therefore, the investigation of factors affecting efficiency demands empirical examination.

Further organogram of the study is as follows. Section 2 illustrates the related literature. Methodology development presents in Section 3 and Section 4 shows the study's empirical findings. Finally, concluding remarks are presented in Section 5.

2. LITERATURE REVIEW

With the expansion of banks' scope and size, banks' efficiency has become a critical consideration in a competitive market. As banks share uniform funding sources, i.e., deposits, capital, etc., efficient use of scarce resources is necessary for sustaining in the competitive business environment. As efficiency affects and is affected by banks' risk, risk needs to be measured explicitly in efficiency measure and vice versa (Koetter, 2008). No conclusive finding is observed to attain a decision regarding the association of risk and efficiency. For the ease of readership and debate of past research, the literature review presents in the following subsections: (1) Literature depicting association of bank risk and efficiency, (2) Literature relating to competition and efficiency, (3) Literature examining the impact of ownership on risk and efficiency.

2.1. Litereature Depicticing the Relationship between Risk and Efficiency

A negative association between risk and efficiency is based on the phenomenon that efficiency gain reduces the risk. However, diversified findings are also evident in the literature opposing and supporting the inverse association. Gupta et al. (2021), Das Gupta et al. (2021), Zheng et al. (2018b), Nguyen and Nghiem (2015), Fiordelisi, Marques-Ibanez, and Molyneux (2011), among others, depict an inverse association between efficiency and risk. Nonperforming loan is one of the significant determinants of banks efficiency (Allen N. Berger & DeYoung, 1997). Finding also points out that monitoring and recovery management has a significant impact on bank efficiency. However, T Deelchand and C Padgett (2009) find the moral hazard hypothesis's relevance[1] in risk and efficiency association. Fiordelisi et al. (2011) pin point low cost and revenue efficiency to enhance banks' risk that supports 'bad management[2]' hypothesis. Technological advancement also affect in achieving cost efficiency of banks Nguyen and Nghiem (2015).

In contrast to the negative relationship, different studies show the positive relationship between risk and efficiency. The single country exposure of Tan and Floros (2013) on China illustrate a significant positive association between risk and efficiency. Similar findings also show Zangina Isshaq, Bokpin, and Amoah (2015) on Ghanian banks.

The technical efficiency of banks increases the loan volume on the one hand and reduces screening and monitoring of investments that enhance bank risk on the contrary (Tan & Floros, 2013). However, Y. Altunbas, S. Carbo, E. P. M. Gardener, and P. Molyneux (2007) do not observe a meaningful association between risk and efficiency in commercial banks. Salim, Arjomandi, and Dakpo (2017) blame political interference as a critical reason for loan default. They opine that over time,

[1] Moral hazard hypothesis (MHH) postulates that undercapitalization leads banks to opt for riskier project that results incremental default risk subsequently.
[2] Bad management hypothesis (BMH) explains that deterioration of cost efficiency act behind incremental credit risk.

although the efficiency of banks increases, the quality of loans decreases because of political interference in loan proposal screening. From the literature between risk and efficiency hypothesis of the study is:

H_1: Risk has a significant positive effect in determining the efficiency of banks.

2.2. Literature Relating to Comptetion and Efficiency

Two dominant hypotheses say, 'competition-efficiency' and 'competition-inefficiency', are dominantly available in the literature. Adopting the efficient structure (Demsetz, 1973), the competition-efficiency hypothesis is presented by Schaeck and Čihák (2008). The authors explain that banks are forced to control their costs and offer low-cost services to cope with the competition to adjust to the exogenous shock. Managers are also forced to increase their profitability through the shifting of outputs. Again due to size benefit, large banks become more efficient in controlling cost and gaining profitability that in turn help efficient banks to have more market power. That means higher competition leads banks to be more efficient. A concentrated market creates the opportunity for managers to enjoy a 'quiet life[3]', and banks become cost-inefficient due to ignorance of cost control.

Competition-inefficiency narrates the opposite concept of the competition-efficiency hypothesis. The hypothesis illustrates that market competition has a detrimental effect on banks' efficiency (Schaeck & Čihák, 2008). Schaeck and Čihák (2008) pinpoint several reasons for the apparent existence of competition-inefficiency. The competitive market creates diversified options for the customer to grasp the best alternative. As a result, the propensity to switch banks increases. Thus banks without robust and loyal customers fall into a liquidity crisis in deposit mobilization.

Moreover, banks do not incur many resources to gain more information to build a solid customer base in competitive markets. In a competitive environment, they are less intended to spend resources to care about relationship-building. Therefore, a competitive market increase cost of banks to retain and attract customers due to aggressive market effort and information asymmetry. Inverse association between efficiency and market competition is also addressed in empirical investigations. For example, Evanoff and Ors (2003), Kumbhakar, Lozano-Vivas, and Hasan (2001), Deyoung, Hasan, and Kirchhoff (1998), among others, show that market competition negatively affects the efficiency of banks. Deyoung et al. (1998) depict the inverse association of the new entrant of banks and efficiency.

Zangina Isshaq et al. (2015) asserts that the cost efficiency of foreign banks moves along with their risk-taking. That means efficiency and risk of banks are positively associated. A similar finding is also observed in the literature. Alhassan and Ohene-Asare (2016) affirm the positive relationship and advocate that market competition significantly impacted banks' efficiency.

In contrast to these findings, the evidence of H. T. M. Phan, Daly, and Akhter (2016) depicts the inverse association of competition and efficiency of banks. Again Fungáčová and Poghosyan (2011) observe no meaningful association between competition and the efficiency of banks. However, contract finding is also evident. A. Kasman and Carvallo (2014) evidence a significant association and opine that enhancing efficiency increases banks' market power, which contributes to further efficiency gains.

H_2: Market competition has a significant negative effect on the efficiency of banks.

2.3. Literature Ecamining the Impact of Ownership on Rsik and Efficiency

Empirical research also evidences the significant association of ownership in risk and efficiency of banks. Amor (2017) opines that concentrated and State ownership reduces Tunisian banks' risk-taking, whereas diversified ownership enhances the same. Similar observation also pinpoints by Liu, Brahma, and Boateng (2019) on Chinese banks. The author advocate government ownership in managing credit risk, whereas private banks exacerbate the default risk of banks. In contrast to these findings, Ehsan and Javid (2018) assert that Government and concentrated ownership have significant positive whereas foreign ownership has a significant negative impact on banks' risk-taking. The debate with contrasting findings also apparent in cross country examination. Hammami and Boubaker (2015) advocate the positive association of credit risk and concentrated ownership from the study of MENA countries. They also opine that foreign banks are taking more risk than domestic banks, where Government-owned banks are more stable than other counterparts. In another work on MENA countries, Haque (2019) evidence the inverse relationship between foreign ownership and risk-taking of banks. They also observe the negative association of concentrated ownership with the risk-taking of MENA banks.

Supporting the "concentration-stability" view, ElBannan (2015) evidence that concentration increases banks' stability. However, Government banks are more porn to credit risk than their counterparts. Pointing differently, Hu, Li, and Chiu (2004) argue that the impact of government ownership over risk-taking follows a nonlinear U-shape curve. With the increase of

[3] Quiet Life hypothesis (QLH) explains insufficient monitoring of market creates market power which makes managers reluctant to take risk that results lower profit and higher cost.

Government ownership, risk-taking decreases at a certain point and then increase. Working on Bangladeshi commercial banks, Moudud-Ul-Huq, Biswas, Chakraborty, and AMIN (2020) preach that ownership structure has a significant positive association in default risk management and stability. Another empirical finding of Sarker and Nahar (2017) on Bangladesh enforces the impact of ownership on the risk-taking of Bangladeshi commercial banks. The authors depict that private commercial banks take less risk than parallel Government commercial banks. Evidence of Srairi (2013) of MENA countries shows that ownership does not significantly impact the stability of banks; however, Islamic banks are more efficient in credit risk management than conventional banks. Shehzad, de Haan, and Scholtens (2010) opine that ownership concentrations significantly affect banks' credit risk; however, these effects depend on protecting shareholders' rights and supervisory control.

The empirical study of Haque and Shahid (2016) examining the impact of ownership on risk-taking and performance of banks depicts that Government ownership increases the stability and credit risk of banks and reduces the performance in the form of profitability. A similar finding is observed in the Iannotta et al. (2007) study. Iannotta et al. (2007) opine that although ownership concentration is not statistically significant in the profitability of banks, but has a meaningful impact on loan quality and stability of banks. They also opine that large shareholders' ownership concentration has no significant effect on banks' risk and stability measures.

In examining the causal effect of ownership on efficiency, Altunbas, Gardener, Molyneux, and Moore (2001) preach that private banks are more efficient than mutual and public German banks. However, public and mutual banks have cost and profit advantages over private banks. Djalilov and Ngoc Lam (2019) findings also acknowledge the impact of ownership on banks' efficiency. The author pinpointed that banks with no controlling shareholders are observing lower efficiency. However, higher risk-taking plays an inverse role in confirming efficiency. In contrast to this finding, Aymen (2014) follows no significant impact of ownership on the performance of Tunisian banks. Few studies on single countries and cross countries also address substantial insights regarding the effects of ownership on the efficiency of banks.

Allen N Berger, Hasan, and Zhou (2009) postulate minority foreign ownership significantly enhance the efficiency of Chinese banks. The authors add that State-owned banks are the least efficient, and multinational banks are most efficient in China. Mamonov and Vernikov (2017) assert that banks' cost-efficiency depends on ownership and lending ratios. They argue that as government banks are led to politically motivated unprofitable loans, they are cost-efficient with a low lending ratio. In contrast, foreign banks are more efficient when they lend more.

Examining 82 cross countries, Doan, Lin, and Doong (2018) opine that State-owned banks are less efficient than their counterparts. However, the efficiency of foreign banks is heterogeneous. The authors pinpoint the efficiency of foreign banks' influence through diversification, and they are less efficient in developed countries but more efficient in developing countries. In contrast to this finding, another work on 105 cross countries Lensink, Meesters, and Naaborg (2008) provide empirical evidence of a negative relationship between foreign ownership and the efficiency of banks. They argue that good governance can make the negative effect of ownership less pronounced.

From the study of existing literature, there is a vacuum of empirical examination of how risk and efficiency are related in different ownership setups. Again the impact of ownership is homogeneous or heterogeneous over time on efficiencies yet to examine from a developing country perspective. Moreover, most of the studies focus on cost and profit efficiency. There is a scarcity of literature observing the effect of risk-taking and competition on human capital efficiency.

H_3: There is a heterogeneous impact of ownership on the efficiency of banks.

3. METHODOLOGY OG THE STUDY

This section explains the data and variables used in the study and the empirical analysis methods. At first, the description of variables and the following econometric models are described in this section.

3.1. Collection of Data

We source macroeconomic and industry-level data from the World Banks dataset and derive from where required from industry data of Bangladesh Bank. There are 61 schedule banks now operating in Bangladesh's Banking industry, including two newly entered banks in 2020. However, after excluding nine foreign commercial banks and three specialized banks due to non-availability and inconsistent reporting nature, we have 43 commercial banks for the study. Banks without having five years' consecutive reports and extreme (ICB commercial bank) outlier effect were also excluded from the dataset. After excluding missing years' data over 2000-2019, we have 666 unbalanced panel observations.

The remaining part of this section explains the data and variable description of the study and empirical econometric model to address the impact of risk and market competition on the Efficiency of Bangladeshi commercial banks.

3.2. Definition of Variables

Efficiency (dependent variable)

Following A. Kasman and Carvallo (2014), Zheng, Gupta, and Moudud-Ul-Huq (2018a), Gupta and Moudud-Ul-Huq (2020), Gupta et al. (2021), among others, we also determine Cost efficiency and Human Capital efficiency through Stochastic Frontier Analysis (SFA). Software FRONTIER version 4.1 opt for measuring bank efficiency from banks level data.

Using the intermediation approach (Sealey & Lindley, 1977) and following recent studies of Moudud-Ul-Huq (2020), Gupta et al. (2021), Zheng et al. (2017), T. Deelchand and C. Padgett (2009), the translog cost function with three inputs and two outputs against the total cost as a dependent variable as follows.

$$\text{Ln TC} = \alpha + \sum_i \alpha_i \, lnQ_i + \sum_j \beta_j \, lnP_j + \tfrac{1}{2} \sum_i \sum_k \gamma_{ik} \, lnQ_i lnQ_k + \tfrac{1}{2} \sum_j \sum_h \delta_{jh} \, lnP_j lnP_h + \sum_i \sum_j \lambda_{ij} \, lnQ_i lnP_j + \varepsilon \quad (1)$$

Changing the error term to $V_n - U_n$ from $V_n + U_n$ and using the equation as a production function following Coelli (1996), we determine the human capital efficiency with three inputs and two outputs. Detailed estimation presents in Appendix A. Summary description of variables with literature reference is given in **Table 3**.

Risk Measures

The study chooses two measures- credit and stability risk to address bank risk.

Credit Risk: Following the previous literature of Abedifar, Molyneux, and Tarazi (2013), Liang, Xu, and Jiraporn (2013), Liang et al. (2013), Zheng et al. (2018b), Gupta et al. (2021), credit risk is also addressed through the ratio of Nonperforming loan to total loans and advances (NPLTL). The ratio indicates the proportion of default to total investment. The higher the ratio NPLTL, the more credit risk exposure.

$$NPTL = \frac{Non - performing\ Loan}{Total\ Loan\ and\ Advances}$$

Stability Risk (Z-score): Z-score is the inverse measure of credit risk and direct measure of stability. A large ratio of Z-score refers to more stability. We derive Z-score by adding CAR with ROA, where CAR refers to capital adequacy ratio, and ROA denotes return on assets—then divided the sum by standard deviation (SD) of ROA. We use three years of successive data of ROA to determine the SD of ROA.

$$\text{Z-score} = \frac{(CAR + ROA)}{\delta(ROA)}$$

Following the study of Craig and Dinger (2013), Zheng et al. (2017), Moudud-Ul-Huq, Zheng, and Gupta (2018), Gupta and Moudud-Ul-Huq (2020), among others, Z-score is used to denote the stability risk. A higher ratio of Z-score indicates more stability and lower insolvency risk of banks (Roy, 1952). Detailed measurements explain in Table 1.

Market Competition (Boone indicator)

Following the literature of Gupta (2018), S. Kasman and Kasman (2015), Gupta and Moudud-Ul-Huq (2020), and Tabak, Fazio, and Cajueiro (2012), this study is also opted for Boone Indicator to examine the competition effect. Boone indicator is a better-fitted model and encounters the problems of theoretical measure of market concentration and inverse competition measure Lerner index and (Lerner, 1934) and Posner and Rosses H-statistic (Zheng et al., 2017). BI assumes efficiency gain at minimum cost with maximum profitability (S. Kasman & Kasman, 2015). The empirical model used by S. Kasman and Kasman (2015) to estimate BI is,

$$\ln(ms_{st}) = \alpha + \sum_{t=1}^{T-1} \beta_t D_t \times \ln(mc_{st}) + \sum_{t=1}^{T-1} \partial_t D_t + \in_{st} \quad (2)$$

'ms' and 'mc' of the above equation refer to market share and marginal cost. Time dummies (D) are also incorporated in the model to control the time effect. Boone indicator represented by the coefficient β stands for Boone indicator and $\in_{st}$ is the error term. An intense competitive market denotes by the large negative value of BI. However, information on the Boone indicator is not available in the World Banks data set after 2017. Following Schaeck and Cihák (2014), we also determine the value of the Boone indicator empirically from the aggregate industry data of Bangladesh Banks. The model for estimating Boone indicator is,

$$\Pi_{it} = \alpha + \beta \ln(MC_{it}) \quad (3)$$

Where Π_{it} refers to measures of profit of bank 'i' at 't' time and is measured through ROA; β is the Boone indicator. To determine the marginal cost, we follow Schaeck and Cihák (2014) suggestions and Boone (2008) and use average variable

cost as a proxy of marginal cost. We regress the logarithmic value of ROA (lnROA) with the logarithmic value of average variable cost (ln MC) and determine the value of the market competition measure.

Detail measures of other variables are given below.

Table 1: Summary of Variables Description of the Study

Classification	Variable	Description	Literature references/Source
Dependent Variable			
Efficiency	Eff_C	Cost efficiency determined through stochastic frontier analysis	Harimaya and Ozaki (2021), Gupta (2018), Zheng et al. (2018b).
	Eff_HC	Human Capital efficiency determined through stochastic frontier analysis	Zheng et al. (2018b), Gupta (2018).
Independent Variables:			
Dummy Variables	Own_C	Ownership dummy- Conventional banks. Conventional Banks = 1, Otherwise = 0 (Islamic Banks).	Authors' calculation.
	Own_P	Ownership dummy- Private banks. Private Banks = 1, Otherwise = 0 (Public Banks)	Authors' calculation.
Industry-level variables:			
	BSD	Banking sector development= Ratio of Industry assets to GDP	Gupta et al. (2021), Das Gupta et al. (2021). Source: World Bank data
	BI	Boone Indicator: Competition proxy (see 3.2.3) $\Pi_{it} = \alpha + \beta \ln(MC_{it})$ Where β is the Boone indicator.	Gupta et al. (2021), Zheng et al. (2017), Schaeck and Cihák (2014). BI Derived by the authors following literature reference.
Macroeconomic variables:			
	GGDP	The growth of real gross domestic product	Moudud-Ul-Huq (2020), Anupam Das Gupta (2021). Source: World Bank data.
	Inflation	Inflation, GDP deflator (annual %)	Gupta and Moudud-Ul-Huq (2020), Gupta et al. (2021). Source: World Bank data.
Bank-level control variables:			
Risk measures			Das Gupta et al. (2021), Fang, Lau, Lu, Tan, and Zhang (2019), (Zheng et al., 2018b)
Credit risk	NPLTL	Nonperforming loan to total loan and advances (Nonperforming loan denotes the default loans)	
Stability risk	Z-score	Z-score= $(\frac{(CAR+ROA}{\delta(ROA)})$, Where ROA= Return on assets, CAR = capital adequacy ratio, & $\delta(ROA)$= standard deviation of ROA of three years overlapping periods.	Gupta and Moudud-Ul-Huq (2020), Farruggio and Uhde (2015), Pan and Wang (2013), Craig and Dinger (2013), Beck, Demirgüç-Kunt, and Merrouche (2013).
Size of Bank	Size	The logarithm of total assets	Yesmin (2018), Bougatef and Mgadmi (2016), Goddard, Molyneux, and Wilson (2004).
Profitability	ROA	Return on assets	Davis and Mathew (2017), Javaid (2016), Tan (2016), Anarfi, Abakah, and Boateng (2016).
Off-balance sheet exposure	OBSTA	Ratio off-balance sheet exposure to total assets (TA)	Yesmin (2018), Gupta (2018), Mongid, Tahir, and Haron (2012).
Deposit ratio	DTA	The ratio of deposit to TA	Yesmin (2018), Gupta (2018), Zheng et al. (2017).

Source: Compilation of authors. Fourth column of the table refers to the literature followed in measurements.

3.3. Empirical Research Framework

To address the effect of risk and market competition on the efficiency banks, we opt for System GMM (Generalized Method of Moments). Ownership dummy is considered to pinpoint the diversified effect of ownership, say Conventional banks vs Islamic banks; Private banks vs Public banks, in risk-taking and competitive market situations. Unbalanced panel data opt for examination to increase the degrees of freedom and cover maximum observations. Unbalanced panel data allows maximum statistical approximation and observation through the multiplication of cross-section with periods (Gupta et al., 2021). For the unbalanced dynamic panel data of the study, we use system GMM following Arellano and Bover (1995) and Blundell and Bond (2000). System GMM addresses the model's endogeneity, heteroskedasticity, and autocorrelation problem (see Appendix B) (Baselga-Pascual, del Orden-Olasagasti, & Trujillo-Ponce, 2018; Gupta & Moudud-Ul-Huq, 2020; Moudud-Ul-Huq, Ashraf, Gupta, & Zheng, 2018; Zheng et al., 2018a).

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \sum_{j=3}^{4} \beta_j \, X_{i,j,t} + \sum_{m=5}^{6} \beta_m \, X_{i,m,t} + \sum_{p=7}^{11} \beta_p \, X_{i,p,t} + \varepsilon_{i,t} \quad (4)$$

In the above empirical model. '$Y_{i,t}$' represents the dependent variable-efficiency. Cross-sectional dimension denotes by the subscript 'i', and the subscript m,n,p denotes macro-economic (ME), industry-level(IL), and bank-level(BL) control variables, respectively. 't' refers to the time dimension and is expressed in the year. One year lagged dependent variable denotes by Yi,t-1. The study covers data from the year 2000 to 2019.

The macroeconomic variables Inflation and GDP growth (GGDP) denotes by $X_{i,j,t}$. The '$X_{i,m,t}$' depicts IL control variables: Competition Boone Indicator (BI) and Banking Sector Development (BSD) at t period. The $X_{i,p,t}$ refers to the banks level control variables of bank *i* at *t* period. Bank-level control variables are risk (NPLTL, Z-score), deposit to total asset (DTA), Size (logarithm of TA), Profitability (ROA), and Off-balance sheet exposure (OBSTA).

The pre-diagnosis test results restrict the use of OLS as a regression method due to heteroskedasticity (Breusch-Pagan / Cook-Weisberg test for heteroskedasticity), autocorrelation (Breusch-Godfrey LM test for autocorrelation). The preliminary model test also advocates the fixed-effect model (Hausman specification test). The lagged dependent variable in equation (4) depicts the dynamic panel and reject the assumption of OLS.

Therefore, system GMM estimates opt for an unbiased and consistent result of the fixed-effect unbalanced dynamic panel data model. System GMM addresses the discrepancies in unobserved and bias estimation (Arellano & Bover, 1995; Blundell & Bond, 2000). Our second-order serial correlation test results cannot reject the null hypothesis 'no serial correlation' of Arellano-Bond hypothesis. Our test results of AR(1) and AR(2) are in line with Nguyen and Nghiem (2020), Gupta and Moudud-Ul-Huq (2020), H. T. Phan, Anwar, Alexander, and Phan (2019), Zheng et al. (2018b), among others. To remove the time-dependent inconsistencies, AR (2) in residuals must be statistically insignificant, observed in all our applied models.

To address the impact of ownership, we redefine the baseline equations with ownership dummies. Two ownership dummies- Conventional banks and Private banks- are considered treatment variables considering counterparts as zero in the model to address Conventional vs Islamic, and Private vs Public banks, respectively. Models with ownership dummy as follows:

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} \times Own_{C/P} + \beta_4 BI_{i,t} \times Own_{C/P} + \beta_5 BSD_{i,t} + \sum_{j=6}^{7} \beta_j \, X_{i,j,t} + \sum_{p=8}^{11} \beta_p \, X_{i,p,t} + \varepsilon_{i,t} \quad (5)$$

Equation (5) precise how risk-taking and market competition affect Conventional vs Islamic banks and Private vs Publics banks of Bangladesh.

However, we also extend our baseline models to address the nonlinear and joint effect of risk and competition on bank efficiency. Assuming heterogeneous behavior of different ownership banks and risk-taking of the competitive market situation, we extend our baseline models as:

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} + \beta_4 risk_{i,t}^2 + \beta_5 BI_{i,t} + \beta_6 BI_{i,t}^2 + \beta_7 BSD_{i,t} + \sum_{j=8}^{9} \beta_j \, X_{i,j,t} + \sum_{p=10}^{13} \beta_p \, X_{i,p,t} + \varepsilon_{i,t} \quad (6)$$

Equations (6) & (7) express the nonlinear and joint effect of risk and competition on bank efficiency.

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} + \beta_4 risk_{i,t}^2 + \beta_5 BI_{i,t} + \beta_6 BI_{i,t}^2 + \beta_7 risk_{i,t} \times BI_{i,t} + \beta_8 risk_{i,t} \times BI_{i,t}^2 + \beta_9 BSD_{i,t} + \sum_{j=10}^{11} \beta_j \, X_{i,j,t} + \sum_{p=12}^{15} \beta_p \, X_{i,p,t} + \varepsilon_{i,t} \quad (7)$$

Equation (8) presents the extended model depicting the quadratic effect of risk and completion in different ownerships.

$$Y_{i,t} = \beta_1 + \beta_2 Y_{i,t-1} + \beta_3 risk_{i,t} \times Own_{C/P} + \beta_4 risk_{i,t}^2 \times Own_{C/P} + \beta_5 BI_{i,t} \times Own_{C/P} + \beta_6 BI_{i,t}^2 \times Own_{C/P} + \beta_7 BSD_{i,t} + \sum_{j=8}^{9} \beta_j \ X_{i,j,t} + \sum_{p=10}^{13} \beta_p \ X_{i,p,t} + \ \varepsilon_{i,t} \quad (8)$$

Where '$BI_{i,t}^2$' and '$risk_{i,t}^2$' refer to the squared term of competition and risk, respectively.

Product of risk and ownership dummy, Competition and ownership dummy address the impact of risk-taking and competition in different ownership concerns. The model efficiency of cost with credit risk and stability in empirical results is levelled as Model I and III. Again, Model II and Model IV denote the efficiency of human capital with credit risk and stability, respectively.

4. EMPIRICAL FINDINGS

This section at first presents the summary statistics (Table 2), Unit root test (Table 3), and multicollinearity test (Table 4-5), then presents the empirical finding of the study. The empirical results depict the impact of risk and market competition on the efficiency of banks presented in Table 6-10.

4.1.1. Descriptive Statistics

Summary statistics of Table 2 note that mean value of dependent variables efficiency of cost and efficiency of human capital are 1.4397 and 0.3596, respectively. The efficiency values are derived from the stochastic frontier analysis (SFA). The value of cost-efficiency is usually more than 1, whereas human capital efficiency is less than 1. Details estimation of efficiency against their dependent variables, inputs, and outputs is given in Appendix A. The average value of risk measures NPLTL and Z-score are 0.0797 and 87.90, respectively. That means the average nonperforming loan ratio to total loan is about 8%. However, there is no NPL (0) ratio and 100% NPL to total loan. Market competition measure Boone Indicator (BI) shows the mean value -3.5736. Boone Indicator usually shows the negative ratio. The higher the BI value, the more intense the competitive market. The mean of BI of the Bangladeshi banking industry depicts low competition than the Asian average ratio of -7.50 (Zheng et al., 2017).

Table 2: Summary Statistics of the Variables

Variable	Mean	Std.	Min	Max
Eff_C	1.4397	0.2527	1.0262	2.7661
Eff_HC	0.3596	0.1971	0.1059	0.9620
NPLTL	0.0797	0.1105	0.0000	1.0000
Z-score	87.9014	151.7654	-227.2060	1624.7390
DTA	0.7969	0.1002	0.1845	2.2597
ROA	1.1558	1.2871	-13.5200	6.0500
Size	11.3713	1.1692	8.3667	14.2031
OBSTA	0.2814	0.1314	0.0000	0.9251
GGDP	6.3381	1.0289	3.8331	8.1527
Inflation	6.0414	1.3036	3.2612	8.1646
BI	-3.5736	2.5085	-8.6020	-0.0952
BSD	50.7405	21.8676	18.3879	80.3359
Number of observations			666	

The mean inflation value is 6.04, which is lower than India, 9.16, and higher than the largest Asian country China 2.97 (Zheng et al., 2017). However, in economic progression (GGDP), Bangladesh 6.33 shows better than the Asian market (Gupta et al., 2021; Soedarmono & Tarazi, 2013). Industry-level variable BSD depicts the mean value of 50.74. Bank-level control variables Size, DTA, ROA, and OBSTA show the average value 11.37, 0.7969, 1.15, and 0.2814, respectively.

4.1.2. Unit Root Test

We run the Fisher Type Augmented Dickey-Fuller test to check the unit root for each variable and the data stationary. From Table 3 of the unit root test, no observation is significant against Fisher-type ADF test statistics at a 5% significance level. Thus the value finds no statistical evidence to accept the null hypothesis of "All panels contain unit roots."

Table 3: Unit Root Test (Fisher type ADF) at Level

Variable	Statistic	Probability
Eff_C	224.300	0.000
Eff_HC	217.738	0.000
NPLTL	6.171	0.000
Z-score	29.203	0.000
Size	36.976	0.000
DTA	30.872	0.000
ROA	13.580	0.000
OBSTA	4.446	0.000
BI	9.140	0.000
BSD	-3.378	0.001
Inflation	1.945	0.025
GGDP	7.302	0.000

It advocates that panel series data does not contain unit root or the data is stationary.

4.1.3. Multicollinearity Test

To check the multicollinearity problem between or among the variables, we run the variables' correlation analysis and VIF test. Table 4 of the correlation matrix does not show any correlation value between independent variables above 0.70, indicating that our models are free from significant multicollinearity problems.

Table 4: Correlation Matrix

	NPLTL	Eff_C	Eff_HC	DTA	ROA	Size	OBSTA	GGDP	Inflation	BI	BSD
NPLTL	1										
Eff_C	-0.1392	1									
Eff_HC	0.3066	-0.0858	1								
DTA	-0.0313	-0.1710	0.1212	1							
ROA	-0.3540	-0.0261	-0.2387	0.0566	1						
Size	0.1327	0.4374	0.3624	0.0226	-0.2832	1					
OBSTA	-0.0786	0.0641	-0.0966	0.1325	0.1973	0.0077	1				
GGDP	-0.0219	0.4590	-0.1604	-0.0607	-0.2362	0.5081	-0.0667	1			
Inflation	-0.1896	0.0913	-0.0464	-0.0538	0.0177	0.2867	-0.0821	0.1222	1		
BI	-0.0999	-0.1774	0.0844	0.0130	0.1438	-0.0935	-0.0063	-0.3673	0.2751	1	
BSD	-0.0210	0.5643	-0.2158	-0.1896	-0.2159	0.6570	-0.2178	0.6233	0.2488	-0.2821	1

Multicollinearity refers to the exact linear relationship between independent variables (Gujarati, 2009). If two or more variables exist in the same model, then the explanation of the independent variable may exaggerate. Gujrati and Porter (2009) state that if the pairwise correlation value is less than 0.80, the model is free from severe multicollinearity problems. Again, Kennedy (2008) refers to the value 0.70. As no pairwise correlation value is more than 0.70 so the models of the study are free from multicollinearity.

Further, we check the Variance Inflation Factor (VIF) test to reinforce the 'no multicollinearity' claim (see Table 5). VIF measures the relationship between one predicator with another in a model. The VIF test predicator value 1 refers to the variable that does not correlate with other variables, where value 10 depicts a high degree correlation (Thompson, Kim, Aloe, & Becker, 2017).

Table 5: Variance Inflation Factors

Variable	VIF
BSD	3.69
Size	2.67
GGDP	2.34
OWN_P	1.73
OWN_C	1.15
NPLTL	1.44
ROA	1.40
BI	1.36
Inflation	1.32
OBSTA	1.28
DTA	1.13

Since no correlation value is above 0.70 and VIF more than 5, we may conclude no multicollinearity problem between variables in the regression models.

4.2. Determinants of Efficiency and Examination Impact of Risk and Market Competition

Table 6 depicts the effect of risk and market competition on the efficiency of commercial banks. The results of Table 6 show that with the increase of credit risk (NPLTL), both cost and human capital efficiency enhances. However, with the growth of stability of banks, efficiencies are inversely affected. These findings align with Zangina Isshaq, Bokpin, and Amoah (2012). Proportionate reduction of loan monitoring cost is one of the possible reasons for increased efficiency with enhancing credit risk (Tan & Floros, 2013). Another explanatory variable, Boone Indicator (BI), shows the negative association with the efficiency of banks. BI usually shows the negative figure; a positive sign of coefficient refers to an inverse relationship with the dependent variable. It advocates that efficiency of cost and human capital decreases in a competitive market. These findings also support the previous results of H. T. M. Phan et al. (2016). The negative association of human capital efficiency may be the outcome of the increased credit risk of banks. Nonperforming loans are considered one of the inputs of measuring human capital efficiency. Thus, incremental nonperforming loans may decrease human capital efficiency in competitive market situations (Gupta et al., 2021).

Table 6: Effect of Risk and Market Competition on Efficiency of Banks

Variable	Model I	Model II	Model III	Model IV
Dep(-1)	1.084021***(4348.22)	1.005078***(4894.55)	1.083911***(5350.90)	1.00528***(6709.63)
NPLTL	0.001842***(7.98)	0.001343***(16.1)		
Z-score			-5.38E-06***(-19.34)	-1.16E-07***(-12.47)
BI	8.69E-06***(6.95)	1.02E-05***(25.84)	2.44E-05***(4.23)	7.41E-06***(13.91)
BSD	-3E-05***(-13.5)	0.000023***(17.08)	-2.7E-05***(-9.78)	2.38E-05***(15.85)
GGDP	0.000123***(17.69)	5.48E-05***(17.58)	0.000178***(7.23)	4.18E-05***(12.30)
Inflation	-0.00014***(-18.7)	2.76E-05***(23.39)	-0.00028***(-13.09)	8.42E-06***(5.03)
Size	-0.00012***(-2.90)	-0.00027***(-13.48)	9.21E-05(1.43)	-0.00027***(-11.25)
DTA	5.56E-05(0.54)	-0.00035***(-4.27)	0.000419*(1.82)	-0.00049***(-11.68)
ROA	-0.0000167*(1.91)	-2.5E-05***(-6.92)	-6.3E-05***(-5.75)	-5.3E-05***(-16.38)

OBSTA	-0.0023***(-12.37)	0.000823***(15.82)	-0.00278***(-13.15)	0.000805***(17.75)
Constant	-0.08689***(-129.44)	-0.00575***(-42.12)	-0.08814***(-140.21)	-0.00542***(-28.30)
Hansen Test (P-value)	0.827	0.947	0.712	0.981
AR(1) (P-value)	0.083	0.795	0.109	0.551
AR(2) (P-value)	0.134	0.379	0.372	0.803
Observations	623	623	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano–Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

The coefficient of BSD, Inflation, and OBSTA depict the negative (positive) association with the efficiency of cost (efficiency of human capital) model. With the passage of banking sector development, inflationary growth, and increased off-balance sheet exposures, the cost efficiency of banks decreases and human capital efficiency increases. Age or experience of operations in the banking industry playing a possible role in such a relationship. However, deposit mobilization (DTA) explores the opposite relationship, which means the proportionate increase of deposit over assets increases cost efficiency and decreases human capital efficiency. Small-sized banks with low profitability are more efficient than their other counterparts. These findings are aligned with Gupta (2018). The significant coefficient of GGDP depicts that economic progress enhances the efficiency of the commercial banks of Bangladesh.

4.3. Determinants of Efficiency and Examination of the Impact of Risk and Market Competition with Ownership Dummy

The study opts for two ownership dummies to examine the impact of risk and market competition on different ownership of banks. Dummy variables address the multiple groups in a single equation. The treatment group was considered 1 and the control group 0 (Wooldridge, 2016). We considered two dummy variables. Conventional banks and Private banks denote through treatment groups, and counterparts refer otherwise, i.e., Islamic and Public banks, respectively, as control groups of formers.

Table 7: Effect of Risk and Market Competition on Efficiency of Banks with Ownership Dummies

Variable	Segment A				Segment B			
	Model I	Model II	Model III	Model IV	Model I	Model II	Model III	Model IV
Dep(-1)	1.084484*** (5229.8)	1.005079*** (2992.16)	1.084371*** (4712.39)	1.005263*** (7653.13)	1.084186*** (5176.72)	1.005094*** (6418.12)	1.084128*** (4716.61)	1.005008*** (7421.95)
NPLTL× Own_C	0.001675*** (7.19)	0.001384*** (17.11)						
NPLTL × Own_P					0.000751** (2.66)	-0.00021** (-2.24)		
Z-score× Own_C			-2.68E-07*** (-10.57)	-1.18E-07*** (-11.88)				
Z-score× Own_P							-8.16E-07*** (-24.65)	-8.98E-07*** (-6.05)
BI × Own_C	8.46E-05*** (23.26)	1.16E-05*** (24.91)	8.22E-05*** (30.49)	5.33E-06*** (8.76)				
BI × Own_P					2.71E-05*** (19.39)	0.000038*** (23.91)	1.32E-05*** (9.53)	2.31E-05*** (12.71)
BSD	-3.1E-05*** (-22.7)	2.32E-05*** (23.87)	-3.2E-05*** (-20.79)	0.000024*** (22.66)	-3.3E-05*** (-24.37)	2.44E-05*** (28.26)	-3.1E-05*** (-17.30)	2.33E-05*** (11.88)
GGDP	0.000161*** (26.99)	5.44E-05*** (20.19)	0.000154*** (27.41)	4.05E-05*** (17.00)	0.000131*** (38.11)	5.62E-05*** (21.75)	0.000106*** (17.26)	3.56E-05*** (6.98)
Inflation	-0.00019*** (-22.02)	2.72E-05*** (28.74)	-0.00023*** (-45.02)	1.12E-05*** (6.70)	-0.00019*** (-26.10)	7.75E-06*** (5.46)	-0.00018*** (-25.17)	4.57E-06*** (3.71)
Size	-0.00011*** (-2.83)	-0.00027*** (-16.47)	-5.6E-05 (-1.64)	-0.00027*** (-15.53)	-3.9E-05 (-1.09)	-0.00029*** (-20.20)	-6E-05 (-1.48)	-0.00025*** (-7.52)
DTA	0.000239** (2.07)	-0.00035*** (-6.99)	0.000172 (1.39)	-0.00048*** (-8.84)	5.67E-05 (0.53)	-0.00047*** (-4.61)	0.000123 (1.14)	-0.00036*** (-3.05)

ROA	-1.9E-05**	-2.4E-05***	-4.7E-05***	-5.2E-05***	-3.5E-05***	-6.1E-05***	-3.6E-05***	-5.5E-05***
	(-2.40)	(-7.60)	(-6.19)	(-13.51)	(-5.67)	(-18.54)	(-5.66)	(-23.35)
OBSTA	-0.00229***	0.000814***	-0.00246***	0.000818***	-0.00254***	0.000899***	-0.00257***	0.000841***
	(-17.02)	(21.74)	(-14.30)	(24.57)	(-15.02)	(19.00)	(-16.35)	(18.47)
Constant	-0.08734***	-0.00569***	-0.08721***	-0.0054***	-0.08736***	-0.00502***	-0.08697***	-0.00548***
	(-232.55)	(-50.78)	(-222.94)	(-34.76)	(-249.26)	(-29.23)	(-205.93)	(-19.07)
Hansen Test (P-value)	0.494	0.955	0.357	0.970	0.546	0.990	0.815	0.954
AR(1) (P-value)	0.093	0.697	0.080	0.781	0.083	0.000	0.103	0.028
AR(2) (P-value)	0.123	0.328	0.181	0.931	0.100	0.166	0.148	0.213
Observations	623	623	623	623	623	623.000	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. Own_C & Own_P refer the ownership dummy of conventional and private banks and present in Segment A and Segment B. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano–Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

In Table 7, Conventional vs Islamic banks addressed through dummy presented in Segment A and Segment B explains dummy presentation of Private vs Public banks.

The empirical finding of equation 5 in Table 7 depicts that different ownership concentrations have a heterogeneous effect on the efficiency of commercial banks. The coefficient of credit risk with conventional banks dummy represents the positive association with cost and human capital efficiency. It refers that with the increase of risk, the efficiency of Conventional banks increases, whereas the efficiency of Islamic banks decreases. Theoretically, the coefficient of dummy variable of treatment group represents the Gap of coefficients of treatment and control groups. Thus, coefficients of the treatment group refer to the opposite impact of control groups (Wooldridge, 2016). Stability effects in the opposite manner of risk, with the incremental Z-score, i.e., stability, the efficiency of Conventional banks decreases, and Islamic banks increases. However, in segment B, we observe the heterogeneous effect of risk on different efficiency of banks. With the rise in risk, the cost efficiency of Private (Public) banks increases (decreases), and Human capital efficiency decreases (increases). On the contrary, stability inversely (positively) affects the efficiency of Private (Public) banks.

Competition proxy affects both Conventional and Private banks similarly. The efficiency of Conventional and Private (Islamic and Public) banks decreases (increases) with the incremental change of market competition. These findings align with H. T. M. Phan et al. (2016), depicting the inverse association of market competition and bank efficiency.

We extend our baseline results in three dimensions. Firstly, we present the nonlinear impact of risk and market competition on the efficiency of banks using equation 6. Secondly, we examine the effect of interim variable risk and market competition to explore the combined effect using equation 7. Finally, report the nonlinear impact of risk and market competition in different ownership addressed through ownership dummy using equation 8.

4.4. Nonlinear Effect of Risk and Market Competition on the Efficiency of Banks

Following Das Gupta et al. (2021), Kouki and Al-Nasser (2017), Tabak et al. (2012), among others, we also extend our model to examine the nonlinear impact of explanatory variables. From Table 8, we observe that risk and stability have a diversified effect on the efficiency of banks. With the increase of credit risk (NPLTL), initially, the cost efficiency (human capital) of banks increases (decreases), and in the long run, it decreases (increases). With the immediate rise of NPTL, banks do not necessarily respond to increased loan monitoring and other recovery costs. However, they proportionately increase the cost to manage risk in the long run. And with time, employees become more efficient in dealing with risk. Stability homogeneously affects the efficiency of the Banks. Stability enhancement deteriorates the efficiency concern in the short run and increases in the long run. These findings are in line with Gupta (2018) examining the impact of risk and competition on the efficiency of commercial banks.

Table 8: Nonlinear Effect of Risk and Market Competition over the Efficiency of Banks

Variable	Model I	Model II	Model III	Model IV
Dep(-1)	1.083953***(3471.03)	1.005347***(5129.73)	1.083895***(4154.08)	1.005208***(5919.69)
NPLTL	0.008808***(17.72)	-0.00228***(-7.50)		
$NPLTL^2$	-0.0103***(-12.86)	0.005012***(7.51)		

Z-score			-4.91E-07***(-15.13)	-8.34E-07***(-8.51)
$Zscore^2$			3.90E-11***(9.12)	8.33E-11***(7.73)
BI	4.83E-05***(5.92)	-0.00000569*(-1.73)	7.36E-05***(13.18)	-1.8E-05***(-5.60)
BI^2	3.51E-06***(4.55)	-1.06E-06***(-3.23)	8.46E-06***(13.61)	-2.15E-06***(-6.55)
BSD	-2.6E-05***(-11.67)	0.000021***(18.62)	-3.2E-05***(-14.44)	2.42E-05***(12.31)
GGDP	0.000172***(14.95)	2.13E-05***(8.00)	8.96E-05***(13.61)	3.34E-05***(6.77)
Inflation	-0.0001***(-14.94)	4.97E-06***(3.38)	-0.00019***(-19.79)	2.56E-05***(9.11)
Size	-0.00023***(-4.66)	-0.0002***(-9.55)	-4.2E-05(-0.97)	-0.00026***(-7.31)
DTA	-4E-05(-0.30)	-0.00029***(-2.81)	0.000141(1.04)	-0.00047***(-3.84)
ROA	-5.13E-05***(-3.36)	-0.00005***(-12.55)	-4.2E-05***(-4.49)	-6.3E-05***(-9.88)
OBSTA	-0.00199***(-16.81)	0.000659***(12.65)	-0.00254***(-15.14)	0.000815***(10.01)
Constant	-0.08664***(-126.32)	-0.00605***(-23.26)	-0.08665***(-154.07)	-0.00554***(17.48)
Hansen Test (P-value)	0.771	0.960	0.107	0.921
AR(1) (P-value)	0.076	0.994	0.100	0.038
AR(2) (P-value)	0.100	0.707	0.548	0.150
Observations	623	623	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano–Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

The market competition also has a heterogeneous effect on the efficiency of banks. With the growth of market competition, the cost efficiency (human capital efficiency) of banks initially decreases(increases) and then increases (decreases) in the long run. In a nutshell, cost efficiency follows an inverted U-shape curve with the increase of risk. And follow a U-shape curve concerning stability and market competition changes. However, human capital efficiency follows a U-shaped with increased risk and stability but responds in a pattern of inverted U-shaped curve in a shift of market competition.

4.5. Nonlinear and Joint Effect of Risk and Competition on the Efficiency of Banks

Table 9 extends the results of Table 8 to examine the joint and nonlinear effect of risk and market competition on the efficiency of banks. The interim variable of risk and market competition evidence that with the increase of risk, the efficiency of cost increases and then decreases in the long run in a competitive market situation. In contrast, stability affects in opposite manners of credit risk. That means, in a competitive market, initially, efficiency decreases and then increases. These findings align with Gupta et al. (2021), explaining the relationship between efficiency and market competition.

Table 9: Nonlinear and Joint Effect of Risk and Market Competition over the Efficiency of Banks

Variable	Model I	Model II	Model III	Model IV
Dep(-1)	1.083747***(3643.06)	1.005084***(6165.09)	1.08398***(3385.50)	1.005171***(5406.96)
NPLTL	0.002083***(4.2)	-0.000773***(4.96)		
$NPLTL^2$	-0.00289***(-3.02)	0.003561***(11.05)		
Z-score			-6.19E-06***(-4.13)	-3.18E-07***(-7.17)
$Zscore^2$			7.28E-10***(5.78)	4.52E-11***(10.53)
BI	0.000154***(11.41)	-4E-05***(-6.4)	1.25E-04***(-3.48)	-1.2E-05***(-2.87)

BI^2	0.000016***(11.97)	-3.77E-06***(-6.09)	2.06E-05***(-4.48)	-2.57E-06***(-5.08)
NPLTL×BI	-0.00105***(-12.90)	0.000882***(13.35)		
NPLTL×BI^2	-0.00011***(-13.36)	7.81E-05***(12.52)		
Z-score ×BI			4.31E-07*(0.92)	1.44E-07***(3.94)
Z-score ×BI^2			1.70E-07***(3.40)	2.32E-08***(5.44)
BSD	-2.7E-05***(-11.25)	2.09E-05***(20.99)	-2.89E-05***(-10.54)	0.000024***(13.99)
GGDP	0.000134***(14.25)	2.19E-05***(5.77)	2.74E-05*(1.56)	3.68E-05***(8.19)
Inflation	-0.00014***(-14.15)	1.02E-05***(7.90)	-8.5E-05***(-10.21)	1.51E-05***(6.93)
Size	-0.00017***(-3.09)	-0.00021***(-9.53)	-0.00011*(-1.77)	-0.00027***(-8.88)
DTA	-8.34E-06(-0.06)	-0.00022(-1.50)	0.000185(0.76)	-0.00047***(-4.71)
ROA	2.65E-05*(1.72)	-4.1E-05***(-8.49)	-5.92E-05***(-3.81)	-5.5E-05***(-13.74)
OBSTA	-0.00213***(-10.76)	0.000717***(10.92)	-0.0024***(-7.90)	0.000838***(11.13)
Constant	-0.0861***(-116.28)	-0.00608***(-20.44)	-0.08648***(-118.21)	-0.00545***(-19.43)
Hansen Test (P-value)	0.946	0.990	0.647	0.972
AR (1) (P-value)	0.100	0.647	0.263	0.152
AR (2) (P-value)	0.346	0.101	0.823	0.429
Observations	623	623	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano–Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

However, the effect of market competition is homogeneous across risk and stability on efficiency. In intense competitive market efficiency of human capital decreases then increases. Human capital efficiency follows a U-shaped curve in the competitive market situation.

4.6 The Nonlinear and Quadratic Effect of Risk & Market Competition with Ownership Dummies

Following S. Kasman and Kasman (2015), Jeon and Lim (2013), Kouki and Al-Nasser (2017), Gupta and Moudud-Ul-Huq (2020), we include the squared term of Boone Indicator (BI) in equation (5) and derived equation (7) & (8). The extended models examine the nonlinear effect of risk and competition in different ownerships. This study spread the previous works by incorporating the nonlinear and quadratic terms of risk and segregating the impact based on ownership.

Table 10: Nonlinear Effect of Risk and Market Competition with Ownership Dummies

Variable	Segment A				Segment B			
	Model I	Model II	Model IIII	Model IV	Model I	Model II	Model III	Model IV
Dep(-1)	1.084637*** (54530.90)	1.005195*** (5024.13)	1.084247*** (3988.07)	1.005189*** (7212.1)	1.084422*** (5347.61)	1.004184*** (3701.63)	1.083828*** (3694.4)	1.00512*** (6178.65)
NPLTL × Own_C	0.003829*** (6.01)	-0.00061** (-2.38)						
$NPLTL^2$ × Own_C	-0.00244* (-1.78)	0.002888*** (5.39)						
NPLTL × Own_P					-0.00449*** (-3.72)	-0.02096*** (-11.79)		
$NPLTL^2$ × Own_P					0.006379*** (2.96)	0.02321*** (5.70)		
Z-score × Own_C			-7.15E-07*** (-6.91)	-4.57E-07*** (-19.54)				

Z-score^2 × Own_C			-4.15E-11***	-2.50E-11***				
			(-5.74)	(-16.33)				
Z-score × Own_P							-1.63E-06***	-5.99E-07***
							(-6.83)	(-7.51)
Z-score^2 × Own_P							8.52E-10***	1.62E-10***
							(7.83)	(4.33)
BI × Own_C	0.000537***	-3.8E-05***	0.000415***	-4.9E-05***				
	(13.58)	(-12.83)	(13.61)	(-12.62)				
BI^2 × Own_C	0.000056***	-4.35E-06***	4.54E-05***	-5.08E-06***				
	(13.56)	(-14.04)	(13.62)	(-12.00)				
BI × Own_P					0.000394***	0.000037***	1.65E-07***	6.75E-08***
					(19.04)	(2.99)	(4.89)	(10.52)
BI^2 × Own_P					4.37E-05***	6.87E-06***	2.44E-08***	1.12E-08***
					(19.22)	(4.71)	(5.25)	(10.77)
BSD	-2.7E-05***	2.09E-05***	-2.9E-05***	2.32E-5***	-3.2E-05***	9.61E-06***	-3E-05***	2.24E-05***
	(-16.71)	(19.62)	(-15.58)	(15.57)	(-15.97)	(4.02)	(-12.95)	(11.93)
GGDP	6.75E-05***	3.71E-05***	2.64E-05***	3.81E-05***	1.52E-05**	-0.00014***	8.62E-05***	2.97E-05***
	(17.70)	(17.39)	(4.33)	(11.94)	(2.02)	(-14.25)	(9.16)	(6.79)
Inflation	-0.00025***	2.74E-05***	-0.00024***	0.000029***	-0.0003***	-0.00018***	-0.00017***	0.000013***
	(-20.56)	(25.54)	(-13.52)	(15.57)	(-21.70)	(-16.10)	(-17.45)	(6.09)
Size	-0.00027***	-0.00022***	-0.00019***	-0.00026***	-0.00014**	-4E-05	-0.000084*	-0.00023***
	(-7.52)	(-10.77)	(-3.52)	(-8.44)	(-2.64)	(-0.56)	(-1.85)	(-6.42)
DTA	-0.00023*	-0.00034***	-0.00027	-0.00044***	-0.00028*	-0.00065**	1.71E-05	-0.00043***
	(-1.97)	(-3.23)	(-1.58)	(-4.52)	(-1.93)	(-2.11)	(0.11)	(-3.22)
ROA	-4.3E-05***	-3.5E-05***	-7.6E-05***	-5.1E-05***	-2.6E-05**	-8.2E-05***	-4E-05***	-5.2E-05***
	(-4.46)	(-12.10)	(-7.30)	(-11.29)	(-2.19)	(-9.31)	(-3.90)	(-10.65)
OBSTA	-0.00167***	0.000676***	-0.00197***	0.000742***	-0.00264***	-0.0004***	-0.00234***	0.000721***
	(-9.14)	(11.32)	(-10.04)	(11.06)	(-13.53)	(-2.89)	(-10.63)	(8.16)
Constant	-0.08456***	-0.00609***	-0.08427***	-0.00568***	-0.08416***	-0.00327***	-0.08628***	-0.00565***
	(-245.66)	(-24.37)	(-145.56)	(-20.41)	(-158.34)	(-4.11)	(-132.02)	(-16.96)
Hansen Test (P-value)	0.919	0.990	0.996	0.992	0.348	0.481	0.997	0.992
AR(1) (P-value)	0.363	0.324	0.313	0.861	0.211	0.867	0.115	0.112
AR(2) (P-value)	0.102	0.454	0.870	0.272	0.133	0.177	0.100	0.546
Observations	623	623	623	623	623	623	623	623

Note: Model I and III present cost efficiency with credit risk and stability, respectively, whereas Model II & IV denotes the efficiency of human capital having independent variable credit risk and stability of banks. Own_C & Own_P refer to the ownership dummy of conventional and private banks, presented in Segment A and Segment B, respectively. t-statistics values are in parentheses; ***, **, * refers significance at 1%, 5%, and 10% level respectively. The dependent variable, efficiency of cost, and efficiency of Human Capital are measured through SFA. J-statistic refers to the p-value of the Hansen test. The Hansen test's null hypothesis depicts that the instruments used are not correlated with residuals (over-identifying restrictions). Arellano–Bond order 1 (2) are tests for first (second) order correlation, asymptotically N (0, 1). These test the first-differenced residuals in the system GMM estimation.

Table 10 reveals the nonlinear impact of risk and market competition on different ownership of banks of equation 8. Comparing the two results of the efficiency of cost and human capital reveals that market competition has a heterogeneous effect on the efficiency of different commercial banks. With the increase of market competition, initially cost efficiency of Conventional and Private (Islamic and Public) commercial banks decreases (increases) and then increases (decreases) in the long run. Human capital efficiency of Conventional and Public (Islamic and Private) commercial banks increases with the increase (decrease) of market competition, and after a certain period, it decreases (increases).

The nonlinear effect of risk and stability is not apparent in all commercial banks of Bangladesh. For example, the nonlinear effect of stability on the efficiency of Conventional and Islamic banks is not evident in the Bangladeshi banking industry. With the increase of stability of Conventional (Islamic) banks, efficiency decreases (increases), having no different nonlinear impact. That means conventional banks with more stability are less efficient. However, the nonlinear effect of stability is valid for private and public banks. Stable public banks are more efficient concerning cost and human capital efficiency, but the efficiency of private banks deteriorates with their enhancement of capital base and profitability (stability).

The impact of credit risk addressed through NPLTL is also found heterogeneous across different ownership of banks. Risk-taking of Conventional banks enhances the cost efficiency and decreases the human capital efficiency initially. Later on, incremental risk-taking improves human capital efficiency and inversely affects banks' cost efficiency. On the contrary, increasing the riskier investment of Islamic banks deteriorates (enhances) cost efficiency (human capital efficiency) initially, then increases (decreases) in the long run. The reaction of private and public banks in response to efficiency is uniform in

both cost and human capital. Risk-taking of Private (Public) banks decreases (increases) the efficiency in the linear relationship, and in quadratic terms, the efficiencies are increasing (decreasing).

Significant coefficients of lagged dependent variables depict the dynamic nature of the models and advocate that the variables are persistently following from year to year. Statistics of AR (1) and AR (2) validate the instrument of the lagged dependent variables. Hensen test validates the instrument of the model. Supporting test of GMM application also present in 'Appendix B' through examination of heteroskedasticity, autocorrelation test.

5. CONCLUDING REMARKS

The financial system of Bangladesh is bank-based and occupies almost two-thirds of the total financial market. Banks are the dominant matchmakers of the economic system and play an active role in circulating financial flows and economic progression. Therefore, it is worth considering how risk, growing market competition, and other factors affect the efficiency of the banking industry of Bangladesh. This study attempts to explain how risk-taking, market competition, and ownership affect the efficiency of Banks. Financial liberalization, reformation, regulatory capital changes, more inclusion of banks increase the market's competitiveness and change the organization's risk-taking paradigm. However, banks' philosophy and business tradition differ due to ownership differentiation. Therefore, it is time demand how banks manage their cost and human capital efficiency in stiff market competition and risk.

The study's findings depict the diversified effect of risk-taking and market competition on different ownership of banks. The risk and stability of banks have a significant impact on the efficiency of banks. The increase of banks' risk (stability) efficiency increases (decreases) in the aggregate model. The effect of risk and stability of Conventional and Private banks is in line with the findings of the aggregate industry model, except for human capital efficiency. The human capital efficiency of private banks decreases with the increase of risk, unlike aggregate and conventional banks models. Islamic and Public banks' efficiency react oppositely in response to the risk and stability of banks. Market competition (BI) and efficiency of banks are inversely associated in the Conventional, Private, aggregate industry model. It refers to increasing market competition deteriorating the efficiency of banks of Bangladesh.

The nonlinear and quadratic impact of risk and market competition over different ownership and aggregate models are heterogeneous. The joint effect of risk and competition depicts that increased risk-taking in a competitive market initially efficiency of cost increases then decreases in the long run. However, the efficiency of banks in the competitive market with stability and human capital efficiency with risk-taking decreases then increases after a certain point. The efficiency of banks follows a U-shape curve in association with risk, stability, and market competition in aggregate model, conventional and private banks' model. Only efficiency of cost in risk change and efficiency of human capital in competition follows an inverted U-shape curve in aggregate and conventional banks models. This study also observes the significant impact of economic, banks level factors and development indicators on the efficiency of banks. The country's economic progression significantly enhances the efficiency of banks, whereas inflationary pressure deteriorates the efficiency of cost and increases human capital efficiency.

The nonlinear impact of risk and market competition on the efficiency of banks is also evident in this study. The study suggests that risk-taking does not necessarily decrease, and stability increases the efficiency of banks. Again all efficiency is not moving in parallel to each other. Risk and market competition heterogeneously affect different efficiency and different ownership of banks. The future direction of the study can incorporate cross-country data and simultaneous examination of risk, efficiency, and banks' competition.

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APPENDİX A: Determination of Cost and Human Capital Efficiency Using Stochastic Frontier Analysis (SFA)

This study approach stochastic frontier analysis to calculate the efficiency of each Bank is based on the stochastic frontier production methodology originated by Aigner, Lovell, and Schmidt (1977). Due to inefficiency and error term, the observed cost of a bank is formulated to differ from the cost-efficient frontier (Deelchand and Padgett, 2009, Gupta et al., 2021, Zheng et al., 2018). The stochastic cost frontier model was developed using this production frontier. For details, see Zheng et al. (2018a); Kwan and Eisenbeis (1997); Schmidt and Knox (1979).

For the 'n'th Bank,

$$\text{Ln } TC_n = f(\text{ln } Q_i, \text{ln} P_j) + \varepsilon_n \quad (1)$$

TC_n is the total operating cost including financial costs, There are two inputs(Q_i), i.e., Q_1=Loans and advances, Q_2= Other earning assets, Inputs are denoted by Pj. There are three inputs that are: P_1= Price of labor which is the personnel expenses, P_2= Price of physical capital, which is non-interest expenses to fixed assets, P_3= Price of fund, which is the ratio of total interest expenses to the total deposit. ε_n depicts the deviation between the actual total cost of a bank and the cost-efficient frontier, and it has two disturbance terms:

$\varepsilon_n = V_n + U_n$

Where V_n and U_n represent the random error term and cost inefficiency, respectively. We assume that the random error term is independent and identically distributed N $(0,\sigma_v^2)$ and cost inefficiency is to be distributed independently of V_n and a half-normal distribution, i.e., N $(0,\sigma_u^2)$.

By using the intermediation approach (Sealey & Lindley, 1977) and by following (T. Deelchand & C. Padgett, 2009), we develop translog cost function to specify the cost function:

$$\text{Ln TC} = \alpha + \sum_i \alpha_i \, lnQ_i + \sum_j \beta_j \, lnP_j + \tfrac{1}{2} \sum_i \sum_k \gamma_{ik} \, lnQ_i lnQ_k + \tfrac{1}{2} \sum_j \sum_h \delta_{jh} \, lnP_j lnP_h + \sum_i \sum_j \lambda_{ij} \, lnQ_i lnP_j + \varepsilon \quad (2)$$

According to Jondrow, Knox, Materov, and Schmidt (1982), the expected value of U_n, conditional ε_n, represents the cost-inefficiency of bank n (defined as C_n).

$$C_n = E\, U_n / \varepsilon_n = [\, \sigma\lambda / (1+\lambda^2)][\varphi(\varepsilon_n\lambda/\sigma)/\phi(\varepsilon_n\lambda/\sigma) + \varepsilon_n\lambda / \sigma] \quad (3)$$

λ denotes the standard deviation of U_n to standard deviation of V_n, ϕ is the cumulative standard normal density function, and φ is the standard normal density function. C_n can be estimated by using equation (3).

We also use the alternative Human Capital inefficiency specification, where the dependent variable is the HC_n =Human capital (no. of employees) of all banks in the sample. Q_i indicates two outputs, i.e., Q_1= Other earning assets, Q_2= Loan and Advances, Pj stands for three input prices, i.e., P_1= Price of labor which is the personnel expenses, P_2= Price of physical operations, which is total operating expenses, P_3= Price of risk-taking, which is the amount of nonperforming loans. We alternate the error term to $V_n – U_n$ from $V_n + U_n$ to use the equation (3) as a production function (Coelli, 1996). In the converted model, Un signifies human capital inefficiency and distributed independently of Vn and a half-normal distribution, i.e., N (0,σ_u^2) (Zheng et al., 2018a). Computer software named Frontier Version 4.1 developed by, Coelli (1996) opt to estimate the SFA Production and Cost function projected by the maximum likelihood method.

APPENDIX B: Diagnostic Test- Supporting the Regression Models

Heteroskedasticity (Breusch-Pagan test for heteroskedasticity), autocorrelation (Breusch-Godfrey Serial Correlation LM Test) have been performed to support the regression models. Each table's results represent the corresponding Tables diagnostic tests. Summarized diagnostic test results are given below.

Table 13: Breusch-Pagan Test for Heteroskedasticity

	Dependent Variables	
	Efficiency of Cost	Efficiency of Human capital
Chi2 Value	210.29	66.54
Prob > chi2	0.000	0.000

Table 14: Breusch-Godfrey LM Test for Autocorrelation

Dependent variable	chi2	df	Prob > chi2
	527.120	1	0.000
Efficiency of Cost	528.614	2	0.000
	453.977	1	0.000
Efficiency of Human Capital	458.624	2	0.000

From the test statistics results, it is clear that there are heteroscedasticity and autocorrelation problems in the model.