The impact of intellectual capital on bank risk: Evidence from banking sectors of Bangladesh

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ABSTRACT

The main purpose of this study is to identify the impact of intellectual capital efficiency (ICE) also known as knowledge capital along with its components human capital efficiency (HCE) and structural capital efficiency (SCE) on bank risk-taking behavior in Bangladesh. To reveal this effect, the study uses generalized method of moment (GMM) estimator and Two Stages Least Square estimator (to check the Robustness) and unbalanced panel data of 32 commercial banks of Bangladesh consisting of 530 bank-year observations during the year 2003-2020. The main results of the study are: (a) ICE is significantly and positively connected with a bank’s credit risk which indicates credit risk grows up with the increase of Intellectual capital efficiency, and (b) Both the human capital efficiency and structural capital efficiency positively impacts credit risk but the impact of SCE is not significant as HCE. (c) Bank performance (ROA), RWATA, macro variable inflation, and size have a negative impact on bank risk whereas ID and GGDP insignificant positively impact on bank’s risk. Finally, the results of the study will assist the stakeholders, policymakers, and academicians for future research.

Keywords:
Bank Performance; Bank Risk;
Commercial Bank; Credit Risk;
Intellectual capital; Bangladesh

JEL Classification:
F65; G14

Introduction

Firms undergo fundamental changes from labor-based business to knowledge-based business. Firms rely on knowledge to enhance their performance or commonly known as intellectual capital (IC). Moreover, Intellectual capital represents the knowledge, experience, intellectual property and information that can be put to use to create wealth (Stewart, 1997). From this definition, academics and management practitioners have given substantial attention to the role of knowledge and firm capabilities for global competitiveness and consider intellectual capital as the lever for sustaining competitive advantage and sustainable corporate performance (Mondal and Ghosh, 2012). Effective intellectual capital tends to reveal that firms utilize their intellectual capital effectively. In this respect, firms with better intellectual capital are more likely to disclose more on intellectual capital (Cahyaningrum and Atahau, 2020).

On the other hand, as financial institutions, banks collect funds from the public, especially in the form of savings, and redistribute the funds to the public through credits or other activities that enhance the public’s quality of life. There has been considerable academic and regulatory interest in how to mitigate bank risk-taking behavior and improve performance in recent years. As a services industry, banks are also recognized as an intellectual capital-intensive industry sector (Branco et al., 2011; Haris, Yao, Tariq, Javaid & Ain, 2019) which makes the recognition and development of intellectual capital an important aspect of bank management (Alhassan & Asare, 2016; Rehman, Aslam, & Iqbal, 2021). The last common strand focuses on the effect of IC efficiency on financial

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performance, especially in the banking industry. Some studies confirm that banks should manage their IC as efficiently as possible because of its significant effects (Atiku, Kaisara, Kaupa & Villet, 2022; Ozkan et al. 2017).

Intellectual capital is a complex concept where entrepreneurial and organizational aspects interact together (Paolini, Massaro, Dal Mas, & Bagnoli, 2022). IC could have on organizational financial performance be deepened (Demartini, & Beretta, 2022). Moreover, the components of IC such as employees’ experience and knowledge, banks’ relationship with their customers, and banks’ organizational or managerial condition likely affect liquidity risk (Cahyaningrum & Atahau, 2020; Joshi, Cahil, Sidhu, & Kahil, 2013). Higher intellectual capital will reduce liquidity risk because banks that manage their intellectual capital effectively arguably manage to minimize their liquidity risk (Cahyaningrum & Atahau, 2020). Additionally, IC can also impact the capital regulations, bank’s ROA, capital regulations and Leverages (Sari and Hidayat, 2020).

Several studies have done on impact of IC on bank’s performance, on profit sharing finance, bank size, corporate performance, bank insolvency, capital efficiency, bank productivity (Cahyaningrum & Atahau, 2020; Nguyen, Le & Ho, 2021; Nazir et al., 2020; Nguyen & Nghiem, 2015; Obeidat et al. 2017). Nevertheless, very few studies attempt to investigate the impact of IC on bank risk-taking (Haris, Yao, Tariq, Malik & Javaid, 2019; Nguyen, Le & Ho, 2021; Xu, Haris & Irfan, 2022). Bangladesh is an Asian emerging economy, with impressive economic growth rates over the last two decades. The Bangladeshi government gradually implemented banking sector reforms in recent years but it is very unfortunate that there is no study on the impact of IC on Bangladeshi bank’s risk management. This study tries to fill these gaps and find out the impact of intellectual capital on risk management of banking sectors of Bangladesh.

The remainder of the paper is structured as follows. Section 2 discusses the relevant literature and development of hypotheses that underlie the paper’s analysis. Section 3 presents the data and methodology. Section 4 describes the empirical results, discussion and deals with the analysis of the robustness of those results. Finally, Section 5 concludes the paper.

**Literature review**

**Theoretical and Conceptual Background**

**Valuation of intellectual capital and element of intellectual capital**

Intellectual assets (IA) also intellectual termed as Intellectual Capital (IC) is the most significant resources of today’s organization and most of the institutions can not define what makes an IA (Andreou et al., 2007). Simply, creativeness of human brain or mind is called intellectual capital. IC is related to value and intangible nature of assets. (Edvinsson, 1997) define IC as “knowledge that can be converted into value”. Knowledge that can be converted into profit(Sullivan,2000). Non accounting researcher define “intellectual is the difference between the firm’s market value and its book value of entity” (Mouritsen, 2001, Stewart, 1997a, Sveiby, 1997). Many researchers and analyst have tried to categorize IC. At first (Sveiby, 1997) categorized IC as 3 types from non-accounting perspective namely, 1) employee (individual) competence, 2) internal structure and 3) External structure. However, (Stewart,1997b) agreed with Sveiby, but he renamed these assets as: human capital, structural capital and customer capital respectively. Again, (Bontis, 1996, Edvinsson and Sullivan, 1996) suggested for three types of IC: people’s know-how (human capital); entity’s routines, procedures, process, and databases (structural capital); and the firm’s ability to relate to markets and stakeholders (relational capital). Additionally,(Gu and Lev,2001) divided IA into five subgroups of focusing on measurement issues and the persuade of intangibles on capital market and investors. These five components are: research and development, advertising, capital expenditures, information systems and technology acquisition. The researchers of IC opinioned for including the human capital and structural capital as the components of IC(Andriessen, 2006, Bontis, 2004, Edvinsson, 1997). In this study we will calculate the efficiency of IC by taking into consideration of HC and SC as the parts of IC (Customer/ relational capital will also include in SC through SFA). Human capital consists of skills, knowledge and experiences of employees which can be enriched through training (Sveiby, 1997) defined HC as “the capacity to act in a wide variety of situations to create both tangible and intangible assets.” Efficient plus effective utilization of entity’s employees’ knowledge, experiences, skills, creativeness etc. ensure the proper utilization of HC and it is used to solve business problems (Mondal, 2012). Structural capital can term as supportive capital consisting of everything of a firm that assists employees and enables human capital to function properly (Mondal, 2012). Structural capital of a firm is formed with structures, systems, organizational cultures, procedures, routines, hardware and databases and it’s also included inventions, process, copyright, patents, technology, strategy(Joshi et al., 2010). Structural capital is the differences between value added and human capital (SC= VA-HC) (Pulic, 1998, Pulic, 2000, Pulic, 2004). According to Pulic (Pulic, 2000) Value Addition of current year resources is called VA which is calculated as VA= Output (total sales) – Input (cost of materials, components, and services). Pulic (2000) also proposed another way of calculating VA which is as follows:

\[ VA = OP + (EC + D) + A \]

Moreover, (Bontis,2001) mentioned Economic Value-added (EVAe) as a comprehensive gauge for studying the achievement of whole business and proposed the following equation for calculating EVAe: \( EVAe = Net\ sales – operating\ expenses – taxes – capital\ charges \). Relational capital of a firm is termed as the relationships with all its interested groups(Chooning, 2008). Again (Mondal, 2012) defines relational capital as the value of an entity’s relationships with the people in relation of whom its business.
Empirical Review and Hypothesis Development

Relationship between ICE and risk

Various researches have been conducted with unending and counterfactual conflicts whether efficiency has supremacy to risks or risk significantly impact the efficiency of banks (Altunbas et al., 2007). There is a continuous debate whether intellectual capital efficiency reduces the level of risk or not. The normal expectation between IC efficiency and risk is negative. It indicates that increased IC efficiency will help to manage risk. So, in this study we can expect a negative correlation, but different outcome also found in the past literature regarding the relationship. Several prior studies, such as, Ghosh and Maji (2014); Zheng et al., (2018); Nawaz et al. (2019); Innayah et al. (2020); Alrashidi and Alarfaj, (2020), Innayah et al., (2020) found negative association between IC efficiency. But opposite result also found in study of Guimon (2005); Nawaz et al., (2019); Sun and Chang (2011) claimed that IC could have positive effect on credit risk as they help in evaluating the organizational competitiveness and provide fine image of firm’s management team. Again Zheng et al., (2018) and they claimed that there is no significant relationship observed between risk and HCE and the capitalized banks are more capable of absorbing risk and enhancing HCE.

As the number of studies in relation to intellectual capital efficiency and bank risk taking behavior are not so high, this study also consider the relationship overall efficiency and risk.

In the study of relationship between overall efficiency and risk, Kwan and Eisenbeis (1997); Deelchand and Padgett (2009) Fiordelisi et al. (2011); and Nguyen and Nghiem (2015) among others found negative association between efficiency and risk.

Whereas, positive relationship also found in some prior studies, such as, Tan and Floor (2013); Isshaq et al. (2010).Tan and Floros,(2013) mention that risk is increased due to reducing monitoring and screening of loans but technical efficiency increases the volume of loans of bank. Isshaq et al (2010) also found positive relationship between risk and efficiency and claim that risk taking and cost efficiency of foreign banks go side by side. Again, Altunbas et al. (2007) claimed that there is no significant relationship between efficiency and risk.

These studies tried to measure the impact of a particular component of IC such as human capital or structural capital on risk but the impact of overall efficiency of IC on risk taking behavior was absent. In this study we will try to fill the gap by showing the impact of overall efficiency of IC calculated using SFA on risk taking behavior of banks. Whilst these and other such studies report a positive/ negative correlation between risk and efficiency, there is limited conclusive evidence to support a direct cause and effect relationship between overall IC efficiency and risk. From the literature it is seen that most of the studies are done on banks of developed countries. No study is done on Bangladeshi banking industry. In this paper, we focus on banks from Bangladesh by using the GMM technique and SFA.

H1: There is a significant negative relation between IC efficiency and risk of Bangladeshi banks.

H2: There is a significant negative relation between HC efficiency and risk of Bangladeshi banks.

H3: There is a significant negative relation between SC efficiency and risk of Bangladeshi banks.

Research and Methodology

Data

The study is based on secondary data on Bangladeshi commercial banks during the period 2003-2020. Data for intellectual capital, risk measures, ownership structure and performance measures would be obtained mainly from the annual reports of banks, bank’s individual website and some information from banks scope database (www.bvdinfo.com) Bloomberg and OSIRIS databases. The data for micro economic variables will be collected from the database of World Bank (http://data.worldbank.org).

After collection, data was arranged in desired layout to analyze. In this study Stochastic frontier analysis (SFA) developed by Aigner et al., (1977) was used to measure the efficiency of intellectual capital, Human capital efficiency, structural capital of the selected banks during the study period. The study used single step Generalized Methods of Moments (GMM) apply two- stage least square (2SLS) estimator, to examine the relationship between risk taking behavior and intellectual capital efficiency. For calculation and analytical purposes the study used various statistical software packages such as Eviews 10, Frontier 4.1, and SPSS 20.
Table 1: Contains details about the source of variables

| Variables                     | Symbol | Definition                              | Sources                                                                 |
|-------------------------------|--------|-----------------------------------------|-------------------------------------------------------------------------|
| Risk                          | NPLTL  | Ratio of nonperforming loans to total loans | Zhang et al., (2013);Chabi and Fitri, (2015); Nitoi and Spulbar,(2015), Zhan ge et al.,(2018); |
| Intellectual Capital Efficiency | ICE    | Intellectual Efficiency Capital         | Ghosh and Maji,(2014); Atrashidi and Alaraj, (2020); Buallay et al., (2019); Chen, (2009); Guerreni, (2014); |
| Human Capital Efficiency      | HCE    | Human Capital Efficiency                | Ghosh and Maji, (2014); Innayah et al, (2020); Chan, (2009);             |
| Structural capital efficiency | SCE    | Structural Efficiency Capital           | Ghosh and Maji, (2014); Innayah et al.,(2020), Guerreni, (2014);        |
| Return on Assets              | ROA    | Return on Assets (ROA) for performance  | Zheng, C., & Das, A. (2018); Aebi et al., (2012); Chen and Vahammar, (2012)|
| Income diversification       | ID     | Ratio of non-interest income to total income | Fiordelisi et al., 2011; Meslier et al., 2014; Lee et al., 2013 |
| Risk weighted assets to total Assets | RWATA | Ratio of risk weighted assets to total assets | Zheng et al., (2018); Gropp and Heider, (2007); Schaeck and Cihak, (2007) |
| Bank size                     | SIZE   | Natural logarithm of total assets       | Zheng et al., (2018); Bougatet and Mgadmi (2016); ChaibiandFititi(2015); Deelchandand Padgett (2009) |
| Inflation rate                | INFR   | Annual inflation rate                   | Zheng et al., 2017, Chaibi and ,Fititi, (2015); Hussain and Hassan(2005) |
| Growth in GDP                | GGDP   | Annual growth in real gross domestic product | Zheng et al., 2017, Chabi and Fitri,(2015); Jokipii and Milni, (2008); Stolz and Wedow, (2011) |

Table 2: Descriptive statistics of all variables (The monetary units are BDT. million where applicable)

| Variables | Minimum | Maximum | Mean  |
|-----------|---------|---------|-------|
| NPLTL     | .00     | .45     | .0771 |
| ICE       | .75     | .98     | .8925 |
| HCE       | .15     | .97     | .4445 |
| SCE       | .37     | .99     | .8224 |
| ROA       | -13.52  | 6.05    | 1.2936|
| ID        | .00     | 2.24    | .5846 |
| RWATA     | .00     | 1.27    | .6773 |
| SIZE      | 8.37    | 14.85   | 11.3392|
| GGDP      | 3.83    | 7.60    | 6.0519|
| IFR       | 3.26    | 8.16    | 6.0703|

Source: Author’s calculation by using SPSS-30

Determination of Intellectual Capital Efficiency Using Stochastic Frontier Analysis (SFA)

By following (Zheng et al. 2017; Kwan and Eisenbeis, 1997; Altunbas et al.2007.2001.2000; Girardone et al. 2004; Nitoi and Spulbar, 2015) we used SFA in measuring efficiency and this paper employ for production function of SFA for deterring intellectual capital efficiency. Methodologically this paper introduce new dimension of intellectual capital efficiency calculating by SFA of the banking industry.

In this study we calculate the efficiency of each bank on the basis of stochastic frontier production methodology developed by Aigner et al. (1977). For the nth Bank,

\[ \ln IC_n = f(\ln Q_i, P_i) + \epsilon_n \]

Where, IC\(_n\) represents Intellectual capital of banks, Q\(_i\) indicates three outputs, i.e. Q\(_i\): Total operating income, Q\(_i\): Loan and advances, Q\(_i\): Non interest income, P\(_i\) represents three inputs,i.e. P\(_i\): Fixed assets, P\(_i\): Personal expenses and P\(_i\): Non performing loan. \(\epsilon_n\) indicates the deviation of the actual intellectual capital of a bank from the intellectual capital-efficient frontier having two disturbance terms that are shown below:

\[ \epsilon_n = V_\alpha - U_\beta \]

Where, \( V_\alpha \) is random error term, and it is assumed that this is independent and identically distributed \( N (\alpha, \sigma_\alpha^2) \). \( U_\beta \) represents intellectual capital inefficiency and assumed to be independently distributed of \( V_\alpha \) and a half normal distribution i.e.,\( N (\alpha, \sigma_\alpha^2) \).

For specifying Intellectual Capital function we formulated the following multiproduct translog production function using intermediation approach (Sealey and Linley, 1977):

\[ \ln IC_n = \alpha + \beta_1 \ln Q_1 + \beta_2 \ln P_1 + \beta_3 \beta_4 \ln Q_2 + \beta_5 \ln Q_3 + \beta_6 \ln P_2 + \frac{1}{2} \sum_j \lambda_j \ln Q_j \ln P_j + \epsilon \]
Based on the Jondrow et al. (1982) the expected value of $U_n$ on conditional to $e_n$ shows the Intellectual capital inefficiency of bank $n$ (termed as $C_n$).

\[
C_n = E(U_n/e_n) = [\lambda/ (1+\lambda^2)](\epsilon_n\lambda/\sigma) + e_n \lambda/\sigma
\]

Where ratio of the standard deviation of $U_n$ to the standard deviation of $V_n$ is denoted as $\lambda_n$, is the cumulative standard normal density function and $\phi$ stands for standard normal density function. Using equation 3, $C_n$ can be estimated. In this study, computer software named Frontier Version 4.1 developed by Coelli in 1996 has been used to obtain the efficiency using Frontier production function estimated by the method of maximum likelihood.

Econometric model

In this study we have developed the following three simultaneous equations by following Tan and Floros (2013); Altunbas et al. (2007); Deelchand and Padgett (2009); Fiordelisi et al. (2011) to specify the empirical model of the study:

\[
RISK_{it} = \beta_0 + \beta_1 RISK_{it-1} + \beta_2 ICE_{it} + \beta_3 ROA_{it} + \beta_4 ID_{it} + \beta_5 RWATA_{it} + \beta_6 SIZE_{it} + \beta_7 GGDP_{it} + \beta_8 IFR_{it} + \epsilon_{it}
\]

\[
RISK_{it} = \beta_0 + \beta_1 RISK_{it-1} + \beta_2 HCE_{it} + \beta_3 ROA_{it} + \beta_4 ID_{it} + \beta_5 RWATA_{it} + \beta_6 SIZE_{it} + \beta_7 GGDP_{it} + \beta_8 IFR_{it} + \epsilon_{it}
\]

\[
RISK_{it} = \beta_0 + \beta_1 RISK_{it-1} + \beta_2 ICE_{it} + \beta_3 ROA_{it} + \beta_4 ID_{it} + \beta_5 RWATA_{it} + \beta_6 SIZE_{it} + \beta_7 GGDP_{it} + \beta_8 IFR_{it} + \epsilon_{it}
\]

Where the $i$ subscript denotes the cross-sectional dimension across banks, and $t$ denotes the time dimension. The main risk measure is NPLTL (dependent variable). Overall efficiency of IC denoted as ICE, HCE and SCE are the main independent variables in this study. ROA, ID, RWATA, SIZE, are to be used as internal control variables (independent variables) for individual bank and some macroeconomic factors INFR, GGDP, used as (independent variables) affecting the relationships among IC efficiency, risk. Besides the above we used twelve instrumental variable for supporting the model in regression analysis and these are NPLTL, ICE, ROA, ID, RWATA, SIZE, LIQ, LEVE, GOVS, INF and constant.

Equation (1) examines whether level of risk is affected by the changes in IC efficiency, whereas equation (2) examines how risk is affected with the changes in HCE efficiency, 3) examines whether level of risk is affected by the changes in SCE efficiency during the study period.

**Table 3: Correlation matrix**

|       | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  | 11  | 12  | 13  | 14  |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| NPLTL |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| ICE   | .418** |    |     |     |     |     |     |     |     |     |     |     |     |     |
| HCE   | .502** | .634** | 1 |     |     |     |     |     |     |     |     |     |     |     |
| SCE   | .158** | -.060 | .127** | 1 |     |     |     |     |     |     |     |     |     |     |
| ROA   | -.379** | -.253** | -.273** | .166** | 1 |     |     |     |     |     |     |     |     |     |
| ID    | -.422** | .209** | .220** | -.018 | -.194** | 1 |     |     |     |     |     |     |     |     |
| RWATA | -.498** | -.169** | -.341** | -.326** | .218** | -.151** | 1 |     |     |     |     |     |     |     |
| SIZE  | .077  | .370** | .286** | -.720** | -.306** | .166** | .241** | 1 |     |     |     |     |     |     |
| GGDP  | -.210** | .063  | -.093** | -.579** | -.189** | -.073 | .224** | .513** | .169** | -.115** | .206** | .215** | 1 |     |
| IFR   | -.304** | .091** | -.094** | -.272** | -.004 | -.077 | .502** | .443** | .140** | -.153** | .578** | .140** | .339** | 1 |

**Source:** Author’s calculation by using SPSS 20

**Note:** The table represents the Pearson’s correlation matrix for the variables used in this paper. The dependent variable in regression model is Non Performing Loan (NPLTL) The primary explanatory variables are Intellectual Capital Efficiency (ICE), Human Capital Efficiency (HCE) and Structural Capital Efficiency (SCE). Where ROA, ID, RWATA, SIZE, Growth of Gross Domestic Product (GGDP) and Inflation (IFR) are used as independent variable. Beside these above CAP, LIQ, LEVE, GOVS, NPLTL are used as instrumental variables along with all independent variables.

**Empirical Results and Discussions**

**Result of GMM Approach**

The Lagrange Multiplier Test (LM test) rejects the null hypothesis. Errors can be identified in variables that are peculiar to a bank. The cross-sectional heteroskedasticity of the investigation was assessed using the white test (White, 1980). The null hypothesis of the homoscedasticity test was rejected (at a 5% significant level) (White, 1980). As a result, the findings of this study are not supported by the ordinary least squares (OLS) method. As a result, we use a generalized method of moments (GMM) estimator to deal with this outcome.
For the probability original model implementation, the GMM estimate uses instrumental variables established by Hansen (1982). The 2SLS estimator is less efficient than the GMM estimator, according to them (Hall, 2005), but it allows for heteroskedasticity. The main findings of this investigation are summarized in Table 4.

**Table 4: Effects of IC Efficiency, HCE, SCE on credit risks**

| Variables | Coefficient | Std. Error | t-Statistic | Coefficient | Std. Error | t-Statistic | Coefficient | Std. Error | t-Statistic |
|-----------|-------------|------------|-------------|-------------|------------|-------------|-------------|------------|-------------|
| NPLTL n-1 | 0.559***    | 0.127      | 4.40        | 0.521***    | 0.061      | 8.751       | 0.552***    | 0.097      | 5.743       |
| HCE       | 0.210**     | 0.087      | 2.411       |             |            |             |             |            |             |
| ROA       | -0.013***   | 0.000      | -2.385      | -0.012***   | 0.000      | -3.500      | 0.009*      | 0.003      | -2.370      |
| ID        | 0.057***    | 0.014      | 3.817       | 0.051***    | 0.014      | 4.552       | 0.053***    | 0.013      | 3.690       |
| RWATA     | -0.052**    | 0.020      | -2.570      | -0.061***   | 0.021      | -2.971      | -0.050*     | 0.021      | -2.734      |
| SIZE      | -0.007      | 0.016      | -0.482      | 0.000^      | 0.000      | 1.903       | 0.011*      | 0.006      | 1.703       |
| GGDP      | 0.018       | 0.037      | 0.481       | -0.012^     | 0.000      | -1.671      | 0.054       | 0.037      | 0.141       |
| IFR       | -0.005      | 0.002      | -1.980      | 0.000^      | 0.000      | -1.671      | 0.055       | 0.004      | -1.260      |
| C         | -0.123***   | 0.102      | -1.202      | 0.042       | 0.041      | 1.011       | 0.139       | 0.250      | -0.551      |
| R-squared | 0.617       | 0.671      | 0.668       |             |            |             |             |            |             |
| Adjusted R-squared | 0.612 | 0.662 | 0.654       |             |            |             |             |            |             |
| S.E. of regression | 0.051 | 0.042 | 0.041       |             |            |             |             |            |             |
| Sargan test (p-value) | 0.866 (0.282) | 1.491 (0.241) | 1.442 (0.219) |
| Probit statistic | 0.833 | 0.681 | 0.693       |             |            |             |             |            |             |
| LM Test (P-value) | 0.000 | 0.000 | 0.000       |             |            |             |             |            |             |
| AR (1) (P-value) | 0.000 | 0.000 | 0.000       |             |            |             |             |            |             |
| AR (2) (P-value) | 0.421 | 0.302 | 0.391       |             |            |             |             |            |             |
| No. of observation | 530 | 530 | 530         |             |            |             |             |            |             |
| Instrument rank | 11 | 11 | 11          |             |            |             |             |            |             |

**Source:** Authors calculation through Eviews-10

Notes: The table shows the empirical results of GMM Panel estimator. Non-Performing Loan to Total Loan (NPLTL) is the dependent variable. This study uses two factors, ID and RWATA, to control bank-specific heterogeneity. Sargan test for over-identifying restrictions. AR (1) and AR (2) = first and second order auto correlation. ***, ** and * indicate the significance level at 1%, 5% and 10% respectively.

When the independent variable IC efficiency, HCE and SCE are taken into account, Model 1, Model-2 and Model-3 are used respectively. The lag value of a dependent variable is positive (Model-1, Model-2, and Model-3), it means that the preceding year had an impact on credit risk.

Credit risk (NPLTL) is positively and significantly connected to ICE (SFA) according to the findings (Model-1), implying that a 1% rise in ICE raises credit risk by 0.210 percent. According to Hypothesis 1, there is a significant negative relationship between IC efficiency and Bangladeshi bank risk. As a result, the results of this study (Model-1) did not back up hypothesis 1, the findings inverse to (Zheng et al., 2018). When HCE (SCE) is used as an independent variable rather than ICE, these Models (Model-2, Model-3) indicate a positive and substantial relationship between credit risk and HCE and SCE. They (HCE and SCE) show that a 1% increase in HCE (SCE) raises credit risk by 0.034 percent (0.080 percent). Model-2 and Model-3 findings are comparable to model.1. Hypotheses 2 and 3 show that there is a significant negative relationship between HC efficiency (SC efficiency) and Bangladeshi banks risk. As a result, the findings of this study (Models 2 and 3) did not corroborate hypotheses 2 and 3. Unfortunately, Model-3 shows an insignificant relationship between SCE and NPLTA. According to the findings, Improved IC efficiency will increase credit risk, which will eventually diminish financial stability in this country. Consequently, special care should be taken to increase the efficiency of banks' intellectual capital in underdeveloped countries (such as Bangladesh).

Model-1 and Model-2 (Model-3) are negatively (positively) connected with credit risk-taking in terms of performance, which indicates that a 1% rise (reduction) in bank performance ROA would result in credit risk lowering (raising) by 0.013 percent, 0.012 percent, (0.009 percent)respectively. Income diversification (ID) and risk weighted assets to total assets (RWATA) are both positively.
(negatively) related to credit risk-taking, meaning that a 1% increase (decrease) in ID (RWATA) would result in credit risk rising (lowering) by 0.057 percent, 0.051 percent, 0.054 percent (0.052 percent, 0.061 percent, 0.050 percent, respectively). The remaining variables are summarized as follows: Models 2 and 3 demonstrate a positive association between NPLTL and bank size, but Model 1 shows a negative and insignificant relationship. Model-1 and Model-3 demonstrate a favorable (insignificant) association between NPLTL and GGDP, whereas Model-2, sadly, reveals a negative relationship. Models 2 and 3 demonstrate that NPLTL and inflation rate have a positive association, but Model 1 shows that NPLTL and inflation rate have a negative (insignificant) relationship.

This study will mainly contribute in two aspects: firstly, from the managerial approach the concept of measuring IC performance is new, this study applies SFA to examine the performance of IC to assist in examining the relationship it with risk taking behavior. The academia would be complemented through the joint analysis of SFA and GMM model. This study will show how to use these two models jointly to come up with the determinants of efficiency. This study will contribute to the development of intellectual capital theory as well as the agency theory, stakeholders’ theory. The results of the study will be useful for bank management, policy maker, and regulator and academia for future research.

Robustness check and analysis

Following Joher et al., (2006); Ori et al., (2010); Matejasak and Cemohorsky, (2009). 2SLS is used to attain the robustness findings in Table 5.

Table 5: Effects of IC Efficiency, HCE, SCE on credit risks

| Variables  | Model-1 | Model-2 | Model-3 |
|------------|---------|---------|---------|
| NPLTL      | 0.577*** | 0.561*** | 0.572*** |
| ICE        | 0.214*** | 0.111   | 0.119   |
| HCE        | 0.051*   | 0.124   | 0.121   |
| SCE        | -0.013***| 0.006   | 0.007   |
| ROA        | 0.060*** | 0.018   | 0.061*** |
| ID         | -0.058***| 0.023   | -0.065***|
| RWATA      | 0.009    | 0.014   | 0.013   |
| SIZE       | 0.024    | 0.033   | 0.021   |
| GGDP       | 0.006**  | 0.003   | 0.009   |
| IFR        | 0.231    | 0.312   | 0.312   |
| Std. Error | 0.040    | 0.021   | 0.078   |
| t-Statistic| 5.440    | 5.103   | 5.244   |
| R-squared  | 0.587    | 0.631   | 0.637   |
| Adj. R-sq. | 0.581    | 0.634   | 0.632   |
| S.E. of regr. | 0.053   | 0.052   | 0.051   |
| Sargan test (p-value) | 0.813 (0.214) | 3.814 (0.245) | 2.443 (0.192) |
| Prohi(J-statistic) | 0.846 | 0.281 | 0.491 |
| LM Test (P-value) | 0.000 | 0.000 | 0.000 |
| AR (1) (P-value) | 0.000 | 0.001 | 0.000 |
| AR (2) (P-value) | 0.329 | 0.251 | 0.372 |
| No. of observation | 530 | 530 | 530 |
| Instrument rank | 12 | 12 | 12 |

Source: Authors calculation through Eviews-10

Notes: The table shows the empirical results of Two stages Least Square Panel estimator (2SLS). Non-Performing Loan to Total Loan (NPLTL) is the dependent variable. This study uses two factors, ID and RWATA, to control bank-specific heterogeneity. Sargan test= for over-identifying restrictions. AR (1) and AR (2) = first and second order auto correlation. ***, ** and * indicate the significance level at 1%, 5% and 10% respectively.

With the exception of a few examples, the most of the findings are identical to the primary results: When the primary findings demonstrate a favorable influence on credit risks, the ROA in Model-3 reveals a negative effect on them. When the primary findings reveal a positive (negative) effect between them, bank size and (GGDP) in Model-2 have a negative (positive) effect on credit risks. When the major findings demonstrate a positive relationship between them, the inflation rate in Model-3 has a negative effect on credit risks.

Conclusions

This study attempts to measure the impact of intellectual capital efficiency on bank risk taking behavior of selected commercial banks in Bangladesh. The study found that ICE and its component HCE significant positively impact on bank’s credit risk although other component SCE has positive but insignificant impact on risk. The result of the study is very much important for the bank management
to think about the investment in IC, as it indicates that there is an increase of bank’s risk with the increase in investment IC. The result of the study agreed with the study Zheng et al., (2018) and disagreed with the study of Alrashidi and Alarfaj, (2020). The results of the study slightly nuance with resource-based theory that state that firms’ strategic valuable resources help in improving effectiveness and neutralize the threats Barney (1991). In this study ICE positively impacts on banks risk that indicates that increase in investment of IC a valuable strategic resource leads to increase banks’ risk. The strength of the study is that the Bangladeshi Banking industry is trying to invest more in intellectual capital such as private commercial banks that encourages the researcher to have study in relation to risk and intellectual capital along with other bank level and macro level variables. However, the major limitation of this study is that it is conducted only in the context of Bangladeshi banking industry and it did not cover all banks of Bangladesh. A cross country analysis would be more authentic in supporting the result. The study recommends that management of banks should endeavor to invest more on IC in order to enhance the banks performance and minimizing risk level. Future studies could be done in the context of multiple countries to show the impact of ICE along with corporate governance both on bank’s credit risk and solvency risk.

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References

Aebi, V., Sabato, G. & Schmid, M. (2012). Risk management, corporate governance, and bank performance in the financial crisis, Journal of Banking & Finance, 36 (12), 3213-3226.

Aigner, D., Lovell, C. K. & Schmidt (1977). Formulation and estimation of stochastic frontier production function models, Journal of econometrics, 6 (1), 21-37.

Alhassan, A. L. & Asare, N. (2016). Intellectual capital and bank productivity in emerging markets: evidence from Ghana, Management Decision, 54 (3).

Alrashidi, A. & Alarfaj, O. (2020). The Impact of Intellectual Capital Efficiency on Bank Risks: Empirical Evidence from the Saudi Banking Industry, International Journal of Economics and Financial Issues, 10 (4), 206-214.

Altunbas, Y., Carbo, S., Gardener, E. P. & Molyneux (2007). Examining the relationships between capital, risk and efficiency in European banking, European financial management, 13 (1), 49-70.

Andreu, A. N., Green, A. & Stankosky, M. (2007). A framework of intangible valuation areas and antecedents, Journal of Intellectual Capital, 8 (1), 52-76.

Andriessen, D. (2006). On the metaphorical nature of intellectual capital: a textual analysis, Journal of Intellectual capital, 7 (1), 93-110.

Atiku, S., Kaisara, G., Kaupa, S., & Villet, H. (2022). Dimensions of learning organization: Implications for human resources effectiveness in commercial banks. Management Science Letters, 12(2), 117-124.

Barney, J. B. 1991. Firm resources and sustained competitive advantage. Journal of Management, 17, 99–120.

Bontis, N. (2001). Assessing knowledge assets: a review of the models used to measure intellectual capital, International journal of management reviews, 3 (1), 41-60.

Bontis, N. (2004). National intellectual capital index: a United Nations initiative for the Arab region, Journal of intellectual capital, 5 (1), 13-39.

Bontis, N. 1996. There & apos; sa price on your head: managing intellectual capital strategically. Business.

Bougafet, K. & Mgdadi, N. (2016). The impact of prudential regulation on bank capital and risk-taking: The case of MENA countries, The Spanish Review of Financial Economics, 14 (2), 51-56.

Branco, M.C., Delgado, C., Sousa, C. and Sa, M. (2011). Intellectual capital disclosure media in Portugal, Corporate Communications: An International Journal, 16(1), 38-52.

Buallay, A., Cummings, R. & Hamdan, A. (2019a). Intellectual capital efficiency and bank’s performance: A comparative study after the global financial crisis, Pacific Accounting Review.

Cahyaningrum, a. d., & Atahau, a. d. r. (2020). Intellectual capital and financial performance: banks’ risk as the mediating variable. jurnal manajemen dan kewirausahaan, 22(1), 21-32.

Chaihi, H. & Fiti, Z. (2015). Credit risk determinants: Evidence from a cross-country study, Research in international business and finance, 33 (C), 1-16.
Chan, K. H. (2009). Impact of intellectual capital on organisational performance: An empirical study of companies in the Hang Seng Index (Part 1), The learning organization, 6 (1), 4-21.

Choong, K. K. (2008). Intellectual Capital: Definitions, Categorization and Reporting Models, Journal of Intellectual Capital, 9 (4), 609-638.

Deelchand, T. & Padgett, C. (2009). The relationship between risk, capital and efficiency: Evidence from Japanese cooperative banks, Capital and Efficiency: Evidence from Japanese Cooperative Banks (December 18, 2009).

Demartini, M. C., & Beretta, V. (2022). Intellectual capital in SMEs: a review and research agenda. International Journal of Learning and Intellectual Capital, 19(1), 5-29.

Edvinsson, L. (1997). Developing intellectual capital at Skandia, Long range planning, 30 (3), 366-373.

Edvinsson, L. & Sullivan (1996). Developing a model for managing intellectual capital, European management journal, 14 (4), 356-364.

Fiori, F., Marques-Ibanez, D. & Molyneux (2011). Efficiency and risk in European banking, Journal of banking & finance, 35 (5), 1315-1326.

Ghosh, S. K. & Maji, S. G. (2014). The impact of intellectual capital on bank risk: Evidence from Indian banking sector, IUP Journal of Financial Risk Management, 11 (3), 18-38.

Girardone, C., Molyneux & Gardener, E. P. (2004). Analysing the determinants of bank efficiency: the case of Italian banks, Applied Economics, 36 (3), 215-227.

Gropp, R., & Heider, F. (2007). What can corporate finance say about banks’ capital structures, European Central Bank working paper.

Gu, F. & Lev, B. (2001). Intangible assets–measurement, drivers, usefulness. Boston University and New York University.

Guerrini, A., Romano, G. & Leardini, C. (2014). Does intellectual capital efficiency affect financial performance? The case of Italian listed firms, International Journal of Learning and Intellectual Capital, 11 (2), 127-148.

Hall, R. (1992). The strategic analysis of intangible resources. Strategic management journal, 13(2), 135-144.

Haris, M., Yao, H., Tariq, G., Javed, H. M., & Ain, Q. U. (2019). Corporate governance, political connections, and bank performance. International Journal of Financial Studies, 7(4), 62.

Haris, M., Yao, H., Tariq, G., Malik, A., & Javed, H. M. (2019). Intellectual capital performance and profitability of banks: Evidence from Pakistan, Journal of Risk and Financial Management, 12(2), 56.

Hussain, M. E. & Hassan, M. K. (2005). Basel capital requirements and bank credit risk taking in developing countries”.

Innayah, M. N., Pratama, B. C. & Hanafi, M. M. (2020). The Effect of Intellectual Capital towards Firm Performance and Risk with Board Diversity as a Moderating Variable: Study in ASEAN Banking Firms, JDM (Jurnal Dinamika Manajemen), 11 (1), 27-38.

Isaac, R. G., Herremans, I. M. & Kline, T. J. (2010). Intellectual capital management enablers: a structural equation modeling analysis, Journal of Business Ethics, 93 (3), 373-391.

Joher, H., Ali, M., & Nazrul, M. (2006). The impact of ownership structure on corporate debt policy: two stage least square simultaneous model approach for post crisis period: evidence from Kuala Lumpur Stock Exchange. International Business & Economics Research Journal (IBER), 5(5)

Jokipii, T. & Milne, A. (2008). The cyclical behaviour of European bank capital buffers, Journal of banking & finance, 32 (8), 1440-1451.

Joshi, M., Cahill, D. & Sidhu, J. (2010). Intellectual capital performance in the banking sector: An assessment of Australian owned banks, Journal of Human Resource Costing & Accounting, 14 (2), 151-170.

Joshi, M., Cahill, D., Sidhu, J., & Kansal, M. (2013). Intellectual capital and financial performance: An evaluation of the Australian financial sector. Journal of Intellectual Capital, 14(2), 264 –285.

Kwan, S. & Eisenbeis, R. A. (1997). Bank risk, capitalization, and operating efficiency. Journal of financial services research, 12 (2), 117-131.

Lee, C.-C. & Hsieh, M.-F. (2013). The impact of bank capital on profitability and risk in Asian banking, Journal of international money and finance, 32), 251-281.

Lee, T., & Chih, S. (2013). Does financial regulation affect the profit efficiency and risk of banks? Evidence from China’s commercial banks, North American Journal of Economics and Finance, 26), 705-724.

Matejašák, M., Teplý , & Černohorský, J. (2009). The Impact of Regulation of Banks in the US and the EU-15 Countries.

Meslier, C., Tacneng, R., & Tarazi, 2014). Is bank income diversification beneficial? Evidence from emerging economy, Journal of Financial Markets, Institutions & Money, 9-1267.

Mondal, A., & Ghosh, K., S. (2012). Intellectual Capital and Financial Performance of Indian Banks. Journal of Intellectual Capital, Intellectual Capital and Financial Performance of Indian Banks, 13 (4), 515-530.

Mouritsen, J., Larsen, H. T., & Buhk, N. (2001). Intellectual capital and the ‘capable firm’: narrating visualising and numbering for managing knowledge 26(7-8), 735-762., Accounting, organizations and society, 26 (7-8), 735-762.

Nawaz, M., Nor, A. M., & Tolos, H. (2019). The Moderating Role of Intellectual Capital between Relationship of Bank Specific Factors and Credit Risk of Islamic Banks: Evidence from Pakistan, SEISENSE Journal of Management, 2 (4), 79-87.
Nazir, Muhammad Imran, Tan Yong, and Muhammad Rizwan Nazir. 2020. Intellectual capital performance in the financial sector: Evidence from China, Hong Kong and Taiwan. International Journal of Finance and Economics

Nguyen, D. T., Le, T. D., & Ho, T. H. (2021). Intellectual Capital and Bank Risk in Vietnam—A Quantile Regression Approach. Journal of Risk and Financial Management, 14(1), 27.

Nguyen, T.P.T. and Nghiem, S.H. (2015). The interrelationships among default risk, capital ratio and efficiency: Evidence from Indian banks, Managerial Finance, 41 (5), 507-525.

Niñoi, M. a. C. S. (2015). An examination of banks’ cost efficiency in central and Eastern Europe, Procedia Economics and Finance, 22), 544-551.

Obeidat, Bader Y., Ali Tarhini, Ra’Ed. Masa’deh, and Noor Aqqad. 2017. The impact of intellectual capital on innovation via the mediating role of knowledge management: A structural equation modelling approach. International Journal of Knowledge Management Studies 8: 273–98.

Orji, A., Mba, N., & Peter, N. (2010). Foreign Private Investment, Capital Formation and Economic Growth in Nigeria: a two stage least square approach. Journal of Economics and Sustainable Development, 6(8), 57-63.

Ozkan, N., S. Cakan, and M. Kayacan (2017). Intellectual Capital and Financial Performance: A Study of the Turkish Banking Sector, Borsa Istanbul Review, 17 (3), 190-198.

Paoloni, Massaro, M., Dal Mas, F., & Bagnoli, C. (2022). Microfoundations of intellectual capital. Evidence from Italian small accounting firms. Knowledge Management Research & Practice, 1-13.

Peni, E. a. S. V. (2012). Did good corporate governance improve bank performance during the financial crisis?, Journal of Financial Services Research, 41 (1-2), 19-35.

Pulic, A. (1998). Measuring the performance of intellectual potential in knowledge economy , 2nd McMaster Word Congress on Measuring and Managing Intellectual Capital by the Austrian Team for Intellectual Potential), 1-20.

Pulic, A. (2000). VAIC – an accounting tool for IC management, International Journal of Technology Management, 20 (5-8), 702-714.

Pulic, A. (2004). Intellectual capital: does it create or destroy value?, Measuring Business Excellence, 8 (1), 62-68.

Rehman, A. U., Aslam, E., & Iqbal, A. (2021). Intellectual capital efficiency and bank performance: evidence from islamic banks. Borsa Istanbul Review.

Sari, A. & Hidayat, I. (2020). The Effect of Company Size, Systematic Risk and Independent Commissioners on Disclosure of Intellectual Capital. Economics and Accounting Journal, 3(3), 163-171.

Schaeck, K., & Cihak, M. (2007). Banking competition and capital ratios, IMF Stewart, T. (1997a). Intellectual capital: The new wealth of organizations.

Stewart, T. A. (1997b). Intellectual Capital: the New Wealth of Organizations, Doubleday, New York.

Stolz, S., & Wedow, M. (2011). Banks’ regulatory capital buffer and the business cycle: Evidence for Germany, Journal of Financial Stability, 7 (2), 98-110.

Sullivan, H. (2000). Value driven intellectual capital: how to convert intangible corporate assets into market value., John Wiley & Sons, Inc.

Sun, L., & Chang, T. P. (2011). A comprehensive analysis of the effects of risk measures on bank efficiency: Evidence from emerging Asian countries, Journal of Banking & Finance, 35 (7), 1727-1735.

Sveiby, K. E. (1997). The new organizational wealth: Managing & measuring knowledge-based assets, Berrett-Koehler Publishers.

Tan, Y., & Floros, C. (2013). Risk, capital and efficiency in Chinese banking., Journal of International Financial Markets, Institutions & Money, 26 (378-393)

Zhang, J., Jiang, C., Qu, B., & Wang), (2013). Market concentration, risk-taking, and bank performance: Evidence from emerging economies, International Review of Financial Analysis, 30), 149-157.

Zheng, C., Gupta, A. D., & Moudud-Ul-Huq, S. (2018a). Do human capital and cost efficiency affect risk and capital of commercial banks? An empirical study of a developing country, Asian Economic and Financial Review, 8 (1), 22-37.

Zheng, C., Gupta, A. D., & Moudud-Ul-Huq, S. (2018b). Effect of human capital efficiency on bank risk-taking behavior and capital regulation: empirical evidence from a developing country, Asian Economic and Financial Review, 8 (2), 231-247.

Zheng, C., Moudud-Ul-Huq, S., Rahman, M. M., & Ashraf, B. N. (2017). Does the ownership structure matter for banks’ capital regulation and risk-taking behavior? Empirical evidence from a developing country, Research in International Business and Finance, 42 (C), 404-421.

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