MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 1021-1025

Intellectual Capital and Technical Efficiency in Indian Banks: An Empirical Note

Sushmita Prasad [1], Bibeth Sharma [2], Harishankar Vidyarthi [3], Jitendra Kumar [4], Subhadeep Mukherjee [5]
[1] Department of Management Studies, Sikkim Manipal Institute of Technology, Majitar, Sikkim Manipal University, Gangtok, Sikkim, India
[2] Department of Management Studies, Sikkim Manipal Institute of Technology, Majitar, Sikkim Manipal University, Gangtok, Sikkim, India
[3] Department of Management Studies, Institute of Public Enterprise, Telangana, Hyderabad, India
[4] Faculty of Management and Commerce, Ramaiah University of Applied Sciences, Bangalore, India
[5] Faculty of Management and Commerce, Ramaiah University of Applied Sciences, Bangalore, India
**Corresponding Author: (Email: sushmitaprasad16@yahoo.com)*

Abstract
Purpose – This study examines the relationship between intellectual capital and Technical Efficiency of Indian banks.
Design/methodology/approach – Firstly, we estimate Data Envelopment Analysis (DEA) – based technical efficiency of 65 scheduled commercial banks during 2004 – 05 to 2022 – 23 and subsequently compute their annual intellectual capital using the Value-Added Intellectual Capital framework. Finally, we estimate the linkage between intellectual capital and efficiency using panel Tobit model.
Findings: Our findings indicate that average technical, pure technical and scale efficiency scores under operating approach are slightly higher than those under intermediation approach for the aggregate sample during study period. Secondly, we also find that aggregate intellectual capital is exerts positive and statistically significant impact on technical, pure technical and scale efficiency when estimated under operating approach whereas no such relationship is confirmed under intermediation approach. Among intellectual capital constituents, human capital is found to be most critical factor impacting all three efficiency parameters and followed by structural capital. Thus, banks should harness intellectual capital to further augment their efficiency.
Keywords: Technical Efficiency, Intellectual Capital, Data Envelopment Analysis (DEA), Tobit Regression, India

1. Introduction

Indian banks have witnessed gradual transformation in their business models - from traditional deposit-lending activities to fee and brokerage services to augment their performance since India's globalisation and banking reforms initiated during early 1990s. This progressive transformation into a knowledge-intensive paradigm has emphasised the critical role of intellectual capital (IC) towards enhancing financial performance, value creation, efficiency and productivity (Kamath, 2007; Mondal & Ghosh, 2012; Tiwari and Vidyarthi, 2018; Mohapatra et al., 2019; Vidyarthi, 2019; Tiwari et al., 2023; Maji and Saha, 2024). Given its inherently unique, rare, inimitable, and non-substitutable features, IC has been widely acknowledged as a strategic asset that enables / helps to achieve and sustain competitive advantage in the volatile economic environment. Further, resource-based view (RBV) theory advocates that human capital, structural capital, and relational capital are primary drivers of the IC. Therefore, numerous researchers have taken considerable interest in quantifying intellectual capital through different methods such as Tobin's Q, Balanced Scorecard, Intangible Asset Score Sheet, and the Value-Added Intellectual Coefficient. However, VAIC approach has gained greater academic focus due to its objectivity and clarity. Recently, bank performance measurement has seen significant change in approach from traditional financial ratios (return on assets, return on capital employed, return on equity, and net interest margin) to more sophisticated and economic factors like economic value added, market value added, operational and economic efficiency, productivity. Among these, efficiency gives clear understanding of how well bank managers are utilising the available resources within given operational and regulatory constraints (Berger & DeYoung, 1997). Therefore, this study employs technical efficiency as a performance parameter of the banks. Literature has widely adopted two frontier-based approach, namely Data Envelopment Analysis and Stochastic Frontier Analysis, to estimate firm level and branch level efficiency of banks (Bhatia et al., 2018; Akdeniz et al., 2024). Among two, DEA has preferred due to its non-parametric framework and ability to handle multiple inputs - outputs without imposing functional form assumptions. therefore, DEA efficiency becomes a robust framework to access bank performance.Empirical literature exploring the relationship between intellectual capital and bank efficiency and productivity at country specific and cross-country level remains mixed (Adesina, 2019; Mahopatra et al., 2019; Duho et al., 2020; Onumah and Duho, 2020; Vidyarthi et al., 2020; Gupta and Raman, 2021; Le et al,; 2022, Hang and Trang, 2023; Maji and Saha, 2024). Therefore, this study takes a modest step to extend the literature on the issue. This study employs DEA to compute technical, pure technical, and scale efficiency within intermediation and operating approach for 65 Indian banks consisting of 18 public sector, 22 domestic private and 25 foreign banks during 2004–05 to 2022–23. It further analyses the relationship with panel Tobit model.The contribution of this study is two-fold. First, we analyse intellectual capital and bank efficiency relationship in an emerging economy – India using a comprehensive dataset of 65 banks covering 18 public, 22 domestic private and 25 foreign banks 2004–05 to 2022–23. This broad coverage will increase the robustness of the findings. Second, we measure technical efficiency within operating and intermediation approach for robust performance analysis and access whether banks have consistent performance in both approaches. This paper is structured as follows: Section 2 briefly discusses data and methodology and followed by result analysis in section 3. Finally, section 4 concludes the paper.

2. Data and Methodology

2.1. Data: Dataset has been extracted from the annual publication titled *"Statistical Tables Relating to Banks in India"* published by the Reserve Bank of India for the year 2004–05 to 2022–23. Final sample consists of 65 Scheduled Commercial Banks comprising of 18 public sector, 22 domestic private and 25 foreign banks operating during this period.

2.2. **Data Envelopment Analysis for Technical Efficiency estimation:** The analysis begins with brief overview of non-parametric Data Envelopment Analysis (DEA) approach, formulated by Farrell (1957) and then further extended by Charnes et al. (1978) – employed to assess the decision-making units (DMUs – here bank) technical, pure technical and scale efficiency within multiple input – multiple output scenario. This approach has been widely used in numerous studies (Bhatia et al., 2018; Akdeniz et al., 2024). Mathematical framework for computing bank efficiency is as follows:

$$\text{Technical Efficiency}: \quad Min_{\theta,\lambda}\ \theta \quad \text{(under constant rate of return)} \tag{1}$$

$$\text{Pure Technical Efficiency}: \quad Min_{\theta,\lambda}\ \theta \quad \text{(under variable rate of return)} \tag{2}$$

$$\text{Scale Efficiency} = \frac{\textit{overall technical efficiency within CRS}}{\textit{Pure technical efficiency under VRS}} \tag{3}$$

Subject to:

$$\begin{aligned} -y_i + Y\lambda &\geq 0 \\ \theta x_i - X\lambda &\geq 0 \\ \lambda &\geq 0 \end{aligned}$$

here, $\theta \leq 1$ is the scalar efficient score and λ is $N \times 1$ vector of constants.

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 1021-1025

There have been two approaches to measure bank efficiency – intermediation and operating approach. Intermediation approach (Sealey & Lindley, 1977; Berger & Humphrey, 1997; Humphrey, 1985) treats banks as financial intermediaries. This approach assumes deposits and loans are as an input to create various interest-earning assets - advances, securities and investments as outputs. This approach has been used in various approach. However, operating approach treats banks as a business unit with the profit-making motive. It considers labour and capital expenses as an input to yield output - total revenue comprising of interest income as well as non-interest incomes. Each bank's relative efficiency with respect to other DMUs is computed between 0 to 1. DMUs with a score of 1 indicate efficient banks and those with efficiency score less than 1 are technically inefficient. Thus, inefficient units have scope of further lowering their input level for same output under input-oriented approach or augment their output with the same level of input proportionately under output-oriented approach. Current study adopts input-oriented DEA approach as banks have greater control over their inputs than their outputs. Technical efficiency is estimated under constant returns to scale (CRS) framework, assuming that output increases proportionately as input increases and vice - versa. PTE, on the other hand, is calculated under variable returns to scale (VRS), allowing for efficiency variation depending on the size of operations. Table 1 presents the specific input and output variables used in this study, based on both the intermediation and operating approaches to assess bank efficiency.

Table 1: Selected output and input variables within Intermediation and Operating approach respectively for DEA based efficiency analysis

Intermediation Approach		**Operating Approach**	
Input	**Output**	**Input**	**Output**
Deposits	Investments	Interest Expended	Interest Earned
Employees Expenses	Advances	Employees Expenses	Other Income
Capital Related operating expenses		Capital Related operating expenses	

Source: Author's own

2.3. Intellectual Capital :

Now, we briefly discuss the methodological framework to measure bank specific annual intellectual capital for each bank using Value Added Intellectual Coefficient approach (Pulic, 1998). Aggregate intellectual capital consists of human capital, structural capital, and physical capital. Further, Bontis (2000) extended the VAIC framework by considering relational capital as it is pivotal component to establish strong relationships with, customers, suppliers, shareholders and other stakeholders. Its computation is presented in Table 2.

Table 2: Annual bank-specific Intellectual capital constituents

Sl. No.	Variable	Measurements	Related Literature
1	Human capital (VAHC)	$VAHC = \frac{Value\ Added\ (=Output-Input)}{Total\ compensation\ paid\ to\ staff\ and\ employees}$	Smriti & Das (2018), Vidyarthi (2019, 2020)
2	Structural capital (SCVA)	$SCVA = \frac{Value\ Added-Total\ compensation\ paid\ to\ staff\ and\ employeest)}{Value\ Added}$	Smriti & Das (2018), Vidyarthi (2019, 2020)
3	Physical capital employed (VACE)	$VACE = \frac{Value\ Added}{\text{Book value of the net assets}}$	Smriti & Das (2018), Vidyarthi (2019, 2020)
4	Relational capital (RCVA)	$RCVA = \frac{\text{Advertising expenses}}{\text{Value added}}$	Smriti & Das (2018), Vidyarthi (2019, 2020)
5	Value Added Intellectual Coefficient (VAIC™)	VAIC™ = VAHC + SCVA + VACE	Vidyarthi (2019, 2020)
6	Modified Value Added Intellectual Coefficient (MVAIC)	MVAIC = VAHC + SCVA + VACE + RCVA	Vidyarthi (2019, 2020)

Source: Author's own

2.4. Control Variables

In line with the literature (Smriti & Das, 2018; Vidyarthi, 2019, 2020), current study uses two bank specific control variables - Size (natural log of total assets) and Equity as a measure of capitalisation (total equity / total assets).

2.5. Tobit Regression

Since the bank efficiency values are censored between 0 to 1, this study uses Tobit regression (Tobin, 1958) to assess the relationship between intellectual capital and bank efficiency for the aggregate panel over the year 2004-05 to 2022-23. Empirical model employed are presented in

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 1021-1025

Table 3 (A).

Table 3 (A): Empirical model employed for estimating the relationship between intellectual capital and bank efficiency

$Efficiency_{it} = \beta_0 + \beta_1 VAIC_{it} + \beta_2 Equity_{it} + \beta_3 Size_{it} + \varepsilon_{it}$ (1)

$Efficiency_{it} = \beta_0 + \beta_1 MVAIC_{it} + \beta_2 Equity_{it} + \beta_3 Size_{it} + \varepsilon_{it}$ (2)

$Efficiency_{it} = \beta_0 + \beta_1 HCE_{it} + \beta_2 SCE_{it} + \beta_3 CEE_{it} + \beta_4 Equity_{it} + \beta_5 Size_{it} + \varepsilon_{it}$ (3)

$Efficiency_{it} = \beta_0 + \beta_1 HCE_{it} + \beta_2 SCE_{it} + \beta_3 CEE_{it} + \beta_4 RCVA_{it} + \beta_5 Equity_{it} + \beta_6 Size_{it} + \varepsilon_{it}$ (4)

Note: β_0 and β_i indicate constant term and coefficients of the respective independent / control variables respectively. Further, term "ε_{it}" is error term for bank i at time t.
Source: *Author's own.*

Table 3 (B): Descriptive Statistics and Pairwise correlations of the variables used in study

Variable	Mean	Std. Dev.	TE_IA	PTE_IA	SE_IA	TE_OA	PTE_OA	SE_OA	VAIC	MVAIC	VAHC	SCVA	VACE	RCVA	SIZE	Equity
TE_IA	0.7019	0.209	1													
PTE_IA	0.8417	0.183	0.632*	1												
SE_IA	0.8419	0.178	0.620*	-0.205*	1											
TE_OA	0.8063	0.154	0.321*	0.411*	0.007	1										
PTE_OA	0.9177	0.115	0.253*	0.495*	-0.176*	0.620*	1									
SE_OA	0.8796	0.127	0.195*	0.100*	0.161*	0.738*	-0.065*	1								
VAIC	4.769	8.132	0.001	0.059*	-0.059*	0.136*	0.127*	0.061*	1							
MVAIC	4.795	8.127	0.002	0.058*	-0.057	0.132*	0.129*	0.054	1.000*	1						
VAHC	3.887	2.46	0.084*	0.239*	-0.131*	0.358*	0.380*	0.123*	0.330*	0.328*	1					
SCVA	0.666	0.177	0.174*	0.292*	-0.090*	0.388*	0.508*	0.051	0.253*	0.248*	0.684*	1				
VACE	0.215	7.673	-0.03	-0.021	-0.018	0.021	0.001	0.024	0.948*	0.949*	0.013	0.026	1			
RCVA	0.026	0.17	0.043	-0.019	0.077*	-0.221*	0.070*	-0.327*	-0.037	-0.016	-0.102*	-0.260*	-0.001	1		
Size	10.394	2.286	0.330*	0.274*	0.124*	-0.044	0.228*	-0.248*	-0.045	-0.047	-0.237*	0.047	0.027	-0.087*	1	
Equity	0.138	0.125	-0.008	0.096*	-0.112*	0.065*	0.011	0.073*	0.117*	0.119*	0.461*	0.244*	-0.029	0.096*	-0.629*	1

Note: * indicates statistical significance at 5 %.
Source: Author's estimation based on the study data.

3. Result and Analysis

Data Envelopment Analysis results indicate that average Technical (*TE_IA)*, Pure Technical (*PTE_IA)* and Scale (*SE_IA)* efficiency under intermediation approach for overall sample during 2004 - 05 to 2022 - 23 are 70.19, 84.17 and 84.19 percent respectively. Thus, these banks have ample scope for further improvement in *TE_IA, PTE_IA and SE_IA* by 29.81, 15.83, and 15.81 percent respectively. Secondly, the average Technical (*TE_OA)*, Pure Technical (*PTE_OA)* and Scale (*SE_OA)* efficiency under operating approach for the overall sample are found to be 80.63, 91.77 and 87.96 percent, respectively, suggesting further scope for efficiency enhancement by 19.37, 8.23 and 12.04 percent respectively.

We now discuss the Tobit regression results presented in Table 3 and Table 4, which access the relationship between intellectual capital and bank efficiency under the intermediation and operating approach respectively for Indian banks during sector during the period 2005–2023. The findings indicate that notable differences in the role and significance of IC across the two approaches, highlighting the contextual nature of efficiency dynamics. Under the operating approach (Table 4), the aggregate intellectual capital computed (using either VAIC and MVAIC) has significant and positive impact on all three efficiency parameters, namely technical, pure technical, and scale efficiency in both model (1) and (2). This suggests that intellectual capital significantly augments bank efficiency when banks are considered as service-oriented firms. Among the IC constituents – only human capital has positive and significant impact on all three efficiency measures both model (3) and (4), thus revealing the critical of employee skills, expertise, and knowledge in superior performance. However, structural capital also exhibits a positive and significant association with technical and pure technical efficiency in both model (3) and (4), however its effect on scale efficiency is significant and negative in model 4. This suggests that internal processes and organisational structures may improve managerial efficiency but don't necessarily translate into optimal scale efficiency. However, physical capital employed remains insignificant, confirming limited role of physical capital in driving efficiency within the operating framework. Regarding control variables, bank size has significant and negative impact on technical and scale efficiency across all four models but positively affecting pure technical efficiency, suggesting potential diseconomies of scale alongside managerial efficiency gains. Equity capitalisation shows inconsistent effects across models.Table 5 presents the Tobit regression results of the relationship between the intellectual capital – bank efficiency under intermediation approach. Results indicate that aggregate intellectual capital either measured through VAIC or MVAIC remain insignificant across all four models. Further, among intellectual capital sub-components, human capital is having positive and significant impact only upon pure technical efficiency in model (2) and (4). Similarly, structural capital is having positive and significant impact on technical efficiency in model (4). Relational capital is having positive impact on technical and scale efficiency in model (4). Thus, results show weaker impact of intellectual capital on these efficiency parameters. Among control variables, size and equity consistently exhibit positive and significant effects on all three efficiency parameters except some deviation in case of insignificant impact of capitalisation on scale efficiency. Thus, our study confirms that larger and better-capitalized banks are more efficient and benefitted by intellectual capital. Overall, the findings suggest that aggregate intellectual capital, along with human and structural capital, have played crucial role in enhancing bank efficiency, with stronger effects visible under the operating approach. These results re-confirm the resource-based and knowledge-based theory, confirming the strategic relevance of intangible assets into competitive advantage and superior performance – measured through efficiency in the banking sector.

Table 4: Tobit regression results of IC – Efficiency (within operating approach) dynamics of Indian banks during 2005-2023

	Model 1			Model 2			Model 3			Model 4		
	TE_OA	PTE_OA	SE_OA	TE_OA	PTE_OA	SE_OA	TE_OA	PTE_OA	SE_OA	TE_OA	PTE_OA	SE_OA
VAIC	0.00296*	0.00318*	0.00143*									
MVAIC							0.00287*	0.00324*	0.00131**			
VAHC				0.0312*	0.0533*	0.0159*				0.0318*	0.0484*	0.0167*
SCVA				0.172*	0.0866**	-0.00453				0.128*	0.198*	-0.0967*
VACE				0.000202	-0.000467	0.000456				0.000236	-0.000519	0.000529
RCVA										-0.127*	0.529*	-0.273*
SIZE	-0.00506***	0.0298*	-0.0244*	-0.0130*	0.0188*	-0.0262*	-0.00504***	0.0298*	-0.0244*	-0.0124*	0.0169*	-0.0246*
Equity	0.133**	0.468*	-0.0957**	-0.255*	-0.0414	-0.229*	0.133**	0.467*	-0.0947**	-0.220*	-0.125**	-0.154*
Constant	0.842*	0.587*	1.154*	0.758*	0.528*	1.141*	0.842*	0.586*	1.154*	0.777*	0.492*	1.178*

Note: "*, ** and * indicates 10, 5 and 1 % statistical significance respectively.**
Source: *Author's estimation based on the study data.*

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 1021-1025

Table 5: Tobit regression results of IC – Efficiency (within intermediation approach) dynamics of Indian banks during 2005-2023

	Model 1			Model 2			Model 3			Model 4		
	TE_IA	PTE_IA	SE_IA	TE_IA	PTE_IA	SE_IA	TE_IA	PTE_IA	SE_IA	TE_IA	PTE_IA	SE_IA
VAIC	-0.000202	0.00113	-0.000865									
MVAIC							-0.000166	0.00112	-0.000818			
VAHC				0.00547	0.0313*	-0.00366				0.00486	0.0310*	-0.00417
SCVA				0.0604	-0.00352	-0.0450				0.106**	0.0153	-0.00686
VACE				-0.000989	-0.00116	-0.000413				-0.00103	-0.00118	-0.000453
RCVA										0.136*	0.0544	0.120*
SIZE	0.0519*	0.0640*	0.00862*	0.0497*	0.0592*	0.0101*	0.0519*	0.0640*	0.00861*	0.0489*	0.0588*	0.00946*
Equity	0.680*	1.136*	0.0223	0.574*	0.794*	0.0826	0.680*	1.136*	0.0219	0.535*	0.774*	0.0503
Constant	0.0821***	0.0782	0.767*	0.0579	0.0625	0.784*	0.0820***	0.0782	0.767*	0.0400	0.0566	0.768*

Note: "*, ** and * indicates 10, 5 and 1 % statistical significance respectively.**

4. Conclusion

This paper explores the relationship between intellectual capital and Technical Efficiency of 65 scheduled commercial banks consisting of 18 public sector, 22 domestic private and 25 foreign banks during 2004 – 05 to 2022 – 23. We estimate bank efficiency using non-parametric data envelopment analysis to estimate technical, pure technical and scale efficiency under operating and intermediation approach and followed by specific annual intellectual capital using the Value-Added Intellectual Capital (VAIC™) framework proposed by Pulic (1998) and extended modified Value-Added Intellectual Capital (MVAIC) framework within Bontis (2000) approach. Finally, we estimate the relationship between intellectual capital and technical efficiency using panel Tobit model. Based on Data Envelopment Analysis results, we found that the average technical, pure technical and scale efficiency under operating approach for the overall sample during 2004-05 to 2022-23 are found to be 80.63, 91.77 and 87.96 percent, respectively, suggesting further scope for respective efficiency enhancement by 19.37, 8.23 and 12.04 percent respectively. Whereas, average technical, pure technical and scale efficiency under intermediation approach for overall sample during study period are 70.19, 84.17 and 84.19 percent respectively. Thus, these banks have ample scope for further improvement in technical, pure technical and scale by 29.81, 15.83, and 15.81 percent respectively. Secondly, we also find that aggregate intellectual capital is exerts positive and statistically significant impact on technical, pure technical and scale efficiency when estimated under the operating approach whereas no such relationship is confirmed under intermediation approach. Among intellectual capital constituents, human capital is found to be most critical factor impacting all three efficiency parameters and followed by structural capital. Thus, banks should harness intellectual capital to further augment their efficiency.The findings provide key input to the bank management, regulators and Government from the policy perspective. Firstly, banks should continuously invest to improve intellectual capital to make them sustainable and competitive in long run. Intellectual capital can these support banks towards achieving shareholders wealth maximisation in long run as they are having positive and significant impact on technical, pure technical and scale efficiency estimated under operating approach. Further, among intellectual capital constituents, human capitals emerge as the most critical diver as they are the contributor in banking operation in dynamic environment. Therefore, regular investment in activities (such as training and development, innovation and skill development) oriented towards improving human capital should be followed. Secondly, structural process should be upgraded year on year basis to further improve their performance to remain competitive among their peers.

This study has also several limitations and thus, future work can consider accommodating these limitations. This study has employed secondary data extracted from “Database of Indian Economy” published by Reserve Bank of India exclusively for Indian banks. Therefore, supplementing this study with primary data may further enrich the understandings on intellectual capital – bank efficiency issues. Secondly, Further, future study should adopt several measures of intellectual capital apart from VAIC™ or MVAIC approach to further supplement the study.

References

Adesina, K. S. (2019). Bank technical, allocative and cost efficiencies in Africa: The influence of intellectual capital. *The North American Journal of Economics and Finance*, *48*, 419–433. https://doi.org/10.1016/j.najef.2019.03.009

Ahamad, S., Al-Jaifi, H. A. A., & Ehigiamusoe, K. U. (2023). Impact of intellectual capital on microfinance institutions' efficiency: The moderating role of external governance. *Journal of the Knowledge Economy*, *14*(2), 691–717. https://doi.org/10.1007/s13132-022-00921-4

Akdeniz, Ö. O., Abdou, H. A., Hayek, A. I., Nwachukwu, J. C., Elamer, A. A., & Pyke, C. (2024). Technical efficiency in banks: A review of methods, recent innovations and future research agenda. *Review of Managerial Science*, *18*(11), 3395–3456. https://doi.org/10.1007/s11846-024-00743-3

Alhassan, A. L., & Asare, N. (2016). Intellectual capital and bank productivity in emerging markets: Evidence from Ghana. *Management Decision*, *54*(3), 589–609. https://doi.org/10.1108/MD-01-2015-0025

Alqahtani, F., Mayes, D. G., & Brown, K. (2017). Islamic bank efficiency compared to conventional banks during the global crisis in the GCC region. *Journal of International Financial Markets, Institutions and Money*, *51*, 58–74. https://doi.org/10.1016/j.intfin.2017.08.010

Anwar, M. (2019). Cost efficiency performance of Indonesian banks over the recovery period: A stochastic frontier analysis. *The Social Science Journal*, *56*(3), 377–389. https://doi.org/10.1016/j.soscij.2018.09.013

Barathi Kamath, G. (2007). The intellectual capital performance of the Indian banking sector. *Journal of Intellectual Capital*, *8*(1), 96–123. https://doi.org/10.1108/14691930710715088

Berger, A. N., & Humphrey, D. B. (1997). Efficiency of financial institutions: International survey and directions for future research. *European Journal of Operational Research*, *98*(2), 175–212. https://doi.org/10.1016/S0377-2217(96)00342-6

Bhatia, V., Basu, S., Mitra, S. K., & Dash, P. (2018). A review of bank efficiency and productivity. *Opsearch*, *55*(3), 557–600. https://doi.org/10.1007/s12597-018-0332-2

Bontis, N. (1998). Intellectual capital: An exploratory study that develops measures and models. *Management Decision*, *36*(2), 63–76. https://doi.org/10.1108/00251749810204142

Chakrabarti, R., & Chawla, G. (2005). Bank efficiency in India since the reforms: An assessment. *ICRA Bulletin: Money and Finance*, *2*(22–23), 31–48.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research*, *2*(6), 429–444. https://doi.org/10.1016/0377-2217(78)90138-8

Chen, F.-C., Liu, Z.-J., & Kweh, Q. L. (2014). Intellectual capital and productivity of Malaysian general insurers. *Economic Modelling*, *36*, 413–420. https://doi.org/10.1016/j.econmod.2013.10.008

Chowdhury, L. A. M., Rana, T., Akter, M., & Hoque, M. (2018). Impact of intellectual capital on financial performance: Evidence from the Bangladeshi textile sector. *Journal of Accounting and Organizational Change*, *14*(4), 429–454. https://doi.org/10.1108/JAOC-11-2017-0109

Das, A. (1997). Technical, allocative and scale efficiency of public sector banks in India. *Reserve Bank of India Occasional Papers*, *18*(2–3), 279–297.

Das, A., & Ghosh, S. (2006). Financial deregulation and efficiency: An empirical analysis of Indian banks during the post-reform period. *Review of Financial Economics*, *15*(3), 193–221. https://doi.org/10.1016/j.rfe.2005.06.002

Das, A., & Ghosh, S. (2009). Financial deregulation and profit efficiency: A nonparametric analysis of Indian banks. *Journal of Economics and Business*, *61*(6), 509–528. https://doi.org/10.1016/j.jeconbus.2009.07.003

Das, A., Nag, A., & Ray, S. C. (2004). *Liberalization, ownership, and efficiency in Indian banking: A nonparametric approach* (Working Paper No. 2004–29). University of Connecticut. http://digitalcommons.uconn.edu/econ_wpapers

MSW MANAGEMENT -Multidisciplinary, Scientific Work and Management Journal
ISSN: 1053-7899
Vol. 36 Issue 1s, 2026, Pages: 1021-1025

Duho, K. C. T. (2020). Intellectual capital and technical efficiency of banks in an emerging market: A slack-based measure. *Journal of Economic Studies*, *47*(7), 1711–1732. https://doi.org/10.1108/JES-08-2019-0378
Duho, K. C. T., Onumah, J. M., & Owodo, R. A. (2020). Bank diversification and performance in an emerging market. *International Journal of Managerial Finance*, *16*(1), 120–138. https://doi.org/10.1108/IJMF-04-2019-0135
Elyasiani, E., & Mehdian, S. (1995). The comparative efficiency performance of small and large US commercial banks in the pre- and post-deregulation eras. *Applied Economics*, *27*(11), 1069–1079. https://doi.org/10.1080/00036849500000090
Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society Series A: Statistics in Society*, *120*(3), 253–281. https://doi.org/10.2307/2343100
Gupta, K., & Raman, T. (2021). Intellectual capital: A determinant of firms' operational efficiency. *South Asian Journal of Business Studies*, *10*(1), 49–69. https://doi.org/10.1108/SAJBS-10-2019-0186
Hang, N. P. T., & Trang, H. N. T. (2023). Does intellectual capital matter for bank stability efficiency? An application in Vietnamese banking. *Journal of System and Management Sciences*, *13*(3), 431–446. https://doi.org/10.33168/JSMS.2023.0328
Humphrey, D. B. (1985). Costs and scale economies in bank intermediation. In R. C. Aspinwall & R. A. Eisenbeis (Eds.), *Handbook for banking strategy* (pp. 745–783). Wiley.
Kumar, S., & Gulati, R. (2009). Measuring efficiency, effectiveness and performance of Indian public sector banks. *International Journal of Productivity and Performance Management*, *59*(1), 51–74. https://doi.org/10.1108/17410401011006112
Le, M., Hoang, V.-N., Wilson, C., & Managi, S. (2020). Net stable funding ratio and profit efficiency of commercial banks in the US. *Economic Analysis and Policy*, *67*, 55–66. https://doi.org/10.1016/j.eap.2020.06.002
Le, T. D., Ho, T. N., Nguyen, D. T., & Ngo, T. (2022). Intellectual capital–bank efficiency nexus: Evidence from an emerging market. *Cogent Economics and Finance*, *10*(1), Article 2127485. https://doi.org/10.1080/23322039.2022.2127485
Maji, S. G., & Saha, R. (2024). Does intellectual capital influence banks' efficiency? Evidence from India using panel data tobit model. *Managerial Finance*, *50*(4), 697–717. https://doi.org/10.1108/MF-04-2023-0236
Meles, A., Porzio, C., Sampagnaro, G., & Verdoliva, V. (2016). The impact of the intellectual capital efficiency on commercial banks performance: Evidence from the US. *Journal of Multinational Financial Management*, *36*, 64–74. https://doi.org/10.1016/j.mulfin.2016.04.005
Mohapatra, S., Jena, S. K., Mitra, A., & Tiwari, A. K. (2019). Intellectual capital and firm performance: Evidence from Indian banking sector. *Applied Economics*, *51*(57), 6054–6067. https://doi.org/10.1080/00036846.2019.1645283
Mondal, A., & Ghosh, S. K. (2012). Intellectual capital and financial performance of Indian banks. *Journal of Intellectual Capital*, *13*(4), 515–530. https://doi.org/10.1108/14691931211276115
Mukherjee, K., Ray, S. C., & Miller, S. M. (2001). Productivity growth in large US commercial banks: The initial post-deregulation experience. *Journal of Banking and Finance*, *25*(5), 913–939. https://doi.org/10.1016/S0378-4266(00)00103-5
Nkambule, N. A., Wang, W.-K., Ting, I. W. K., & Lu, W.-M. (2022). Intellectual capital and firm efficiency of US multinational software firms. *Journal of Intellectual Capital*, *23*(6), 1404–1434. https://doi.org/10.1108/JIC-09-2020-0314
Olohunlana, A. O., Odeleye, A. T., & Isola, W. A. (2022). Determinants of the intellectual capital efficiency of listed banks in Nigeria: A DEA approach. *Journal of Business and Socio-economic Development*, *3*(1), 86–96. https://doi.org/10.1108/JBSED-07-2021-0100
Onumah, J. M., & Duho, K. C. T. (2020). Impact of intellectual capital on bank efficiency in emerging markets: Evidence from Ghana. *International Journal of Banking, Accounting and Finance*, *11*(4), 435–460. https://doi.org/10.1504/IJBAAF.2020.110287
Pant, A., & Nidugala, G. K. (2022). Board characteristics and efficiency of value added by banks: Evidence from an emerging economy. *Journal of Asian Economics*, *79*, Article 101455. https://doi.org/10.1016/j.asieco.2022.101455
Pennathur, A. K., Subrahmanyam, V., & Vishwasrao, S. (2012). Income diversification and risk: Does ownership matter? An empirical examination of Indian banks. *Journal of Banking and Finance*, *36*(8), 2203–2215. https://doi.org/10.1016/j.jbankfin.2012.03.021
Pulić, A. (1998). *Measuring the performance of intellectual potential in the knowledge economy.* Proceedings of the 2nd World Congress on the Management of Intellectual Capital. McMaster University.
Ray, S. C. (2004). *Are some Indian banks too large? An examination of size efficiency in Indian banking* (Working Paper No. 2004–28). University of Connecticut. http://digitalcommons.uconn.edu/econ_wpapers
Roy, S. G. (2014). Determinants of non-performing assets in India: Panel regression. *Eurasian Journal of Economics and Finance*, *2*(3), 69–78. https://doi.org/10.15604/ejef.2014.02.03.005
Safiullah, M., & Shamsuddin, A. (2019). Risk-adjusted efficiency and corporate governance: Evidence from Islamic and conventional banks. *Journal of Corporate Finance*, *55*, 105–140. https://doi.org/10.1016/j.jcorpfin.2018.08.009
Sarkar, S. (2016). The dynamics of revenue diversification and efficiency of banks in India. *IIM Kozhikode Society and Management Review*, *5*(2), 156–172. https://doi.org/10.1177/2277975216644807
Sarkar, S., & Sensarma, R. (2016). The relationship between competition and risk-taking behaviour of Indian banks. *Journal of Financial Economic Policy*, *8*(1), 95–119. https://doi.org/10.1108/JFEP-05-2015-0030
Sathye, M. (2003). Efficiency of banks in a developing economy: The case of India. *European Journal of Operational Research*, *148*(3), 662–671. https://doi.org/10.1016/S0377-2217(02)00471-X
Sealey, C. W., Jr., & Lindley, J. T. (1977). Inputs, outputs, and a theory of production and cost at depository financial institutions. *The Journal of Finance*, *32*(4), 1251–1266. https://doi.org/10.1111/j.1540-6261.1977.tb03324.x
Shih, K., Chang, C., & Lin, B. (2010). Assessing knowledge creation and intellectual capital in banking industry. *Journal of Intellectual Capital*, *11*(1), 74–89. https://doi.org/10.1108/14691931011013343
Singh, P. K., & Thaker, K. (2020). Profit efficiency and determinants of Indian banks: A truncated bootstrap and data envelopment analysis. *Cogent Economics and Finance*, *8*(1), Article 1724242. https://doi.org/10.1080/23322039.2020.1724242
Smriti, N., & Das, N. (2018). The impact of intellectual capital on firm performance: A study of Indian firms listed in COSPI. *Journal of Intellectual Capital*, *19*(5), 935–964. https://doi.org/10.1108/JIC-11-2017-0156
Ting, I. W. K., Chen, F.-C., Kweh, Q. L., Sui, H. J., & Le, H. T. M. (2022). Intellectual capital and bank branches' efficiency: An integrated study. *Journal of Intellectual Capital*, *23*(4), 840–863. https://doi.org/10.1108/JIC-08-2020-0271
Ting, I. W. K., Lu, W.-M., Kweh, Q. L., & Ren, C. (2023). Value-added intellectual capital and productive efficiencies: Evidence from Taiwan listed electronics companies. *International Journal of Emerging Markets*, *18*(9), 2816–2838. https://doi.org/10.1108/IJOEM-10-2021-1562
Tiwari, R., Vidyarthi, H., & Kumar, A. (2023). Nexus between intellectual capital and bank productivity in India. *Journal of Risk and Financial Management*, *16*(1), 54.
Tobin, J. (1958). Estimation of relationships for limited dependent variables. *Econometrica: Journal of the Econometric Society*, *26*(1), 24–36. https://doi.org/10.2307/1907382
Tran, N. P., & Vo, D. H. (2022). Do banks accumulate a higher level of intellectual capital? Evidence from an emerging market. *Journal of Intellectual Capital*, *23*(2), 439–457. https://doi.org/10.1108/JIC-07-2020-0245
Vidyarthi, H. (2019). Dynamics of intellectual capitals and bank efficiency in India. *The Service Industries Journal*, *39*(1), 1–24. https://doi.org/10.1080/02642069.2018.1435502
Vidyarthi, H., & Tiwari, R. (2020). Cost, revenue, and profit efficiency characteristics, and intellectual capital in Indian banks. *Journal of Intellectual Capital*, *21*(1), 1–22. https://doi.org/10.1108/JIC-05-2019-0107