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Unlocking the synergy between intellectual capital and cost efficiency in Islamic bank

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Abstract

Purpose – This study examines the contribution of intellectual capital (IC) to Islamic banks' cost efficiency.

Methodology – The data envelopment analysis (DEA) method uses an intermediation approach to measure the cost efficiency of Islamic banks and modified value-added intellectual capital (MVAIC) as a measurement of IC. The sample of this research comprises 11 Islamic commercial banks registered with the financial services authority (Otoritas Jasa Keuangan, OJK) and operating from to 2014-2023. This research method uses the system generalized method of moments (SGMM) regression to analyze the impact of IC on the cost efficiency of Islamic banks.

Findings – The results showed that IC positively affects the cost efficiency of Islamic banks in Indonesia. Another finding is that human capital (HC) contributes significantly to improving the cost efficiency of Islamic banks. structural capital (SC), capital employed (CE), and relational capital (RC) do not affect the cost efficiency of Islamic banks.

Implications – This research implies that Islamic banks can determine which IC components require additional investment to improve efficiency and provide future Islamic banking performance-oriented towards new technology.

Originality – This study seeks to fill the gap in previous research by analyzing the impact of IC and its components on the cost efficiency of Islamic banks.

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Introduction

In a dynamic digital era, increasing the capacity and capability of companies, especially insights and skills, is crucial for survival, including in the banking industry, which increasingly relies on technology, including Islamic banking. The transformation from physical resources to intangible assets is the primary key to creating a competitive advantage and improving a company's financial performance (Klimontowicz & Majewska, 2022; Pratama & Innayah, 2021; Ur Rehman et al., 2022). This also applies to the banking industry, which includes Islamic banking.

Although the Islamic banking industry in Indonesia has experienced significant growth, Islamic banks still need to catch up to conventional banks in terms of their profit margins. Moreover, the overall efficiency level of Islamic commercial banks remains below that of conventional commercial banks from 2014 to 2022. This indicates the high operational costs of Islamic banks, as reflected in their low-cost efficiency. Therefore, it is vital to examine the factors

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that determine Islamic banks' efficiency. The efficiency of Islamic banks is the key to achieving a competitive advantage in Indonesia (Masrizal et al., 2023).

This is based on the Resource-Based View (RBV) theory developed by Barney (2001). This theory focuses on the internal resources and capabilities of the organization and how to use these resources and capabilities to create a sustainable competitive advantage and improve efficiency (Aslam et al., 2024). Intellectual capital (IC) is the development of the RBV as a knowledge-based resource that provides added value to Islamic banks (Aslam et al., 2024; Farooque et al., 2023; Prasojo et al., 2023).

IC creates value through employee skills, knowledge, information technology, and stakeholder relationships. Ulum et al. (2017) modified IC (Bontis, 1998; Pulic, 2000) into four components consisting of internal and external companies, where human capital (HC), employed capital (CE), and structural capital (SC) are internal and relational capital (RC) is external to the company. These four components include HC, which refers to bank employees' knowledge, skills, and experience. CE refers to financial capital, whereas SC includes technology, procedures, and information systems that support bank operations. RC is related to relationships with customers, regulators, and other stakeholders.

According to Kweh et al. (2022), IC investment in banking can improve bank efficiency by engaging in non-interest businesses and providing diversified financial innovation services, which can increase non-interest income and the bank's net financial profit. However, IC is generally considered to have a positive effect on bank efficiency. However, this must be generalized to something other than Islamic banking. Given the different business models that use interest-free principles by applying profit-loss sharing (PLS), non-profit loss sharing (Non-PLS)-based financing, and the costs incurred from being sharia-compliant in the business operations of Islamic banks (Shah et al., 2021), plus IC investment without a sustainable strategy will increase costs, and direct increases in profits may not always be offset.

Previous empirical studies on the impact of IC on bank efficiency still need to be conducted. Several studies have investigated the relationship between IC and cost efficiency in conventional banks, including Adesina (2019), Gupta and Raman (2021), Kweh et al. (2022), Le et al. (2022), Onumah and Duho (2020), Ting et al. (2022), Vidyarthi (2019), and Vidyarthi and Tiwari (2020). However, previous studies are yet to exploit Islamic banking, especially in Indonesia. Hence, it is essential to conduct this study as a reference for Islamic bank stakeholders to grow efficiently and sustainably.

In addition, there are inconsistencies in the findings of previous studies on the influence of IC components on bank efficiency. Gupta and Raman (2021) find a positive relationship between SC, RC, and bank efficiency. However, Ting et al. (2022) argue that HC does not contribute to efficiency because it is considered a cost rather than an investment. In addition, high employee standards in Chinese banks do not improve efficiency. Furthermore, Ting et al. (2022) found a negative impact of RC as it diverted bank resources. Mohapatra et al. (2019) found a negative impact of SC on banks in India, as the main focus of public banks in India is the government's social banking agenda; thus, SC capabilities do not positively impact bank efficiency.

The research gap regarding the impact of IC on the cost efficiency of Islamic banks in Indonesia, particularly in developing countries, forms the basis of this study. The existing literature is limited to Vietnam and Ghana (Le et al., 2022; Onumah & Duho, 2020), and needs to focus more on the specific context of Indonesia with its dual banking system. This study contributes two main aspects to the literature on Islamic banking and IC. First, it broadens the scope of the IC literature in developing countries by focusing on the cost efficiency of Islamic banks in Indonesia. Second, this study explores how Islamic banks optimize IC resources and examines their impact on the efficiency and performance of Islamic banks.

This study fills the gap in previous research by analyzing the impact of IC and its components on the cost efficiency of Islamic banks in Indonesia from 2014 to 2023. The results are expected to provide a deeper understanding of the role of IC in improving the efficiency of Islamic banks. This study is relevant to OJK's policy, which prioritizes improving the efficiency of Islamic banks. This study is also expected to provide insights for practitioners, regulators, and other

stakeholders to develop more effective strategies for improving the performance and competitiveness of Islamic banks in the Indonesian financial market.

Literature Review

Farrell (1957) first introduced the concept of measuring efficiency was first introduced by Farrell (1957) when empirically measuring efficiency. Efficiency is a measure of effectiveness that minimizes wasted time, effort, and skills (Archer, 2010). Efficiency is simply about doing things the right way, which means doing things the right way to obtain the best results.

According to Farrell (1957), efficiency measurement is divided into two parts: technical efficiency (TE) and allocative efficiency (AE). TE is defined as a bank's ability to produce banking services using the maximum amount of existing resources. For example, a bank that can produce high-quality banking products and services with few employees can have high TE. AE is the bank's ability to optimize the use of resources, taking into account the price structure and technology. For example, banks that use the latest banking technology to produce more efficient banking services can have high AE.

Ascarya and Yumanita (2008) posit that financial institutions' efficiency can be evaluated through their activities, which are generally categorized into three distinct approaches: production, intermediation, and assets. The production approach conceptualizes financial institutions as producers who offer a range of services to their customers, encompassing the processing of deposit transactions and the provision of management services aimed at channelling funds through financing. By contrast, the intermediation approach perceives financial institutions as intermediaries that facilitate the transformation and transfer of financial assets from surplus to deficit units, thereby playing a pivotal role in resource allocation within the economy. Finally, the asset approach assesses the efficiency of financial institutions by examining their capability to manage income-producing assets, highlighting the importance of effective asset management in enhancing financial performance. These three approaches collectively provide a comprehensive framework for analyzing the operational efficiency of financial institutions, thereby contributing to a deeper understanding of their roles and functions in the financial system.

The three approaches above show differences in determining the input and output variables, especially in the production and intermediation approaches for treating deposits. In the production approach, deposits are treated as outputs, because they are services produced through bank activities. However, the intermediation approach considers deposits as inputs because the deposits collected by the bank are used as assets that mainly produce channeled loans.

Paradi et al. (2011) classify efficiency measurement techniques into three approaches: ratio analysis, regression, and frontier efficiency. The ratio analysis approach has the advantage of being easy to understand and apply because it does not require complex statistical models. However, it is difficult to handle this approach with many inputs and outputs. The regression approach allows for the consideration of multiple inputs and outputs and provides more accurate efficiency estimates. However, high-quality data is required to build a reliable regression model. The Efficiency Frontier approach identifies inefficient units and potential performance improvements. This approach is divided into two types: parametric and non-parametric approaches. The parametric approach uses statistical models to estimate the efficiency frontier, with commonly used models such as the Stochastic Frontier Approach (SFA) and distribution-free approach (DFA). By contrast, non-parametric approaches do not use parametric statistical models. The most commonly used non-parametric approach is data envelopment analysis (DEA).

In banking, efficiency is an essential resource for creating a competitive advantage (Lotto, 2019). Efficiency can be defined as an organization's ability to use resources effectively and efficiently to minimize operational and nonoperational costs. A high level of efficiency allows banks to offer better services at lower prices, thereby attracting and retaining customers. In addition, efficient operations can lead to improved profitability and more robust market positioning, enabling banks to invest further in innovation and customer satisfaction (Taylor et al., 2022).

The RBV theory explains a company's sustainable competitive advantage by focusing on its strategic resources. These include valued resources, Rare, Imperfectly imitable, and organization

(VRIO), which can create a competitive advantage (Kozlenkova et al., 2013). According to Ahmad (2007), the use of resources and capabilities of an organization together form distinctive competencies, such as innovation, quality, responsiveness, and efficiency of the company.

IC is an intangible knowledge asset that provides added value to a company, as described by knowledge, experience, capabilities, information systems, and stakeholder relationships (Bontis et al., 2000). IC, as measured by MVAIC, is an indicator of intellectual value added to the company. According to Ulum (2013), in the context of measuring IC variables in Islamic banks, it must be measured based on accounts in Sharia-based financial statements. The MVAIC model is popular, because it was developed by Ulum et al. (2017). IC is an intangible resource consisting of a company's knowledge, skills, and information that can be used to improve bank efficiency (Kweh et al., 2022).

IC can be implemented by providing human resource development such as training to employees, providing facilities that support employee productivity such as organizational structural synergy, good organizational culture, and infrastructure in the organization. Implementing a competent information technology system, having good relationships with all stakeholders, and utilizing the physical assets of Islamic banks will minimize costs such as cost of funds and minimize errors in screening problematic financing to avoid incurring additional costs.

Previous empirical studies have explained that a higher investment or a high IC score will improve bank efficiency (Kweh et al., 2022; Le et al., 2022; Vidyarthi, 2019; Vidyarthi & Tiwari, 2020). These studies suggest that IC enhances a bank's ability to leverage its resources effectively, leading to better operational performance and a competitive advantage. Furthermore, improved bank efficiency can result in higher profitability and stability in the financial system. Based on some of the findings described earlier, IC plays an essential role in improving efficiency in the banking sector, emphasizing the need for banks to invest in and manage their intellectual capital strategically.

IC is grouped into four components: HC, SC, CE, and RC (Ulum et al., 2017). HC is a knowledge-based resource that can be prioritized in a company's human resources (HR), which has been proven to increase bank efficiency (Adesina, 2019). Investments or costs incurred by banks for HR in the form of salaries, development, training, and considerable benefits will motivate employee productivity, increase the bank's operating income against operating costs, and increase bank efficiency. Several empirical studies have found that HC has a positive effect on banks' overall efficiency. In other words, an increase in HC at the bank will encourage it to improve its business operations (Adesina, 2019; Gupta & Raman, 2021; Le et al., 2022; Mohapatra et al., 2019).

SC is a corporate database, culture, management, policy, framework, infrastructure, and information technology (Barney, 2001; Pulic, 2000). The implementation of SC in Islamic banks can be through an organizational culture supported by adequate infrastructure such as a transparent database, appropriate corporate structure, and competent information technology, which will increase employee productivity and reduce the portion of costs to provide cost efficiency.

Some previous studies have found that an efficient SC can strengthen trust or accountability, thus increasing bank efficiency (Ting et al., 2022). In addition, Maji and Hussain (2021) and Vidyarthi and Tiwari (2020) confirmed the impact of SC on bank efficiency in India. Banks investing in their SC can better navigate operational challenges and mitigate the risks associated with credit and insolvency, thereby improving overall efficiency (Maji & Hussain, 2021). Moreover, an enhanced SC facilitates better knowledge management and innovation, enabling banks to offer superior customer services and maintain a competitive edge. Furthermore, investing in SC helps banks adapt to regulatory changes more effectively, ensuring compliance and reducing the likelihood of financial penalties. Consequently, these improvements contribute to efficiency and sustainability in the banking sector.

According to Pulic (2000), CE is one of the developments of the RBV, which is physical capital or business capital used in business operations that will provide added value. Capital adequacy is important for banks as intermediary institutions that collect and distribute funds. In addition, a large CE will support the optimization of HC and SC to achieve optimization to provide

added value and minimize costs on loans, affecting cost efficiency. Gupta and Raman (2021) found that CE positively affects the cost efficiency of 79 financial institutions in India.

RC, a component that focuses on the external bank, provides added value to the company by establishing good relationships with stakeholders. RC is one of the developments in RBV, which aims to utilize relationships or collaborate with stakeholders (Mention & Bontis, 2013). Banks with high RC can be illustrated by the promotional costs incurred to establish good relationships and trust with stakeholders to increase bank productivity. Research Gupta and Raman (2021) and Le et al. (2022) confirms that RC positively affects bank efficiency in India and Vietnam. Based on previous studies, the following hypothesis is proposed:

H_1 : IC has a positive effect on cost efficiency of Islamic bank
H_{1a} : HC has a positive effect on cost efficiency of Islamic bank
H_{1b} : SC has a positive effect on cost efficiency of Islamic bank
H_{1c} : CE has a positive effect on cost efficiency of Islamic bank
H_{1d} : RC has a positive effect on cost efficiency of Islamic bank

Research Methods

This study uses a sample of 11 Islamic banks in Indonesia and data obtained from the OJK database for the period 2014-2023. The research data type was annual data with an unbalanced panel data model. The sample was selected based on Islamic commercial bank criteria listed in Table 1.

Table 1. Number of samples

No	Name of Islamic bank	Initial	Number of periods
1.	Bank Muamalat Indonesia	BMI	10
2.	Bank Victoria Syariah	BVS	10
3.	Bank Jabar Banten Syariah	BJBS	10
4.	Bank Mega Syariah	BMS	10
5.	Bank Panin Dubai Syariah	PNBS	10
6.	Bank KB Syariah Bukopin	BSB	10
7.	Bank Central Asia Syariah	BCAS	10
8.	Bank Tabungan Pensiunan Nasional Syariah	BTPNS	10
9.	Bank Aceh Syariah	BAS	8
10.	Bank Pembangunan Daerah Nusa Tenggara Barat syariah	BNTBS	6
11.	Bank Syariah Indonesia	BSI	3

Source: Created by authors.

Measuring bank efficiency: Non-parametric DEA

In recent years, the efficiency level of a bank has often been measured using a non-parametric DEA approach based on the mathematical programming model developed by Charnes et al. (1978). This model is the Charnes, Cooper, and Rhodes (CCR) model. DEA is formulated to measure the efficiency of decision-making unit (DMU) that uses many inputs and outputs. Many studies have measured the efficiency of Islamic banks using DEA approach (Ascarya & Yumanita, 2008; Maji & Hussain, 2021; Mohapatra et al., 2019; Sufian, 2013; Sufian & Shah Habibullah, 2014; Sufian & Zulkhibri, 2015; Vidyarthi & Tiwari, 2020).

This study uses DEA because it has three advantages (Masrizal et al., 2023). First, it requires fewer econometric specifications and is easier to use. Second, the DEA is more suitable for small sample sizes. Third, the measurement of efficiency is technical. Therefore, only the absolute value of a variable is considered. This study also uses the DEA method with the help of the MaxDEA 12.0 application and adopts the CCR model, which assumes that each DMU operates at an optimal scale.

This study adopts the intermediation approach with output orientation because it is the most widely chosen approach by researchers examining the efficiency of the banking sector in developing countries (Le et al., 2022; Maji & Hussain, 2021; Mohapatra et al., 2019; Vidyarthi & Tiwari, 2020). Moreover, the intermediation approach is highly relevant for Islamic banking, aligning with the principle of distributing wealth to deficit units.

Table 2. Bank inputs and outputs

Variable input	Initial	Description of variables	Source
Total operating cost	TOP	The total sum of operating costs of fund disbursement and operating costs other than fund disbursements, such as labor costs, promotional costs, administrative and general costs, and costs incurred for purposes that support the management activities of the institution.	Financial Services Authority (OJK)
Total deposit	TD	The total sum of Wadiah Deposit Funds (current accounts, savings accounts) and Non-Profit Sharing Investment Funds (current accounts, savings accounts, and deposits).	Financial Services Authority (OJK)
Variable output		Description of variables	Source
Total earning asset	TEA	Sum of current accounts with Bank Indonesia, placements with other banks, total receivables from murabahah, salam, istishna', multijasa, qardh, rent, total profit-sharing financing from mudharabah and musyarakah. Lease financing.	Financial Services Authority (OJK)

Source: Created by authors.

This study follows Masrizal et al., (2023) in determining the output and input variables. The output variable is total earnings assets (TEA). The TEA was obtained from the annual financial statements in the balance sheet section during the study period. The input variable is total deposits (TD), which can be obtained from annual financial statements in the balance sheet section during the study period. Other input variables, namely, total operating costs (TOC), can be obtained from the profit and loss accounts issued periodically by the IBs concerned during the study period (Table 2).

This technique creates a frontier set for efficient Islamic banks and compares it with inefficient banks. DEA calculates all sample inputs and outputs using the following equation:

$$e_s = \frac{\sum_{i=1}^{m} u_i \, y_{is}}{\sum_{j=1}^{n} v_i \, x_{js}}$$

where es = bank efficiency, m = observed output of banks, n = observed input of bank s, yis = total output i produced by bank s, xjs = total output j produced by banks, ui is the output weight, and vj is the input weight.

The DEA efficiency output shows a value or score ranging from 0 to 1. The closer the score is to 1, the more efficient the Islamic commercial bank is, while the closer the score is to 0, the lower the efficiency level. After obtaining the efficiency score of Islamic banks, the score was analyzed using several independent variables, namely intellectual capital (IC), as well as several control variables, such as non-performing financing (NPF), interest rate (RATE), and inflation (INF).

We calculate IC using the modified value-added intellectual capital (MVAIC) model developed by Ulum et al. (2017) to measure the level of intellectual capital efficiency (ICE), which describes how much IC the company utilizes from the costs incurred on HC, SC, CE, and RC to provide added value for the company.

First, the company's value-added (VA) is estimated, followed by calculating human capital efficiency (HCE), which describes how much human capital is utilized by the funds spent on labor. Next, structural capital efficiency (SCE) is calculated, reflecting the contribution of structural capital to value creation. Calculating capital employed efficiency (CEE) describes how much business capital the company utilizes to generate added value. Finally, it calculates relational capital efficiency (RCE), which describes the extent to which the firm utilizes RC from funds spent on promotion as a value creator. Table 3 provides the details of these measures.

In contrast to previous studies examining IC, there is dominant bank efficiency using static panel regression Tobit regression as the primary analysis (Gupta & Raman, 2021; Mohapatra et al., 2019; Kweh et al., 2022; Le et al., 2022; Vidyarthi, 2019; Vidyarthi & Tiwari, 2020). Previous

researchers have reported that endogeneity issues can lead to unobserved heterogeneity (Adesina, 2019; Farooque et al., 2023; Nadeem et al., 2017). According to Wintoki et al. (2012), this problem can be overcome by using dynamic regression models.

Table 3. Variable measurement

Independent Variables	Initial	Formula	Source
Value Added	VA	$\mathrm{VA} = \mathrm{OUTPUT} - \mathrm{INPUT}$ Output is measured by total revenue from sharia activities, and input is measured by operational and non-operational costs (other than employee costs).	(Vishnu & Gupta, 2014; Maji & Hussain, 2021; Ur Rehman et al., 2022; Adesina, 2019; Poh et al., 2018; Akkas, 2023; Asutay & Ubaidillah, 2023)
Human capital efficiency	HCE	$\mathrm{HCE} = \mathrm{HC/VA}$ Where HC is Personnel expenses	
Structural capital efficiency	SCE	$\mathrm{SCE} = \mathrm{SC/VA}$ Where SC is VA – HC	(Buallay et al., 2020; Farooque et al., 2023; Ulum et al., 2017; Vidyarthi & Tiwari, 2020).
Capita employed efficiency	CEE	$\mathrm{CEE} = \mathrm{VA/CE}$ Where CE diukur dengan total ekuitas.	
Relational capital efficiency	RCE	$\mathrm{RCE} = \mathrm{RC/VA}$ Where promotion expenses measure RC.	
Intellectual Capital efficiency	ICE	$\mathrm{ICE} = \mathrm{HCE} + \mathrm{SCE} + \mathrm{CEE} + \mathrm{RCE}$	
Variable control	**Initial**	**Formula**	**Source**
Non-Performing Financing	(NPF)	$\mathrm{NPF} = \frac{\text{Bad debt financing}}{\text{Total financing}}$	
Bank Indonesia Rate	BIRate	The annual percentage change in the BI rate.	(Rani et al., 2024; Sutrisno & Widarjono, 2018).
Inflasi	(INF)	The annual inflation rate is expressed as a percentage.	

Source: Created by authors.

This study employs a dynamic panel model utilizing the system generalized method of moments (SGMM) estimator method. This approach is more efficient than the others in that it eliminates the need for external instruments using lagged values (Tran et al., 2022). Furthermore, SGMM provides more consistent and efficient results for unbalanced panel data, particularly when N is large and T is small (Arellano & Bond, 1991; Roodman, 2009). To address the issue of instrument over-identification and mitigate the impact of standard error bias, collapse and robust standard error options are employed (Roodman, 2009; Windmeijer, 2005). Diagnostic tests were conducted to ensure consistency of the SGMM model. These included the Wald F statistic for overall model significance, the AR (2) test for high levels of serial autocorrelation, and the Hansen J test for instrument validity. This study employs robustness tests to assess the robustness of the model by utilizing Tobit regression, which is well suited to the characteristics of censored data, namely, the value of the Islamic bank cost efficiency variable is limited to the range 0 to 1, as observed in previous research (Adesina, 2019).

Two regression models are developed to measure the effect of IC on the cost efficiency of Islamic banks in Indonesia. Model 1 examined the relationship between IC and cost efficiency. Similarly, Model 2 explored the relationship between IC components and cost efficiency. Model 1 was used to test H1. Model 2 was used to test hypotheses H1a-H1d.

Model 1:

$$EFF_{it} = \beta_0 EFF_{it-1} + \beta 1 IC_{it} + \beta 2 NPF_{it} + \beta 3 BIrate_{it} + \beta 1 INF_{it} + \upsilon_{it}$$

Model 2:

$$EFF_{it} = \beta_0 EFF_{it-1} + \beta 1 HC_{it} + \beta 2 SC_{it} + \beta 3 CE_{it} + \beta 4 RC_{it} + \beta 5 NPF_{it} + \beta 6 BIrate_{it} + \beta 7 INF_{it} + \upsilon_{it}$$

where i denotes the bank, t denotes the time examined, and υ denotes the residual error term. The dependent variable, EFF, is cost efficiency. IC, HC, SC, CE, and RC are the primary independent variables, and NPF, Birate, and INF are the control variables in this research model. All the variables, their measurements, and references are listed in Table 3.

Results and Discussion

Table 4 shows cost efficiency and IC data on 11 Islamic banks from 2014 to 2023. Cost efficiency with a value of 1 indicates maximum cost efficiency, and values below 1 indicate cost inefficiency. The average cost efficiency for all Islamic banks and all periods is 0.63. This indicates that, on average, DMUs can achieve 63% of their output with the same input level. As for BCAS, it is an Islamic bank that obtains cost efficiency above the average Islamic bank.

Table 4. Development of cost efficiency and intellectual capital from 2014-2023

Cost efficiency by DEA											
Kode	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Mean
PNBS	0.78	0.69	0.82	0.45	0.59	0.74	0.75	0.57	0.76	0.76	0.69
BTPNS	0.54	0.55	0.54	0.51	0.59	0.56	0.56	0.46	0.45	0.44	0.52
BCAS	1.00	0.66	0.70	0.96	0.71	0.73	0.67	0.66	0.65	0.67	0.74
BMS	0.47	0.48	0.46	0.66	0.45	0.45	0.28	0.53	0.58	0.54	0.49
BJBS	0.83	0.58	0.58	0.61	0.64	0.66	0.63	0.63	0.66	0.62	0.64
BVS	0.55	0.51	0.60	0.60	0.51	0.55	0.50	0.43	0.54	0.54	0.53
BMI	0.63	0.63	0.71	0.68	0.59	0.52	0.56	0.41	0.44	0.45	0.56
BSB	0.70	0.71	0.67	0.73	0.74	0.76	1.00	0.64	0.71	0.60	0.72
BAS			0.82	0.58	0.56	0.60	0.58	0.59	0.59	0.62	0.62
BNTBS					0.93	0.60	0.65	0.67	0.68	0.69	0.70
BSI								0.59	0.67	0.70	0.65
Mean	0.69	0.60	0.66	0.64	0.63	0.62	0.62	0.56	0.61	0.60	0.63
MVAIC score in Islamic bank											
Kode	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Mean
PNBS	3.59	2.69	4.96	-7.48	1.19	1.44	1.16	-6.8	3.96	3.52	0.82
BTPNS	2.37	2.38	3	3.44	3.67	3.99	2.97	3.71	4.01	2.86	3.24
BCAS	6.12	1.95	2.12	5.42	2.4	1.64	2.43	2.49	2.77	2.92	3.03
BMS	1.61	1.41	2.62	7.07	1.81	1.89	2.69	6.44	3.6	3.15	3.23
BJBS	9.04	1.43	-1.73	3.83	1.72	1.79	1.61	2.1	2.27	1.86	2.39
BVS	-3.49	4.76	2.7	1.5	0.18	1.11	1.36	2.03	1.68	3.15	1.5
BMI	1.65	1.73	1.47	1.29	1.4	1.26	1.07	1.29	1.46	1.21	1.38
BSB	1.66	2.2	-1.84	1.26	1.2	1.18	1.28	-0.93	-5.96	-3.63	-0.36
BAS			1.61	2.8	2.88	2.81	2.43	2.47	2.42	2.48	2.49
BNTBS					3.44	3.49	2.9	-2.27	2.84	2.98	2.23
BSI								2.78	3.07	3.52	3.12

Source: Created by authors

Table 5. Descriptive statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
EFF	97	.597	.148	.283	1
HC	97	1.435	1.901	-7.617	6.881
SC	97	.354	1.094	-6.413	5.17
CE	97	.19	.412	-2.983	1.283
RC	97	.031	.056	-.133	.297
IC	97	2.01	2.407	-7.484	9.036
NPF	97	3.703	5.818	0	43.99
BIrate	97	5.314	1.333	3.5	7.75
INF	97	3.49	1.809	1.68	8.36

Source: Created by authors

Based on the descriptive statistical analysis presented in Table 5, this study identifies that out of 97 observations, the lowest efficiency score of 0.28 was owned by BMS in 2020. On the other hand, only two banks are classified as efficient: the BCAS in 2014 and the BSB in 2020. The average efficiency score of Islamic commercial banks in Indonesia is 0.58 or 58 percent, indicating that Islamic banks must operate more efficiently.

Analysis of the IC components showed significant variation in the HC, SC, CE, and RC scores. The PNBS obtained the lowest HC score (-7.61 in 2021, while the highest HC score was 6.88 2014 BJBS. The average HC score was 1.31. The lowest SC score was -6.41 in 2022, obtained by BSB, while the highest SC score was 5.17 in 2015 by BVS, with an average SC score of 0.35. The lowest CE score was -2.98 in 2017 was obtained by the PNBS, while the highest CE score was 1.28 in 2014 by the BJBS, with an average CE score of 0.19. The lowest RC score was -0.13 in 2015 was obtained by BVS, while the highest RC score was 0.29 in 2014 was obtained by BVS, with an average RC score of 0.031.

In terms of the overall IC score, the highest value was recorded by the BJBS in 2014, with a score of 9.036. Conversely, the lowest value was observed in the PNBS in 2017, with a score of -7.48. The mean IC value of Islamic commercial banks in Indonesia was 2.01 over the observation period. This score is classified as that of a common performer. This score is still below the levels reported in previous studies on Islamic banks operating in Gulf Cooperation Council (GCC) countries and the top 10 countries in Islamic finance and banking, with an average score of 5.081 (Asutay & Ubaidillah, 2023; Buallay et al., 2020). This finding indicates that Islamic commercial banks in Indonesia require further optimization of their IC operations.

Table 6. Result SGMM and Tobit regression

Independent variable		Cost efficiency			
		SGMM		Tobit	
		Model 1	Model 2	Model 3	Model 4
Lag 1 EFF	Coefficient	-0.5298 *	0.2250		
	Std. err.	0.3098	0.6789		
IC	Coefficient	0.0142 ***		0.0198***	
	Std. err.	0.0049		0.0040	
HC	Coefficient		0 .0324 **		0.0222***
	Std. err.		0 .0136		0.0066
SC	Coefficient		-0.0288		0.0059
	Std. err.		0 .0989		0.0149
CE	Coefficient		-0.0101		0.0265
	Std. err.		0 .1381		0.0333
RC	Coefficient		-0.1413		-0.0457
	Std. err.		1.317		0.3021
NPF	Coefficient	0.0004	0 .0028	-0.0001	0.0004
	Std. err.	0.0010	0 .0046	0.0016	0.0016
BIrate	Coefficient	0.0035	-0.0107	-0.0031	-0.0024
	Std. err.	0.0051	0 .0198	0.0083	0.0084
INF	Coefficient	-0.0066	0.0011	0.0109*	0.0087
	Std. err.	0.0275	0 .0103	0.0060	0.0061
Constant	Coefficient	0.9081 ***	0.4704	0.5636***	0.5676***
	Std. err.	0.2288	0 .3955	0.0446	0.0448
Wald chi2		2040.51	1819.10	33.27	37.07
Prob > chi2		0.000***	0.000***	0.000***	0.000***
Sargan		0.161	0.161		
AR (1)		0.637	0.508		
AR (2)		0.326	0.905		
Hansen		0.587	1.000		
Number of Islamic bank		11	11	11	11
No of observation		86	86	97	97

Note: ***, **, and * denote significance at the 1, 5%, and 10% levels, respectively.
Source: Created by authors

Table 6 presented the estimation results for the impact of IC on the cost efficiency of Islamic banks. Model 1 presents the overall estimation results, wherein the IC coefficient has a positive and statistically significant value. This indicates a positive correlation between IC and cost efficiency of Islamic banks. Model 2 provides further insight into the impact of IC components on cost efficiency by analyzing these effects separately. The results indicate that the HC coefficient is positive and statistically significant, suggesting that HC contributes positively to cost efficiency. Nevertheless, the coefficients of SC, CE, and RC are not statistically significant, indicating that these three IC components do not individually influence the cost efficiency of Islamic banks.

This study reveals's the positive contribution to the cost efficiency of Islamic banking in Indonesia. Islamic bank investments focusing on IC have been proven to improve cost efficiency. Optimizing IC investment opens opportunities for Islamic banks to increase added value through network building and strategic cooperation, especially in sharing resources, redesigning business innovation, and developing new business models by utilizing information technology (Wang et al., 2021). This finding aligns with the view that IC can improve cost efficiency by increasing profits and decreasing operating costs (Kweh et al., 2022; Le et al., 2022; Vidyarthi, 2019; Vidyarthi & Tiwari, 2020).

The findings of this study are in line with those of previous studies, which show that HC has a positive and significant impact on bank operational efficiency (Mohapatra et al., 2019; Onumah & Duho, 2020; Le et al., 2022). In addition, Adesina (2019) and Gupta and Raman (2021) found that HC development can significantly improve bank efficiency levels in various contexts, including Africa and India.

However, SC, CE, and RC did not significantly affect cost efficiency. This may be due to the suboptimal utilization of SC to reduce operational costs by applying cutting-edge technology. Onumah and Duho (2020), and Vidyarthi (2019) also find that SC do not impact the cost efficiency of Islamic banks. According to the Islamic Financial Services Board (IFSB), in 2023, the information technology infrastructure in Islamic banks remains underdeveloped compared to the Islamic capital market. Additionally, most technology investments focus on mobile banking and security systems rather than on cost efficiency.

Similarly, CE does not impact cost efficiency, possibly due to the lower market share of Islamic banks compared with conventional banks (Adesina, 2019; Vidyarthi & Tiwari, 2020). According to the OJK's 2022 progress report, the market share of Indonesian Islamic Finance is only 10.69 percent. Additionally, RC does not influence cost efficiency, suggesting that the current allocation of funds to RC is insufficient to significantly enhance efficiency. This finding aligns with Vidyarthi (2019), who observed that RC allocations are generally smaller than other IC components.

Overall, the results of this study emphasize the importance of IC investment, especially in HC, as a critical driver of cost efficiency in Islamic banks. In its 2022 progress report, OJK also supports the importance of Islamic banking synergy and strengthening Islamic banking identity through investment in IC, especially HC, to improve efficiency.

According to Campanella et al. (2023), HC is a catalyst for banks in the era of technology that requires new types of personnel and high qualifications and skills; hence, there is a need for significant investment in human resources, not only in money but also in continuous training, employee turnover rates that will now prove more costly and risky, and incentive schemes to ensure talent attraction and flexibility to fit the business model.

The IFSB posits that the trajectory of human resources (HR) development can be enhanced through a combination of training, workshops, internships in reputable Islamic financial institutions, attendance at conferences and seminars, and certifications. In this regard, the Accounting and Auditing Organization for Islamic Financial Institutions (AAOIFI) has introduced professional qualifications such as Certified Sharī`ah Adviser and Auditor (CSAA) and Certified Islamic Professional Accounting (CIPA). Additionally, the provision of scholarships, specifically for the actualization of the Islamic finance sector, is a notable initiative.

This will create competent human resources in the financial intermediation of Islamic banks, which has implications for efficient financing delivery, in addition to providing good

customer service and actively participating in continuous professional development in the areas of risk, treasury, and financing management, which will have a more significant impact on efficiency.

The results of this study indicate that Islamic banks in Indonesia should prioritize the development of exceptional human resources, effective utilization of information technology, and strategic management of IC to enhance their operational efficiency. Furthermore, the impact of HC must be continuously optimized to capitalize on the opportunities presented by the digital technology era. Moreover, it is of utmost importance that human resources in Islamic banks comprehend the ontology, epistemology, and axiology of Islamic bank operations. This facilitates the establishment of trust and enhances customer loyalty, thereby conferring added value to Islamic banks. In essence, technology is merely a tool; in the absence of superior human resources, it will not be able to exert its full potential in terms of efficiency and performance within the context of Islamic banks in Indonesia.

Conclusion

This study examined the effect of intellectual capital (IC) on the cost efficiency of Islamic banks in Indonesia. The results demonstrate that IC has a positive and significant impact on Islamic banks' cost efficiency. Investment in IC, particularly human capital (HC), improves cost efficiency. These findings have important implications for Islamic banking practitioners as well. First, Islamic banks must invest in HC development through training, career development and competitive compensation. Second, Islamic banks must identify methods to enhance the value of Structural Capital (SC) by fostering an environment conducive to innovation and collaboration. Third, Islamic banks must increase the value of capital employed (CE) by optimizing the utilization of capital. Fourthly, Islamic banks must cultivate and sustain robust relationships with customers, suppliers, and other stakeholders to elevate the value of relational capital (RC).

This study has several limitations. First, the study employs the Data Envelopment Analysis (DEA) approach, which focuses on intermediation to measure cost efficiency. Future research should consider other approaches such as stochastic frontier analysis (SFA), which comprehensively focuses on asset, production, and intermediation approaches. Second, this study did not differentiate between Islamic banks based on their core capital. Future research could divide Islamic banks based on the provisions of the 2016 Financial Services Authority (Otoritas Jasa Keuangan, OJK) regulation on bank core capital. Third, this study was limited to 11 Islamic commercial banks in Indonesia from 2014 to 2023. Future research should expand sample coverage and research period to obtain more comprehensive results. In addition, this study recommends including Islamic business units (UUS) or Islamic Rural Banks (Bank Pembiayaan Rakyat Syariah, BPRS), extending the research period to analyze the long-term relationship between IC and the cost efficiency of Islamic banks, and analyzing other factors that affect cost efficiency, such as the regulatory environment, macroeconomic conditions, and business strategy.

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