

## TECHNOLOGICAL INNOVATION AND HUMAN CAPITAL: UNVEILING ITS ROLE IN ENHANCING ISLAMIC BANK PERFORMANCE

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### ABSTRACT

This study aims to examine how technological capital affects financial performance and investigate the moderating role of human capital efficiency in this relationship. This study is analyzed using panel data estimation techniques obtained from the financial statements of Islamic banks in Indonesia for 2013-2024. We also performed a robustness check using alternative control variable. The results indicate that technological capital does not significantly enhance the performance of Islamic banks. In the moderating relationship, human capital efficiency moderates the relationship between technological capital and financial performance. Islamic banks should focus on optimizing the use of technological innovations to provide easier public access to services. Furthermore, Islamic banks must position their human resources as the driving force, ensuring that the adaptation, development, and implementation of technology remain in line with sharia principles.

**Keywords:** Technological Innovation, Human Capital, Financial Performance, Islamic Bank

### INTRODUCTION

Islamic banks are financial institutions that operate based on sharia principles. With the Muslim population in Indonesia reaching approximately 244 million people, or around 87% of the total population, Islamic banks have experienced significant growth. The Financial Services Authority (OJK) reported that Islamic banks recorded positive performance in 2024, with total assets reaching 980 trillion rupiah.

Despite demonstrating growth, Islamic banks continue to expand their outreach. However, amidst the increasing public awareness, one critical issue that warrants attention is the relatively low level of Islamic financial inclusion. The Financial Services Authority (OJK) reported that Islamic financial inclusion remains stagnant at 13%. This figure highlights a significant gap between the relatively high level of public literacy and the still limited inclusion of sharia-compliant financial products. In other words, although the public has become more knowledgeable about the concept of Islamic finance, relatively few have utilized such services.

Hasibuan & Oktaviana (2023) stated that this condition is attributed to the still-limited utilization of technology. The distribution of branch offices and ATMs has not been widespread, and the adoption of technology-based services remains suboptimal. Similarly, Mohamed & Otake (2025) argued that the availability of Sharia-compliant products is still insufficient in terms of relevance and diversity. In addition, Zafar & Jafar (2024) found that human resources remain limited, particularly in terms of an in-depth understanding of sharia products and related technologies.

The role of technological innovation is not limited to operational efficiency but also extends to creating service differentiation that complies with sharia principles (Naser et al., 2024). The utilization of technologies such as digital banking, Islamic fintech, big data analytics, artificial intelligence, and blockchain represents strategic opportunities that enable Islamic banks to expand financial inclusion, reach wider segments of society, and

strengthen customer trust (Gyau et al., 2024). Hasibuan & Oktaviana (2023) found that the adoption of technology contributes positively to enhancing the financial performance of Islamic banks.

In addition, human capital is regarded as a strategic asset that is capable of managing and utilizing technology effectively (Saruchi et al., 2019). The quality of human resources is determined not only by technical competencies but also by an understanding of Sharia principles, which provides a unique added value compared to conventional banks (Nawaz, 2016). Farooque et al. (2023) demonstrated that human capital has a positive effect on the financial performance of Islamic banks. Nawaz (2016) further emphasized that the quality of human resources in Islamic banks plays a significant role in optimizing the use of technology, thereby expanding financial inclusion.

Intellectual capital has been widely examined and utilized to identify intangible assets that contribute to enhancing the performance of Islamic banks (Akkas & Asutay, 2022, 2023; Farooque et al., 2023). This study extends the intellectual capital model by discussing the role of technological innovation and human capital—an area that remains underexplored in prior research (Asutay & Ubaidillah, 2024; Nawaz, 2016; Nawaz & Haniffa, 2017). Specifically, this study investigates the role of technological innovation in improving the performance of Islamic banks. It examines the moderating effect of human capital efficiency on the relationship between technological innovation and Islamic bank performance.

This study contributes to the intellectual capital literature in several ways. First, it extends the existing research model, as previously undertaken by Bayraktaroglu et al. (2019) and Nazari & Herremans (2007), to provide a deeper and more comprehensive understanding of intellectual capital. Second, this study introduces human capital as a moderating variable to examine its role in strengthening the relationship between technological innovation and the performance of Islamic banks.

## **LITERATURE REVIEW**

Resource-based view (RBV) emphasizes that an organization's sustainable competitive advantage is largely determined by its internal resources (Barney, 1991; Wernerfelt, 1984). Human capital is regarded as a strategic asset because the knowledge and expertise of human resources directly contribute to the creation of innovative services that comply with sharia principles (Bontis, 1998; Zafar & Jafar, 2024). Similarly, technological innovation constitutes an organizational capability that can enhance operational efficiency, improve the quality of digital services, and expand public access to sharia-compliant financial products (Effendi et al., 2023). The integration of competent human capital with appropriate technological innovation enables Islamic banks to build sustainable competitive advantage while addressing the challenges of an increasingly competitive banking industry (Mohamed & Otake, 2025). Several studies demonstrate that human capital efficiency plays a significant role in improving the financial performance of Islamic banks (Akkas & Asutay, 2023; Asutay & Ubaidillah, 2024; Prasojo et al., 2023). On the other hand, Nawaz (2019) asserts that technology serves as a strategic asset that, when combined with human resource competence, can strengthen efficiency and service differentiation. Thus, RBV provides a robust theoretical framework to explain how the interaction between human capital and technological innovation becomes a key determinant in enhancing the performance of Islamic banks.

## **HYPOTHESIS**

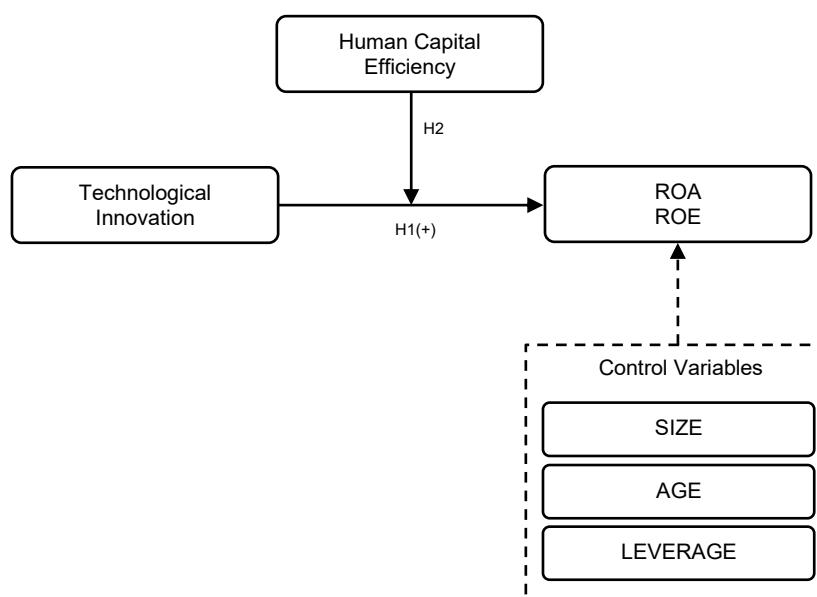
Technology is considered a strategic factor that can drive the financial performance of Islamic banks through operational efficiency, service quality improvement, and the creation of innovative products (Hasibuan & Oktaviana, 2023). Previous studies have shown that the utilization of technology contributes significantly to the profitability and

competitiveness of financial institutions (Wang et al., 2021). In addition, Gyau et al. (2024) found that the adoption of digital technology enhances customer satisfaction and loyalty, which in turn positively affects banks' financial performance. Buallay (2019) emphasized that the integration of technological innovation into Islamic banking systems is positively associated with financial performance. Furthermore, Nawaz (2019) demonstrated that the digitalization of Sharia-compliant services can expand financial inclusion and strengthen the profitability of Islamic banks. Therefore, the hypothesis proposed is:

**Hypothesis 1.** TI has a positive effect on financial performance of Islamic bank

Human capital is believed to play a crucial role in maximizing the benefits of technology on the financial performance of Islamic banks (Hasibuan & Oktaviana, 2023). Technology cannot generate optimal value without the support of competent human resources to operate, manage, and integrate it into business strategies (Naser et al., 2024). Akkas & Asutay (2022) found that human capital efficiency contributes significantly to improving the profitability of Islamic banks. (Abdurrahman, 2024) emphasized that the combination of technological innovation and human capital capability creates a positive synergy in enhancing organizational performance. Furthermore, Nawaz (2019) demonstrated that the success of digital transformation is highly influenced by the quality of human capital, indicating that human capital serves as a critical factor in strengthening the relationship between technology and financial performance. Therefore, the hypothesis proposed is:

**Hypothesis 2.** HCE moderates the relationship between TI with financial performance of Islamic bank



**Figure 1. Research Model**  
**Source(s): Own elaboration (2025)**

## METHODS

This study employs a quantitative approach. The data were obtained from the published financial reports of Islamic banks registered with the Financial Services Authority (OJK) covering the period from 2013 to 2024. Using a purposive sampling method, the sample consists of 124 observations from 13 Islamic banks. We selected Islamic banks because Indonesia possesses a substantial potential market share. Financial performance is proxied by return on assets (ROA) and return on equity (ROE). ROA is used to measure the ability of banks to utilize their assets to generate net income. In contrast, ROE

measures the ability of banks to generate net income from shareholders' equity (Ousama & Fatima, 2015). Following Lee & Manorungrueangrat (2019) and Modjo et al. (2025), technological innovation is measured using a dummy variable. Technological innovation indicates whether Islamic banks adopt technologies such as mobile banking applications, online banking platforms, digital onboarding, QRIS, e-wallets, and digital security systems. Human capital is measured using human capital efficiency (HCE), which is adapted from the method of (Pulic, 2004). Following Akkas & Asutay (2023), variable control include organizational size, organizational age, and leverage. control variables include organizational age, organizational size, and leverage. The measurement of variables is presented in Table 1. We used panel data estimation and moderation regression analysis to examine the variables in this study. Following (Lu & White, 2014; Zakiy & Falikhatun, 2024), robustness check was carried out using alternative control variables. The regression model are as follows.

$$ROA = \alpha + \beta_1 TI + \beta_2 HCE + \beta_3 SIZE + \beta_4 AGE + \beta_5 LEV + \varepsilon \quad (i)$$

$$ROA = \alpha + \beta_1 TI + \beta_2 HCE + \beta_3 TI \times HCE + \beta_4 SIZE + \beta_5 AGE + \beta_6 LEV + \varepsilon \quad (ii)$$

$$ROE = \alpha + \beta_1 TI + \beta_2 HCE + \beta_3 SIZE + \beta_4 AGE + \beta_5 LEV + \varepsilon \quad (iii)$$

$$ROE = \alpha + \beta_1 TI + \beta_2 HCE + \beta_3 TI \times HCE + \beta_4 SIZE + \beta_5 AGE + \beta_6 LEV + \varepsilon \quad (iv)$$

**Table 1. Measurement Variables**

| Variables                | Codes | Measurement                                                                                                                                                                                                                                                      | Data Source      |
|--------------------------|-------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------|
| <i>Dependent</i>         |       |                                                                                                                                                                                                                                                                  |                  |
| Return on asset          | ROA   | Net income/total asset                                                                                                                                                                                                                                           | Financial report |
| Return on equity         | ROE   | Net income/total equity                                                                                                                                                                                                                                          | Financial report |
| <i>Independent</i>       |       |                                                                                                                                                                                                                                                                  |                  |
| Technological innovation | TI    | If an organization adopts technological innovation, it is scored 1; otherwise, it is scored 0 (dummy variable)                                                                                                                                                   | Financial report |
| Human capital efficiency | HCE   | $VA = OUT - IN$<br><i>Where:</i><br>VA = Value added; OUT = Total income; IN = Total expenses other than employee salary expenses<br><br>$HCE = VA/HC$<br><i>Where:</i><br>HCE = Human capital efficiency; VA = Value added; HC = Total employee salary expenses | Financial report |
| <i>Control Variables</i> |       |                                                                                                                                                                                                                                                                  |                  |
| Organizational size      | SIZE  | Natural log of organization total assets                                                                                                                                                                                                                         | Financial report |
| Organizational age       | AGE   | Year n – the first year of the organization's establishment                                                                                                                                                                                                      | Financial report |
| Leverage                 | LEV   | Total debt/total equity                                                                                                                                                                                                                                          | Financial report |

**Source(s): Authors' analysis from previous studies (2024)**

## RESULTS

### Statistic Descriptive

The descriptive statistics in Table 2 show that the average ROA of Islamic banks is relatively small, indicating that the ability to generate profits from assets is fairly stable, although within a limited range. Meanwhile, ROE records a negative average, suggesting that some Islamic banks experienced substantial losses during the observation period. TI has a mean value of 0.354 with a maximum of 1, implying that technology adoption in Islamic banks remains relatively low. On the other hand, HCE has an average of 3.327, reflecting significant differences among Islamic banks in utilizing human resource efficiency. Furthermore, the interaction between TI and HCE shows a mean of 1.098, indicating considerable heterogeneity in how both variables jointly influence financial performance. Control variables also demonstrate diverse characteristics. SIZE suggests a relatively large average value, while AGE averages 11 years with a range from 1 to 32 years. LEV is relatively low, suggesting that Islamic banks tend to employ a conservative capital structure. Table 3 presents the correlation matrix among variables to test for potential multicollinearity. The correlation results confirm that no multicollinearity issues are present in the regression model.

### Regression Model Result

The regression results in Table 4 indicate that TI has no significant effect on the financial performance of Islamic banks, suggesting that the influence of TI on financial performance remains weak and unstable. This can be attributed to the limited availability of human resources with technological expertise that can be integrated with sharia principles. Nawaz (2019) found that technological innovation can only be optimized when supported by competent human capital. Moreover, Islamic banks still lack digital infrastructure that is as extensive and efficient as that of conventional banks, alongside limited investment capacity to support innovation and digital transformation. Mondal et al. (2022) highlighted that even though Islamic banks have adopted digital technologies, their internal business processes remain inefficient and may even hinder productivity. In addition, existing regulations are not yet fully adaptive to technological developments, which slows the implementation of digital innovations in Islamic banks. Modjo et al. (2025) noted that the implementation of technological innovations in Islamic banks is constrained by strict and conservative regulations, which often fail to keep pace with the rapid advancement of technology.

Meanwhile, HCE is found to moderate the relationship between TI and the financial performance of Islamic banks. This indicates that technological innovation can contribute significantly when supported by efficient and competent human resources. Nawaz (2019) demonstrated that digital transformation yields positive outcomes when accompanied by adequate human capital development. Human capital with higher capabilities is better able to operate complex systems and integrate them effectively into business processes. In addition, the role of human capital enables Islamic banks to be more innovative in adopting and developing financial technologies (Kamukama et al., 2011). This may expand market reach, thereby positively influencing financial performance. The combination of technological innovation and efficient human capital can create a sustainable competitive advantage for Islamic banks. With this synergy, Islamic banks become more responsive to market changes and customer needs, which directly enhances their financial performance (Hasibuan & Oktaviana, 2023).

### Robustness check

Following (Lu & White, 2014), robustness check in this study sustainability reporting (SR) as an alternative control variable. SR is the report presented by Islamic banks concerning their environmental, social, and governance (ESG) performance. This report informs stakeholders about the banks' operational impacts, their commitment to ethical business practices, and their contribution to achieving sustainable development goals (Wijayanti & Setiawan, 2022). The estimation results presented in Table 5 do not show any significant

differences from the main findings. Therefore, it can be concluded that the estimation results are sufficiently robust.

Table 2. Statistice Descriptive

| Variables | Obs. | Mean   | Std. Dev. | Min     | Max    |
|-----------|------|--------|-----------|---------|--------|
| ROA       | 124  | 0.004  | 0.035     | -0.168  | 0.108  |
| ROE       | 124  | -0.004 | 0.347     | -.3.533 | 0.274  |
| TI        | 124  | 0.354  | 0.480     | 0       | 1      |
| HCE       | 124  | 3.327  | 1.775     | -2.452  | 8.279  |
| TI*HCE    | 124  | 1.098  | 1.883     | -2.452  | 7.704  |
| SIZE      | 124  | 25.911 | 3.522     | 19.538  | 31.094 |
| AGE       | 124  | 11.040 | 6.835     | 1       | 32     |
| LEV       | 124  | 0.163  | 0.090     | 0.040   | 0.822  |

Source: Authors' work (2025)

Table 3. Matrix Correlation

| Variables | ROA    | ROE    | TI     | HCE    | TI*HCE | SIZE  | AGE   | LEV |
|-----------|--------|--------|--------|--------|--------|-------|-------|-----|
| ROA       | 1      |        |        |        |        |       |       |     |
| ROE       | 0.564  | 1      |        |        |        |       |       |     |
| TI        | 0.071  | 0.106  | 1      |        |        |       |       |     |
| HCE       | 0.035  | -0.003 | -0.097 | 1      |        |       |       |     |
| TI*HCE    | 0.151  | 0.137  | 0.789  | 0.322  | 1      |       |       |     |
| SIZE      | 0.057  | 0.101  | 0.096  | 0.073  | 0.084  | 1     |       |     |
| AGE       | -0.047 | 0.031  | 0.173  | -0.167 | 0.053  | 0.018 | 1     |     |
| LEV       | 0.024  | 0.104  | 0.010  | -0.044 | 0.017  | 0.071 | 0.131 | 1   |

Source: Authors' work (2025)

Table 4. Regression Model Result

| Variables            | (1)<br>Coeff.<br>(Prob.) | (2)<br>Coeff.<br>(Prob.) | (3)<br>Coeff.<br>(Prob.) | (4)<br>Coeff.<br>(Prob.) |
|----------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| TI                   | -0.002<br>(0.292)        | -0.013<br>(0.005)***     | -0.002<br>(0.853)        | -0.042<br>(0.127)        |
| HCE                  | 0.003<br>(0.001)***      | 0.002<br>(0.017)**       | 0.018<br>(0.001)***      | 0.015<br>(0.005)***      |
| TI*HCE               |                          | 0.004<br>(0.008)***      |                          | 0.016<br>(0.094)*        |
| SIZE                 | -0.002<br>(0.565)        | -0.003<br>(0.355)        | -0.107<br>(0.646)        | -0.015<br>(0.502)        |
| AGE                  | 0.000<br>(0.160)         | 0.000<br>(0.108)         | 0.003<br>(0.251)         | 0.003<br>(0.207)         |
| LEV                  | 0.237<br>(0.205)         | 0.007<br>(0.702)         | 0.129<br>(0.218)         | 0.070<br>(0.520)         |
| _cons                | 0.047<br>(0.642)         | 0.087<br>(0.386)         | 0.196<br>(0.733)         | 0.338<br>(0.557)         |
| Adjusted (R2)        | 0.130                    | 0.186                    | 0.139                    | 0.161                    |
| Prob. (F-statistics) | 0.010                    | 0.001                    | 0.006                    | 0.004                    |
| Obs.                 | 124                      | 124                      | 124                      | 124                      |

\*\*\*1% significant level;

\*\*5% significant level;

\*10% significant level

Source: Authors' work (2025)

Table 5. Robustness Check: Alternative Control Variable

| Variables            | (1)<br>Coeff.<br>(Prob.) | (2)<br>Coeff.<br>(Prob.) | (3)<br>Coeff.<br>(Prob.) | (4)<br>Coeff.<br>(Prob.) |
|----------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| TI                   | -0.002<br>(0.332)        | -0.014<br>(0.006)***     | -0.001<br>(0.903)        | -0.043<br>(0.138)        |
| HCE                  | 0.003<br>(0.002)***      | 0.002<br>(0.017)**       | 0.018<br>(0.001)***      | 0.016<br>(0.005)***      |
| TI*HCE               |                          | 0.004<br>(0.008)***      |                          | 0.016<br>(0.098)*        |
| SIZE                 | -0.022<br>(0.573)        | -0.003<br>(0.345)        | -0.010<br>(0.657)        | -0.015<br>(0.501)        |
| AGE                  | 0.000<br>(0.175)         | 0.000<br>(0.163)         | 0.003<br>(0.255)         | 0.003<br>(0.251)         |
| LEV                  | 0.023<br>(0.205)         | 0.006<br>(0.733)         | 0.130<br>(0.217)         | 0.069<br>(0.531)         |
| SR                   | -0.000<br>(0.900)        | 0.000<br>(0.743)         | -0.002<br>(0.849)        | 0.001<br>(0.927)         |
| _cons                | 0.046<br>(0.651)         | 0.090<br>(0.373)         | 0.188<br>(0.745)         | 0.344<br>(0.554)         |
| Adjusted (R2)        | 0.130                    | 0.187                    | 0.139                    | 0.161                    |
| Prob. (F-statistics) | 0.020                    | 0.002                    | 0.013                    | 0.008                    |
| Obs.                 | 124                      | 124                      | 124                      | 124                      |

Source: Authors' work (2025)

\*\*\*1% significant level; \*\*5% significant level; \*10% significant level

## CONCLUSION

Based on the empirical findings, it is evident that TI does not yet make a significant contribution to the financial performance of Islamic banks. However, HCE is found to moderate the relationship between TI and financial performance in Islamic banks. This study identifies the critical role of human capital in strengthening technological innovation within Islamic banks. In line with RBV, the combination of TI as a strategic asset and human capital as an internal capability creates a synergy that is difficult for competitors to imitate, thereby generating competitive advantage and improving the financial performance of Islamic banks. Theoretically, this study extends the understanding that the synergy between TI and human capital is a strategic factor that determines the success of Islamic banks in enhancing their financial performance. Technological innovation should be complemented by human capital development strategies, such as training, digital competency enhancement, and the establishment of a work culture that is adaptive to technology. By strengthening human capital, Islamic banks can maximize the benefits derived from adopted technologies. Furthermore, the findings of this study can serve as a basis for regulators and policymakers to promote integrative policies that combine the strengthening of technological infrastructure with the development of human capital capacity, enabling the Islamic banking industry to undergo digital transformation and maintain competitiveness in the era of global competition. This study has several limitations. First, it only focuses on Islamic banks in a single country. Thus, the findings may not be fully generalizable to Islamic banking systems in other countries with different regulatory environments, organizational cultures, and levels of technological adoption. Second, the study emphasizes the moderating role of HCE on the relationship between TI and financial performance, while other factors may also influence this relationship. Future research may incorporate different components of intellectual capital, as well as aspects of Sharia governance, to provide a more comprehensive picture. In addition, cross-country panel data are recommended for subsequent studies to enhance generalizability.

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