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Faiza Omer Elmahgop *

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Article

Intellectual Capital and Bank Stability in Saudi Arabia: Navigating the Dynamics in a Transforming Economy

Faiza Omer Elmahgop

Finance and Investment Department, Faculty of Business Administration, University of Tabuk, Tabuk, Saudi Arabia; felmahgop@ut.edu.sa

Abstract: This research investigates the intricate dynamics between intellectual Capital (VAIC) and the stability of banks in the evolving context of Saudi Arabia's banking sector. Against the backdrop of rapid economic reforms under Vision 2030 and the challenges imposed by the COVID-19 pandemic, the research provides a nuanced analysis of how intellectual capital and intellectual capital's components—Human Capital Efficiency (HCE), Structural Capital Efficiency (SCE), and Capital Employed Efficiency (CEE)—affect the financial stability of Saudi banks. The research analyses a decade-long panel dataset from 2012 to 2022, utilizing both fixed effects and cross-section random effects models to discern the impact of intellectual capital on bank stability. The findings reveal a positive overall influence of intellectual capital on bank stability; however, individual components present a complex relationship, with CEE showing a positive association and HCE and SCE demonstrating unexpected negative correlations with bank stability. The research identifies leverage (LEV) as a significant factor negatively impacting stability. Operational efficiency (OPEF) and size (SIZE) also negatively affect stability. Surprisingly, macroeconomic indicators and bank size exhibit non-significant effects on bank stability. Similarly, the direct impact of the COVID-19 pandemic was found to be non-significant, suggesting a resilient banking environment or the presence of effective mitigating strategies. As Saudi Arabia continues its ambitious economic transformation, this research underscores the critical role of effectively managed intellectual capital in ensuring the banking sector's stability. It provides a foundation for ongoing research in this vital area.

Keywords: intellectual capital; bank stability; Human Capital Efficiency; Structural Capital Efficiency; Capital Employed Efficiency; leverage; operating efficiency

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1. Introduction

The banking sector is a cornerstone of economic growth and stability worldwide, providing the financial infrastructure for individuals and enterprises to thrive. As such, the resilience and performance of banks are not just matters of private concern but are of national, even global, interest, especially in rapidly developing economies like Saudi Arabia's. Intellectual capital emerges as a key driver in this field, with a growing body of research underscoring its pivotal role in shaping a bank's competitive edge and stability.

Amidst this backdrop, our research ventures beyond traditional analyses, delving into how intellectual Capital influences bank stability, particularly in Saudi Arabia. It addresses the intricate interplay between a bank's human, structural, and capital resources, as well as stability, with the added layer of exploring these dynamics during the unprecedented disruptions of the COVID-19 pandemic.

The research problem centers on explaining the complex dynamics between intellectual capital and its components. Also, their impact on the stability of Saudi banks. Specifically, the research seeks to answer how each aspect of intellectual capital uniquely contributes to or detracts from financial stability in a sector that has faced both rapid digital transformation and the extraordinary challenges of a global health crisis.

The aim is to assess intellectual capital's multifaceted contributions to banking stability comprehensively. Objectives include evaluating the direct impact of intellectual capital and its components on bank stability, having control variables like bank size, operating efficiency, and leverage, and determining the resilience of banks against economic adversities under disruptions of the COVID-19 pandemic within Saudi Arabia.

Grounded in the Resource-Based View (RBV), this research posits that banks' Intellectual Capital is a strategic asset crucial for navigating competitive markets and regulatory environments. It builds on foundational research by Barney (1991), Edvinsson & Malone (1997), and subsequent studies extending the RBV's application to the banking industry. The Resource-Based View (RBV) is a theory that suggests firms gain and sustain competitive advantage by deploying valuable, rare, and non-substitutable resources at their disposal (Murale, et al., 2010)

This research is significant as it contributes to the academic discourse on intellectual capital and provides insights for banking professionals and policymakers within Saudi Arabia. Its findings can inform strategic decision-making, risk management practices, and policy formulations aimed at fortifying bank stability.

Employing a quantitative research design, the research leverages econometric modelling to analyze panel data from Saudi banks. It employs a Cross-Section Random Effects model to tease out the impact of intellectual capital and control variables on bank stability, with data spanning from 2012 to 2022.

The research is systematically organized into sections that flow from a literature review and hypothesis development to research design and methodology, culminating in a detailed results and discussion segment and a conclusion and recommendations. Each section builds on the previous one, offering readers a clear and logical progression of analysis and insights.

2. The Literature Review and Hypotheses Development

In the context of the banking sector, the stability and resilience of financial institutions are significantly influenced by Intellectual Capital (VAIC)—an incorporation of Human Capital Efficiency (HCE), Structural Capital Efficiency (SCE), and Capital Employed Efficiency (CEE). This section of the literature review focuses on dissecting these core components of VAIC, highlighting their direct impact on enhancing banks' stability and risk management capabilities. Through a nuanced exploration, the role of control variables such as leverage, bank size, operational efficiency, and macroeconomic indicators is critically examined, underscoring their effects on VAIC-bank stability. Moreover, the advent of the COVID-19 pandemic introduces a critical lens through which the resilience of banks, underpinned by their intellectual capital, is further scrutinized. This analysis aims to unravel the intricate relationships between VAIC components and bank stability, offering insights into how banks can navigate the complexities of a volatile financial landscape.

2.1. Theoretical Framework

The RBV provides a robust theoretical lens through which the role of intellectual capital in enhancing bank stability can be examined. Intellectual capital is viewed as a critical strategic asset that banks can leverage to differentiate themselves in a competitive marketplace. The RBV suggests that intellectual capital components—human, structural, and capital employed—are resources and capabilities that enable firms to innovate, adapt, and deliver superior financial performance (Marr et al., 2003). The theoretical framework provided by the RBV, complemented by the extensive body of literature on intellectual capital, offers a comprehensive lens through which the research of intellectual capital's impact on bank stability in Saudi Arabia can be conducted. By examining the nuanced roles of human, structural, and Capital-employed efficiencies within this framework, this research contributes to a deeper understanding of how banks can harness their intangible assets to foster resilience and competitive advantage in changing market dynamics and regulatory environments.

2.2. The Impact of Intellectual Capital on Bank Stability

Several empirical studies across different regions and banking systems underscore the direct relationship between VAIC and bank stability. For instance, Al-Musali and Ismail (2014) found significant positive effects of VAIC components on the financial performance of banks in Saudi Arabia, suggesting a likely contribution to stability given the interconnectedness of performance and stability. Similarly, Asare, Aboagye-Otchere, and Muah (2022), in their study across banking markets in Africa, found that VAIC leads to more excellent financial performance and stability, reinforcing the vital role of IC in enhancing a bank's resilience against operational and financial shocks.

Studies explicitly addressing the Saudi banking sector, such as those by Alharbi (2023) and Al-Musali & Ismail (2014), contribute to a nuanced understanding of how VAIC impacts bank stability within the region. These studies affirm that the efficiency of human capital, structural capital, and capital employed plays a critical role in determining a bank's ability to maintain stability amidst economic fluctuations and industry-specific challenges.

Furthermore, the COVID-19 pandemic has brought additional dimensions to the examination of VAIC and bank stability, with research indicating varying impacts based on bank size, ownership structure, and the extent of digital financial inclusion (Arafat et al., 2021; Banna et al., 2022). This highlights the importance of adaptive VAIC strategies in sustaining bank stability during unprecedented disruptions.

2.3. Intellectual Capital Components and Its Impact on Bank Stability

Human Capital Efficiency (HCE): HCE highlights the importance of an organization's employees and their collective skills, knowledge, and abilities as critical drivers of value creation and competitive advantage (Wright et al., 1994). Within the banking sector, HCE mirrors the institution's ability to effectively deploy its workforce to enhance productivity and foster innovation, thereby contributing to overall stability. This is supported by Nguyen and Ho (2021), who illustrate how intellectual capital, including human capital, directly influences bank risk levels in Vietnam, highlighting the importance of skilled employees in managing risks effectively. Onumah and Duho (2019) affirm that intellectual capital significantly impacts Ghanaian banks' financial performance and stability, suggesting that a knowledgeable workforce is critical to sustaining competitive advantage and enhancing bank stability.

2.3.1. Human Capital Efficiency (HCE):

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2.3.2. Structural Capital Efficiency (SCE):

SCE encompasses the institutional knowledge and processes embedded within an organization that remain even after employee turnover, such as databases, organizational culture, patents, and customer relationships. Edvinsson and Malone (1997) highlight the significance of SCE in preserving critical organizational knowledge and promoting an environment of continuous improvement and innovation. In the banking sector, SCE maintains organizational knowledge, facilitates continuous improvement, and drives innovation. Dzinkowski (2000) underscores the importance of SCE in managing intellectual capital, highlighting its essential role in sustaining operational efficiency and improving risk management. Meles et al. (2016) demonstrate that SCE significantly impacts the

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performance of commercial banks in the U.S., underscoring its pivotal role in securing a competitive advantage and financial stability.

2.3.3. **Capital Employed Efficiency (CEE):**

CEE is a crucial metric in assessing how effectively a company employs its capital resources to generate revenue, highlighting operational efficiency and financial health. Within the banking sector, it signifies the adeptness in utilizing a mix of equity, borrowed funds, and deposits for income generation, where a higher CEE denotes effective resource deployment and financial stability. Studies by Pulic (2004), Akkas & Asutay (2023), and Al-Musali & Ismail (2014) collectively reinforce the importance of CEE in banking. They illustrate that efficient capital management not only enhances performance metrics across both conventional and Islamic banks but also contributes to superior financial health and stability by ensuring a balanced growth-risk dynamic and sustaining long-term viability, thereby underscoring the pivotal role of CEE in achieving competitive advantage and ensuring financial stability within the banking industry.

2.4. Control Variables and Their Impact

The impact of Intellectual Capital (VAIC) on bank stability is significantly influenced by various control variables. These include internal bank characteristics such as leverage (LEV), bank size (SIZE), and operational efficiency (OPEF), as well as macroeconomic conditions indicators like GDP growth (GGDP), inflation (INF), and the effects of the COVID-19 pandemic (COV). These variables are crucial for analysing the nuanced relationship between VAIC and bank stability, allowing for a comprehensive understanding that accounts for both internal bank characteristics and macroeconomic conditions indicators.

2.4.1. Internal Bank Characteristics

The internal characteristics of banks, such as leverage, size, and operational efficiency, are critical in influencing their stability. Understanding these factors is essential for assessing a bank's resilience and its capacity to manage economic challenges effectively.

Leverage (LEV) defined as the ratio of a bank's total debt to its total assets, is a critical factor influencing its risk profile and stability. High leverage can amplify the bank's vulnerability to market fluctuations and economic downturns (Ermawati et al. 2023). Booth, Aivazian, Demirguc-Kunt, and Maksimovic (2001) demonstrate how capital structures in developing countries, including leverage, affect their financial health and resilience.

Bank Size (SIZE) as measured by the natural logarithm of total assets, also influences stability. According to Vidyarthi (2019) and Ghassan & Fachin (2016), larger banks may enjoy economies of scale and more diversified portfolios, contributing to enhanced stability. However, these advantages may be offset by increased complexity and systemic risk. Berger and DeYoung (1997) explore the relationship between bank size, problem loans, and cost efficiency, and their collective impact on bank performance and stability.

Operational Efficiency (OPEF), the ratio of operating expenses to operating income, directly impacts a bank's profitability and, consequently, its stability. Banks that achieve operational efficiency by reducing costs while maintaining service quality are generally more stable. Koetter and Kolari (2005) underscore the importance of operational efficiency in determining banking performance.

2.4.2. Macroeconomic Conditions Indicators

Macroeconomic conditions indicators such as GDP growth and inflation play a crucial role in shaping bank stability, underscoring the need to consider these factors when evaluating the banking sector's performance and resilience. GDP growth can signal a healthy economy, potentially leading to better banking performance due to increased lending opportunities and lower default rates (Nguyen & Tran, 2023). Conversely, high inflation rates may erode the value of collateral and increase the cost of funds. Research by King and Levine (1993) illustrates how financial development and economic growth are interconnected, affecting bank stability. Similarly, Fisher (1930) and Mishkin (1992) have explored how inflation influences interest rates and, subsequently, banking operations and stability.

2.4.3. COVID-19 Pandemic (COV) and its Impact

The COVID-19 pandemic has underscored the importance of considering external shocks in analyzing bank stability. The pandemic has affected banks through increased credit risk, operational disruptions, and changes in consumer behaviour towards digital banking channels. Studies by Trabelsi and Mansour (2024), Maria, Yudaruddin, & Azizil Yudaruddin (2022), and Riadi, Hadjaat, & Yudaruddin (2022) highlight how the pandemic has impacted bank performance and stability, with varying effects based on bank size, ownership structure, and the degree of digital financial inclusion.

2.5. The Intellectual Capital and Bank Stability within the Context of Saudi Arabia

A wealth of literature offers compelling insights into the nexus between intellectual Capital (VAIC) and bank stability in Saudi Arabia. This section synthesizes findings from key studies that delve into the multifaceted dimensions of VAIC—including Human Capital Efficiency (HCE), Structural Capital Efficiency (SCE), and Capital Employed Efficiency (CEE)—and their pronounced impacts on the stability and resilience of banks.

Abdul Razak and Tobiagi (2016) underscore the significance of intellectual capital disclosures among Saudi Arabian financial institutions, highlighting a growing awareness of VAIC's role in enhancing transparency and investor confidence, which are crucial for bank stability. Concurrently, Abuzayed, Al-Fayoumi, and Molyneux (2018) explore the diversification strategies within the GCC banking sector, suggesting that a nuanced approach to leveraging VAIC can foster greater stability amidst market volatility.

Akkas and Asutay (2023) present an in-depth analysis of how VAIC formation and the knowledge economy influence banking performance in the GCC, providing evidence that both conventional and Islamic banks benefit from strategic VAIC management. This is further corroborated by Alharbi (2023), whose study within the Saudi Arabian context affirms the positive impact of VAIC on firm performance, hinting at its potential to fortify bank stability.

Al-Musali and Ismail (2014) offer empirical evidence on the direct correlation between VAIC components and the financial performance of Saudi banks, suggesting that VAIC's efficient management is pivotal for sustaining profitability and stability. This is aligned with the findings of Alrashidi and Alarfaj (2020), who investigate the efficiency of VAIC in mitigating bank risks within the Saudi banking industry, underscoring the strategic importance of VAIC in risk management frameworks.

Further, Alshadadi and Deshmukh (2023) examine systemic risks within the Saudi banking sector, elucidating how VAIC, through its influence on organizational resilience and adaptability, can mitigate risks that threaten bank stability. Similarly, studies by Buallay (2018) and Buallay et al. (2020) delve into the governance aspects and VAIC efficiency, revealing that sound corporate governance mechanisms enhance the positive impact of VAIC on bank performance and stability across Saudi Arabia.

These studies collectively emphasize the critical role of VAIC in shaping the stability of banks in Saudi Arabia. By focusing on VAIC's components—HCE, SCE, and CEE—and considering the moderation effects of corporate governance, risk management practices, and market diversification strategies, banks can navigate the challenges posed by economic fluctuations and regulatory changes. The COVID-19 pandemic further tests the resilience of these financial institutions, spotlighting the necessity for robust VAIC frameworks to sustain operational continuity and stability in unprecedented times.

2.6. Research Gap

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Despite the extensive body of research on Intellectual Capital (VAIC) and its implications for the banking sector, a discernible gap persists in understanding the nuanced dynamics of VAIC's impact on bank stability, particularly within the context of Saudi Arabia. While studies like those of Abdul Razak and Tobiagi (2016) and Al-Musali and Ismail (2014) have laid foundational insights into the disclosure practices and financial performance implications of VAIC in Saudi banks, they often stop short of delving deeply into how these VAIC components directly influence bank stability in the face of economic adversities and regulatory changes specific to the region. Moreover, the existing literature predominantly aggregates findings across conventional and Islamic banks without adequately distinguishing the potentially unique impacts of VAIC on each banking model within the varied economic landscape of the GCC.

Furthermore, the onset of the COVID-19 pandemic has introduced unprecedented challenges, underscoring the need for a more contemporary analysis considering the pandemic's transformative effects on banking operations and stability. Studies such as those by Alshadadi and Deshmukh (2023) and Abuzayed, Al-Fayoumi, and Molyneux (2018) touch upon systemic risks and diversification strategies but do not specifically address how VAIC has equipped banks to navigate the pandemic-induced volatility. There is a pressing need for research that not only bridges these gaps by providing a detailed exploration of VAIC's components on bank stability in the Saudi and GCC contexts post-pandemic but also distinguishes between the impacts on conventional versus Islamic banking systems. This nuanced understanding will equip stakeholders with the insights necessary to foster resilience and stability in the evolving banking landscape.

2.7. Hypotheses Development

Based on the literature review and the objectives aimed at exploring the impact of Intellectual Capital (VAIC) and its components—Human Capital Efficiency (HCE), Structural Capital Efficiency (SCE), and Capital Employed Efficiency (CEE)—on bank stability within the Saudi Arabian banking sector, the following hypotheses are proposed.

2.7.1. Main Hypotheses

H1: Intellectual Capital (VAIC) positively influences the stability of banks in Saudi Arabia.

This hypothesis stems from the consensus in the literature that VAIC, as a holistic construct, enhances organizational performance and resilience, which are critical determinants of bank stability.

2.7.2. Sub-Hypotheses on VAIC Components

H1a: Human Capital Efficiency (HCE) positively impacts the stability of banks in Saudi Arabia.

Rationale: HCE, indicative of the knowledge, skills, and competencies of the bank's workforce, is fundamental to innovation, risk management, and adaptive strategies that enhance bank stability.

H1b: Structural Capital Efficiency (SCE) positively influences the stability of banks in Saudi Arabia.

Rationale: SCE, representing institutionalized knowledge and processes, supports operational continuity and innovation, contributing to the bank's ability to withstand market fluctuations.

H1c: Capital Employed Efficiency (CEE) positively affects the stability of banks in Saudi Arabia.

Rationale: Efficient use of financial and physical resources (CEE) is crucial for maintaining a competitive edge and sustainable growth, impacting the bank's stability.

3. Research Design and Methodology

This section presents the research design and methodology utilized to investigate the influence of intellectual capital on the stability of banks in Saudi Arabia. It covers the overarching research framework, data collection strategies, methodological approach, variable measurement techniques, and the analytical model used in the research.

3.1. The Research Framework

The research's theoretical framework is grounded in the resource-based view (RBV) of the firm, which posits that a firm's competitive advantage lies primarily in applying a bundle of valuable resources at the firm's disposal (Barney, 1991). Intellectual capital is one such resource, comprising Human Capital Efficiency (HCE), Structural Capital Efficiency (SCE), and Capital Employed Efficiency (CEE). It is posited to impact the stability of banks, which measures their risk and resilience. This relationship is explored through a quantitative research design using econometric modelling.

3.2. Data Collection

The research utilized data from the annual reports and financial statements of ten Saudi Arabian banks, ranging from 2012 to 2022, and made available through the Saudi Stock Exchange (Tadawul). Macroeconomic variables were derived from the Saudi Central Bank (SAMA) publications. An assessment of the effects of the COVID-19 pandemic was conducted, incorporating data on operational changes and regulatory reforms during the pandemic period from SAMA releases and relevant financial news sources. The research included all banks listed on the Tadawul, except for Samba Bank, which was omitted following its merger into the Saudi National Bank in 2021.

3.3. Methodology

In our methodology in this research, we utilize panel data to adeptly manage variables that evolve over time but not uniformly across different entities, specifically banks. This approach is particularly effective for integrating the distinctive characteristics of each bank while tracking the progression of key variables, ensuring that the analysis comprehensively addresses both time series and cross-sectional data variations (Baltagi, 2008).

The Fixed Effects (FE) model is pivotal for analyzing variables that exhibit variation over time. This model is instrumental in distinguishing between the endogenous and exogenous factors influencing each entity, thereby facilitating a detailed examination of relationships captured within the panel dataset. Specifically, it focuses on attributes unique to each entity and remains consistent across the research period. Utilizing the FE model presupposes that the intrinsic factors characteristic of the Saudi banking sector has a negligible impact on the independent variables. However, these factors could influence or introduce bias into the dependent variables. To mitigate this, the FE model incorporates dummy variables for each bank. This approach is designed to isolate and neutralize the effects of time-invariant, bank-specific characteristics on the dependent variable, in this instance, bank stability. This ensures a refined analysis, accounting for internal consistencies within entities while examining their temporal dynamics (Wooldridge, 2010).

The random effects (RE) model assumes that differences across entities—Saudi banks—are stochastic and uncorrelated with the independent variables. This model is chosen under the presumption that the unique effects of each bank, which could include aspects like management quality or corporate culture, are randomly distributed and do not systematically affect the independent variables. The ROE model offers the advantage of examining time-invariant variables, which are omitted in the FE model due to the within transformation. As such, the CSRE model is an alternative approach that may yield more generalized inferences about the population from which the banks are drawn (Hsiao, 2003; Bell, 2019). The mathematical representation of the fixed effects model and the random effects model is as follows (Borenstein, 2010)

The fixed effects model:

$$Y_{it} = \alpha_i + \beta X_{it} + \epsilon_{it}$$

The random effects model is given by:

$$Y_{it} = \gamma + \beta X_{it} + u_i + \epsilon_{it}$$

Here, Y_{it} represents the dependent variable of bank stability, X_{it} encapsulates the independent variables, including various measures of intellectual capital and control factors, α_i are the individual-specific effects, u_i captures the random effects, ϵ_{it} is the idiosyncratic error term, and β and γ are the coefficients to be estimated.

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Measurement of Variables

The measurement of variables is critical to the validity of our research. The dependent variable, bank stability (STAB), is measured using the Z-score, a widely acknowledged financial metric indicative of a bank's risk of insolvency (Lepetit et al., 2008; Karim et al., 2016). The Z index is calculated as:

$$Z\text{-score}\_(i,t)=(ROA\_(i,t)+E\_(i,t))/(TA\_(i,t)\ \sigma ROA\_(i,t)\ )$$

The Z-score encompasses three components: bank performance (return on assets, ROA), bank risk (standard deviation of ROA), and a gauge of financial robustness (the ratio of bank equity capital to total assets). Higher Z-scores signify a stronger capital buffer against potential losses, implying reduced risk and heightened stability. The Z-score's extensive use in prior research underscores its relevance in assessing the soundness of financial institutions (Iannotta et al., 2007; Liu et al., 2013; Hang & Trang, 2023).

The main independent variable, Value Added Intellectual Coefficient (VAIC), is decomposed into human capital efficiency (HCE), structural capital efficiency (SCE), and capital employed efficiency (CEE) to dissect the multifaceted impact of intellectual capital. Pulic developed the value-added intellectual coefficient (VAIC) model (2004) in this research. This model is a finance-based efficiency measurement tool that quantifies the value added by a firm through its human, structural, and capital-employed inputs into the value creation process. To calculate VAIC, two main steps are outlined:

Step 1: The basis of VAIC is determined as the difference between output (OUT) and input (IN), represented as:

$$VA = OUT - IN$$

Where, OUT is total revenues and IN encompasses all expenses, excluding staff costs, which are considered investments in human capital. Therefore, VAIC according to (Public, 2004; Purohit & Tandon, 2015), which can be represent as:

$$VAIC = NI + LC + I + T + DP$$

Where NI is net income, LC is labor cost, I is interest, T is taxes, and DP is depreciation

Step 2: VAIC Composition: VAIC computed as the sum of Structural Capital Efficiency (SCE), Human Capital Efficiency (HCE) and Capital-Employed Efficiency (CEE). Thus:

$$VAIC = SCE + HCE + CEE$$

Where CEE is calculated as VA / (Total assets-intangibles assets), HCE as VA/ Total Employee Expenditure, and SCE as (Value Added - Human Capital) / Value Added (Nuryaman, 2015; Mavridis & Kyrmizoglou, 2005; Meles et al., 2016; Haris et al., 2019; Alharbi, 2023).

Control variables are crucial in offering a complete bank stability analysis, accounting for additional factors that might impact the dependent variable beyond the central emphasis on intellectual capital. These variables encompass bank size, operational efficiency, leverage, macroeconomic indicators like inflation and GDP growth, and considerations specific to the impact of the COVID-19 pandemic. The selection of each control variable is grounded in its documented significance in prior research and its expected influence on bank stability. Table 1 shows the equations used to measure these variables.

Table 1. Variable Measurements.

Variables	**Symbol**	**Measurement**	**Citations**
Bank Stability (STAB)	STAB	STAB = Z-score $Z{-}score_{i,t}{=}ROA_{i,t}{+}E_{i,t}/\ TA_{i,t}\sigma ROA_{i,t}$	Hang & Trang 2023; Ullah et al. 2023, Boyd & Runkle, 1993; Lepetit et al., 2008
Structural Capital Efficiency (SCE)	SCE	SCE = Natural Logarithm of (Value Added - Human Capital) / Value Added	Rehman et al. 2023; Haris et al. 2019; Dzinkowski, 2000; Edvinsson & Malone 1997

Human Capital Efficiency (HCE)	HCE	HCE = Value Added / Total Employee Expenditure	Van 2023; Mavridis & Kyrmizoglou 2005; Bontis et al. 2000; Marr et al. 2003; Wright et al., 1994
Capital Employed Efficiency (CEE)	CEE	CEE = Value Added / Total assets-intangibles assets	Majumder et al. 2023; Nuryaman 2015; Pulic, 2000
Value-Added Intellectual Capital (VAIC)	VIC	VAIC = CEE + HCE + SCE	Alharbi 2023; Meles et al. 2016; Iazzolino & Laise 2013; Cabrita & Bontis, 2008; Pulic, 2004
Leverage (LEV)	LEV	LEV = Total Debt / Total Assets	Ullah 2023; Booth et al., 2001; Rajan & Zingales 1995)
Size (SIZE)	SIZE	SIZE = Natural Logarithm of Total Assets	Barak & Sharma 2023; Zheng et al., 2022; Berger & DeYoung, 1997;
Operational Efficiency (OPEF)	OPEF	OPEF = Operating Expenses / Operating Income /	Riadi et al. 2022; Koetter & Kolari, 2005;
Gross Domestic Product (GGDP)	GGDP	GGDP = Annual % Growth Rate of GDP	Majumder & Li 2018; King & Levine, 1993; Levine & Zervos, 1998; Barro, 1991
Inflation (INF)	INF	INF = Annual % Change in CPI	Zheng et al., 2022; De Gregorio, 1993; Mishkin, 1992; Fisher, 1930
COVID-19 Impact (COV)	COV	COV = Dummy Variable (1 for years 2020 and beyond, 0 otherwise)	Trabelsi & Mansour 2024; Maria et al., 2022; Riadi et al., 2022

3.4. Models

This subsection delineates the econometric models constructed to examine the relationship between intellectual capital and the stability of banks within the Saudi Arabian financial sector. Depending on a dataset covering ten banks from 2012 to 2022, the research assesses the extent to which intellectual capital—both as an aggregated construct and through its discrete components—and a set of control variables correlate with the Z-score indicator of stability. The Z-score amalgamates profitability, volatility, and leverage to provide a multifaceted financial health and resilience picture.

Model 1: Aggregate Impact of Intellectual Capital on Bank Stability

Model 1 is designed to estimate the cumulative impact of intellectual capital on bank stability. It incorporates the Value-Added Intellectual Coefficient (VAIC) as a holistic measure of intellectual capital alongside control variables that capture a range of financial and economic factors:

$$\boldsymbol{STAB_{it} = \alpha + \beta_1 VAIC_{it} + \beta_2 SIZE_{it} + \beta_3 OPEF_{it} + \beta_4 LEV_{it} + \beta_5 GDP_t + \beta_6 INF_t + \beta_7 COV_t + \epsilon_{it} \ (1)}$$

Model 2: Impact of Individual Intellectual Capital Components on Bank Stability

Model 2 disaggregates intellectual capital into its constituent components to discern their influences on bank stability. This nuanced approach allows for the identification of the specific aspects of intellectual capital that are most salient for ensuring stability in the banking context:

$$STAB_{it} = \alpha + \beta_1 SCE_{it} + \beta_2 HCE_{it} + \beta_3 CEE_{it} + \beta_2 SIZE_{it} + \beta_3 OPEF_{it} + \beta_4 LEV_{it} + \beta_5 GDP_t + \beta_6 INF_t + \beta_7 COV_t + \epsilon_{it} \quad (2)$$

Model 2 serves as a robust analytical framework to capture the dynamics of intellectual capital within the banking sector. Through applying these models, the research aims to contribute meaningful insights into how the intangible assets encapsulated by intellectual capital metrics influence the foundational stability of banks in Saudi Arabia. By employing both aggregate and disaggregated measures of intellectual capital, the research offers a comprehensive assessment expected to provide valuable implications for banking management and policy formulations geared towards enhancing financial stability.

4. Results and Discussion

This section tries to examine the empirical findings derived from investigating the impact of Intellectual Capital (VAIC) and its components—Human Capital Efficiency (HCE), Structural Capital Efficiency (SCE), and Capital Employed Efficiency (CEE)—on the stability of banks in Saudi Arabia. Leveraging a robust analytical framework, this section delineates the outcomes of the statistical tests conducted to validate the proposed hypotheses, offering a nuanced exploration of how VAIC influences bank stability amid varying economic conditions and the unforeseen challenges posed by the COVID-19 pandemic.

Through a detailed examination of the data collected from financial statements, annual reports, and relevant macroeconomic indicators, this segment elucidates the direct and moderating effects of VAIC components and control variables, such as leverage, size, and operational efficiency, on banks' resilience and risk management capacities. The subsequent analysis sheds light on the theoretical propositions posited in the hypotheses. It provides practical insights into the strategic value of VAIC in enhancing the stability and sustainability of banking institutions within the volatile financial landscape of the Saudi banking sectors.

4.1. Descriptive Statistics and Correlation Analysis

Table 2 shows the descriptive statistics for all variables in the Saudi banking sector. It shows a range of bank stability (STAB) with a mean of 9.8873 and a standard deviation of 4.2775. Intellectual Capital (VAIC) registers a mean of 4.5158 with less fluctuation. Bank size (SIZE) maintains a consistent mean of 18.9268, suggesting uniformity in scale, and operational efficiency (OPEF) has a mean of 0.5298, both reflecting relative stability within the sector. Leverage (LEV) and inflation (INF) have mean values of 0.8502 and 0.0240, respectively, with moderate standard deviations, indicating managed variability in financial leverage and economic conditions. Other variables, including human capital efficiency (HCE), GDP growth (GGDP), and Capital employed efficiency (CEE), show lower means and standard deviations, indicating more uniformity. Due to the logarithmic transformation applied to SCE, specific statistical metrics, including the mean, median, minimum value, maximum value, and coefficient of variation, resulted in values approaching zero, with a few even turning negative.

The coefficient of variation (CV) measures the extent of variability about the mean. GGDP has a notably high CV of 112.68%, indicating high relative variability, while SIZE has a lower CV. For most variables, the median values slightly exceed the mean, suggesting a slight left skewness in the distribution, as evidenced by the skewness coefficient values. The non-normal distributions identified by Jarque-Bera tests underscore the sector's complex financial dynamics.

Table 2. The descriptive statistics of all variables.

Statistic	STAB	VAIC	SIZE	OPEF	SCE	LEV	INF	HCE	GGDP	CEE
Mean	9.8873	4.5158	18.9268	0.5298	-3.94E-07	0.8502	0.0240	3.4892	0.0284	0.0266
Median	9.1674	4.6420	18.9985	0.5105	-3.53E-07	0.8550	0.0250	3.6172	0.0285	0.0266

Maximum	20.4778	7.4720	20.6672	0.9955	-9.83E-08	0.9075	0.0350	6.4433	0.0874	0.0520
Minimum	1.8830	0.1042	17.2093	0.3308	-1.20E-06	0.6915	0.0080	-0.8896	-0.0434	-0.0062
Std. Dev.	4.2775	1.0389	0.7107	0.1140	2.15E-07	0.0322	0.0082	1.0359	0.0320	0.0066
CV.	43.26%	23.01%	3.75%	21.52%	-5.45E-01	3.79%	34.17%	29.69%	112.68%	24.81%
Skewness	0.7802	-0.5032	0.0585	1.2675	-1.0531	-1.6149	-0.4537	-0.4937	-0.4762	-0.6210
Kurtosis	3.4332	5.3266	2.6822	5.8462	4.1764	8.4073	2.3856	5.2802	3.5322	9.1701
Jarque-Bera	12.0189	29.4529	0.5259	66.5815	26.6732	181.8197	5.5047	28.2990	5.4552	181.5571
Probability	0.0025	0.0000	0.7688	0.0000	0.0000	0.0000	0.0638	0.0000	0.0654	0.0000
Sum	1087.59	496.73	2081.95	58.2799	-4.33E-05	93.5273	2.6400	383.8143	3.0000	2.9236

The correlation matrix for all variables in the Saudi banking sector, in Table 3, indicates a moderately positive relationship between bank stability (STAB) and intellectual Capital (VAIC), suggesting that increased intellectual capital tends to be associated with greater stability. The correlation between human capital efficiency (HCE) and VAIC is almost perfect, underscoring the crucial role of human capital in creating intellectual value. Interestingly, both VAIC and HCE show a robust negative correlation with operational efficiency (OPEF), implying that higher intellectual capital might not translate to immediate operational efficiencies. Structural capital efficiency (SCE) strongly correlates with the size of the banks (SIZE), suggesting that larger banks typically have more efficient structural capital. Capital employed efficiency (CEE) positively correlates with STAB, VAIC, and HCE, suggesting that efficient use of capital is associated with greater stability and intellectual capital. Other variables, such as GDP growth (GGDP), have less pronounced correlations, indicating a lesser direct linear relationship with the banking variables considered in this matrix. The relationships suggest that while intellectual capital significantly impacts bank stability and efficiency, the interplay is complex and multifaceted.

Table 3. The correlation matrix of all variables**.**

	STAB	**VAIC**	**SIZE**	**OPEF**	**SCE**	**LEV**	**INF**	**HCE**	**GGDP**	**CEE**
STAB	1									
VAIC	0.362	1								
SIZE	0.221	0.648	1							
OPEF	-0.297	-0.831	-0.594	1						
SCE	0.207	0.401	0.849	-0.434	1					
LEV	-0.207	-0.028	-0.027	0.117	0.135	1				

INF	-0.031	-0.057	0.035	0.155	-0.066	-0.004	1			
HCE	0.361	0.999	0.649	-0.831	0.401	-0.03	-0.056	1		
GGDP	0.066	0.265	0.005	-0.284	-0.067	0.046	-0.08	0.265	1	
CEE	0.34	0.45	0.007	-0.349	0.174	0.23	-0.225	0.445	0.207	1

4.2. Unit Root Test

Table 4 and Table 5 present the results of Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests to assess the stationarity of time series data regarding the banking sector in Saudi Arabia. The tests are applied to various variables at their original levels (At Level) and after applying first differences (At First Difference). The STAB and the impact of VAIC are central to this research. The tests include different models: one with a constant term only, another with a constant and a linear trend and a third with neither.

The ADF and PP test results examine variables such as HCE, CEE, and SCE, along with control variables like LEV, SIZE, OPEF, INF, and GGDP. These are crucial in evaluating how various capital and economic factors influence bank stability.The t-statistic in both tests determines whether to reject the null hypothesis of a unit root, which suggests non-stationarity. A low p-value, indicated by asterisks, signifies that the variable is stationary. Most variables show non-stationarity at their original levels but become stationary after differencing, indicating the appropriateness of differencing them in the research's random effects model.

Table 4. Panel unit root (Augmented Dickey Fuller-ADF).

ADF At Level											
		STAB	VAIC	HCE	SCE	CEE	SIZE	OPEF	LEV	GGDP	INF
With Constant	t-Statistic	0.1201	0.2650	0.2662	0.0031	0.0985	0.0003	0.0584	0.2643	0.1924	0.1963
	Prob.	0.0206	0.1570	0.1578	0.0203	0.0611	0.6711	0.1454	0.6529	0.1924	0.1963
			n0	n0		*	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.2568	0.3176	0.3168	0.0471	0.2198	0.0709	0.1845	0.1312	0.0586	0.4368
	Prob.	0.0832	0.2021	0.2050	0.6141	0.1583	0.6553	0.1007	0.6555	0.0586	0.4368
		*	n0	n0	n0	n0	n0	n0	n0	*	n0
Without Constant & Trend	t-Statistic	0.5333	0.4828	0.4469	0.2973	0.5018	0.8806	0.4564	0.6872	0.1881	0.3586
	Prob.	0.7080	0.5103	0.4970	0.0051	0.6326	0.9699	0.6847	0.4480	0.1881	0.3586
		n0	n0	n0	*	n0	n0	n0	n0	n0	n0
ADF At First Difference											
		d(STAB)	d(VAIC)	d(HCE)	d(SCE)	d(CEE)	d(SIZE)	d(OPEF)	d(LEV)	d(GGDP)	d(INF)
With Constant	t-Statistic	0.0207	0.0284	0.0285	0.1825	0.0151	0.0046	0.0117	0.1088	0.0043	0.0081
	Prob.	0.0483	0.1018	0.1032	0.1111	0.0052	0.1074	0.0033	0.1971	0.0043	0.0081
			n0	n0	n0	*	n0	*	n0	*	*
With Constant & Trend	t-Statistic	0.0750	0.0947	0.2302	0.7331	0.0596	0.1706	0.1868	0.2109	0.0172	0.0200
	Prob.	0.0865	0.0307	0.0307	0.0600	0.1298	0.3194	0.0192	0.4514	0.0172	0.0200
		*			*	n0	n0		n0		
Without Constant & Trend	t-Statistic	0.0010	0.0017	0.0017	0.0181	0.0006	0.0002	0.0005	0.0121	0.0005	0.0003
	Prob.	0.0027	0.0002	0.0002	0.1019	0.0002	0.0248	0.0001	0.0280	0.0005	0.0003
		*	*	*	n0	*		*		*	*

Significance codes: 0.01 ‘*’, 0.05 ‘’,0.10 ‘’, n0 not significant

Table 5. Panel unit root (Phillips–Perron PP).

PP At Level											
		STAB	VAIC	HCE	SCE	CEE	SIZE	OPEF	LEV	GGDP	INF
With Constant	t-Statistic	0.1263	0.3056	0.3071	0.0027	0.1018	0.0005	0.0537	0.2237	0.6883	0.2067
	Prob.	0.0211	0.1570	0.1578	0.0001	0.0611	0.6587	0.1490	0.6389	0.6883	0.2067
			n0	n0	*	*	n0	n0	n0	n0	n0
With Constant & Trend	t-Statistic	0.1622	0.2290	0.2294	0.0002	0.1060	0.0001	0.0590	0.0001	0.9979	0.4368

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	Prob.	0.0709	0.0386	0.0395	0.2154	0.1497	0.6553	0.0120	0.8362	0.9979	0.4368
		*			n0	n0	n0		n0	n0	n0
Without Constant & Trend	t-Statistic	0.5373	0.4329	0.4220	0.0083	0.5711	0.9775	0.5148	0.6958	0.2779	0.4087
	Prob.	0.4123	0.1742	0.1762	0.0036	0.4683	0.9709	0.7209	0.4523	0.2779	0.4087
		n0	n0	n0	*	n0	n0	n0	n0	n0	n0
PP At First Difference											
		d(STAB)	d(VAIC)	d(HCE)	d(SCE)	d(CEE)	d(SIZE)	d(OPEF)	d(LEV)	d(GGDP)	d(INF)
With Constant	t-Statistic	0.0017	0.0042	0.0043	0.0155	0.0010	0.0002	0.0003	0.0003	0.1318	0.0093
	Prob.	0.0004	0.0021	0.0021	0.1122	0.0003	0.1086	0.0005	0.1954	0.1318	0.0093
		*	*	*	n0	*	n0	*	n0	n0	*
With Constant & Trend	t-Statistic	0.0025	0.0035	0.0035	0.8259	0.0018	0.0010	0.0017	0.0192	0.1248	0.0200
	Prob.	0.0001	0.0152	0.0153	0.0600	0.0004	0.3271	0.0075	0.4709	0.1248	0.0200
		*			*	*	n0	*	n0	n0	
Without Constant & Trend	t-Statistic	0.0001	0.0006	0.0006	0.0023	0.0000	0.0001	0.0000	0.0010	0.0115	0.0004
	Prob.	0.0000	0.0001	0.0001	0.0406	0.0000	0.0270	0.0001	0.0280	0.0115	0.0004
		*	*	*		*		*			*

Significance codes: 0.01 '*', 0.05 '',0.10 '', n0 not significant

4.1. Panel Least Squares Estimation Results

The results of the panel least squares estimation, encompassing cross-sectional random effects and fixed effects, as well as estimations excluding these effects, are presented in Table 6.

Table 6. Panel least squared estimation using the cross-section random and fixed effects financial stability.

Variable	Without Fixed and Random Effects			Fixed Effect			With Cross-Section Random Effect		
	Coefficient	**t-Statistic**	**Prob.**	**Coefficient**	**t-Statistic**	**Prob.**	**Coefficient**	**t-Statistic**	**Prob.**
C	24.0998	1.3641	0.1755	50.4831	12.3024	0.0000	50.2105	11.4499	0.0000
VAIC	1.7065	2.3033	0.0233	0.3737	3.7407	0.0003	0.3759	3.7639	0.0003
SIZE	0.0047	0.0060	0.9952	-1.4564	-6.6757	0.0000	-1.4373	-6.6141	0.0000
OPEF	2.6180	0.4066	0.6851	-4.1848	-4.5152	0.0000	-4.1979	-4.5314	0.0000
LEV	-27.3600	-2.2431	0.0271	-14.8582	-6.3743	0.0000	-14.9691	-6.4313	0.0000
GGDP	-6.0534	-0.4248	0.6719	1.0532	0.5468	0.5858	0.9721	0.5051	0.6146
INF	7.6076	0.1330	0.8944	6.1432	0.8313	0.4080	6.3524	0.8600	0.3918
COV	-0.7900	-0.5614	0.5758	-0.2468	-1.2178	0.2264	-0.2570	-1.2702	0.2069
R-squared	0.1754			0.9887			0.7028		
Adjusted R-squared	0.1188			0.9867			0.6824		
Durbin-Watson stat	0.0602			1.5642			1.4544		
F-statistic	3.0988			507.4014			34.4629		
Prob (F-statistic)	0.0053			0			0		

Based on Table 6 and according to the results of the model without fixed or random effects, it is observed that the VAIC stands out with a coefficient of 1.7065, a t-statistic of 2.3033, and a probability of 0.0233, indicating a statistically significant positive impact on bank stability. Conversely, the LEV carries a negative coefficient of -27.36, a t-statistic of -2.2431, and a probability of 0.0271, showing a

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significant adverse effect. The OPEF, though positive, is not significant with a high p-value, implying no clear influence. The SIZE and the GGDP also appear insignificant, suggesting they do not play a critical role in this context. The INF has a positive coefficient, while the COV has a negative coefficient. However, both are not statistically significant, implying that within the scope of this model, their impacts on bank stability are not discernible. The R-squared and adjusted R-squared are relatively low at 0.1754 and 0.1188, respectively, suggesting that the model without fixed or random effects explains only a modest portion of the variance in bank stability.

The Durbin-Watson statistic is low at 0.0602, indicating potential autocorrelation issues, and the F-statistic, while significant at 3.0988 with a p-value of 0.0053, suggests that the model is better than none but may not be optimal.

Moving to the fixed effects model, we notice a stark improvement in the fit, as evidenced by an adjusted R-squared of 0.9867. Here, VAIC's significance is even more pronounced with a coefficient of 0.3737, a t-statistic of 3.7407, and a probability nearing zero, reinforcing the strong positive relationship with bank stability. The LEV variable remains negative and is highly significant, which underscores the consistent negative influence of LEV on stability. Interestingly, SIZE and OPEF show negative coefficients of -1.4564 and -4.1848, respectively, a departure from the previous model, indicating that when accounting for individual bank effects, both SIZE and OPEF have a noticeable negative impact on stability. The GGDP continues to show insignificance, whereas the INF and COV variables maintain positive and negative coefficients but still lack statistical significance. The model's robustness is confirmed by a substantial F-statistic of 507.4014 and a probability of zero, alongside a satisfactory Durbin-Watson statistic of 1.564238, suggesting less concern over autocorrelation.

In the model with cross-section random effects, we observe consistency with the fixed effects model regarding the significance and direction of all variables. The VAIC is still positive and significant. The SIZE, OPEF, and LEV variables remain significant negative relationships, while GGDP, INF, and COV remain insignificant.

This model's F-statistic of 34.4629 with a zero probability indicates a good model fit. The Durbin-Watson statistic is moderate at 1.454395, which may indicate minimal autocorrelation concerns.

The result of the Husman test in Table 7 shows that the preference would be towards a random effects model rather than a fixed effects model because the p-value associated with the Chi-Square test in the cross-section random effects model is indeed 1, which is much greater than the conventional significance level of 0.05. This high p-value indicates no evidence to reject the null hypothesis, which states that the individual bank effects are not correlated with the other explanatory variables in the model. In other words, the test suggests that the variation across banks does not systematically affect the dependent variable, which, in this case, represents bank stability. Generally, the random effects effectively capture the individual differences among banks, preventing any correlation with the predictors.

Table 7. Husman Test Model 1**.**

Test Summary Model 1	**Chi-Sq. Statistic Model 1**	**Chi-Sq. d.f. Model 1**	**Prob. Model 1**	**Note Model 1**
Cross-section random	0	7	1	* Cross-section test variance is invalid. Hausman statistic set to zero.

Analyzing the Random Effect results in Table 6, we find that the overall impact of VAIC on financial stability is positive and statistically significant, supporting the main hypothesis (H1) that Intellectual Capital positively influences the stability of banks in Saudi Arabia. This aligns with the literature, which generally contends that Intellectual Capital enhances organizational performance, a critical factor in banking stability. Asare et al. (2022) and Aslam et al. (2024) found evidence supporting intellectual capital's positive role in banking performance and stability, suggesting a consistency with the positive coefficient of VAIC in the provided table. Dalwai et al. (2021) and Hang et al. (2023) also support the idea that intellectual capital contributes to bank stability and risk management, which aligns with the significance of VAIC in the table's model.

Studies like Nguyen et al. (2021) and Nurhidayat and Syarief (2020) explore the impact of intellectual capital on bank risk, providing a broader context for understanding the implications of VAIC on financial stability. Onumah & Duho (2019) and Taheri et al. (2013) examine the relationship between intellectual capital and stability, with findings that could provide insights into the broader implications of the positive VAIC coefficient. Ullah et al. (2023) and Festa et al. (2020) offer insights into the efficiency of intellectual capital and its contribution to financial stability, potentially corroborating the positive impact of VAIC.

Size is significantly and negatively associated with bank stability; larger banks may confront specific challenges and risks, such as regulatory and systemic risks, that can impair their financial stability. This result aligns with the findings of Liu et al. (2013). Conversely, Hang & Trang (2023) found that bank size might positively correlate with stability, attributing this to the efficiency benefits of economies of scale. The OPEF, which exhibits both significance and a negative association, tells us that banks spending more on their operations than they make can lead to less stability. More spending can help a bank's stability and profit. This concept supports the Cost-Benefit Theory, which argues that businesses aim to balance their spending and earnings to maximize profits. Similar findings were observed in the research done by Riadi et al. (2022), Maria et al. (2022), and Altunbas et al. (2007).

LEV is significantly negative, indicating that higher leverage is associated with decreased stability. This is a common finding in the literature, as excessive leverage can increase risk, supported by studies such as those by Bilgin et al. (2021), Alshadadi & Deshmukh (2023) and Rajan & Zingales (1995).

GGDP and INF are not statistically significant, suggesting that these macroeconomic variables do not have a discernible impact on bank stability within this model. This is interesting as macroeconomic factors are often seen as significant in literature, such as Adrian et al. (2022) and Trabelsi & Mansour (2024), who discuss macro-financial stability in crises.

They are comparing the non-significant impact of COV on bank stability with Studies such as Maria et al. (2022) and Trabelsi & Mansour (2024), who discuss the impact of the COVID-19 pandemic on bank stability, with an implication that the pandemic had a noticeable effect on the financial sector. The non-significant impact in our results suggests that banks in this research had stronger resilience or better management practices to buffer against the pandemic's effects. Adrian et al. (2022) and Aduku et al. (2023) reflect on macro-financial stability during COVID-19, and they likely predict a significant impact of the pandemic on bank stability. The discrepancy with the provided table's results might indicate that the banks in the research were insulated from some of the broader economic shocks, possibly due to specific regulatory environments, risk management strategies, or government interventions.

Table 8 displays the second model, which analyses the regression results for the three models in the research on the Saudi banking sector; we begin with the model without fixed and random effects. In this model, intellectual capital components such as HCE and CEE display positive coefficients, with CEE nearing significance with a p-value of 0.069. However, the SCE is not significant. LEV presents a significant negative coefficient, implying an inverse relationship with bank stability. The other control variables, including SIZE, OPEF, GGDP, INF, and the impact of COV, are not statistically significant. The model's explanatory power, as indicated by the R-squared, is relatively low at 25.92%, and the adjusted R-squared is at 19.25%, suggesting that other unobserved factors may be influencing bank stability. The Durbin-Watson statistic is at 0.110087, suggesting potential autocorrelation issues, and the F-statistic is significant, suggesting that the variables are jointly significant.

Table 8. Panel least squared estimation using the cross-section random and fixed effects financial stability.

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Variable	Without Fixed and Random Effects			Fixed Effect			With Cross-Section Random Effect		
	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.	Coefficient	t-Statistic	Prob.
C	47.1888	1.1205	0.2652	3.2425	0.2997	0.7651	2.9297	0.2682	0.7891
SCE	4520266	0.8572	0.3934	-2845789	-2.8662	0.0052	-2856051	-2.8804	0.0049
HCE	1.2717	1.1946	0.2351	-0.3779	-2.3036	0.0235	-0.3804	-2.3222	0.0223
CEE	185.7038	1.8385	0.0690	139.8948	6.1607	0.0000	140.6238	6.2081	0.0000
SIZE	-0.6686	-0.3260	0.7451	0.8088	1.5571	0.1229	0.8268	1.5967	0.1135
OPEF	4.4410	0.6984	0.4865	-3.2625	-4.0400	0.0001	-3.2628	-4.0416	0.0001
LEV	-41.4361	-3.3089	0.0013	-12.6241	-5.9207	0.0000	-12.6747	-5.9486	0.0000
GGDP	-1.9595	-0.1431	0.8865	0.8949	0.5436	0.5880	0.8608	0.5233	0.6019
INF	30.4727	0.5490	0.5842	12.5738	1.9330	0.0564	12.7049	1.9539	0.0535
COV	-0.2141	-0.1563	0.8761	-0.2664	-1.5595	0.1223	-0.2705	-1.5851	0.1161
R-squared	0.2593			0.9921			0.7956		
Adjusted R-squared	0.1926			0.9906			0.7772		
Durbin-Watson stat	0.1101			1.6894			1.5968		
F-statistic	3.8890			638.7210			43.2474		
Prob(F-statistic)	0.0003			0			0		

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The fixed effects model adjusts for unobserved heterogeneity within entities (banks). Here, HCE becomes significant with a negative coefficient, and CEE remains significant with a positive coefficient, reinforcing the importance of efficiently managing capital employed for bank stability. LEV's negative influence on stability is pronounced and highly significant, a consistent theme from the previous model. SIZE and OPEF show different coefficients in signs from the first model. However, the OPEF is significant while SIZE is still insignificant, indicating their relationship to stability may be influenced by entity-specific characteristics. The adjusted R-squared value increases dramatically to 99.05%, implying that much of the variability in bank stability is explained when controlling for individual bank effects. The Durbin-Watson statistic improves to 1.689428, and the F-statistic remains significant, underscoring the model's robustness.

CEE retains its significance and positive relationship with bank stability in the model with cross-section random effects. Interestingly, LEV's negative coefficient is consistent across all models, affirming the adverse impact of higher leverage on stability. SCE becomes significant, suggesting that when random effects are considered, the efficiency of structural capital plays a role in bank stability. SIZE is still significant with a negative coefficient, while OPEF is insignificant, like the fixed effects model. The adjusted R-squared is not provided, but the R-squared remains high, and the F-statistic is significant, indicating the model's goodness of fit. The Durbin-Watson statistic indicates a potential for autocorrelation, like the fixed effects model.

The output of the Husman test in Table 9 demonstrates that the preference would be towards a random effects model rather than a fixed effects model, and the null hypothesis that the individual bank effects are not correlated with the other explanatory variables in the model is not rejected. The random effects effectively capture the individual differences among banks, preventing any correlation with the predictors.

Table 9. Husman Test Model 2.

Test Summary Model 2	Chi-Sq. Statistic Model 2	Chi-Sq. d.f. Model 2	Prob. Model 2	Note Model 2
Cross-section random	0	9	1	* Cross-section test variance is invalid. Hausman statistic set to zero.

Analyzing the random effects results presented in Table 8, we observe that the coefficient for HCE is a negative sign and significant (Prob. = 0.0223), indicating that higher human capital efficiency is associated with lower financial stability. This result is counterintuitive, as H1 hypothesizes a positive relationship, indicating that human capital in the banking sector of Saudi Arabia may need help with challenges that reduce stability, such as skill mismatches or inefficient use of talent. The negative impact of SC and HCE contradicts findings from several studies, such as those by Asare et al. (2022) and Aslam et al. (2024), which generally find positive associations between various components of intellectual capital and bank stability.

SCE is negative and statistically significant (Prob. = 0.0049), indicating that an increase in structural capital efficiency negatively impacts the financial stability of banks. This finding is unexpected and contradicts Hypothesis H1b, which anticipated a positive influence. This may imply that within the context of this research, increases in structural capital could be more effectively utilized or may reflect an overemphasis on the non-human elements of intellectual capital. This aligns with the findings of Onumah & Duho (2019) but contradicts those of most studies, including those by Zheng et al. (2022) and Wang et al. (2014).

CEE shows a positive coefficient with high statistical significance (Prob. = 0.0000), which supports H1c, indicating that efficient use of financial and physical resources contributes positively to financial stability. The positive relationship between CEE and bank stability aligns with Ullah et

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al. (2023) and Festa et al. (2020), suggesting that efficient capital deployment contributes to stability and is consistent across different geographies and banking systems.

SIZE is slightly positive but not statistically significant (Prob. = 0.1135), indicating that the size of the bank does not clearly impact financial stability in this model. OPEF's negative coefficient is significant (Prob. = 0.0001), suggesting that higher operational costs are negatively associated with financial stability. The significant negative relationship between OPEF and bank stability aligns with conventional financial theory, which suggests that inefficiencies in operations can be detrimental to performance, echoing sentiments from Abuzayed et al. (2018) and Akkas and Asutay. (2023)

LEV is negatively associated with financial stability and is highly significant (Prob. = 0.0000), indicating that more leveraged banks are less stable. The negative impact of leverage on stability is a well-established finding in the literature on financial stability, supported by studies like Bilgin et al. (2021) and Alshadadi and Deshmukh (2023), which discuss the risks associated with high leverage.

Both GGDP and INF are not statistically significant (Prob. > 0.05), suggesting they do not significantly impact bank stability in this model. The non-significant effect of macroeconomic variables (GGDP and INF) contrasts with studies like Maria et al. (2022) and Trabelsi & Mansour (2024), which reflects a disconnect between broader economic trends and the financial stability of banks in the context.

COV is not significant (Prob. = 0.1161), suggesting that the model does not find a direct impact of the COVID-19 pandemic on the financial stability of banks within the scope of this research. The non-significant impact of COV is notably different from the findings of several studies, such as Adrian et al. (2022) and Aduku et al. (2023), which discuss the profound impact of the pandemic on financial systems. This might suggest that the specific banks in this research were insulated from the pandemic's worst effects or that other variables are capturing the pandemic's impact.

The empirical analysis of the data in Tables 6 and 8 highlights the complex role of intellectual capital in banking stability. While intellectual capital bolsters stability, the structural and human capital components may have intricate effects that warrant further investigation. Operational efficiency and leverage are critical, with inefficiencies and high leverage posing risks to stability. The influence of bank size and broader economic conditions, including the impact of the COVID-19 pandemic, appears to be less pronounced than expected. This nuanced understanding underscores the multifaceted nature of factors contributing to banks' financial resilience and suggests areas for future research to unpack these dynamics more fully.

5. Conclusion and Recommendations

This research has embarked on an analytical journey through the multifaceted landscape of intellectual Capital and its influence on the stability of banks in Saudi Arabia. The empirical findings, drawn from a decade-long panel data analysis, shed light on the intricate relationships between the components of intellectual capital—human, structural, and employed capital—and their collective and individual impacts on financial stability.

Our analysis suggests that while intellectual capital, as a holistic construct, is generally conducive to bank stability, the interplay of its components presents a more complex scenario. Notably, the counterintuitive negative association of human and structural capital efficiencies with bank stability indicates that an increased capacity in these areas only sometimes translates to financial resilience. Conversely, the positive impact of capital-employed efficiency underscores the importance of effectively leveraging financial and physical resources.

The non-significant influence of macroeconomic factors such as GDP growth and inflation, as well as the size of the banks, points to a need for a more granular understanding of local banking conditions and the unique ways these institutions navigate economic trends. Moreover, the absence of a significant direct impact of the COVID-19 pandemic on bank stability suggests an underlying robustness within the sector or effective mitigating strategies that have shielded banks from the brunt of the pandemic's economic shockwaves.

In the dynamic and evolving financial landscape of Saudi Arabia, where economic diversification and technological innovation are paramount, this research presents an opportunity

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for Saudi banks to reassess and recalibrate their approach to intellectual capital. The unexpected negative correlation between human and structural capital efficiencies and bank stability calls for critically evaluating current investment strategies in these areas. Banks in the Kingdom should consider optimizing their intellectual capital to ensure that the workforce's skills and organizational processes are not merely expansive but strategically aligned with the demands of a competitive and increasingly digital marketplace.

This research highlights the need for Saudi banks to integrate their intellectual resources with risk management and operational strategies more effectively. The resilience demonstrated by Saudi banks during the COVID-19 pandemic suggests existing strengths to build upon. Banks should leverage these strengths, particularly in capital-employed efficiency, to further solidify their financial stability. Prudent capital management and an emphasis on leveraging financial resources efficiently can serve as a buffer against economic volatility.

Additionally, the role of technology in operational efficiency has never been more evident. Investment in digital infrastructure should be a priority, not just as a tool for efficiency but as a foundational pillar for stability. The non-significant impact of macroeconomic variables and the pandemic on bank stability indicates that the Saudi banking sector may have untapped potential in terms of technological adaptation and innovation that can insulate it from external shocks.

Saudi banks should also continue to work within the regulatory frameworks that support the strategic development of intellectual capital. Policymakers and regulators are encouraged to facilitate this by providing clear guidelines and supportive policies. Educational initiatives focusing on the intersection of finance and technology could prepare a workforce adept at navigating the banking sector's future challenges.

Given the robustness and resilience that Saudi banks have displayed, they are well-positioned to capitalize on their intellectual capital as a strategic asset. As the Kingdom advances towards its Vision 2030 objectives, the banking sector's ability to harness intellectual capital will play a critical role in its growth and stability. Continual learning, adaptation, and strategic investment in the components of intellectual capital will ensure that banks not only survive future challenges but thrive in the face of them.

6. Research Limitations and Future Research

While this research offers valuable insights into the relationship between intellectual capital and bank stability in Saudi Arabia, its limitations pave the way for future research opportunities.

One fundamental limitation lies in the scope of data employed. Although the panel data provided a substantial time frame for analysis, the dynamic and rapidly changing Saudi financial landscape, spurred by Vision 2030 and its associated reforms, could mean that more recent developments may lead to different insights. For instance, integrating advanced technologies and digital banking initiatives that have taken place post-data collection could significantly influence the impact of intellectual capital on bank stability. Hence, continuous updating and expansion of the dataset would yield a more current and accurate picture of the banking sector's state.

While robust, the research's methodological approach is predominantly quantitative and may not capture the qualitative nuances of how banks operationalize their intellectual capital. Qualitative analyses involving case studies, interviews, and surveys could provide deeper insights into the strategic decisions that underpin the management of human and structural Capital in Saudi banks. Additionally, these qualitative methods could shed light on the organizational culture and internal processes that significantly contribute to the resilience of these financial institutions.

Another limitation is the focus on aggregate bank stability, which overlooks the possibility that different types of banks—such as commercial vs. investment banks or Islamic vs. conventional banks—may utilize and benefit from intellectual capital differently. Future research could segment the banking sector to compare how various banks leverage intellectual capital to achieve stability.

Furthermore, while the research accounted for the impact of the COVID-19 pandemic via a dummy variable, the long-term repercussions of such a global crisis are still unfolding. Subsequent studies could focus on the specific strategies that Saudi banks employed to navigate the pandemic and how these have altered the region's financial stability landscape.

Lastly, the research's findings present an invitation to explore the impact of intellectual capital on other significant outcomes, such as customer satisfaction, digital transformation success, and international competitiveness. As Saudi Arabia continues to invest heavily in becoming a global economic powerhouse, research into these areas could provide strategic insights for banks looking to expand their domestic and global influence.

Acknowledging these limitations does not diminish the research's contributions but recognizes the financial sector's ever-changing nature and the ongoing quest for knowledge that can support its growth and resilience. The journey of understanding the complexities of intellectual capital in banking is far from over, and Saudi Arabia's unique economic environment makes it a fertile ground for continued exploration.

Acknowledging the limitations inherent in this research invites several avenues for future investigation, particularly in the unique and rapidly advancing financial context of Saudi Arabia. The shifting tides of the Saudi economy, fueled by ambitious initiatives like Vision 2030, necessitate a continuous re-evaluation of the role of intellectual capital in banking stability.

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