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Exploring the Link between Intellectual Capital, Technical Efficiency and Income Diversity and Banks Performance: Insights from Taiwan

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Abstract

This research paper investigates the banking sector in Taiwan, focusing on the intricate dynamics between intellectual capital, efficiency, and performance. Utilizing a dual-method of Random Effects regression and Systems Generalized Method of Moments (SGMM) models, the study analyzes 39 Taiwanese commercial banks from 2010 to 2023. The findings reveal that intellectual capital enhances efficiency and revenue growth but has intricate effects on profitability. Total factor productivity change and technological change present mixed, yet the nonlinear associations of leverage and income diversification emerge as significant factors. Challenging conventional wisdom within the Resource-Based Theory framework, the study uncovers profound complexities, calling for refined theoretical insights. On a practical level, the findings advocate for a comprehensive, tailored approach to enhance bank performance in Taiwan and offer valuable insights for regulatory authorities, bank managers, and investors. The research also has broader implications for other emerging economies, significantly contributing to theking efficiency, performance, resand sustainability.

Keywords: Bank efficiency, Intellectual capital, Taiwan banks, Systems Generalized Method of Moments (SGMM), Income Diversity

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1. Introduction

The stability and efficiency of a banking sector are pivotal to the equilibrium of a financial system and the progressive development of an economy, as the industry plays an instrumental role in the allocation of funds that stimulate economic growth (Cao et al. 2021). The direct correlation between the banking sector's performance and a nation's economic development has been widely examined in scholarly research. The robustness and efficacy of a banking sector play a central role in upholding a stable financial system and fostering economic progress, given its vital role in allocating resources and boosting economic activity. Though the correlation between banking performance and economic growth is well-studied, the focus is mainly on developed nations, leaving a gap in empirical evidence for emerging economies like Taiwan, a global leader in semi-conductor manufacturing. Evaluating the impact of banking efficiency and intellectual capital in Taiwan's banking sector will provide invaluable insights for policymakers, investors, and bank managers, informing decision-making about resource allocation, investment, and strategic planning. These insights could serve as a roadmap for other emerging economies[1] experiencing similar growth patterns. Additionally, in a world where regulators and investors demand greater transparency about environmental impact, studying how Taiwanese banks perform will assess their readiness to meet these demands, thus guiding policy development. As in Taiwan, the unique intersection between a banking sector and a manufacturing-driven economy could offer unique insights for countries with similar economic structures. This study's potential to serve as a model for other emerging economies navigating similar growth trajectories underscores its broader significance and applicability.

In Taiwan, the banking system is a critical component of the financial structure, functioning differently than developed nations' banking systems. Taiwan's financial system is essentially bank-based (Chen et al. 2023), with the volume of banking business being considerably larger than the level of stock market activities (Luu and Luong 2020). This characteristic is generally true for financial systems in emerging countries, contrasting with the market-based approaches typically found in developed countries. The banking sector, an integral part of Taiwan's service sector, forms the backbone of its economy, contributing significantly to the country's Gross Domestic Product[2]. Over the years, Taiwan's banking sector has undergone significant changes due to many reforms, including the introduction of prudential norms, interest rate deregulation, digitalization of operations, and opening up of the sector for new private entities, including foreign banks. However, the industry faces a declining trend in competition and profitability, despite the increased competition witnessed in the early 2000s. Given Taiwan's aspiration to remain competitive and its banking sector's crucial role, there is an ardent need for a study to examine the factors affecting bank performance in Taiwan. Such a study is not only timely but also essential in light of Taiwan's economic goals and the recent changes in its banking sector.

Taiwan's banking system is a vital component of its financial structure, contributing significantly to its economic goals. With aspirations to become a regional financial hub and lead in fintech, Taiwan has undertaken specific measures to enhance its banking sector. Notably, in 2019, the country allowed the establishment of new digital banks with niche focuses like fintech and e-commerce (Global 2023). Additionally, bank mergers and acquisitions have consolidated the number of domestic banks from 50 to 38, streamlining the sector (of Commerce 2023). Taiwan has relaxed bank ownership limits for foreign and Chinese investors to attract foreign investment and boost regional trade. These efforts align with the country's goal of expanding trade and supporting its export-driven economy. Embracing technological advancements, banks in Taiwan have also partnered with fintech firms to offer innovative services like payments, lending, and wealth management (EY 2023). Despite these changes and increased competition, Taiwan's banking sector faces challenges in maintaining profitability. A thorough study examining the factors affecting bank performance becomes essential to ensure sustained growth and success. It reflects the country's commitment to achieving its economic objectives and adapting to recent banking sector development

With this study we aim to address significant gaps in the empirical literature related to the performance of the banking sector in Taiwan, specifically focusing on three key research questions. First, we examines the impact of technical efficiency on bank performance. Technical efficiency refers to the ability of banks to optimize their output through a given set of inputs or, conversely, to produce a specific output with the minimum required inputs. This concept is of particular interest, given that the banking sector essentially operates as a financial intermediary, linking agents with surplus to those with deficits of financial resources. Second, the study scrutinizes the role of intellectual capital (IC) on bank performance. IC, which encompasses knowledge creation, dissemination, and acquisition, has emerged as a critical factor for corporate sustainability in an economy increasingly dominated by the creation and diffusion of knowledge. Thirdly, we examine the impact of income diversity on performance. Income diversity is essential to study as it provides insights into the risk exposure and stability of banks' revenue streams. Banks that rely heavily on interest income from loans may face greater volatility than those with more diversified income sources like fees, commissions, and trading revenue. Analyzing the relationship between income diversity and performance can reveal whether income

[1] MSCI's 2023 classified Taiwan as emerging

[2] Taiwan's 2021's banking-system assets accounted for 292% of nominal GDP, higher than the ratio of most regional peers (Ratings 2023).

diversification benefits banks by reducing risk exposure. Additionally, income diversification may allow banks to tap new sources of profit and value creation amid a challenging low-interest rate climate. Understanding these dynamics can help guide banks' business mix and risk management strategies.

As we navigate through the complex intersections of technical efficiency, intellectual capital efficiency, and banking performance in Taiwan, structured systematically to enhance clarity and comprehension. The following section (Section 2) explores relevant literature and formulates our research questions. Section 3 delineates our data collection and methodology, providing a clear view of our research design. The interpretation of our findings and their comparison with prior studies occurs in Section 4, which aids in understanding our study's implications. Finally, Section 5 concludes the paper with a recap of our findings, their theoretical and practical implications, thereby providing a comprehensive and enriching examination of the banking efficiency landscape in Taiwan.

2. Review of literature and formulation of hypothesis

2.1. Definition and components of intellectual capital

Intellectual capital (IC) is a conceptual framework that encompasses the productive knowledge assets of a firm (Bayraktaroglu et al. 2019), and has attracted significant scholarly attention. As identified by scholars, the main components of IC are human capital, organizational capital, and social capital. This classification is instrumental in understanding and analyzing organisations' diverse knowledge resources, considering them valuable assets in specific locations. The body of research investigating the practical application of knowledge within firms has grown extensively, with empirical findings consistently indicating that these three components of intellectual capital significantly enhance firm performance (Mention and Bontis 2013). This underscores their crucial role in the success of an organization (Youndt and Snell 2004).

The traditional models for measuring IC focus primarily on three major efficiency components: human capital efficiencies (HCE), capital employed efficiencies (CEE), and structural capital efficiencies (SCE). Pulic (1998)'s VAIC^{TM} model is one such popular measurement tool due to its simplicity, enabling effective comparisons across enterprises or countries (Xu, 2019). However, the original VAIC model was criticized for focusing solely on corporate labour and capital investment efficiency rather than IC efficiency and excluding the firm's relational and innovation capital (Sthle et al. 2011; Smriti and Das 2018). To address these shortcomings, Ulum et al. (2017) amended Pulic's model to include relational capital efficiency (RCE), thus creating the modified VAIC (MVAIC) method.

2.1.1. Human Capital Efficiency (HCE)

Human capital efficiency (HCE), representing employees' knowledge, experience, education, and skills, is integral to sustaining an organization's competitive advantage (Alhassan and Asare 2016; Anosa 2021). Investment in human capital is acknowledged to enhance work quality, contribute to national wealth, and drive economic growth (Eniola et al. 2015). The Organization for Economic Cooperation and Development stresses that HCE propels economic activity, competitiveness, and prosperity (Anaduaka et al. 2014).

2.1.2. Capital Employed Efficiency (CEE)

Capital Employed (CE) represents the amalgamation of physical and financial assets owned by a bank. Capital Employed Efficiency (CEE), a key metric, contextualizes the value produced by a firm in relation to its capital investments. This measure quantifies the value generated per dollar invested in physical or financial capital. The efficient use of capital is crucial for businesses, given that it represents their asset value at book value (Duho and Agomor 2021). The combined effect of intellectual and financial capital, which is generated through budgeting processes, is pivotal in enhancing business performance. Theory posits a positive correlation between CEE and bank efficiency (Nawaz and Haniffa 2017), signifying that improved capital utilization correlates with enhanced performance.

2.1.3. Structural Capital Efficiency (SCE)

Structural capital efficiency (SCE) refers to the effective utilization and management of an organization's tangible and intangible assets, such as processes, technologies, patents, and organizational culture (Ismail and Karem 2011). It involves creating a supportive environment that encourages experimentation, learning, and the integration of knowledge. SCE is a component of intellectual capital and has been found to impact organizational performance and financial outcomes. Research on SCE has shown mixed results, with some studies indicating a positive relationship between structural capital and corporate performance (Saleem et al. 2022; Olarewaju and Msomi 2021), while others report negative or inconclusive findings (Ting and Lean 2009).

2.1.4. Relational Capital Efficiency (RCE)

Relationship Capital Efficiency (RCE) is an essential intangible asset emanating from an organization's interactions with external entities like consumers, shareholders, and banks, encapsulating elements such as customer and brand loyalty, market image, goodwill, bargaining power, strategic alliances, and coalitions (Kaplan and Norton 2004; Buallay 2018). An integral part of RCE, Relational Capital (RC), defines the network of relationships an organization maintains with its external stakeholders. The strategic cultivation of these relationships significantly bolsters an organization's competitiveness and long-term success, improving the comprehension of its industry and enhancing decision-making processes. Theoretically, an elevated RCE positively correlates with efficiency (Nimtrakoon 2015). When assessing RC, longevity and its positive impact on an organization's competitive edge are considered key indicators.

2.2. Intellectual Capital and Performance in the literature

Studies from diverse global regions have investigated the relationship between IC and firm performance. In Asia, substantial research on financial institutions in Malaysia and Indonesia has demonstrated a positive association between IC and performance measures such as Return on Assets (ROA) (Goh 2005; Ting and Lean 2009; Muhammad and Ismail 2009a). Parallel results were found in Indonesia, with IC exerting a positive influence on financial performance, although not necessarily corporate social responsibility disclosure (Razafindrambinina and Kariodimedjo 2011; Sari and Rahmawati 2019).

Despite often low IC efficiency in Australia, analyses still detected IC's broad impact on metrics like ROE and ROA (Clarke et al. 2011; Joshi et al. 2013). The Middle East evidenced similar patterns, Al-Musali and Ismail (2014) found a positive IC-performance relationship in Saudi banks, though overall IC efficiency was low. In Western Europe, Sardo and Serrasqueiro (2018) showed positive IC associations with ROA and Tobin's Q among non-financial firms. Related studies in Pakistan and India reinforced IC's significant positive effect on bank performance (Hussain et al. 2019; Okoye et al. 2019).

Investigations in other regions reveal nuances in IC's performance impact. In East Africa, income diversification affected the IC-ROA relationship (Githaiga 2020). South Korean manufacturing displayed the criticality of HCE for value creation (Xu and Wang 2020). Meanwhile, an Asian food industry study highlighted mediating effects between IC components and corporate social responsibility via financial performance (Tsai and Mutuc 2020). In Latin America, Garc'ıa Castro et al. (2021) found complexity in the Colombia IC-performance connections. Though in Indonesia, IC still significantly influenced financial performance (Cindiyasari et al. 2022).

Despite geographical variances, IC often positively correlates with firm success, highlighting its importance. However, effectively leveraging IC, especially human capital, remains an organizational challenge requiring further attention. Table 1 summarizes some salient research in the IC space.

2.3. Efficiency and bank performance

Bank performance and efficiency are critical elements within the dynamics of the banking sector, having been the focus of numerous empirical studies. Within the context of more developed banking markets such as the U.S. and Europe, research by Fung et al. (2010) has validated the Efficiency-Strength Hypothesis (ESH), indicating a positive relationship between bank efficiency and profitability. However, the relationship is less evident in the context of Taiwan and other developing economies, highlighting the need for further research. These findings underscore the potential impact of differing local market conditions in moderating this relationship. Furthermore, the examination of bank efficiency within the Taiwanese market has been primarily concentrated on traditional facets such as productivity, cost, and profit efficiency. Nevertheless, it's important to recognize that the Taiwanese banking sector's unique characteristics might necessitate more context-specific approaches or further empirical testing.

The influence of moderating factors like bank size, market competition, regulatory changes, and macroeconomic conditions on the efficiency-performance relationship in Taiwanese banks also warrants attention. The size of a bank can contribute to efficiency through economies of scale and scope, while market competition can induce efficiency by creating market pressures. Regulatory shifts can redefine the banking sector's operational dynamics, indirectly influencing efficiency and macroeconomic conditions reflecting variables such as inflation and GDP growth rate can also have substantial impacts.

IC's role is another significant facet of the efficiency-performance discourse. Notably, studies in Taiwan indicate that relationship capital negatively impacts efficiency, while human and structural capital don't exhibit any discernible effect. This underlines the importance of intellectual capital in shaping bank performance and highlights a research gap regarding its role across periods of economic stability. Consequently, there is a clear need for more geographic and temporal research on the influence of intellectual capital on efficiency, particularly in markets like Taiwan.

Table 1: Relevant literature on intellectual capital

Authors	Objective	Country	Findings
Goh (2005)	This paper measures the intellectual capital performance of commercial banks in Malaysia from 2001 to 2003, using an efficiency coefficient called VAICe developed by Ante Pulic.	Malaysia	The results indicate that the intellectual capital performance of Saudi banks is low and positively associated with bank financial performance indicators.
Ting and Lean (2009)	This study examines the influence of intellectual capital on 20 financial sector companies from 1999-2007 in Malaysia.	Malaysia	The results reveal that VAIC positively affected ROA.
Muhammad and Ismail (2009a)	This study investigates the efficiency of intellectual capital and its performance in Malaysian financial sectors.	Malaysia	The results reveal that intellectual capital has significant and positive relationships with the company's performance, measured by profitability and return on assets.
Razafindrambinina and Kariodimedjo (2011)	This study examines whether there is an association between intellectual capital and its components and corporate social responsibility disclosure of listed firms in Indonesia.	Indonesia	The study provides findings regarding the insignificant effect of the aggregate VAIC model and its components such as HCE and SCE on CSR disclosure.
Clarke et al. (2011)	This study examined the effect of intellectual capital on 1,676 companies listed on the Australian Stock Exchange.	Western Europe	Intellectual capital influences ROE, ROA, EP, and RG, using control variables such as leverage, R&D, year, and industry.
Joshi et al. (2013)	This study examines the intellectual capital (IC) performance of the Australian Financial Sector for the period 2006-2008.	Australia	The value creation capability of the financial sector in Australia is highly influenced by human capital, and about two-thirds of the sample companies have very low levels of intellectual capital efficiency.
Al-Musali and Ismail (2014)	This study examines intellectual capital (IC) performance of listed banks in Saudi Arabia using value-added intellectual coefficient (VAIC) methodology and investigates the impact of IC on financial performance.	Saudi Arabia	The results show that the IC performance of Saudi banks is low and positively associated with bank financial performance indicators.
Sardo and Serrasqueiro (2018)	This study examined the influence of intellectual capital using a sample of 2,090 non-financial firms registered in 14 countries in Western Europe from 2004-2015.	Australia	The study proves that there is a positive relationship between intellectual capital with ROA and Tobin's Q.
Saeidi et al. (2015)	This study explores the effect of enterprise risk management implementation on firm performance and value creation in Malaysia.	Malaysia	The study concludes that the implementation of enterprise risk management significantly positively impacts firm performance and value creation in Malaysia.
Hussain et al. (2019)	This study investigates the relationship between intellectual capital performance and banks' profitability in Pakistan, using VAIC as a measure of IC performance.	Pakistan	The study finds a significant positive relationship between intellectual capital performance and bank profitability in Pakistan, identifying human capital efficiency as the most significant component of VAIC in explaining bank profitability.
Okoye et al. (2019)	The study investigates the impact of intellectual capital on productivity in commercial banks in India.	India	The study found that intellectual capital, particularly human capital efficiency, structural capital efficiency, and capital employed efficiency, significantly impacted bank productivity in India.
Sari and Rahmawati (2019)	The research explores the connection between intellectual capital and the financial performance of banking firms in Indonesia.	Indonesia	The findings affirm that intellectual capital influences financial performance and offer insights into how each component of intellectual capital efficiency corresponds to financial performance.
Githaiga (2020)	This study examines whether income diversification moderates the relationship between intellectual capital and bank performance among East African banks.	East African countries	The study finds that income diversification significantly impacts the relationship between intellectual capital and return on assets in East African banks.
Xu and Wang (2020)	The study investigates the relationship between intellectual capital and firm performance using an adapted and extended VAIC model.	South Korea	The study reveals that human capital efficiency is the most crucial aspect of intellectual capital efficiency values, showing the vital role of human resources in creating value for manufacturing firms.
Tsai and Mutuc (2020)	This study investigates the mediating effects of corporate financial performance on the relationship between intellectual capital components and CSR of firms from the food industry in Asia.	Asia	The findings indicate the presence of a mediation effect between intellectual capital components and CSR through corporate financial performance.
Garc'ia Castro et al. (2021)	This study aims to investigate the relationship between intellectual capital and the financial performance of 7 Colombian banks from 2010-2016.	Colombia	The analysis shows that associations between intellectual capital and financial performance and corporate value vary, so a homogeneous trend cannot be identified.
Cindiyasari et al. (2022)	The study aims to analyze the impact of intellectual capital on the financial performance of companies in the financial sector listed on the Indonesia Stock Exchange.	Indonesia	The study found that intellectual capital significantly influences a company's financial performance as measured by ROA and ROE.

2.4. Malmquist index and its use in measuring efficiency

The Malmquist index, a widely used tool to gauge productivity growth, has found utility in numerous studies across varied sectors, most notably in financial institutions. One such study by Berg et al. (1992) identified a significant shift in productivity growth in the Norwegian banking sector, a phenomenon which occurred post-deregulation in the 1980s. Interestingly, the growth was most pronounced among the larger banks. Expanding their study, Berg et al. (1993) applied the same index to multiple countries - Finland, Norway, and Sweden - to provide a comparative view of bank productivity growth.

A similar use of the Malmquist index by Leightner and Lovell (1998) found an increase in total factor productivity within Thai banks during an era of extensive financial deregulation. Here, foreign-owned banks showed particularly striking growth. Comparable findings were noted by Isik and Hassan (2003) who observed significant productivity gains in Turkish commercial banks post-deregulation, predominantly driven by efficiency increases. A similar efficiency-driven growth pattern was also observed in Australian credit unions by Worthington (1999).

Globally, various studies have examined banking efficiency, productivity, and sustainability. For example, in the United States, Liu et al. (2018) developed a superior model for assessing bankruptcy risk. Meanwhile, in Algeria, Boukhetala and Boudriga (2019) discovered that technological progress was the chief driver of productivity growth, with foreign banks leading the pack.

Research in China has focused on the impact of digital transformation on bank efficiency, finding that digital maturity leads to better technical efficiency (Zuo et al. 2021). In addition, Huang et al. (2017) identified bank size, market competition, and business diversification as key efficiency influencers within Chinese commercial banks. In Taiwan, Yu et al. (2021) recognized lending efficiency surpassing deposit efficiency. On a broader scope, sustainability concerns have been explored. Novickytė and Droždz (2018) evaluated the efficiency of Lithuania's banking sector, noting room for cost efficiency and profitability improvement.

2.4.1. Related Concepts in the Literature

Research around the globe has investigated the impact of Intellectual Capital (IC) and various operational strategies on banking efficiency. In Taiwan, studies have demonstrated varying results, from increased productivity due to improved operating efficiency (Chen and Yeh 2000) to contrasting efficiency scores from different analytical approaches (Chen 2002). Bank mergers have been shown to enhance cost efficiency (Peng and Wang 2004), with further benefits realized when mergers involve banks from differing cultural backgrounds (Lin 2005). Chiu and Chen (2009) highlighted the external factors affecting bank efficiency and argued that privately-owned banks were the most impacted. The efficiency benefits of Taiwan's commercial banks forming or joining financial holding companies were less conclusive (Chiou 2009). A two-stage series performance model suggested that mixed-ownership bank branches outperform state-owned ones (Yang and Liu 2012). Wang et al. (2013) found superior CAMEL and IC performance in higher efficiency banks across 10 ASEAN countries. Lastly, the application of three-stage data envelopment analysis revealed that environmental conditions significantly impact banking efficiency (Shyu et al. 2015), while lending efficiency was found to surpass deposit efficiency in a dynamic situation (Yu et al. 2021).

In Indonesia, research confirmed that a company's financial performance could mediate the relationship between IC and Good Corporate Governance (GCG) (Anik et al. 2021,?). Similarly, IC was found to influence the financial performance of banks positively (Suardi and Chandra 2014). Furthermore, the technical efficiency of rural banks was shown to affect their loan supply to micro-small banks (Anwar et al. 2019). Amalia and Safira (2021) determined that human capital and structural capital significantly affect Islamic banks' financial performance, but capital-employed efficiency and Sharia compliance do not.

In other regions, a study conducted in India (Kamath 2004) revealed significant differences in bank performance and a bias favouring foreign banks over domestic ones. Research in Malaysia by Muhammad and Ismail (2009b) showed positive relationships between IC and company performance. A cross-country study involving China and Pakistan by Xu et al. (2019) found that capital employed efficiency significantly contributes to bank performance in both countries. A similar comparison of rising Asian countries Saha (2018) noted that risk measures affect bank efficiency and variability. Meanwhile, a Taiwanese study (Ni et al. 2020) found that knowledgeable employees give firms an innovative advantage, boosting firm value. In China, fintech innovations enhanced banks' cost efficiency and technology, despite state-owned commercial banks' poor performance (Lee et al. 2021). Finally, a Taiwanese study (Kweh et al. 2021) reported a positive relationship between IC and banks' resource use and investment efficiencies. Table 2 synthesises salient scholarly literature analyzing the association between bank efficiency and performance.

Table 2: Relevant literature on bank efficiency

Authors	Objective	Country	Findings
Chen and Yeh (2000)	This paper develops a non-parametric approach for measuring the relative operating efficiency of commercial banks	Taiwan	Authors confirm a slight increase in the productivity of banks examined.
Anik et al. (2021)	To analyze the impact of the company's financial performance in mediating the relationship between IC Capital and GCG on Corporate Value in listed banks	Indonesia	The financial performance of banking companies were proven to mediate the relationship between intellectual capital and GCG.
Chen (2002)	This study employed both chance-constrained data envelopment analysis (CCDEA) and SFA to measure the technical efficiency of 39 banks in Taiwan.	Taiwan	Chance-constrained DEA and stochastic frontier production function have significantly different efficiency scores.
Peng and Wang (2004)	This research focuses on how bank mergers affect cost efficiency, economies of scale, and scope in Taiwan's banking business.	Taiwan	Analysis shows that bank mergers boost cost efficiency.
Kamath (2004)	The study aims to estimate and analyze the IC for measuring the value-based performance of the Indian banking sector	India	The study reveals substantial differences in the performance of Indian banks and an overall bias favouring the performance of foreign banks over domestic banks.
Lin (2005)	This study evaluates the effects of bank mergers on bank efficiency during the period from 1997 to 1999 and used the two-stage method	Taiwan	Findings suggest bank's cost efficiency would be improved if mergers happened between banks with different culture background
Chiu and Chen (2009)	This study adopts a three-stage approach to estimate bank efficiency based on information obtained from 29 banks in Taiwan from 2002 to 2004.	Taiwan	External factors affect domestic bank efficiency with the most impact experienced on privately-owned banks' efficiency.
Muhammad and Ismail (2009b)	To investigate the efficiency of intellectual capital and its performance in Malaysian financial sectors.	Malaysia	intellectual capital has significant and positive relationships with the company's performance measured by profitability and Return on Assets
Chiou (2009)	The paper examines whether Taiwan's commercial banks forming or joining financial holding companies can boost their efficiency and productivity	Taiwan	Except for pure technical efficiency, other efficiencies and productivity of commercial banks do not improve because of their joining FHC.
Yang and Liu (2012)	To evaluate bank branches	Taiwan	The results show that mixed-ownership bank branches perform better than state-owned bank branches, indicating that banking privatization improves the managerial inefficiency of state-owned banks.
Wang et al. (2013)	The objectives were to evaluate bank efficiency using DEA and CAMEL ratios, analyze CAMEL differences across efficiency tiers, and examine intellectual capital across efficiency groups	10 ASEAN countries	Results show higher efficiency banks had superior CAMEL and intellectual capital performance, indicating intellectual capital is crucial for bank success
Suardi and Chandra (2014)	To examine the effect of intellectual capital on the financial performance of banks in Indonesia.	Indonesia	Intellectual capital positively and significantly affects bank financial performance as measured by return on assets (ROA).
Shyu et al. (2015)	This study uses the three-stage data envelopment analysis to explore the actual managerial efficiency of the banking firms	Taiwan, Hong Kong, China	Results indicate that the environmental conditions have a significant impact on banking efficiency
Huang et al. (2017)	To evaluate the efficiencies of Chinese commercial banks in the context of stochastic multistage technologies.	China	The study found that the efficiency of Chinese commercial banks is affected by various factors, including the size of the bank, the level of competition in the market, and the degree of diversification of the bank's business.
Saha (2018)	This research examines the influence of risk on international banks' cost efficiency in eight rising Asian countries.	Emerging Asian countries.	Results show that risk measures affect bank efficiency and variability and that impacts vary by country and time.
Liu et al. (2018)	this paper aims to propose a nonparametric and dynamic model based on DEA to assess the bankruptcy risk of banks.	United States	The study finds that the proposed nonparametric method, Malmquist DEA with Worst Practice Frontier, outperforms previous methods used to link efficiency measures to bank failure prediction.
Xu et al. (2019)	To determine and compare the relationship between intellectual capital (IC) and banks' performance in China and Pakistan	China and Pakistan	CEE makes the highest contribution to bank performance in both countries. SCE drives bank profitability in China, while HCE positively affects bank profitability and productivity.
Anwar et al. (2019)	This article examines rural banks' efficiency and micro-small bank lending in West Java, Indonesia	Indonesia	Findings show that rural banks' technical efficiency affects their loan supply and the necessity of rural banks to maintain and strengthen their efficiency in lending to micro-small banks.
Boukhetala and Boudriga (2019)	this study aims to measure the productivity change and its components for banks using the DEA-based MPI Index Approach.	Algeria	Results show that the productivity growth of Algerian banks is mainly driven by technological progress, and foreign banks outperform domestic in terms of productivity change.
Chen et al. (2020)	This paper discusses network DEA by considering a bank's inputs and outputs as undesirable factors and integrating the dual nature of risks.	Taiwan	The probability of losses for financial institutions fluctuates based on commodity prices and the investment tolerance of risk managers.
Ni et al. (2020)	This study aims to find evidence of the impact of IC on firm value and improve existing literature	Taiwan	Firms with knowledgeable employees will have an advantage in innovation, and their good reputation will encourage people to consume and invest more.
Anik et al. (2021)	To analyze the impact of the company's financial performance in mediating the relationship between Intellectual Capital and GCG.	Indonesia	The financial performance of banking companies were proven to mediate the relationship between IC and GCG.
Ting et al. (2021)	Examine the relationship between intellectual capital (IC) and the efficiency of Taiwanese bank branches.	Taiwan	RC adversely affect bank efficiency. Human capital and structural capital do not contribute to bank efficiency in Taiwan.
Amalia and Safira (2021)	To examine the effects of Intellectual Capital (IC) and its components and Sharia Compliance on Islamic banks' financial performance in Southeast Asia.	Indonesia, Malaysia, Brunei, Philippines	HCE and SCE significantly affect Islamic banks' financial performance. However, CEE did not.
Yu et al. (2021)	This study discusses meta-technology heterogeneity while assessing performance in a dynamic situation.	Taiwan	Findings show that lending efficiency surpasses deposit efficiency.
Lee et al. (2021)	This article explores whether the growth of the fintech sector affected China's banking industry.	China	State-owned commercial banks have poor cost efficiency and technology, yet fintech innovations boost banks' cost efficiency and technology.
Kweh et al. (2021)	This study estimates banks' resource utilization and investment efficiencies after incorporating risk measures.	Taiwan	Regression analyses show a positive relationship between IC and banks' resource use and investment efficiencies.
Zuo et al. (2021)	To investigate the impact of digital transformation on the sustainable efficiency improvement of commercial banks.	China	The study found that digital transformation positively impacts the sustainable efficiency improvement of commercial banks.
Yu et al. (2021)	This study discusses meta-technology heterogeneity while assessing performance in a dynamic situation.	Taiwan	Findings show that lending efficiency surpasses deposit efficiency.
Li et al. (2022)	To evaluate the innovation efficiency of Chinese commercial banks under the impact of internet finance using the DEA-BCC model and DEA-Malmquist index.	China	The study found that Chinese commercial banks have increased their innovation investment in information technology, and innovation efficiency has improved over time.
Yu and Huang (2023)	To measure the efficiency of commercial banks in Poland and provide a cut-off line for bank failure efficiency using the super-efficient DEA model and Malmquist index.	Poland	The study found that comprehensive technical efficiency inhibits the rise of banks' efficiency and that banks' efficiency shows a zigzag fluctuation trend from 2017 to 2021.

2.5. Income diversity and bank performance

The question of how bank income diversification influences financial performance is gaining substantial academic attention. Central to this debate is whether expanding revenue sources beyond traditional interest income positively or negatively impacts bank performance. This discussion is closely related to the broader conversation on the effect of market concentration on bank performance, which is tied to two main theories: the Structure-Conduct-Performance (SCP) hypothesis and the Efficient-Structure Hypothesis (ESH). The SCP hypothesis posits that higher profits are achievable in a highly concentrated banking structure, whereas the ESH argues that profitability reflects individual bank efficiency, regardless of market concentration (Lelissa and Kuhil 2018; Samad 2008).

2.6. Income Diversity in the Literature

The analysis of the relevant literature points to a diverse array of findings on the impacts of income diversification, greatly influenced by geographical location. Research conducted in Kenya (Kiweu et al. 2012), Pakistan (Shahzad et al. 2016), and India (Vidyarthi 2019) demonstrated a positive correlation between diversification and increased bank profitability. Similarly, in Vietnamese listed firms, a trend of improved return on assets and market value with increased diversification was observed (Nguyen et al. 2019). However, studies from other African nations, Vietnam, and Indonesia reported findings that contradict these results, suggesting that diversification may have a limited or no positive effect on performance (Marshall and Elzinga-Marshall 2017; Ho 2020; Nguyen et al. 2021; Wulandari et al. 2021). These diverse outcomes underline the importance of context in the diversification-performance relationship.

The moderating factors such as bank size, business model, and the level of economic development can significantly influence these outcomes. Larger banks tend to diversify more, while smaller banks are subject to greater volatility in non-interest revenues (Marshall and Elzinga-Marshall 2017). Furthermore, banks in developing countries, typically reliant on interest earnings, are often slower in diversifying towards non-interest income (Ho 2020).

While the direct impact of diversification on performance remains debatable, there is consensus on the significance of investigating the conditions and strategies that lead to positive outcomes. These may involve examining optimal diversification strategies tailored to specific bank types and business models (Nguyen et al. (2019)), and the role of risk management as a necessary complementary capability (Wulandari et al. (2021)).

Recent research has also centred on the influence of non-traditional banking activities on efficiency, especially in African markets where data has been historically limited. While some studies have shown that diversification can enhance profits for international and domestic banks, there's a disagreement on the impact of non-interest financial gains on profitability. Some evidence, (see Malik et al. (2013)) suggests that these might marginally negatively affect profitability. Findings like those from Tariq et al. (2021) highlight that diversification significantly positively affects the operational efficiency of Vietnamese commercial banks, and banks with more diverse income channels, particularly in Asia, show better performance in terms of return on assets (Najam et al. 2022).

In light of these diverse findings and the increasing trend of diversification in global banking practices, further exploration of the diversification-performance relationship is necessary. The literature in Table 3 summarises critical literature on income diversification and underscores the necessity for a more context-specific and nuanced understanding of income diversification and its impacts on financial institutions, considering various moderating factors.

2.7. Theoretical Framework

Establishing a theoretical framework to characterise firms' operations and facilitate identifying factors and conditions that can influence firm performance has piqued the interest of scholars and economic and management experts. The idea that a firm's resources are the basis of its long-term success is based on the premise that its resources and skills provide strategic direction and are its primary profit source (Grant 1991). Porter and Advantage (1985) supports this foundation for success in noting that for a firm to generate returns over its cost of capital is contingent upon its attractiveness within its industry and creating a competitive edge over its rivals. These concepts align with the resource-based viewpoint, focus on knowledge management and organisational learning, and highlight knowledge as an indispensable resource. RBT finds that owning and controlling tangible and intangible strategic assets is the basis for a sustainable comparative advantage Riahi-Belkaoui (2013) and ultimately for its performance (Dubey et al. 2019). Barney (1991) asserts that if all firms had the same resources, there would be no discrepancies in their profitability.

The advent of a knowledge-based economy identified knowledge and IC as significant production variables and essential drivers of companies' sustained competitive advantages. Knowledge-based resources complement resource-based view and IC management (Theriou et al. 2009). IC is a core managerial duty from which scholars have underlined scarcity, value, and the inability of replication or substitution as strategic aspects for lasting competitive advantage (Massaro et al. 2018). Numerous studies (see Mikalef and Gupta (2021); Isola et al. (2020); Prajogo and Oke (2016)), have examined the relationship between IC and firm performance through the lens of RBT. In RBT, strategic resources enable businesses to compete more effectively and economically (Huo et al. 2016) and that firm failure is due to the

Table 3: Relevant literature on income diversity

Authors	Objective	Country	Findings
Kiweu et al. (2012)	this study aimed to examine the effect of income stream diversification on the financial performance of commercial banking institutions in Kenya.	Kenya	The study found few benefits, if any, from income diversity away from traditional and normal banking activities but revealed benefits of growing non-interest incomes during the duration of inquiry ranging from the year 2000 and 2010.
Shahzad et al. (2016)	To explore the effect of income diversification on the performance of banks in Pakistan and to provide guidelines for banks to improve profitability through income diversification.	Pakistan.	The study found a positive relationship between income diversification and bank profitability in Pakistan, suggesting that banks can use non-interest income as a source of diversification to reduce the earning volatility attached to core operations and the risk of default.
Marshall and Elzinga-Marshall (2017)	To investigate the impact of income diversification on bank stability in African markets.	45 African countries	The study found that income diversification can improve financial stability, but excessive diversification can have a negative impact.
Vidyarthi (2019)	This study aims to examine the relationship between income diversification and various measures of bank performance for listed Indian banks.	India.	The study finds that income diversification positively impacts bank performance in India and that this relationship varies across different types of banks.
Nguyen et al. (2019)	To investigate the relationship between income diversification and firm performance of Vietnamese listed firms.	Vietnam.	The study found that income diversification positively impacts the performance of Vietnamese listed firms, as measured by return on assets (ROA) and market value added (MVA).
Wei (2020)	To analyze diversification's influence on commercial banks' market valuation.	23 countries	Income diversity has a positive influence on excess value and a negative influence on Tobin's Q, and the effect is significant (at a 5% significance level).
Ho (2020)	To explore the relationship between financial performance and income diversity in Vietnamese commercial banks and examine state ownership's moderating effects on this relationship.	Vietnam.	The study found that income diversity does not impact financial performance in Vietnamese commercial banks, as banks are still heavily reliant on lending activities and interest income. However, the study suggests that as banks diversify their income streams, the impact of income diversity on financial performance may become clearer in the future.
Ho (2020)	To explore the relationship between financial performance and income diversity in Vietnamese commercial banks and whether state ownership moderates this relationship.	Vietnam	The study found that income diversity does not impact financial performance in Vietnamese commercial banks, as they are still heavily reliant on lending activities and interest income.
Nguyen et al. (2021)	This study aims to evaluate the impact of income diversification on the production efficiency and business activities of non-financial firms listed in Vietnam.	Vietnam	The study found that income diversification can help reduce risk, stabilize cash flow, and improve book efficiency, but it negatively impacts market efficiency.
Wulandari et al. (2021)	To investigate the impact of market structure and income diversity on the stability of Indonesian commercial banks.	Indonesia	The study found that banks in Indonesia, on average, diversify their income, which is still relatively small or equal to 27.1% of the total income. The non-interest income earned is mostly generated from commission income, followed by trading and other non-interest sources.
Adem (2022)	To examine the impact of income diversification on bank stability in African economies using longitudinal data.	45 African countries.	Income diversification decreases risks and improves bank financial stability in African economies.

heterogeneity of firm resources (Bakar and Ahmad 2010). Firm value is determined by its ability to organise its resources and capabilities. RBT emphasises the importance of organisations conceptualising and successfully exploiting tangible and intangible assets (Akter et al. 2016), which comprise a company's administrative capabilities, routines and organisational processes, and the information and knowledge under control (Fischer et al. 2020). To better understand the institutional potential of IC, we extend extant research by examining IC and efficiency through the lens of RBT – a source of a firm's core competency infused into each IC dimension.

2.8. Research Questions

This literature review investigates the theory that efficiency, intellectual capital, and income diversity improvements may enhance banking performance metrics. With this backdrop, we formulate our core research questions:

1. There is a positive relationship between the Modified Value-Added Intellectual Coefficient (MVAIC) and bank performance in Taiwan.
   (a) Relational capital efficiency (RCE), an intellectual capital component, is positively correlated with bank performance in Taiwan.
   (b) Structural capital efficiency (SCE), an intellectual capital component, is positively correlated with bank performance in Taiwan.
   (c) Capital employed efficiency (CEE), an intellectual capital component, is positively correlated with bank performance in Taiwan.
   (d) Human capital efficiency (HCE), an intellectual capital component, is positively correlated with bank performance in Taiwan.
2. Bank efficiency, as measured by the Malmquist DEA, is positively associated with bank performance in Taiwan.
3. Income diversity is positively associated with bank performance in Taiwan.

3. Data and methodology

3.1. Data and study period

This study draws upon the BankFocus database to examine secondary data related to 44 Taiwanese commercial banks operating between 2010 and 2022, inclusive of both domestic and foreign entities. As shown in Table 4, due to unavailable annual reports or essential data, the sample was pruned to 39 banks, a reduction of 11.4%. The final ensemble comprises 33 domestic banks, forming 84.6% of the sample, and six foreign banks accounting for the remaining 15.4%. Although this selection necessitates the exclusion of certain banks to maintain balanced panel data for efficiency score computation, it still represents a substantial portion of the Taiwanese banking sector in terms of total asset ownership.

Table 4: Data Sample

Description	No. of Banks	Percent
Initial Sample	44	111.4%
Companies with unavailable annual reports or data	5	11.4%
Final Sample	39	100.00%
Domestic Banks	33	84.6%
Foreign Banks	6	15.4%
Full Sample	39	100.00%

The BankFocus database provides a comprehensive dataset, allowing an extensive exploration of industry dynamics, including the observation of market entrants like HWBK, JSIB, and ESUN over the study period, thus enriching the overall understanding of long-term trends and impacts. Table 12 outlines the banks involved in the study over the study's time frame.

3.1.1. Descriptions and measurement of variables

In this study, the dependent variable under consideration is bank performance. Existing literature in this domain has predominantly relied on indicators such as Return on Assets (ROA), Return on Equity (ROE), and Net Interest Margin (NIM) to gauge bank profitability (Liu and Wilson 2010; Seenaiah et al. 2015; Ghosh et al. 2019). However, it is important to note that these accounting-based measures offer only a partial view of the overall state of the firm. To enrich the scope of our research, we extend our analysis to encompass additional accounting-based metrics to assess bank performance comprehensively.

We incorporate five performance measures: Operating Ratio (*Oper_Ratio*), Earnings Per Share (*EPS*), Return on Equity (*ROE*), Revenue Growth (*Rev_Growth*), and Profit Margin (*Profit_Margin*). The Operating Ratio is calculated by dividing operating expenses by net sales, with lower values indicating higher operational efficiency. EPS, a significant profitability indicator, is obtained by dividing net profit by the number of outstanding shares. A higher EPS value suggests improved financial health and enhanced profitability for the bank. ROE, computed by dividing net income by shareholders' equity, is a critical measure for evaluating a bank's efficiency in generating profits from the capital invested by shareholders. *Rev_Growth* indicates the percentage increase in a bank's revenue from one period to the next, serving as a gauge of the bank's ability to enhance sales over time. Lastly, *Profit_Margin* is derived by dividing net profit by total revenue and multiplying the result by 100 to get a percentage. A higher profit margin signifies a bank's proficiency in controlling costs and implies stronger financial performance. In an initial observation, the five performance measures may seem interrelated, where a higher profit margin implies increased profitability, potentially leading to enhanced ROE and EPS. However, each metric is influenced by distinct factors, and an increase in one measure does not necessarily guarantee a corresponding increase in the others. Various factors uniquely impact each performance measure, warranting a comprehensive examination to avoid unwarranted assumptions of their interdependency. As such, the five performance measures provide a comprehensive, multifaceted evaluation of a company's financial health by assessing operational efficiency, profitability, shareholder returns, growth trends, and cost management capabilities within a single succinct framework. Figure 1 illustrates bank performance measures by domestic and foreign banks in addition to the MVAIC.

3.1.2. Bank-specific explanatory variables

In evaluating bank performance, we have employed the frontier analysis method, specifically Data Envelopment Analysis (DEA), known for its simplicity and fewer restrictive assumptions. DEA is a non-parametric method used to measure the relative efficiency of decision-making units (DMUs) that use similar inputs to produce comparable outputs. Within this DEA framework, we utilize the Malmquist Productivity Index (MPI), a component of DEA that measures efficiency changes over time by constructing a yearly production frontier for each DMU.

The MPI is a composite measure of efficiency change that decomposes the change in efficiency into two components: technical change and efficiency change. The technical change pertains to alterations in the best-practice frontier, while

efficiency change refers to variations in the DMU's distance from the frontier. Specifically, MPI is computed as the product of the technical change index (TCI) and the efficiency change index (ECI). While TCI gauges the change in the output-to-input ratio of the best-practice frontier, ECI measures the shift in the DMU's output-to-input ratio.

This study applies an input-oriented Banker et al. (1996) model in DEA, an apt choice given that banks typically exert more control over their input usage than their output demand. For defining the input-output relationship, we adopt the intermediation approach, viewing banks as intermediaries that gather deposits and convert them into loans using labour. Our selected input variables include interest expenses, fee and commission expenses, operating expenses and provisions. In contrast, our output variables consist of interest and fee-commission income, the latter encompassing revenue from varied sources such as overdrafts, ATMs, service charges, and investment banking and trading activities. In this way, the MI is a useful tool for assessing the overall performance of DMUs over time and identifying the sources of efficiency change, such as technical or efficiency change. All DEA and MI analyses were conducted using Stata, version 18.

In the context of the MI approach, a set of DMU, specifically banks in this study, is selected to create an optimal performance benchmark through input-output combinations of the chosen DMUs. The objective is to determine the disparity between individual observations and this established benchmark, thereby measuring the distance. Following the methodologies proposed by Shephard (1970) and Caves et al. (1982), the output distance function at time t, denoted as $D_0{}^t$, is defined as follows as per Equation 1

$$D_0^t(X_tY_t) = \left\{\theta : (X_t, Y_t/\theta) \in T^t\right\} \qquad (Eq.\ 1)$$

where

T^t denotes the production technology, which is represented as $T^t = X_t, Y_t$,
X_t can produce Y_t at time t.
X_t is a vector of inputs at time t
Y_t is a vector of outputs at time t

It is important to note that $D_0^t \leq 1$ indicates that the pair (X_t, Y_t) belongs to the production technology T^t and lies on the best-practice frontier when $D_0^t = 1$. The output-based Malmquist index for an individual decision-making unit (DMU) or bank, spanning from period t to period t + 1, is established by employing the output distance function as specified in Equation 2

$$M_0(X_{t+1}, Y_{t+1}, X_t, Y_t) = \left[\frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)} \frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_t, Y_t)}\right]^{1/2} \qquad (Eq.\ 2)$$

A Malmquist index (M_0) value greater than 1 signifies an enhancement in input-output efficiency from period t to period $t+1$, whereas a value less than 1 symbolizes a decline in efficiency. Following Fa¨re et al. (1994), Equation 2 can be re-expressed as Eq. 3

$$M_0(X_{t+1}, Y_{t+1}, X_t, Y_t) = \frac{D_0^{t+1}(X_{t+1}, Y_{t+1})}{D_0^t(X_t, Y_t)} \times \left[\frac{D_0^t(X_{t+1}, Y_{t+1})}{D_0^{t+1}(X_{t+1}, Y_{t+1})} \times \frac{D_0^t(X_t, Y_t)}{D_0^{t+1}(X_t, Y_t)}\right]^{1/2} \qquad (Eq.\ 3)$$

Equation 3 elucidates that the Malmquist index is bifurcated into two primary elements: "technical change" and "efficiency change". Each proportion within the bracket on the right-hand side of Eq. (3) quantifies a shift in the best-practice frontier, gauged at the input level for periods t and $t+1$. The geometric mean of these two shifts epitomizes "technical change" transpiring from period t to period $t+1$. On the other hand, the first ratio on the right-hand side of Eq. (3) exemplifies "efficiency change", which measures the variation in technical efficiency from period t to period $t+1$. Consequently, "efficiency change" establishes whether production is progressing toward or distancing from the existing frontier, thereby capturing the efficiency catch-up effect between the two periods t and $t+1$. An efficiency change value exceeding 1 suggests that a DMU has contracted its efficiency gap vis-à-vis the extant best practice.

3.2. Measurement of intellectual capital

This study follows Tran et al. (2020); Soetanto and Liem (2019) in using the MVAIC model as an IC proxy as the IV independent variable. MVAIC is calculated as the sum of HCE, SCE, CEE, and RCE as per Eq.4.

$$MVAIC_i = HCE_i + SCE_i + CEE_i + RCE_i \qquad (Eq.\ 4)$$

The four components of MVAIC are estimated as follows:

$$HCE_{it} = \mathrm{VA}_{it}/\mathrm{HC}_{it} \quad (Eq.\ 5)$$

$$SCE_{it} = \mathrm{SC}_{it}/\mathrm{VA}_{it} \quad (Eq.\ 6)$$

$$CEE_{it} = \mathrm{VA}_{i}/\mathrm{CE}_{it} \quad (Eq.\ 7)$$

$$RCE_{it} = \mathrm{RC}_{i}/\mathrm{VA}_{it} \quad (Eq.\ 8)$$

where

HCE	is human capital proxied by funds spent compensating employees
SCE	is structural capital efficiency and is the result of VA less HCE
CEE	is capital employed proxied by the net of total assets less total liabilities
RCE	is relational capital proxied by expenditures associated with maintaining relationships between customers, suppliers, shareho
VA	is Value Added (VA) is the difference between output and inputs

Higher HCE, SCE, CEE, and RCE values indicate greater IC value creation.

$$VA_{it} = \mathrm{Output}_{it} - \mathrm{Input}_{it} \quad (Eq.\ 9)$$

where

Output	is total bank revenue made up of interest and non-interest income, including fees and commissions
Input	is calculated as operation costs, including interest, administration, and other expenses, excluding personnel costs

3.3. Macro and Firm Control Variables

This study incorporates macro-specific control variables to discern the relationship between our hypotheses and potential confounders. Population Change is the first control variable for demographic shifts influencing economic dynamics. GDP Growth is also included, serving as a measure of overall economic performance and development. Gross Domestic Savings is included to control a nation's saving behaviour, thereby assessing its impact on economic stability and potential investment opportunities. The measure of resource efficiency is controlled by Return-on-Assets (ROA), which indicates how profitably a company uses its assets. Inflation is accounted for as it mirrors the overall economic health and could potentially affect corporate strategies and financial results. Lastly, dichotomous variables for year effects are incorporated to account for temporal trends.

We also note the inclusion of leverage as a control variable in the study helps distinguish the effects of a bank's capital structure on its performance from other predictor variables. The quadratic term, leverage squared, is additionally added to capture the potential non-linear relationship between leverage and performance, accounting for leverage's diminishing or increasing effects at different levels.

4. Results and Discussion

4.1. Bank Performance, Efficiency, and Intellectual Capital

Figure 1 presents the performance of domestic and international banks operating in Taiwan and several key study metrics on Taiwan's banks from 2010 to 2022 and presents data from an. The first row of the chart illustrates the progression of MVAC and the Operating Ratio. The MVAC paints a picture of steady growth over the past five years. Meanwhile, the Operating Ratio, a measure of corporate asset efficiency, has remained remarkably consistent during this period. This trend suggests that firms in Taiwan have woven a tale of sustained value creation for shareholders, all the while maintaining their operational efficiency. The second row illustrates EPS and ROE developments. The EPS has followed the path of an uphill trek over the past five years. Yet, quantifying profitability derived from shareholders' equity, the ROE reveals a slight downward divergence from this upward narrative. It implies that while Taiwanese firms have managed to ascend in their earnings per share, the efficiency of generating returns on equity has seen a gentle downhill slope.

Bringing these threads together, the overall narrative of Taiwan's banking landscape over the recent years is one of success. Companies have been skilful authors of value for shareholders, penned a steady story of efficiency, and elevated their earnings per share. Yet, a subplot of slightly declining profitability.

The descriptive statistics of the variables in our analysis are presented in Table 5 (Panel A). As performance indicators, we consider *Oper_Ratio*, *EPS*, and *ROE*. The average *Oper_Ratio* is around 0.57, with a standard deviation of 0.18, indicating moderate variability across firms. *EPS* and *ROE* have averages of 0.05 and 0.075, respectively, with slightly

higher variability seen in *ROE*. With regard to intellectual capital variables, *MVAIC*, *HCE*, *SCE*, *CEE*, and *RCE* have been considered. With means ranging from 0.18 to 3.88, these variables present diverse profiles, with the highest variation observed in RCE.

Panle B in Table 5 provides descriptive statistics of the variables, highlighting local and foreign variables, such as the MPI, Tech Change (TECCH), and Tech Efficiency (TECH). The local and foreign MPI means are roughly equal at 1.01 and 1.02, indicating comparable productivity levels. However, the standard deviations show greater variability for the foreign MPI. Similar trends are visible for Tech Change and Tech Efficiency, with slightly higher averages and variability for the foreign variables.

Finally, Table 6 (Panel A) summarizes 'the annual means of the Malmquist index in terms of intellectual capital efficiency. This index incorporates Technical Efficiency Change (TECH), Technological Change (TECCH), and Total Factor Productivity Change (TFPCH). From 2011 to 2022, there have been fluctuations in these parameters, with TECH achieving a high of 1.07 in 2021–2022. TFPCH peaked at 1.11 in 2020–2021, showing a period of productivity growth. The data in Panel B, showcases the top eight firms with *TFPCH* greater than 1, with JSIB leading with a TFPCH of 1.0713.

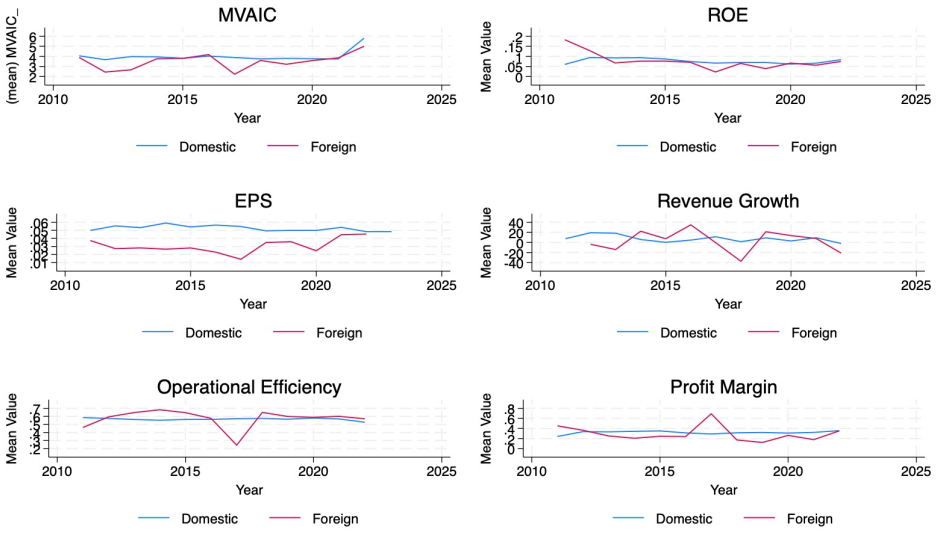

Figure 1: Performance measures by domestic and foreign Banks

4.2. Correlation Analysis

Tn examination of the correlation matrix (Table 7) reveals positive and negative interrelationships of varying strengths between key financial and operational metrics. Notably, *Oper_Ratio* positively correlates with *RCE*. *EPS* shows moderate positive correlation with *RCE* but strong negative correlation with *SCE*. *ROE* demonstrates strong positive correlations with *CEE* and *HCE* yet moderate negative correlation with *RCE*. *Profit_margin* is strongly negatively tied to *RCE*. *MVAIC* has strong positive correlations with *RCE* and *HCE*, while *HCE* itself positively correlates with *ROE*, *CEE*, and *MVAIC*. *RCE* is strongly positively associated with *EPS* but strongly negatively with *Profit_margin*. The interrelationships reveal nuances in how the financial and operational metrics are associated, with correlation strength and direction varying across variable pairs.

4.3. Random Effects Regression

In examining the performance drivers across various banks, our study recognizes the necessity to account for both within and between bank variations. Factors such as efficiency, capital, and diversity will likely have unique influences on different banks, pointing to the importance of modelling unobservable heterogeneity. We chose to apply random effects regression, a model that appreciates these intrinsic variations by allowing the intercepts to differ across the sampled banks. This approach not only aligned with our sampling process and theoretical understanding of bank performance but was also statistically supported by the results of the Hausman test (with a chi-squared statistic of 3.37 and a p-value of 0.3382). The outcome of this test, favouring the random effects model, strengthened our confidence in the appropriateness of our chosen methodology. By encompassing time-invariant and time-variant factors, the random effects model enables a more robust, flexible, and efficient analysis. It is exceptionally well-suited for our investigation into the complex dynamics influencing bank performance. The models for testing bank performance are shown in

Table 5: Descriptive Statistics

Variables	Obs	Mean	Std. Dev	Median
Panel A				
Performance Indicators				
Oper_Ratio	411	0.568	0.188	0.548
EPS	195	0.045	0.038	0.036
ROE	411	0.075	0.044	0.076
Rev_Growth	399	7.318	38.026	5.072
Profit_Margin	411	0.314	0.203	0.331
Efficiency Variables -Inputs				
Interest Exp (1)	466	274292.40	325108.80	141767.400
Fee & Commission Exp (2)	377	28887.78	35081.35	19693.68
Operating Exp (3)	466	481188.60	936289.60	207354.30
Provisions (4)	466	752687.10	3766823.00	0.00
Efficiency Variables -Outputs				
Interest Income (1)	411	780331.60	763997.90	405921.200
Fee Commission Income (2)	466	153060.10	215893.50	83203.770
Intellectual Capital				
MVAIC	411	3.846	2.552	3.139
HCE	411	2.788	1.413	2.616
SCE	411	0.380	0.275	0.420
CEE	411	0.587	0.316	0.645
RCE	411	1.719	3.084	0.775
Income Diversity				
Inc_Diversity	410	6.114	50.018	2.674
Macro Control Variables				
Population Change	466	0.128	0.201	0.200
GDP Growth	466	3.123	1.296	2.800
Gross Domestic Savings	466	34.181	3.172	33.840
Inflation	466	1.152	0.880	1.300
Firm Control Variables				
Size	411	17.090	1.235	17.043
ROA	411	0.054	0.038	0.052
Capitalization	411	14.345	1.313	14.401
Panel B				
Firm Efficiency Results -Domestic				
Local MPI (TFPCH)	–	1.009289	0.0911398	1.009289
Tech Change (Local) (TECCH)	–	1.010425	0.0871156	1.010425
Tech Efficiency (Local) (TECH)	–	1.004923	0.0688093	1.004923
Firm Efficiency Results -Foreign				
Foreign MPI (TFPCH)	–	1.018431	0.1553367	1.018431
Tech Change (Foreign) (TECCH)	–	1.009239	0.1375266	1.009239
Tech Efficiency (Foreign) (TECH)	–	1.012164	0.0761907	1.012164

Note: Macroeconomic data including population changes and gross domestic savings, were obtained from the Asian Development Bank (ADB). GDP growth rates and inflation statistics were sourced from the International Monetary Fund (IMF). The variable of bank size was operationalized as the natural logarithm of total assets. Capitalization was quantified as the natural logarithm of total equity.

Table 6: The Malmquist index summary of annual means in terms of intellectual capital efficiency

Panel A				*Panel B - Top eight firms (TFPCH > 1*			
Year(s)	TFPCH	TECH	TECCH	Abbrev.	TFPCH	TECH	TECC
2010–2011	.	.	.	JSIB	1.0713	1.0125	1.0567
2011–2012	0.9889	0.9652	1.0325	BOPC	1.0593	1.0210	1.0364
2012–2013	1.0233	1.0128	1.0348	ENCB	1.0514	1.0000	1.0514
2013–2014	1.0085	0.9806	1.0319	CTBT	1.0481	1.0000	1.0481
2014–2015	1.0059	1.0015	1.0039	KTBK	1.0430	1.0000	1.0430
2015–2016	1.0277	1.0038	1.0113	OBCK	1.0366	1.0196	1.0392
2016–2017	0.9822	1.0214	0.9722	CCBK	1.0298	1.0000	1.0298
2017–2018	0.9865	0.9918	0.9961	HSBC	1.0273	1.0028	1.0251
2018–2019	0.9921	1.0094	0.9910				
2019–2020	1.0303	1.0088	1.0411				
2020–2021	1.1069	1.0114	1.1000				
2021–2022	0.8219	1.0727	0.7333				
2022–2023	.	.	.				

Note: TFPCH measures total productivity change, where $TFPCH > 1$ indicates growth and $TFPCH < 1$ indicates decline. TECH measures efficiency change, where $TECH > 1$ indicates improvement and $TECH < 1$ indicates decline. TECCH measures technological change, where $TECCH > 1$ indicates progress and $TECCH < 1$ indicates regress.

Table 7: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Oper_Ratio	1.00													
(2) EPS	0.11	1.00												
	(0.14)													
(3) ROE	-0.24***	0.01	1.00											
	(0.00)	(0.92)												
(4) Rev-Grwth	0.00	-0.00	0.27***	1.00										
	(0.96)	(0.95)	(0.00)											
(5) Profit_margin	-0.81***	-0.09	0.41***	0.02	1.00									
	(0.00)	(0.21)	(0.00)	(0.66)										
(6) MVAIC_	0.01	0.08	0.19***	0.29***	-0.07	1.00								
	(0.85)	(0.28)	(0.00)	(0.00)	(0.17)									
(7) HCE_	-0.59***	-0.06	0.48***	0.17***	0.31***	0.35***	1.00							
	(0.00)	(0.46)	(0.00)	(0.00)	(0.00)	(0.00)								
(8) CEE_	-0.07	0.15	0.79***	0.21**	0.06	0.04	0.40***	1.00						
	(0.40)	(0.25)	(0.00)	(0.01)	(0.48)	(0.60)	(0.00)							
(9) SCE_	0.00	-0.44***	0.33***	-0.03	0.13	0.07	-0.08	0.27***	1.00					
	(0.98)	(0.00)	(0.00)	(0.74)	(0.11)	(0.37)	(0.34)	(0.00)						
(10) RCE_	0.54***	0.40**	-0.22**	0.20*	-0.34***	0.81***	-0.37***	-0.29***	0.00	1.00				
	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)	(0.00)	(0.96)					
(11) Leverage	0.13**	-0.05	-0.15**	0.06	-0.21***	0.04	-0.18***	0.16*	-0.11	0.21**	1.00			
	(0.01)	(0.52)	(0.00)	(0.25)	(0.00)	(0.47)	(0.00)	(0.05)	(0.15)	(0.01)				
(12) TFPCH	-0.03	0.01	0.03	-0.07	0.05	-0.11	0.05	0.01	-0.07	-0.08	-0.12*	1.00		
	(0.61)	(0.93)	(0.64)	(0.22)	(0.39)	(0.05)	(0.33)	(0.96)	(0.49)	(0.41)	(0.03)			
(13) TECH	0.00	0.08	-0.04	0.01	-0.04	-0.02	-0.03	-0.06	-0.07	-0.02	-0.01	0.34***	1.00	
	(0.98)	(0.38)	(0.45)	(0.88)	(0.49)	(0.77)	(0.61)	(0.51)	(0.43)	(0.85)	(0.89)	(0.00)		
(14) TECCH	0.01	-0.04	0.02	0.00	0.03	-0.04	0.05	-0.00	-0.09	-0.00	-0.12*	0.65***	-0.27***	1.00
	(0.90)	(0.67)	(0.73)	(0.98)	(0.54)	(0.44)	(0.37)	(1.00)	(0.36)	(0.96)	(0.02)	(0.00)	(0.00)	

Note: P-values in parentheses = "* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$".

Equation 10 and 11. Equation 10 incorporates the collective IC value, whereas Equation 11 examines the individual IC components.

$$\pi_{i,t} = \beta_1 \pi_{i,t-1} + \beta_2 \text{Eff}_{i,t}(\text{MPI}_{i,t}, \text{TECH}_{i,t}, \text{TECCH}_{i,t}) + \beta_3 \text{MVAIC}_{i,t} + \beta_4 \text{IncDiversity}_{i,t} + \beta_3 \text{IncDiversity}_{i,t} + \beta_4 \text{Leverage}_{i,t} + \beta_5 \text{Leverage}^2_{i,t} + \mu_{i,t} \sum \text{Macro Control}_{i,t} + \sum \text{Firm Control}_{i,t} + \varepsilon_{i,t} \quad (Eq.\ 10)$$

$$\pi_{i,t} = \beta_1 \pi_{i,t-1} + \beta_2 \text{Eff}_{i,t}(\text{MPI}_{i,t}, \text{TECH}_{i,t}, \text{TECCH}_{i,t}) + \gamma_1 \text{HCE}_{i,t} + \gamma_2 \text{SCE}_{i,t} + \gamma_3 \text{CEE}_{i,t} + \gamma_4 \text{RCE}_{i,t} + \beta_3 \text{IncDiversity}_{i,t} + \beta_4 \text{Leverage}_{i,t} + \beta_5 \text{Leverage}^2_{i,t} + \mu_{i,t} \sum \text{Macro Control}_{i,t} + \sum \text{Firm Control}_{i,t} + \varepsilon_{i,t} \quad (Eq.\ 11)$$

where i and t denotes bank and year, respectively. π is the performance indicator. The inclusion of a one-period lagged variable of π in the analysis accounts for persistence and path dependence in bank performance, capturing the influence of past profitability and performance on current outcomes and mirroring managerial behaviour that bases decisions on past performance benchmarks. Additionally, by controlling for the effects of past shocks to π , this approach helps to isolate the effects of the current period's variables, reducing potential endogeneity concerns between performance and predictors like efficiency, capital, and diversity and enhancing the accuracy of the estimates. *MPI* is the Malmquist productivity index, *EFFCH* is the catch-up effect of efficiency changes; *TECHCH* is the technical changes of frontier shifts; *MVAIC* is the intellectual capital efficiency; *CEE* is capital employed efficiency; *HCE* is human capital efficiency; *SCE* is structural capital efficiency. *IncDiversity* is the distribution of a bank's income across different sources. μ represent the macro and firm control variables as outlined in Section 3.3

The provided Random Effects regression in Table 8 assesses the impact of various intellectual variables on five distinct measures of operational efficiency, *EPS*, *ROE*, Revenue Growth and Profit Margin. The table analysis reveals π_{t-1} consistently shows a significant positive association with *Oper_ratio*, *EPS*, and *ROE*, and a significant negative one with *Rev_Growth*. *TFPCH*, a measure of total productivity change, exhibits a mixed effect, positively influencing *EPS* but negatively influencing *Oper_ratio*. *Leverage* and its quadratic form have contrasting impacts on performance indicators, indicating a non-monotonic relationship. The variable *MVAIC* also shows consistent significance across different metrics, positively affecting *Oper_ratio* and *Rev_Growth* but negatively impacting *EPS*, *ROE*, and *Profit_margin*. This finding suggests IC aids in operational efficiency and revenue growth but is not as good a predictor of profitability. *Inc_Diversity* can help banks to reduce risk; if a bank's income is concentrated in a single source, then a decline in that source could significantly impact the bank's overall profitability. Yet, the variable is positively associated with *EPS* yet not other profitability measures, highlighting the necessity for additional study.

In an examination of the analysis of the individual *IC* variables, as shown in Table 9, we delve into the relationships between *IC* factors, *CEE*, total factor productivity change (*TFPCH*), and technological change (*TECCH*) with various performance metrics in the banking sector. Surprisingly, we find that *RCE* and *HCE* exhibit negative associations with profitability measures like *ROE* and profit margin. This suggests that while *IC* may foster growth in certain dimensions such as operating ratio and revenue, it does not significantly contribute to overall profitability. Moreover, *CEE* is found to have a dual impact on performance metrics. On the one hand, it positively affects the operating ratio, indicating that better capital utilization improves operational efficiency. However, this improvement in efficiency comes at the cost of reduced profit margin, revealing a trade-off between these two performance dimensions. Additionally, income diversity positively impacts *EPS* but does not yield significant benefits in other areas, suggesting that its contribution to overall bank performance remains limited. Lastly, we uncover the complex influence of leverage effects on various bank outcomes, further highlighting the intricacies of the capital structure's role in shaping performance.

In a focus on efficiency variables, *TFPCH* demonstrates a positive effect on *EPS*, implying that efficiency gains can lead to higher earnings. However, its impact on the operating ratio is adverse, suggesting that overall operational performance might not see commensurate improvements despite enhanced efficiency. On the other hand, *TECCH* showcases a positive influence on *EPS*, underscoring its significance in bolstering profitability. These findings underscore the importance of understanding the nuanced relationships between different performance dimensions and the role of intellectual capital and technological advancements in shaping a bank's financial performance. Future research should focus on exploring strategies to harness the potential of intellectual capital while mitigating the trade-offs identified between capital efficiency and profitability. Additionally, deeper investigations into the underlying mechanisms driving the influence of technological change on bank performance can offer valuable insights into the banking industry's sustainable growth and success.

The two regression results from separate analyses of the relationships between various financial performance variables in the banking sector. The most important findings include a consistent positive association between lagged performance variable (π_{t-1}) and operating ratio, *EPS*, and *ROE*, indicating that prior period profitability contributes to current and future success. However, it shows a negative relationship with revenue growth, suggesting that better-

performing banks might experience diminishing growth over time. *Leverage* has mixed effects on *EPS*, implying that its influence on earnings varies depending on the specific context.

Implications of these findings highlight the significance of past profitability in driving current and future financial performance. Banks should consider leveraging their past success while recognizing the potential trade-offs between improved efficiency and profit margins. Furthermore, the impact of intellectual capital factors, such as *RCE*, on different performance metrics requires careful consideration. To achieve sustained growth and success, banks must explore strategies that harness their IC potential while adapting to the complexities of the banking industry. These findings underscore the need for a nuanced understanding of the relationships between financial performance variables, which can guide banks in formulating effective strategies and achieving long-term profitability and competitiveness.

Concerning this study's research questions, the relationship between *MVAIC* and bank performance in Taiwan yielded mixed results. Mixed support was found for *RCE*'s positive relationship with bank performance, indicating inconsistent effects across different contexts. There was no support for the hypothesis that *SCE* positively correlates with bank performance, hinting that structural aspects might not translate into improved performance. The relationship between *CEE* and bank performance also showed mixed support. Additionally, the study partially supported the positive association between bank efficiency, as measured by the Malmquist DEA, and bank performance, implying other influencing factors. The hypothesis that income diversity is positively associated with bank performance was weakly supported and partially supported in detail. Far from a simplistic portrait, the results reveal an intricate web of interactions between diverse facets of IC and bank performance in Taiwan, emphasizing the contextual sensitivities and complexities inherent in enhancing competitiveness. Unexpected findings, such as the reverse relationship with *HCE*, and partial support for relationships between bank efficiency and *IncDiversity*, emphasize the need for further research to understand the intricate dynamics shaping bank performance in Taiwan.

Table 8: Random Effects Regression Of Performance Indicators On Combiner Intellectual Variables

	Oper_ratio			EPS			ROE			Rev_Growth			Profit_margin		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.722***	0.704***	0.715***	0.346**	0.269	0.302	0.076*	0.075*	0.075*	-0.154	-0.168	-0.162	0.157**	0.151*	0.160**
	(16.45)	(15.80)	(15.76)	(2.59)	(1.66)	(1.90)	(2.20)	(2.18)	(2.17)	(-1.45)	(-1.62)	(-1.55)	(2.59)	(2.51)	(2.66)
TFPCH	-0.089*			0.079**			0.007			-28.090			-0.002		
	(-2.40)			(3.07)			(0.86)			(-0.54)			(-0.03)		
TECH		-0.065			0.030			0.003			13.990			-0.098	
		(-1.23)			(0.94)			(0.28)			(0.19)			(-1.22)	
TECCH			-0.047			0.051			0.003			-39.350			0.077
			(-0.96)			(1.31)			(0.30)			(-0.61)			(1.06)
MVAIC	0.013***	0.013***	0.013***	-0.001	0.007	0.004	-0.002***	-0.002***	-0.002***	5.438*	5.453*	5.299*	-0.017***	-0.017***	-0.017***
	(5.41)	(5.56)	(5.20)	(-0.07)	(0.71)	(0.40)	(-5.46)	(-5.44)	(-5.38)	(2.10)	(2.10)	(2.04)	(-5.48)	(-5.52)	(-5.37)
IncDiversity	-0.000	-0.000	-0.000	0.003***	0.004***	0.004***	-0.000	-0.000	-0.000	-0.006	-0.004	-0.006	-0.000	-0.000	-0.000
	(-1.42)	(-1.54)	(-1.37)	(3.85)	(3.32)	(3.55)	(-1.52)	(-1.49)	(-1.52)	(-0.11)	(-0.07)	(-0.11)	(-0.50)	(-0.63)	(-0.48)
Leverage	-144.200	-168.500	-146.000	0.000	0.000	0.000	38.490*	39.850*	38.630	25961.60	21139.60	36792.200	387.200**	393.200**	354.300**
	(-1.70)	(-1.96)	(-1.63)	(0.00)	(0.00)	(0.00)	(1.96)	(2.03)	(1.92)	(0.23)	(0.18)	(0.31)	(2.89)	(2.97)	(2.61)
Leverage^2	92.59	107.7*	93.41	-3.497**	-2.133	-2.141	-23.40	-24.23*	-23.46	-16470.6	-13594.3	-23349.0	-239.0**	-242.5**	-218.4**
	(1.75)	(2.01)	(1.67)	(-3.07)	(-1.69)	(-1.75)	(-1.92)	(-1.99)	(-1.87)	(-0.23)	(-0.19)	(-0.32)	(-2.87)	(-2.95)	(-2.58)
_cons	59.87	70.14	60.73	0.553	-0.00949	0.0407	-16.71*	-17.29*	-16.78*	-10369.3	-8321.2	-14849.8	-164.6**	-167.1**	-150.8**
	(1.67)	(1.93)	(1.61)	(1.02)	(-0.02)	(0.07)	(-2.01)	(-2.08)	(-1.97)	(-0.21)	(-0.17)	(-0.30)	(-2.90)	(-2.99)	(-2.63)
N	102.0000	102.0000	102.0000	29.0000	29.0000	29.0000	102.0000	102.0000	102.0000	100.0000	100.0000	100.0000	102.0000	102.0000	102.0000
R^2 within	0.3686	0.3285	0.3032	0.8028	0.6955	0.7214	0.9113	0.9113	0.911	0.1711	0.1671	0.1701	0.7546	0.7603	0.7555
R^2 between	0.9939	0.9938	0.9944	0.9985	0.9971	0.9957	0.9954	0.9951	0.9952	0.9061	0.9173	0.9129	0.9533	0.9535	0.9536
R^2 overall	0.9685	0.967	0.9667	0.9697	0.9544	0.9566	0.9682	0.968	0.968	0.2254	0.2231	0.2261	0.9105	0.912	0.9116
Wald Chi2	2702.83 ***	2575.65 ***	2558.48 ***	.	.	.	2683.26 ***	2662.83 ***	2663.17 ***	25.02 **	24.70 **	25.12 **	895.01 ***	911.71 ***	907.51 ***

Note: z-scores in parenthesis. TFPCH measures total productivity change, where $TFPCH > 1$ indicates growth and $TFPCH < 1$ indicates decline. TECH measures efficiency change, where $TECH > 1$ indicates improvement and $TECH < 1$ indicates decline. TECCH measures technological change, where $TECCH > 1$ indicates progress and $TECCH < 1$ indicates regress. SECH measures scale efficiency change, where $SECH > 1$ indicates improvement and $SECH < 1$ indicates decline. Wald Chi^2 H0: coefficients of the random effects being tested are equal to zero simultaneously

Table 9: Random Effects Regression Of Performance Indicators On Combiner Intellectual Variables

	Oper_ratio			EPS			ROE			Rev_Growth			Profit_margin		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.525***	0.496***	0.507***	0.308**	0.320**	0.261*	0.072	0.068	0.068	-0.154	-0.168	-0.161	0.149**	0.143**	0.144**
	(-10.070)	(-9.650)	(-9.390)	(-3.050)	(-2.590)	(-2.580)	(-1.780)	(-1.670)	(-1.700)	(-1.420)	(-1.580)	(-1.510)	(-3.210)	(-3.050)	(-3.110)
TFPCH	-0.066*			0.075**			0.006			-29.380			0.053		
	(-2.000)			(-2.700)			(-0.740)			(-0.550)			(-1.300)		
TECH		-0.089			0.022			-0.000			11.490			0.008	
		(-1.930)			(-0.700)			(-0.000)			(-0.150)			(-0.130)	
TECCH			-0.007			0.110**			0.007			-42.000			0.047
			(-0.160)			(-2.820)			(-0.650)			(-0.620)			(-0.880)
RCE	0.021***	0.022***	0.021***	-0.005	0.028	0.034	-0.002***	-0.002***	-0.002***	6.651	6.501	6.131	-0.032***	-0.032***	-0.031***
	(-7.120)	(-7.500)	(-6.770)	(-0.110)	(-0.530)	(-0.840)	(-3.590)	(-3.470)	(-3.380)	(-1.730)	(-1.660)	(-1.560)	(-10.370)	(-10.160)	(-9.960)
SCE	-0.042	-0.034	-0.044	-0.090	-0.089	-0.014	-0.019	-0.019	-0.018	9.837	10.300	2.991	-0.044	-0.046	-0.036
	(-1.010)	(-0.820)	(-1.030)	(-0.950)	(-0.750)	(-0.140)	(-1.730)	(-1.730)	(-1.590)	(-0.150)	(-0.150)	(-0.040)	(-0.860)	(-0.890)	(-0.700)
HCE	-0.016**	-0.018***	-0.018***	-0.003	0.001	-0.004	-0.003**	-0.003**	-0.003**	0.403	0.170	0.636	-0.012*	-0.011	-0.012*
	(-3.290)	(-3.730)	(-3.440)	(-0.830)	(-0.420)	(-1.200)	(-2.710)	(-2.640)	(-2.700)	(-0.060)	(-0.020)	(-0.090)	(-2.000)	(-1.860)	(-1.960)
CEE	0.366**	0.398**	0.342**	0.396	0.376	0.425	0.044	0.049	0.051	93.650	74.120	67.140	-1.667***	-1.644***	-1.627***
	(-2.860)	(-3.040)	(-2.590)	(-1.300)	(-1.000)	(-1.410)	(-1.140)	(-1.250)	(-1.340)	(-0.450)	(-0.350)	(-0.320)	(-10.570)	(-10.230)	(-10.310)
IncDiversity	-0.000	-0.000	-0.000	0.003	0.002	0.002	-0.000	-0.000	-0.000	-0.002	0.000	-0.001	-0.000	-0.000	-0.000
	(-1.190)	(-1.440)	(-1.110)	(-1.720)	(-0.990)	(-0.860)	(-1.170)	(-1.170)	(-1.180)	(-0.040)	(-0.010)	(-0.020)	(-0.090)	(-0.100)	(-0.120)
Leverage	-272.400***	-296.600***	-295.900***	0.000	0.000	0.000	32.400	34.370	31.910	19791.100	13299.100	27761.800	236.200*	251.900*	235.900*
	(-3.440)	(-3.790)	(-3.570)	(0.000)	(0.000)	(0.000)	(-1.580)	(-1.680)	(-1.540)	(-0.170)	(-0.110)	(-0.230)	(-2.420)	(-2.560)	(-2.370)
Leverage_2	170.900***	186.000***	185.300***	-3.563***	-2.235*	-2.492**	-19.550	-20.730	-19.210	-12921.900	-9049.600	-18019.300	-146.100*	-155.600*	-145.600*
	(-3.480)	(-3.830)	(-3.600)	(-3.400)	(-1.970)	(-2.870)	(-1.540)	(-1.630)	(-1.500)	(-0.180)	(-0.120)	(-0.240)	(-2.410)	(-2.560)	(-2.360)
Macro Control	included	included	included	included	included	included	included	included	included	included	included	included	included	included	included
Firm Control	included	included	included	included	included	included	included	included	included	included	included	included	included	included	included
_cons	114.900***	125.300***	124.900***	0.110	-0.383	0.140	-14.210	-15.050	-14.020	-7553.700	-4778.100	-10858.900	-100.700*	-107.400**	-100.700*
	(-3.43)	(-3.79)	(-3.56)	(-0.19)	(-0.57)	(-0.25)	(-1.63)	(-1.73)	(-1.60)	(-0.15)	(-0.10)	(-0.21)	(-2.43)	(-2.58)	(-2.39)
N	102	102	102	29	29	29	102	102	102	100	100	100	102	102	102
R^2 within	0.4383	0.4323	0.4008	0.8535	0.7772	0.8524	0.9108	0.9105	0.9109	0.1784	0.1744	0.1773	0.797	0.7916	0.7938
R^2 between	0.9955	0.9954	0.9951	0.9997	0.9993	0.9998	0.9968	0.9967	0.9967	0.932	0.9409	0.942	0.9942	0.9944	0.9944
R^2 overall	0.9769	0.9768	0.9758	0.9783	0.9674	0.979	0.9694	0.9692	0.9693	0.232	0.2295	0.2328	0.9571	0.9563	0.9567
Wald Chi^2	3587.95 ***	3576.65 ***	3423.71 ***	.	.	.	2691.83 ***	2674.24 ***	2688.00 ***	25.08 *	24.72 *	25.19 *	1897.62 ***	1859.56 ***	1876.92 ***

Note: z-scores in parenthesis. TFPCH measures total productivity change, where $TFPCH > 1$ indicates growth and $TFPCH < 1$ indicates decline. TECH measures efficiency change, where $TECH > 1$ indicates improvement and $TECH < 1$ indicates decline. TECCH measures technological change, where $TECCH > 1$ indicates progress and $TECCH < 1$ indicates regress. SECH measures scale efficiency change, where $SECH > 1$ indicates improvement and $SECH < 1$ indicates decline. Wald Chi^2 H0: coefficients of the random effects being tested are equal to zero simultaneously

4.4. Additional Analysis

To further analyze the sensitivity of bank performance, we employ the System-GMM estimator. As noted by Shahzad et al. (2020), studies on performance, intellectual capital, *Income Diversity*, and efficiency often encounter endogeneity issues. The System-GMM estimator effectively handles these concerns by tackling endogeneity, heterogeneity, and persistence in bank performance, as outlined by Blundell and Bond (1998). This method accounts for the unit root property and generates more precise estimates than alternatives (Bond 2002). Given these advantages, we utilize the one-step System-GMM, which provides asymptotically efficient estimates in a single step. The validity of the SGMM depends on two conditions: the instruments must correlate with the endogenous variables, but not the error terms, and second-order serial correlation in the errors should be absent despite allowing for first-order correlation. We verify these conditions using the Sargan test for overidentifying restrictions and the Arellano-Bond test for autocorrelation. In the SGMM regression methodology, determinants of bank performance were carefully chosen. *Income Diversity* and *Gross Domestic Savings* were selected as instrumental variables to address endogeneity bias. *Size*, *Solvency*, and *Leverage* were included as GMM variables to model direct impacts on performance. This approach provides a nuanced framework to understand the dynamics influencing bank success, demonstrating a commitment to robustness and relevance.

In assessing the results of the SGMM, we begin by reviewing results as demonstrated in 10 To begin with a focus particularly on the impacts of *TFPCH*, (*TECH*), (*TECCH*), (*MVAIC*), (*IncDiversity*), and Leverage. The findings for *TFPCH* show a negative relationship with the (*Oper_ratio*) and (*Rev_Growth*), but a highly significant positive relationship with (*EPS*). This suggests that changes in total factor productivity may drive profitability but adversely impact operational efficiency.

When considering *TECH*, the results show a significant positive relationship with *EPS*, but a negative relationship with *ROE* and *Rev_Growth*. This highlights that while technical efficiency changes may enhance earnings per share, they might also inhibit revenue growth and *ROE*. The *TECCH* impacts show a significant negative relationship with *Oper_ratio*, *ROE*, and *Rev_Growth*, but a less significant positive relationship with Profit Margin. The mixed impacts of technological changes necessitate strategic planning to harness their potential benefits.

Further, the study underscores the widespread influence of *MVAIC* on all performance metrics, with various significant positive and negative relationships observed. This points to the critical role of IC in organizational performance and the need for an in-depth understanding of its management and leverage. The negative impact of *IncDiversity* on most measures, except for a positive correlation with *EPS*, may suggest that income source diversification might increase earnings but lead to operational inefficiencies. Lastly, the findings on *Leverage* (including squared leverage) reveal the double-edged sword of debt financing, emphasizing the need for judicious capital management to fully harness the potential benefits while safeguarding against inherent vulnerabilities

In the analysis of the performance variables using the individual IC variables (see Table 11. we find *TFPCH* showed a negative relationship with *Oper_ratio* but a positive association with Profit Margin, implying productivity enhancements may improve profitability yet reduce operational efficiency. This highlights the need to balance productivity initiatives. For *TECH*, a positive relationship emerged with *EPS*, suggesting technical efficiency gains can increase earnings.

Regarding *TECCH*, positive correlations arose with both *Oper_ratio* and Profit Margin. These findings emphasize the merit of technology-focused strategies for boosting operational efficiency and profit margins. For *RCE*, mixed results appeared, with positive relationships with *Oper_ratio*, Profit Margin, and *ROE* but a negative association with *EPS*. This complexity underscores careful relational capital management, given its nuanced performance impacts.

The findings for *SCE* indicate its vital role in driving revenue growth and profitability through positive relationships, yet potential challenges translating it into operational efficiency given negative *Oper_ratio* and *EPS* correlations. *HCE* and *CEE* results were also mixed, highlighting the multifaceted nature of performance effects. *IncDiversity* exhibited mainly negative relationships except with *EPS*, suggesting diversification's double-edged sword nature. Lastly, the mixed results for *Leverage* and $Leverage^2$ underscore the nuanced interplay between capital structure and financial performance, once again suggesting that optimal leverage levels must be astutely calibrated to maximize benefits, such as positive impacts on *ROE* and Profit Margin while minimizing potential negative repercussions.

With regard to this study's research question, *MVAIC*'a role on bank performance in Taiwan yielded mixed results. For RQ 1, *RCE* was supported as positively correlated with bank performance, underlining the importance of relational aspects. The correlation between *SCE* and bank performance was partially supported, reflecting potential variances in structural capital's impact on performance. A positive correlation between *CEE* and bank performance was fully supported, whereas *HCE* was partially supported, highlighting complex dynamics in capital employment and human resources. RQ 2 supported the positive relationship between bank efficiency, as measured by the Malmquist DEA, and bank performance, reinforcing efficiency's critical role in banking success.

Contrarily, RQ 3's hypothesis that income diversity is positively associated with bank performance was not supported,

and subsequent examination showed mixed support. This result challenges conventional assumptions about income diversity's role in enhancing performance in Taiwan's banking sector. The findings reveal a multifaceted landscape, with supported relationships between *RCE*, *CEE*, and bank performance, partial support for *SCE* and *HCE*, and contradictions concerning income diversity.

Table 10: SGM Regression Of Performance Indicators On Combined Intellectual Variables

	Oper_ratio			EPS			ROE			Rev_Growth			Profit_margin		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.725***	0.713***	0.732***	0.346***	0.269	0.302*	0.163*	0.158*	0.160*	-0.154***	-0.167***	-0.161***	0.201	0.199	0.192
	(-8.22)	(-7.83)	(-8.82)	(-3.66)	(-1.68)	(-2.18)	(-2.17)	(-2.04)	(-2.2)	(-13.93)	(-12.17)	(-19.68)	(-1.48)	(-1.39)	(-1.43)
TFPCH	-0.0488			0.0787***			0.00739			-27.73			0.0481		
	(-1.36)			(-10.38)			(-1.01)			(-0.66)			-0.89		
TECH		-0.0717			0.0299**			-0.0146			14.07			-0.0244	
		(-1.10)			(-3.02)			(-1.11)			(-0.51)			(-0.26)	
TECCH			-0.0874**			0.0505			-0.00409			-37.28			0.104*
			(-2.66)			(-1.81)			(-0.45)			(-0.69)			(-2.16)
MVAIC	0.00899***	0.00929***	0.00907***	-0.000551	0.00652	0.00366	-0.00211***	-0.00210***	-0.00210***	5.568***	5.563***	5.487***	-0.0146***	-0.0146***	-0.0151***
	-3.91	-3.83	-4.11	(-0.21)	-1.23	-0.77	(-5.29)	(-5.09)	(-4.76)	-12.28	-13.12	-13.83	(-4.31)	(-4.09)	(-4.72)
IncDiversity	-0.0000549**	-0.0000658**	-0.0000553**	0.00333***	0.00351***	0.00364***	-0.0000093	-0.0000120*	-9.83E-06	-0.0062	-0.00391	-0.00632	-0.0000358	-0.0000427	-0.0000314
	(-2.77)	(-2.59)	(-3.08)	-8.15	-4.37	-4.8	(-1.70)	(-2.13)	(-1.67)	(-0.61)	(-0.34)	(-0.58)	(-0.80)	(-0.93)	(-0.73)
Leverage	-0.442	-0.41	-0.352	0.000	0.000	0.000	-0.385***	-0.345***	-0.362***	14099.4	11201.7	19666	-0.222	-0.0804	-0.354
	(-1.22)	(-1.47)	(-1.14)	(0.00)	(0.00)	(0.00)	(-8.25)	(-4.88)	(-6.02)	(-0.46)	(-0.42)	(-0.57)	(-0.66)	(-0.26)	(-0.98)
Leverage^2	0.830*	0.843***	0.808***	-3.497***	-2.133*	-2.141*	0.486***	0.473***	0.479***	-9093.1	-7412.2	-12693.4	-0.322	-0.373	-0.312
	(-2.28)	(-3.32)	(-3.83)	(-7.10)	(-2.16)	(-2.03)	(-4.99)	(-5.03)	(-5.01)	(-0.48)	(-0.44)	(-0.59)	(-0.99)	(-1.24)	(-0.74)
Macro Control	included	included	included	included	included	included	included	included	included	included	included	included	included	included	included
Firm Control	included	included	included	included	included	included	included	included	included	included	included	included	included	included	included
_cons	0.000	0.000	0.000	0.553**	-0.00948	0.0407	0.000	0.000	0=0.000	-5358.7	-4123.8	-7620.2	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	-2.59	(-0.02)	-0.1	(0.000)	(0.000)	(0.000)	(-0.42)	(-0.37)	(-0.54)	(0.000)	(0.000)	(0.000)
N	102	102	102	29	29	29	102	102	102	100	100	100	102	102	102
AR(1)[1]	-2.53 **	-2.48 **	-2.35 **	-1.43	-1.04	-1.83 *	-1.88 *	-1.88 *	-1.91 *	0.96	0.94	0.98	-1.95 *	-1.91 *	-2.13 **
AR(2)[2]	1.21	1.05	0.65	-0.97	-1.01	-0.66	-2.41 **	-2.04 **	-2.08 **	-0.99	-0.93	-1.1	-1.57	-1.04	-1.3
Sargan[3]	115.81 *	115.28 *	110.95 *	33.86 ***	47.19 ***	39.72 ***	116.48 **	128.05 ***	120.77 **	188.47 ***	188.67 ***	187.30 ***	162.17 ***	162.56 ***	163.14 ***
Hansen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.00	0.00	0.00	0.00	0.00
Wald chi[2,4]	5.30e+06 ***	2.36e+07 ***	4.82e+06 ***	660.47 ***	216.96 ***	327.46 ***	264956.67 ***	28563.94 ***	75241.33 ***	3.90e+06 ***	658193.75 ***	2.45e+06 ***	9832.01 ***	16196.22 ***	55078.47 ***

Note: z-score in parenthesis. [1]Arellano-Bond first-order autocorrelation test (Ho: no autocorrelation); [2]Arellano-Bond second-order autocorrelation test (Ho: no autocorrelation); [3]Test for overidentifying restrictions in GMM dynamic model estimation; Wald Chi^2 (Ho: estimated parameters not significantly different from the true values).

Table 11: SGM Regression Of Performance Indicators On Individual Intellectual Variables

	Oper_ratio			EPS			ROE			Rev_Growth			Profit_margin		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.560***	0.550***	0.579***	0.308***	0.320***	0.261***	0.114**	0.0915	0.110**	-0.153***	-0.167***	-0.160***	0.204***	0.195***	0.194***
	(-6.08)	(-5.84)	(-5.56)	(-5.02)	(-3.68)	(-5.72)	(-2.75)	(-1.84)	(-3.19)	(-16.92)	(-12.89)	(-20.86)	(-4.4)	(-4.45)	(-3.95)
TFPCH	-0.0647*			0.0749***			0.007			-29.04			0.0857**		
	(-2.33)			-6.58			-0.9			(-0.68)			-3.13		
TECH		-0.0748			0.0215*			-0.0272			11.71			-0.0197	
		(-1.42)			(-2.31)			(-1.44)			(-0.49)			(-0.35)	
TECCH			-0.0824**			0.110***			0.00643			-40.6			0.0721*
			(-3.02)			(-3.52)			(-0.98)			(-0.80)			(-1.96)
RCE	0.0125***	0.0131***	0.0120***	-0.00469	0.0276	0.0344	0.000186	0.000208	0.000191	6.731***	6.558***	6.257***	-0.0208***	-0.0213***	-0.0210***
	(-5.15)	(-4.22)	(-4.43)	(-0.13)	(-1.3)	(-1.15)	(-0.13)	(-0.15)	(-0.16)	(-5.95)	(-6.2)	(-7.62)	(-5.21)	(-5.21)	(-4.86)
SCE	-0.144	-0.126	-0.139	-0.0903	-0.0892	-0.0139	0.0489	0.0489	0.0487	9.651	10.13	2.995	0.137	0.111	0.131
	(-0.99)	(-0.83)	(-1.42)	(-0.88)	(-0.87)	(-0.13)	(-0.76)	(-0.84)	(-0.93)	(-0.42)	(-0.43)	(-0.16)	(-1.05)	(-0.85)	(-1.01)
HCE	-0.0148**	-0.0146*	-0.0136**	-0.00271	0.00149	-0.00419*	-0.00709	-0.0064	-0.00709	0.426	0.191	0.656	-0.0215	-0.0198	-0.0213
	(-2.61)	(-2.38)	(-2.87)	(-1.57)	(-1.06)	(-2.45)	(-1.77)	(-1.57)	(-1.79)	(-0.12)	(-0.05)	(-0.19)	(-1.69)	(-1.45)	(-1.80)
CEE	0.438	0.406	0.382	0.396	0.376**	0.425	0.0347	0.046	0.0399	92.04	72.96	65.57	-1.528***	-1.476***	-1.481***
	(-1.29)	(-1.24)	(-1.48)	(-1.86)	(-2.73)	(-1.75)	(-0.36)	(-0.56)	(-0.51)	(-0.83)	(-0.76)	(-0.75)	(-4.82)	(-4.88)	(-5.01)
IncDiversity	-0.0000222	-0.0000362	-0.0000206	0.00327*	0.00227***	0.00158	-0.0000193	-0.0000237	-0.0000193	-0.00215	0.000414	-0.00111	-0.0000274	-0.0000291	-0.0000273
	(-0.62)	(-0.97)	(-0.83)	-2.55	-3.55	-1.5	(-0.80)	(-0.97)	(-0.87)	(-0.22)	-0.04	(-0.11)	(-0.43)	(-0.42)	(-0.41)
Leverage	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10200.6	6332.5	14238.7	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	-0.28	-0.2	-0.38	(0.00)	(0.00)	(0.00)
Leverage^2	-0.0229	0.0758	0.0414	-3.563***	-2.235***	-2.492***	0.295	0.318	0.29	-6966.7	-4722.3	-9619.6	0.931	0.905	0.857
	(-0.04)	(-0.11)	(-0.1)	(-6.38)	(-3.67)	(-6.73)	(-1.03)	(-1.19)	(-1.17)	(-0.31)	(-0.25)	(-0.42)	(-1.53)	(-1.46)	(-1.59)
Macro Control	included	included	included	included	included	included	included	included	included	Included	Included	Included	Included	Included	Included
Firm Control	included	included	included	included	included	included	included	included	included	Included	Included	Included	Included	Included	Included
_cons	0.000	0.000	0.000	0.11	-0.383	0.14	0.000	0.000	0.000	-3499.3	-1833.8	-5143.4	0.000	0.000	0.000
	(0.00)	(0.00)	(0.00)	-0.33	(-1.39)	-0.33	(0.00)	(0.00)	(0.00)	(-0.23)	(-0.14)	(-0.33)	(0.00)	(0.00)	(0.00)
N	102	102	102	29	29	29	102	102	102	100	100	100	102	102	102
AR(1)[1]	-1.38	-1.46	-1.71 *	-1.59	-1.64	-1.64	-1.96 **	-2.87 ***	-2.12 **	1.02	1	1.03	-1.29	-1.3	-1.46
AR(2)[2]	0.44	0.36	0.25	-0.64	-1.5	0.8	-0.62	-1.04	-0.77	-0.9	-0.84	-1.02	-2.26 **	-1.66 *	-2.67 ***
Sargan[3]	141.71 ***	141.18 ***	128.78 ***	30.91 ***	40.55 ***	28.39 ***	126.19 ***	131.77 ***	139.22 ***	189.87 ***	190.23 ***	188.50 ***	121.51 ***	126.08 ***	142.08 ***
Hansen	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Wald chi[2][4]	164724.79 ***	52208.92 ***	8.03e+10 ***	2322.98 ***	115.75 ***	65.69 ***	221939.75 ***	323158.46 ***	2.12e+10 ***	1.14e+08 ***	5.03e+06 ***	1.43e+09 ***	75576.54 ***	95691.89 ***	89471.78 ***

Note: z-score in parenthesis. [1]Arellano-Bond first-order autocorrelation test (Ho: no autocorrelation); [2]Arellano-Bond second-order autocorrelation test (Ho: no autocorrelation); [3]Test for overidentifying restrictions in GMM dynamic model estimation; Wald Chi^2 (Ho: estimated parameters not significantly different from the true values.

5. Conclusion

This research investigates the influences of technical efficiency and MVAIC on Taiwanese banks' performance, considering bank-specific, industry-specific, and macroeconomic variables. Initially, a Fixed Effects regression model assesses the impact of technical efficiency and MVAIC at different performance levels. Subsequently, a one-step SGMM model is employed to confirm the results and address endogeneity, heterogeneity, and persistence concerns. This dual-method approach provides intricate insights into the factors governing banks' performance in Taiwan, contributing novel insights to the empirical literature.

The findings weave a multifaceted picture of banking performance in Taiwan. Intellectual capital (MVAIC) enhances efficiency and revenue growth but has negligible effects on profitability. Total factor productivity change (TFPCH) positively influences earnings per share but may undermine the operational ratio. Technological change (TECCH) exhibits mixed results on profitability metrics, improving profit margins but varying in its impact on ROE and revenue growth. Income diversification significantly impacts EPS positively, while the complex nonlinear associations of leverage with performance indicators call for careful calibration. Challenges were revealed with RCE and HCE, both negatively correlated with profitability metrics such as ROE. Capital-employed efficiency shows a double-edged effect, improving the operational ratio but reducing the profit margin. Lastly, past profitability and performance (lagged π) consistently underpin current operational and financial success.

5.1. Practical Implications

The findings from this study elucidate multifaceted strategies and have important policy implications for regulatory authorities, bank managers, and investors to enhance bank performance in Taiwan. Banks must work to increase technical efficiency, allowing more institutions to operate on the efficient production frontier. Recognizing that MVAIC is foundational to organizational success and consists of a continuous knowledge acquisition, creation, and dissemination cycle, banks should invest in acquiring experienced staff and providing ample training opportunities. Given the importance of MVAIC in value creation, banks should provide transparent disclosure about the intellectual resources they possess in annual or other relevant reports, and regulatory authorities should foster an environment that encourages detailed reporting. Banks should also seek to diversify their activities, as this has been shown to impact performance significantly. Overall, this research underscores the need for a comprehensive, nuanced approach for banking practitioners in Taiwan. The interplay of factors such as MVAIC, TFPCH, and TECCH, coupled with the complexities of leverage levels and the delicate balance between CEE and profitability, necessitates careful, tailored strategies—the overarching message advocates for a holistic perspective that acknowledges and navigates the multifaceted nature of modern banking.

5.2. Theoretical Implications

This research, grounded in RBT, provides rich contributions to the academic discourse, focusing on the complex interplay between tangible and intangible strategic assets, such as IC, in driving a firm's sustained competitive advantage. The study's conclusion reveals nuanced findings concerning the influence of IC components (RCE, HCE, and CEE), Total Factor Productivity Change (TFPCH), Technological Change (TECCH), Income Diversification, and Leverage on banking performance. While some relationships, such as MVAIC's impact on operational efficiency and revenue growth and TFPCH's influence on earnings per share (EPS), were positively affirmed, others, including negative associations with RCE and HCE on profitability metrics like ROE, present a more intricate picture.

These complexities, including the negative RCE, HCE, and CEE associations with profits and the trade-offs between efficiency and earnings, challenge conventional wisdom within the RBT framework and underline the importance of context-specific theoretical models. Given these findings, it is evident that the theoretical framework is partially supported and might benefit from further refinement or supplementation with additional perspectives to capture the nuanced relationships influencing bank performance fully.

Theoretically, the intricate relationships uncovered advanced paradigms like RBT by revealing profound complexities and nuances in how intellectual capital, technological innovations, and operational strategies influence bank profitability. The mixed, conditional, and paradoxical impacts challenge reductive perspectives, underscoring the contextual sensitivities and elaborateness inherent in enhancing competitiveness. By elucidating this multifaceted landscape, the study enriches the theoretical understanding of the dynamics driving banking performance, efficiency, and sustainability. These revelations highlight the need to evolve refined theoretical insights that capture the intricate interdependencies and trade-offs revealed across the dimensions of intellectual capital. Ultimately, the research spotlights the intricacies and subtleties fundamental to intellectual capital's role in shaping bank competitiveness, moving beyond simplistic narratives.

5.3. Limitations and Direction for Future Research

Notwithstanding its contributions, thits study is subject to certain inherent limitations. The generalizability of the findings is confined largely to the banking and finance sector within Taiwan, which may yield results peculiar to this region and industry. Such confinement makes it essential to consider cross-industry studies, acknowledging differences in regulatory environments, especially those relative to non-financial firms. The methods for measuring IC, including MVAIC, may lack precision and are often difficult to apply due to the requirement for extensive information. Furthermore, the focus on a single country – Taiwan – entails potential regulatory and legislative constraints that influence IC accounting practices and productivity. This limitation accentuates the need for caution in interpreting the study's applicability to different contexts with distinct regulatory regimes.

Given these limitations, future research presents opportunities to broaden and deepen understanding. Expanding the analysis to include banks from other countries, particularly within Africa, can enhance the generalizability of the findings. Investigating the intellectual capital performance of banks in various regulatory contexts and exploring other measurement methods besides MVAIC would add nuance to the study. Surveys could be employed to explore the causality and interrelationships among factors affecting IC and performance, pivotal to bank development. Further exploration of contextual variables, such as corporate governance, on mediating the effect of IC on bank performnce, would offer a richer perspective. Studies focusing on specific events or incorporating additional metrics and perspectives, would help substantiate the findings and contribute significantly to the existing literature.

Appendix A

Table 12: Descriptive Statistics of Key Variables

No.	DMU (Bank Name)	2010 - 2011	2011 - 2012	2012 - 2013	2013 - 2014	2014 - 2015	2015 - 2016	2016 - 2017	2017 - 2018	2018 - 2019	2019 - 2020	2020 - 2021	2021 - 2022	2022 - 2023
1	AGRICULTURAL BANK OF TAIWAN	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT	AGBT
2	BANCO BILBAO VIZCAYA ARG, TPE BRANCH†		BBVA	BBVA	BBVA	BBVA	BBVA	BBVA	BBVA	BBVA	BBVA	BBVA	BBVA	BBVA
3	BANK OF COMMUNICATIONS. TAIPEI BRANCH†			BOCC	BOCC	BOCC	BOCC	BOCC	BOCC	BOCC	BOCC	BOCC	BOCC	BOCC
4	BANK OF KAOHSIUNG	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW	BOKW
5	BANK OF PANHSIN PUBLIC COMPANY	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC	BOPC
6	BANK OF TAIWAN	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA	BOTA
7	BANK SINOPAC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC	BSPC
8	CATHAY UNITED BANK	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC	CUBC
9	CHANG HWA COMMERCIAL BANK	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB	CHCB
10	CHUNGHWA POST CO LTD	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO	CHPO
11	CITIBANK TAIWAN LIMITED†	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT	CTBT
12	COTA COMMERCIAL BANK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK	CCBK
13	CTBC BANK CO LTD		CTBC	CTBC	CTBC	CTBC	CTBC	CTBC	CTBC	CTBC	CTBC	CTBC	CTBC	CTBC
14	DBS BANK (TAIWAN)†			DBST	DBST	DBST	DBST	DBST	DBST	DBST	DBST	DBST	DBST	DBST
15	E. SUN COMMERCIAL BANK			ESUN	ESUN	ESUN	ESUN	ESUN	ESUN	ESUN	ESUN	ESUN	ESUN	ESUN
16	ENTIE COMMERCIAL BANK PUBLIC	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB	ENCB
17	FAR EASTERN INTERNATIONAL BANK	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB	FEIB
18	FIRST COMMERCIAL BANK		FCBK	FCBK	FCBK	FCBK	FCBK	FCBK	FCBK	FCBK	FCBK	FCBK	FCBK	FCBK
19	HSBC BANK (TAIWAN)†	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC	HSBC
20	HUA NAN COMMERCIAL BANK LTD.	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB	HNCB
21	HWATAI BANK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK	HWBK
22	JIH SUN INTERNATIONAL BANK	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB	JSIB
23	KGI BANK	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB	KGIB
24	KING'S TOWN BANK	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT	KBWT
25	LAND BANK OF TAIWAN	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT	LBOT
26	MEGA INTERNATIONAL COMMERCIAL BANK	MICB	MICB	MICB	MICB	MICB	MICB	MICB	MICB	MICB	MICB	MICB	MICB	MICB
27	O-BANK CO., LTD.	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL	OBCL
28	SHANGHAI COMMERCIAL & SAVINGS BANK	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB	SCSB
29	STANDARD CHARTERED BANK TAIWAN†	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT	SCBT
30	SUNNY BANK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK	SNBK
31	TAICHUNG BANK LTD	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL
32	TAIPEI FUBON COMMERCIAL BANK	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB	TFCB
33	TAIPEI STAR BANK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK	TSBK
34	TAISHIN INTERNATIONAL BANK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK	TIBK
35	TAIWAN BUSINESS BANK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK	TBBK
36	TAIWAN COOPERATIVE BANK	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL	TCBL
37	TAIWAN SHIN KONG COMMERCIAL BANK	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB	TSKB
38	UNION BANK OF TAIWAN	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT	UBOT
39	YUANTA COMMERCIAL BANK	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB	YUCB

Foreign banks noted by †

This document contains 1 Figures, 12 Tables, 11 Equations and 119 References.

4835 (errors:24) words

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