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The Knowledge Edge: Intellectual Capital and Competitiveness in Taiwanese Banking

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Abstract

This study explores determinants of bank performance in Taiwan by focusing on income diversification, leverage, and intellectual capital (IC). Utilizing data from 39 Taiwanese banks (2010-2022), the research employs System-GMM and random effects regression for robust findings. The Modified Value-Added Intellectual Coefficient (MVAIC) model measures IC, incorporating relational capital efficiency for comprehensive assessment. Five performance metrics—Operating Ratio, Earnings Per Share (EPS), Return on Equity (ROE), Revenue Growth, and Profit Margin—provide a holistic view of bank performance. Results reveal that income diversification enhances EPS, while leverage shows complex, nonlinear effects on performance. Relational and human capital efficiency (RCE and HCE) negatively correlate with ROE, indicating challenges in leveraging these IC components. Capital employed efficiency (CEE) improves operational efficiency but reduces profit margins. Efficiency metrics like the Malmquist Productivity Index (MPI) significantly influence performance, with total factor productivity (TFP) boosting EPS but adversely affecting the operating ratio. These findings highlight the need for strategic financial management and IC optimization. Implications for both theory and practice are discussed.

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

JEL Classification: M41, F30, D89

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1. Introduction

In an era where globalization has amplified the significance of intangible assets, the role of intellectual capital (IC) in value creation has become increasingly crucial. This is especially pertinent for the banking sector, which is the linchpin for economic development and financial stability (Karacan and Ergin 2011). The focus on IC is not merely academic but has tangible implications for the performance and competitiveness of banks. In the context of Taiwan, an emerging economy[1] that has shown resilience amid global disruptions (KPMG 2022), understanding the impact of IC on banking efficiency becomes imperative. This study aims to fill the empirical gap by evaluating the role of IC in firm efficiency in Taiwan's banking sector, thereby offering insights for firms on ways to improve innovation, knowledge management, employee productivity, customer satisfaction, and competitive advantage (Lewis and Mazvancheryl 2011).

Taiwan's financial structure hinges critically on its banking system, distinguishing itself from developed nations. Unlike market-based systems prevalent in advanced economies, Taiwan's financial landscape is predominantly bank-centric (Chen et al. 2023). This characteristic aligns with the financial architectures typically observed in emerging markets (Yadav and Pathak 2013). As the cornerstone of Taiwan's service sector, banking significantly propels the country's economic engine, with its assets dwarfing the nominal GDP[2]. Over time, Taiwan's banking sector has undergone a metamorphosis, shaped by reforms encompassing prudential norms, interest rate liberalization, operational digitalization, and market entry of new private and foreign entities. Despite an initial surge in competition in the early 2000s, the industry now grapples with declining competitive vigour and profitability. Given Taiwan's global economic aspirations and the banking sector's pivotal role, a thorough examination of factors influencing bank performance is both timely and imperative.

To address these challenges and opportunities, this study employs the resource-based view of the firm as its theoretical framework. This perspective posits that superior performance stems from the strategic organization and deployment of key resources, with IC emerging as a critical asset in knowledge-intensive sectors like banking. This approach is particularly salient for Taiwan's banking industry, which must balance a conservative stance—necessitated by regional geopolitical risks—with global competitiveness. IC, encompassing human expertise, organizational processes, and relational networks, serves as a cornerstone for sustainable competitive advantage in this context, potentially offering insights into how Taiwan's banks can navigate their complex operating environment while striving for efficiency and growth.

This study addresses the critical role of IC in the globalized banking sector by investigating three key relationships: IC and firm performance, technical efficiency and bank performance, and income diversity's influence on performance. Employing Fixed Effects regression and Generalized Method of Moments models for robustness, alongside Malmquist efficiency calculations, we uncover a complex landscape of banking performance drivers. Our findings reveal nuanced relationships between IC components, efficiency metrics (including Total Factor Productivity Change and Technological Change), and income diversity. Grounded in Resource-Based Theory, this study challenges conventional wisdom by demonstrating IC's limited impact on profitability, mixed efficiency effects, and a positive link between income diversification and Earnings Per Share. These insights offer valuable guidance for policymakers, investors, and bank managers in Taiwan, potentially serving as a blueprint for emerging economies facing similar challenges. By integrating methodological rigour with theoretical underpinnings, this research contributes to a deeper understanding of the multifaceted factors shaping bank performance in evolving financial landscapes.

The remainder of this paper is structured as follows: Section 2 reviews the relevant literature and poses the research questions. Section 3 outlines the methodology used in this study. Section 4 presents the results of the analysis. Section 5 provides a robustness analysis. Finally, Section 6 concludes with a discussion and summarizes the implications for theory and practice.

2. Review of literature and formulation of hypothesis

2.1. Definition and Components of Intellectual Capital and Its Global Impact

Intellectual capital (IC) is a conceptual framework that encompasses a firm's productive knowledge assets and has garnered substantial scholarly attention (Bayraktaroglu et al. 2019). The primary components of IC are human capital, organizational capital, and social capital, which are key in understanding and valuing an organization's diverse knowledge resources as assets in specific contexts. Empirical research in this area has grown extensively, consistently showing that these components significantly enhance firm performance (Rehman et al. 2022). Traditional models for measuring IC, such as Pulic (1998)'s VAIC^{TM} model, focus mainly on three efficiency components: human capital efficiencies (HCE), capital employed efficiencies (CEE), and structural capital efficiencies (SCE). This model is popular for its simplicity and utility in enabling effective comparisons across enterprises or countries. However, it has

[1] Emerging country classification as per MSCI (2023)

[2] In 2021, Taiwan's banking-system assets represented 292% of nominal GDP, surpassing most regional peers (Ratings 2023).

been criticized for its narrow focus on labour and capital investment efficiency, neglecting IC efficiency and excluding relational and innovation capital (Sthle et al. 2011; Smriti and Das 2018). To address these limitations, Ulum et al. (2017) amended the original VAIC model to include relational capital efficiency (RCE), resulting in the modified VAIC (MVAIC) method.

Global studies corroborate the importance of IC in enhancing firm performance. Research in Asia, Australia, and the Middle East has shown a positive correlation between IC and performance metrics like ROA and ROE (Xu and Li 2022; Cindiyasari et al. 2022; Ousama et al. 2020). However, the relationship is nuanced, influenced by factors such as income diversification in East Africa and human capital efficiency in South Korean manufacturing (Githaiga 2020; Xu and Wang 2020). Despite geographical variances, the overarching consensus is that IC positively correlates with firm success, although its effective management, especially of human capital, remains a challenge (Cindiyasari et al. 2022). Below is an outline of the four IC components and their association with performance.

2.2. Intellectual Capital and Performance Impact

2.2.1. Human Capital

Human capital, encompassing employees' collective knowledge, skills, education, and experience, is a cornerstone of intellectual capital and a vital source of organizational competitive advantage. It serves as an internal driver of economic growth (Lanfang et al. 2021), with the OECD emphasizing its role in propelling economic activity, competitiveness, and prosperity (Anaduaka et al. 2014). Human capital efficiency (HCE) is a key metric used to assess its impact on organizational performance. Research on HCE's influence shows mixed results across different contexts. In Taiwan, some studies found no significant impact of HCE on performance (Tsao and Hung 2014; Xìnpú 2012), while others revealed a significant positive impact in the banking sector (Zheng et al. 2018). Similarly, studies in China (Xiaopeng et al.) and broader Asia (Zheng et al. 2018) present varied findings, underscoring the importance of geographical and industry-specific factors in understanding the relationship between human capital and organizational outcomes.

2.2.2. Capital Employed Efficiency (CEE)

Capital Employed Efficiency (CEE), which measures the value generated per dollar of asset investment, has varying regional impacts. It boosts performance in several Southeast Asian countries and the Middle East (Esti Damayanti et al. 2021; Rehman et al. 2013). However, it demonstrates weak performance in Kuwait (Abdulsalam et al. 2011) and adverse post-crisis effects in Turkey (Nassar 2018). Notably, a research gap exists regarding CEE's influence on Taiwanese banks.

2.2.3. 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. It involves creating a supportive environment that encourages experimentation, learning, and the integration of knowledge. SCE is a component of IC 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 a moderated performance impact (Nguyen et al. 2023).

2.2.4. Relational Capital Efficiency (RCE)

Relationship Capital Efficiency (RCE), a vital intangible asset derived from an organization's external interactions, influences metrics like customer loyalty and market image. The strategic cultivation of RCE theoretically enhances competitiveness and efficiency (Efenyumi et al. 2022). However, research findings are mixed. For instance, Shairi et al. (2021) found an inverse but insignificant relationship, while Sohel Rana and Hossain (2023) demonstrated a significant negative relationship. These inconsistent findings could be attributed to differences in banking environments, regulatory frameworks, or the extent to which banks rely on relationship capital for their business models, which may affect how RCE impacts financial performance.

2.3. Insights on Efficiency and Bank Performance

The literature provides a multifaceted view of the factors that contribute to bank efficiency and performance, particularly in Taiwan. Various methodologies, such as non-parametric approaches and chance-constrained data envelopment analysis (DEA), have been employed to measure and improve these metrics (Kong et al. 2017; Chen 2002). The Malmquist index is another tool globally employed to measure productivity growth in banking sectors. It has been beneficial in identifying shifts in productivity post-deregulation and assess efficiency-driven growth patterns (Lu et al. 2013; Isik and Hassan 2003). This index provides an additional perspective for understanding and improving banking efficiency and performance.

Research in other regions, such as Indonesia and India, also focuses on operational strategies for improving banking efficiency and performance (Anik et al. 2021; Suardi and Chandra 2014). In Indonesia, financial performance has been found to mediate the relationship between IC and Good Corporate Governance (GCG), thereby enhancing performance (Anik et al. 2021). In Turkey, foreign banks have been shown to outperform domestic banks, suggesting that different operational strategies can lead to performance improvements (Ünlü et al. 2022). Mergers generally enhance cost efficiency, although the gains are not uniform across all cases (Bonnet and Philip Schain 2020).

Improving bank efficiency and performance is a complex but achievable objective. Various methodologies and tools, such as the Malmquist index, offer ways to measure and improve these metrics (Berg et al. 1992, 1993). While traditional factors like mergers and size often contribute to efficiency gains, the role of IC and external factors adds complexity to the landscape of performance improvement (Ting et al. 2021a; Kweh et al. 2021).

2.4. Income Diversity and Bank Performance

The impact of bank income diversification on financial performance has become a focal point of contemporary research. 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). The literature on income diversification's impact on bank performance is complex and influenced by geographical and economic factors. Several studies show a positive correlation with profitability (Addai et al. 2022; Luu et al. 2020), whereas other findings suggest limited or no positive effects (Ho 2020; Nguyen et al. 2021; Wulandari et al. 2021).

Moderating factors like bank size and business model can significantly shape the effects of income diversification. This is particularly pertinent for Taiwan, given its diverse banking sector. There is a consensus on the need to explore the conditions for positive outcomes, including risk management and tailored diversification strategies (Nguyen et al. 2019; Wulandari et al. 2021). Recent research sheds light on the efficiency implications of non-traditional banking (Najam et al. 2022), emphasizing the growing imperative for targeted research on the diversification-performance relationship in Taiwan's evolving banking sector.

2.5. Research Gap

Despite the extensive research on IC, income diversification, and bank performance globally, there is a notable lack of focused studies on the Taiwanese banking sector. Specifically, the application of the MVAIC model to include RCE, the use of comprehensive performance metrics beyond traditional measures, and the assessment of efficiency changes using the Malmquist Productivity Index (MPI) are underexplored. Additionally, the mixed results on the impact of income diversification, relational, and human capital efficiency on bank performance indicate a need for targeted research to understand these dynamics within Taiwan's unique banking environment. This study aims to fill these gaps by providing a holistic analysis of the determinants of bank performance in Taiwan, incorporating innovative methodologies and a broad set of performance metrics.

2.6. Theoretical Framework

The Resource-Based View (RBV) is a cornerstone for understanding how banks can achieve long-term success and profitability. This theory posits that a firm's unique resources and capabilities, both tangible and intangible, are pivotal for gaining a sustainable competitive advantage and thereby enhancing performance (Vu et al. 2022, 2023; Martens et al. 2023). Bressan et al. (2022) further argues that the heterogeneity of these resources among firms explains the variations in their profitability. This concept is particularly relevant for assessing bank performance, especially in the context of a knowledge-based economy where IC has been identified as a significant driver of sustained competitive advantages (Martens and Bui 2024). Studies have emphasized the role of IC, characterized by its scarcity, value, and non-replicability, in achieving lasting competitive advantage and influencing bank performance (Mikalef and Gupta 2021; Isola et al. 2020). The RBV framework underscores the importance of effectively organizing these strategic resources, including IC, to maximize bank value and performance.

2.7. Research Questions

In light of the literature surveyed, this paper establishes three central research questions:

(H1) Is there a positive relationship between the Modified Value-Added Intellectual Coefficient (MVAIC) and bank performance in Taiwan?

(a) Is relational capital efficiency (RCE) positively correlated with bank performance in Taiwan?

(b) Is structural capital efficiency (SCE) positively correlated with bank performance in Taiwan?

(c) Is capital employed efficiency (CEE) positively correlated with bank performance in Taiwan?

(d) Is human capital efficiency (HCE) positively correlated with bank performance in Taiwan?

(H2) Is bank efficiency, as measured by the Malmquist DEA, positively associated with bank performance in Taiwan?

(H3) Is income diversity 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 from 44 Taiwanese commercial banks operating between 2010 and 2022, including domestic and foreign entities. This period encompasses significant economic events and regulatory changes, providing a robust context for analyzing trends and patterns in bank performance. As shown in Table 1, the sample was pruned to 39 banks due to data unavailability, resulting in a final sample of 33 domestic banks (84.6%) and six foreign banks (15.%). Despite excluding some banks to maintain balanced panel data for efficiency score calculation, this selection still significantly represents the Taiwanese banking sector in terms of total assets. Table **??** outlines the banks involved in the study over the study's time frame..

Table 1: Data Sample

Description	No. of Banks	Percent
Initial Sample	44	111.4%
Banks with unavailable 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%

3.1.1. Descriptions and measurement of variables

This study's dependent variable is bank performance, traditionally measured by Return on Assets, Return on Equity, and Net Interest Margin. To provide a more comprehensive view, this study follows Choiriyah et al. (2020) and examines performance via the following five metrics: Operating Ratio (*Oper_Ratio*), Earnings Per Share (*EPS*), Return on Equity *(ROE*), Revenue Growth (*Rev_Growth*), and Profit Margin (*Profit_Margin*). These metrics evaluate operational efficiency, profitability, shareholder returns, growth trends, and cost management, each influenced by unique factors. This multifaceted approach allows for a nuanced understanding of a bank's financial health, avoiding unwarranted assumptions of interdependency among these measures. By incorporating these diverse metrics, we gain broader insights into different dimensions of bank performance, including cost efficiency, revenue generation, and shareholder value, providing a more holistic view than traditional metrics alone. Figure 1 illustrates bank performance measures by domestic and foreign banks in addition to the IC proxy (MVAIC) which is discussed in Section 3.3

3.2. Measurement of Efficiency

Data Envelopment Analysis (DEA) is employed to assess efficiency changes over time for each bank due to its ability to handle multiple inputs and outputs without needing a predefined functional form, chosen for its straightforwardness and minimal assumptions. Within this framework, the Malmquist Productivity Index (MPI) is used to calculate the efficiency change, which is a composite measure of technical change and efficiency change, calculated as the product of the technical change index (T) and the efficiency change index (TE), using an input-oriented model that considers banks' control over inputs like interest expenses and operating expenses (Banker et al. 1996).

The output distance function measures the distance between individual observations and the optimal performance benchmark. The production technology is represented as $T^t = \{X_t, Y_t\}$, where X_t is a vector of inputs at time t and Y_t is a vector of outputs at time t. The output distance function at time t, $D_0^t(X_t, Y_t)$, is defined as:

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

The Malmquist productivity index is calculated as:

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

A value greater than 1 indicates an improvement in input-output efficiency, while a value less than 1 represents a decline in efficiency.

3.3. Measurement of intellectual capital

Following the methodology of Martens and Bui (2024) and Xu and Li (2022), this study employs the MVAIC model as a proxy for IC, serving as the independent variable, computed as the sum of four key components: HCE, SCE, CEE, and RCE, as defined by Equation 3, where HCE, SCE, CEE, and RCE are calculated from VA/Human Capital, SC/VA, VA/Capital Employed, and expenditures/VA, respectively, with higher values indicating greater efficiency in IC value creation.

$$MVAIC_{i,t}=HCE_{i,t}+SCE_{i,t}+CEE_{i,t}+RCE_{i,t} \quad (Eq.\ 3)$$

Value Added itself is defined as the difference between output and input. Output comprises total bank revenue, including interest and non-interest income, such as fees and commissions. Input is calculated as operational costs, which include interest, administration, and other expenses but excludes personnel costs.

3.4. Macro and Firm Control Variables

This study integrates macro-specific and firm-specific control variables, as detailed in Table 2, to isolate the impact of potential confounders on the hypotheses. The macro-specific control variables include Population Change, GDP Growth, Gross Domestic Savings, and Inflation, each reflecting different economic dynamics and health aspects. Year effects are also controlled for through dichotomous variables to capture temporal trends. Additionally, firm-specific control variables such as Size, Return on Assets, Capitalization, and Leverage are included to isolate their impact on bank performance from other predictors. A quadratic term for leverage is incorporated to account for potential non-linear relationships between leverage and performance.

Table 2: Variable Descriptions and Formulas

Variable	Abbreviation	Definition	Formula
Performance Indicators			
Operating Ratio	Oper_ratio	Efficiency of expenses to revenue	Source: Calculated
Earnings Per Share	EPS	Profitability per outstanding share	Source: BankFocus
Return on Equity	ROE	Net income divided by equity	Source: BankFocus
Revenue Growth	Rev_Growth	Increase in revenue over a period	Source: Calculated
Profit Margin	Profit_margin	Profitability via net income to revenue ratio	Source: Calculated
Firm Control Variables			
Size	Size	Natural log of firm's total assets	Source: Calculated
Return on Assets	ROA	Profitability relative to total assets	Source: Calculated
Capitalization	Cap	Measure of a firm's capital structure	Source: Calculated
Leverage	Lev	Ratio of total debt to equity	Source: Calculated
Macro Control Variables			
Population Change	Pop_change	Population change over time	Source: World Bank
GDP Growth	GDP_growth	Economic performance over time	Source: World Bank
Gross Domestic Savings	GDS	Total savings as a percentage of GDP	Source: World Bank
Inflation	Inflation	Rate of price increase for goods and services	Source: World Bank
Intellectual Capital Components			
Modified Value Added IC	MVAIC	Overall intellectual capital efficiency	Source: Calculated
Human Capital Efficiency	HCE	Efficiency of human capital	Calculated: VA/HC
Structural Capital Efficiency	SCE	Efficiency of structural capital	Calculated: SC/VA
Capital Employed Efficiency	CEE	Efficiency of capital employed	Calculated: VA/CE
Relational Capital Efficiency	RCE	Efficiency of relational capital	Calculated: RC/VA
Value Added	VA	Total value added	Source: Calculated
Efficiency Metrics			
Malmquist Productivity Index	MPI	Measures productivity changes over time	Source: Calculated
Technical Efficiency	TE	Compares output to best practice frontier	Source: Calculated
Technical Change	TC	Assesses shifts in best practice frontier over time	Source: Calculated

Note: Definitions and formulas are provided for clarity.

4. Results

4.1. Bank Performance, Efficiency, and Intellectual Capital

Figure 1 illustrates the performance metrics and IC as measured by the MVAIC variable, for domestic and foreign banks in Taiwan from 2010 to 2022. The data reveals consistent IC performance, peaking in 2022. While ROE shows a minor decline, EPS indicates domestic banks outperforming their foreign counterparts. Revenue growth, operational efficiency, and profit margin exhibit significant fluctuations in 2015 and 2020 but stabilize towards the end of the period, suggesting resilience in domestic banks and volatility in foreign entities.

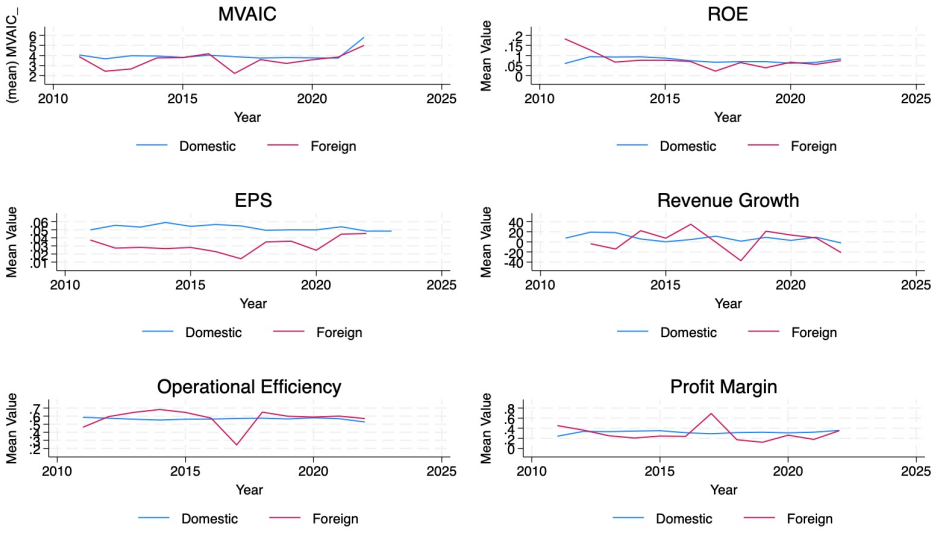

Figure 1: Performance measures by domestic and foreign Banks

The descriptive statistics of the five performance variables are presented in Table 3 (Panel A). The average Oper_Ratio is 0.57 (SD = 0.18), indicating moderate firm variability. EPS and ROE average 0.05 and 0.075 respectively, with ROE showing slightly higher variability. The IC variables (MVAIC, HCE, SCE, CEE, and RCE) display means ranging from 0.17 to 3.88, with RCE exhibiting the highest variation. Panel B presents efficiency results for local and foreign banks. The Malmquist Productivity Index (MPI) means are comparable (local: 1.01, foreign: 1.02), though foreign banks show greater variability in MPI, Technical Change (TC), and Technical Efficiency (TE). Panel C summarizes annual efficiency scores from 2010 to 2022. Fluctuations are evident, with TE peaking at 1.07 in 2021-2022 and Total Factor Productivity (TFP) reaching a high of 1.11 in 2020-2021, indicating a period of productivity growth. Panel B also highlights the top eight firms with TFP exceeding 1, led by JSIB with a TFP of 1.071.

4.2. Correlation Analysis

An examination of the correlation matrix (Table 4) 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. Modeling Bank Performance

To account for variations both within and between banks, this study employs random effects regression. This model allows for differing intercepts across the sampled banks, capturing intrinsic variations in factors such as efficiency, capital, and diversity. Statistical support for this choice comes from the Hausman test ($\chi^2 = 3.37$, p-value $= 0.3382$) favouring the random effects model. This methodology enables a robust, flexible, and efficient analysis of time-invariant and time-variant factors affecting bank performance. Equation 4 focuses on collective IC value, while Equation 5 examines individual IC components, both serving to outline the models used for assessing bank performance.

Table 3: Descriptive Statistics and Malmquist Index Summary

Descriptive Statistics										Malmquist Index Summary			
Variables	**Obs**	**Mean**	**SD**	**Med**	**Variables**	**Obs**	**Mean**	**SD**	**Med**	**Year(s)**	**TFP**	**TC**	**TE**
Panel A - Key Study Variables										***Panel C - Malmquist Index***			
Performance Indicators					*Efficiency Variables - 2Outputs*					2010–2011	.	.	.
Oper_Ratio	411	0.568	0.188	0.548	Interest Income	411	7.80e5	7.64e5	4.06e5	2011–2012	0.989	0.965	1.033
EPS	195	0.045	0.038	0.036	Fee Comm Income	466	1.53e5	2.16e5	8.32e4	2012–2013	1.023	1.013	1.035
ROE	411	0.075	0.044	0.076	*Intellectual Capital*					2013–2014	1.009	0.981	1.032
Rev_Growth	399	7.318	38.026	5.072	MVAIC	411	3.846	2.552	3.139	2014–2015	1.006	1.002	1.004
Profit_Margin	411	0.314	0.203	0.331	HCE	411	2.788	1.413	2.616	2015–2016	1.028	1.004	1.012
					SCE	411	0.380	0.275	0.420	2016–2017	0.982	1.021	0.972
Efficiency Variables - 4Inputs					CEE	411	0.587	0.316	0.645	2017–2018	0.987	0.992	0.996
Interest Exp	466	2.74e5	3.25e5	1.42e5	RCE	411	1.719	3.084	0.775	2018–2019	0.992	1.009	0.991
Fee & Comm Exp	377	2.89e4	3.51e4	1.97e4						2019–2020	1.031	1.009	1.041
Operating Exp	466	4.81e5	9.36e5	2.07e5	*Income Diversity*					2020–2021	1.107	1.012	1.100
Provisions	466	7.53e5	3.77e6	0.00	Inc_Diversity	410	6.114	50.018	2.674	2021–2022	0.823	1.073	0.733
Macro Control Variables					*Firm Control Variables*					***Top firms (TFP > 1)***			
Pop Change	466	0.128	0.201	0.200	Size	411	17.090	1.235	17.043	JSIB	1.071	1.013	1.057
GDP Growth	466	3.123	1.296	2.800	ROA	411	0.054	0.038	0.052	BOPC	1.059	1.021	1.036
GD Savings	466	34.181	3.172	33.840	Capitalization	411	14.345	1.313	14.401	ENCB	1.051	1.000	1.052
Inflation	466	1.152	0.880	1.300						CTBT	1.048	1.000	1.048
Panel B - Firm Efficiency Results										KTBK	1.043	1.00	1.043
Domestic					*Foreign*					OBCK	1.037	1.020	1.039
Local MPI (TFP)	–	1.009	0.091	1.009	Foreign MPI (TFP)	–	1.018	0.155	1.019	CCBK	1.029	1.000	1.029
Tech Change (Local)	–	1.011	0.087	1.011	Tech Change (Foreign)	–	1.009	1.138	1.009	HSBC	1.027	1.003	1.025
Tech Efficiency (Local)	–	1.005	0.069	1.0049	Tech Efficiency (Foreign)	–	1.012	0.076	1.012				

Note: SD = Standard Deviation, Med = Median. Macroeconomic data from ADB and IMF. Bank size is ln(total assets). Capitalization is ln(total equity). MPI = Malmquist Productivity Index, TFP = Total Factor Productivity, TC = Technical Change, TE = Technical Efficiency. TFP >1 1 indicates growth, TFP <1 1 indicates decline. TE >1 1 indicates improvement, TE <1 1 indicates decline. TC >1 1 indicates progress, TC <1 1 indicates regress.

Table 4: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) Oper_Ratio	1												
(2) EPS	0.11	1											
(3) ROE	-0.24***	0.01	1										
(4) Rev-Growth	0.00	-0.00	0.27***	1									
(5) Profit_margin	-0.81***	-0.09	0.41***	0.02	1								
(6) MVAIC	0.01	0.08	0.19***	0.29***	-0.07	1							
(7) HCE	-0.59***	-0.06	0.48***	0.17***	0.31***	0.35***	1						
(8) CEE	-0.07	0.15	0.79***	0.21**	0.06	0.04	0.40***	1					
(9) SCE	0.00	-0.44***	0.33***	-0.03	0.13	0.07	-0.08	0.27***	1				
(10) RCE	0.54***	0.40**	-0.22**	0.20*	-0.34***	0.81***	-0.37***	-0.29***	0.00	1			
(11) Leverage	0.13**	-0.05	-0.15**	0.06	-0.21***	0.04	-0.18***	0.16*	-0.11	0.21**	1		
(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	
(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
(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***

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

$$\pi_{i,t} = \beta_1 \pi_{i,t-1} + \beta_2 \text{Eff}_{i,t}(\text{MPI}_{i,t}, \text{TE}_{i,t}, \text{TC}_{i,t}) + \beta_3 \text{MVAIC}_{i,t} + \beta_4 \text{IncDiversity}_{i,t} + \beta_3 \text{IncDiversity}_{i,t} + \beta_4 \text{Leverage}_{i,t} + \beta_5 \text{Leverage}^2_{i,t} + \mu_{i,t} \sum \text{Macro Control}_{i,t} + \sum \text{Firm Control}_{i,t} + \varepsilon_{i,t} \quad (Eq.\ 4)$$

$$\pi_{i,t} = \beta_1 \pi_{i,t-1} + \beta_2 \text{Eff}_{i,t}(\text{MPI}_{i,t}, \text{TE}_{i,t}, \text{TC}_{i,t}) + \gamma_1 \text{HCE}_{i,t} + \gamma_2 \text{SCE}_{i,t} + \gamma_3 \text{CEE}_{i,t} + \gamma_4 \text{RCE}_{i,t} + \beta_3 \text{IncDiversity}_{i,t} + \beta_4 \text{Leverage}_{i,t} + \beta_5 \text{Leverage}^2_{i,t} + \mu_{i,t} \sum \text{Macro Control}_{i,t} + \sum \text{Firm Control}_{i,t} + \varepsilon_{i,t} \quad (Eq.\ 5)$$

where i and t denotes bank and year, respectively. π is the performance indicator. The inclusion of a one-period lagged variable of π serves dual purposes: it captures the persistence and path dependence in bank performance and mitigates potential endogeneity between performance and key predictors like efficiency, capital, and diversity. Consequently, this methodological choice enhances the robustness and accuracy of the estimates. *Eff* represents the efficiency scores via MPI, *TC* and *TE*. The IC variable is captured via *MVAIC* in Eq.4 and via its four components in Eq.5. *IncDiversity* is the distribution of a bank's income across different sources. μ represents the macro and firm control variables as outlined in Section 3.4.

4.4. Random Effects Regression

The Random Effects regression analysis in Table 5 shows distinct patterns in Panels A and B. In Panel A, π_{t-1} consistently shows a significant positive association with *Oper_ratio*, *EPS*, and *ROE*, and a significant negative one with *Rev_Growth*. *TFP* positively influences *EPS* but negatively affects *Oper_ratio*, indicating mixed effects on productivity. *Leverage* and its quadratic form demonstrate a non-monotonic relationship with performance indicators. *MVAIC* positively affects *Oper_ratio* and *Rev_Growth*, but negatively impacts *EPS*, *ROE*, and *Profit_margin*, suggesting its varied influence on operational efficiency and profitability. Income Diversity positively impacts *EPS* but has limited effect on other performance metrics.

In Panel B, individual IC variables show *RCE* and *HCE* negatively associated with *ROE* and *Profit_margin*, indicating a limited role in enhancing profitability. *CEE* positively influences *Oper_ratio* but negatively affects *Profit_margin*, highlighting a trade-off between operational efficiency and profitability. *TFP* positively affects *EPS* but negatively impacts *Oper_ratio*, while *TE* shows a positive influence on *EPS*. These findings emphasize the multifaceted impact of IC and efficiency metrics on different aspects of bank performance, underscoring the importance of robustness testing to validate these relationships.

5. Robustness Analysis

The one-step System-GMM (SGMM) estimator assesses bank performance, addressing endogeneity and heterogeneity issues (Blundell and Bond 1998). This method provides more precise estimates than others (Bond 2002). The SGMM approach's validity relies on the relevance of instruments and the absence of second-order serial correlation in errors, confirmed by the Sargan and Arellano-Bond tests. Instruments like *Income Diversity* and *Gross Domestic Savings* mitigate endogeneity bias, while GMM variables such as *Size*, *Solvency*, and *Leverage* model their direct impacts on performance. This ensures robustness and relevance.

The SGMM analysis in Table 6 (Panel A) reveals that *TFP* negatively correlates with *Oper_ratio* and *Rev_Growth*, but positively with *EPS*, indicating a trade-off between profitability and operational efficiency. *TE* positively influences *EPS* but negatively affects *ROE* and *Rev_Growth*, showing that while TE boosts EPS, it may inhibit revenue growth and ROE. *TC* shows mixed effects, highlighting the need for strategic planning.

In contrast, Panel B shows that *RCE* and *HCE* negatively associate with *ROE* and *Profit_margin*, suggesting that these forms of IC enhance operational efficiency and revenue growth but not overall profitability. Conversely, *CEE* positively impacts the *Oper_ratio* but negatively affects the *Profit_margin*, indicating a trade-off between operational efficiency and profitability.

Further insights from Table 6 indicate that *TFP* positively affects the *Profit_margin* while negatively impacting the *Oper_ratio*, emphasizing a balanced approach to productivity. *TE* and *EPS* share a positive relationship, reinforcing technical efficiency's value in enhancing earnings. *TC* positively correlates with both *Oper_ratio* and *Profit_margin*, advocating for technology-focused strategies.

Lastly, *MVAIC* significantly influences all performance metrics, underscoring intellectual capital's critical role in bank performance. However, *IncDiversity* generally negatively impacts performance metrics but positively correlates with *EPS*, highlighting income diversity's role in enhancing earnings per share while suggesting a limited overall influence on bank performance.

6. Discussion & Conclusion

This study provides new insights into the determinants of bank performance in Taiwan, particularly focusing on income diversification, leverage, and various components of intellectual capital. Income diversification significantly impacts EPS positively, suggesting that a diversified income stream can enhance a bank's per-share profitability. This novel finding highlights the potential of income diversification as a strategic tool for Taiwanese banks.

The complex nonlinear associations of leverage with performance indicators underscore the need for careful calibration. Leverage exhibits both positive and negative effects on various performance metrics, indicating the importance of strategic financial management. This study was needed to shed light on the intricate dynamics of leverage in the Taiwanese banking sector, which has not been extensively explored in previous research.

Challenges are revealed with RCE and HCE, which are negatively correlated with profitability metrics such as ROE. This finding is partially supported by Nazir et al. (2021), who also find HCE is not significant in its contribution to profitability and that RCE negatively impacts profitability in the Taiwan bank setting. These findings diverge from previous studies (e.g., Ting et al. (2021b) and Young et al. (2009)), highlighting how temporal context and methodological approaches can yield distinct insights into the role of IC.

CEE shows a double-edged effect, improving the operational ratio but reducing the profit margin. This indicates that better capital utilization can enhance operational efficiency but may also lead to trade-offs that adversely impact profitability. Understanding this trade-off is crucial for bank managers aiming to optimize performance.

The efficiency variables, including TFP and TE, also play significant roles. TFP 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. Conversely, TE positively influences EPS, underscoring its significance in bolstering profitability. These findings align with previous research and provide a robust understanding of the efficiency-performance relationship.

The data was tested using the System-GMM estimator and random effects regression, with both methods supporting the robustness of the findings. Past profitability and performance (lagged π) consistently underpin current success, capturing performance dynamics and mitigating autocorrelation and endogeneity issues. This approach enhances estimate robustness and accuracy, underscoring the importance of sustained financial practices, aligning with Shiu (2006). The hypotheses regarding the positive relationship between income diversification and EPS (H3) and the influence of efficiency variables on performance (H2) are supported.

Overall, this study significantly advances our knowledge of the determinants shaping bank performance in Taiwan. The results illuminate the sophisticated interplay of IC, financial management practices, and performance metrics. Practical and theoretical implications will follow.

6.1. Practical Implications

The findings from this study provide essential strategies and policy implications for regulatory authorities, bank managers, and investors to enhance bank performance in Taiwan. Recognizing the trade-offs associated with CEE, banks should balance operational efficiency improvements with potential impacts on profit margins and carefully manage human, structural, and relational capital investments. Strategic initiatives should enhance relational and human capital while continuously monitoring their effects on financial performance. Adopting a balanced approach to leverage and optimizing debt levels to improve performance without incurring excessive risk is crucial. Leveraging efficiency gains, particularly in TFP and TE, can significantly boost earnings and profitability. The positive impact of income diversification on EPS suggests that banks should diversify their revenue streams to enhance shareholder value. These findings advocate for a holistic perspective, recognizing the interplay between IC, efficiency, leverage, and diversification in shaping modern banking practices in Taiwan.

6.2. Theoretical Implications

Anchored in RBV, this study extends the understanding of its application in the banking sector by highlighting the critical role of IC components, such as human and relational capital, in enhancing performance. It demonstrates the challenges I.C. presents regarding profitability, contributing to the RBV discourse on resource utilization. The study reinforces the importance of intangible resources (like IC) in creating value and competitive advantage, a fundamental tenet of RBV. The positive impact of income diversification on earnings per share further supports RBV's emphasis on diverse revenue streams as a strategic asset for superior performance. This research thus provides a robust framework for leveraging internal resources for enhanced performance in the banking sector.

6.3. Limitations and Direction for Future Research

While offering deep insights into this specific context, the study's focus on Taiwan's banking sector suggests opportunities for future research to expand the geographical scope and test the findings' applicability in diverse regulatory environments. Although the sample size was limited to 39 banks, it represented a significant portion of Taiwan's banking assets, ensuring robust analysis. Future studies could enhance the research by incorporating additional performance metrics beyond traditional financial indicators, particularly those related to sustainability and social impact. While the current study sheds light on the role of IC and efficiency in bank performance, future research could benefit from exploring the impact of corporate governance structures and other mediating factors. Additionally, employing mixed-method approaches, including qualitative surveys, could offer deeper insights into the causal relationships between variables. Incorporating more advanced measures of technological innovation could further enrich our understanding of long-term trends in banking performance. These directions for future research would build upon the current study's findings, providing a more comprehensive picture of the factors influencing bank performance in evolving financial landscapes.

Table 5: 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)
Panel A - Performance Indicators With Combined Intellectual Variable															
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)
TFP	-0.089*			0.079**			0.007			-28.090			-0.002		
	(2.40)			(3.07)			(0.86)			(0.54)			(0.03)		
TC		-0.065			0.030			0.003			13.990			-0.098	
		(1.23)			(0.94)			(0.28)			(0.19)			(1.22)	
TE			-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	-0.00948	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	102	102	29	29	29	102	102	102	100	100	100	102	102	102
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 χ^2	2702.83***	2575.65***	2558.48***	.	.	.	2683.26***	2662.83***	2663.17***	25.02**	24.70**	25.12**	895.01***	911.71***	907.51***
	Oper_ratio			EPS			ROE			Rev_Growth			Profit_margin		
Panel B - Performance Indicators With Individual Intellectual Variable															
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)
TFP	-0.066*			0.075**			0.006			-29.380			0.053		
	(2.000)			(2.700)			(0.740)			(0.550)			(1.300)		
TC		-0.089			0.022			-0.000			11.490			0.008	
		(1.930)			(0.700)			(0.000)			(0.150)			(0.130)	
TE			-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 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 χ^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. TFP measures total factor productivity change, where TFP $>$ 1 indicates growth and TFP $<$ 1 indicates decline. TE measures technical efficiency change, where TE $>$ 1 indicates improvement and TE $<$ 1 indicates decline. TC measures technical change, where TC $>$ 1 indicates progress and TC $<$ 1 indicates regress. SECH measures scale efficiency change, where SECH $>$ 1 indicates improvement and SECH $<$ 1 indicates decline. Wald χ^2 H0: coefficients of the random effects being tested are equal to zero simultaneously

Table 6: SGMM Regression Of Performance Indicators On 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)
Panel A - Performance Indicators With Combined Intellectual Variables															
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)	(2.20)	(13.93)	(12.17)	(19.68)	(1.48)	(1.39)	(1.43)
TFP	-0.0488			0.0787***			0.00739			-27.73			0.0481		
	(1.36)			(10.38)			(1.01)			(0.66)			(0.89)		
TC		-0.0717			0.0299**			-0.0146			14.07			-0.0244	
		(1.10)			(3.02)			(1.11)			(0.51)			(0.26)	
TE			-0.0874**			0.0505			-0.00409			-37.28			0.104*
			(2.66)			(1.81)			(0.45)			(0.69)			(2.16)
MVAIC	0.0099***	0.0093***	0.0091***	-0.00065	0.0065	0.0037	-0.0021***	-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	-0.0001**	-0.0001**	-0.0001**	0.0034***	0.0036***	0.0037***	-0.0001	-0.0001*	-0.0001	-0.0062	-0.0040	-0.0064	-0.0001	-0.0001	-0.0001
	(2.77)	(2.59)	(3.08)	(8.15)	(4.37)	(4.80)	(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	0.000	-5358.7	-4123.8	-7620.2	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(2.59)	(0.02)	(0.10)	(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)	-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)	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	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 χ^2	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 ***
Panel B - Performance Indicators With Individual Intellectual Variables															
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)	(4.40)	(4.45)	(3.95)
TFP	-0.0647*			0.0749***			0.007			-29.04			0.0857**		
	(2.33)			(6.58)			(0.90)			(0.68)			(3.13)		
TC		-0.0748			0.0215*			-0.0272			11.71			-0.0197	
		(1.42)			(2.31)			(1.44)			(0.49)			(0.35)	
TE			-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)	(1.30)	(1.15)	(0.13)	(0.15)	(0.16)	(5.95)	(6.20)	(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)	(1.50)	(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)	(0.20)	(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)	(0.10)	(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)	-1.38	-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)	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	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 χ^2	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).

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Appendix A

Table 7: 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 †