Review Article

From Silicon to Services: How Intellectual Capital Shapes Taiwan's Economic Transformation

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In today's knowledge-driven economy, Intellectual Capital (IC) is a crucial driver of corporate success and sustainability. This study examines the impact of IC—comprising Human Capital (HC), Structural Capital (SC), and Relational Capital (RC)—on firm performance across Taiwan's key industries: manufacturing, technology, and services. Through a comprehensive literature review and empirical analysis, the research explores how sector-specific IC management strategies enhance financial performance, innovation, and corporate value. The findings highlight the pivotal role of HC in fostering innovation, SC in optimizing operational efficiency, and RC in strengthening market positioning and customer loyalty. Additionally, the study identifies significant barriers to effective IC management in Taiwan, including challenges in strategic integration and the measurement of intangible assets. The results underscore the importance of tailored IC management practices for maintaining competitiveness in global markets, particularly in high-tech sectors. This research also contributes to the theoretical frameworks of Resource-Based View (RBV), Knowledge-Based View (KBV), and Human Capital Theory (HCT), offering strategic insights for policymakers and business leaders in leveraging IC for sustainable growth and innovation in emerging economies.

1. Introduction

1.1. Background and motivation

In today's knowledge-driven economy, Intellectual Capital (IC) is increasingly recognized as a pivotal factor in corporate success and sustainability. IC, comprising human capital, structural capital, and

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relational capital, represents the intangible assets that drive value creation and competitive advantage across industries[1]. The strategic significance of IC has been well documented, particularly in knowledge-intensive sectors where a strong correlation between IC and financial performance is consistently observed[2].

Taiwan's evolving economic landscape exemplifies the shift toward a knowledge-based economy, where the emphasis on intangible assets has become a cornerstone of its global competitive trends; digital transformation's impact on industries, notably in semiconductors and electronics, makes Taiwan a unique context for examining the role of IC in driving firm performance and innovation. The country's technological advancements and rising position in global innovation indices underscore the importance of understanding how IC contributes to organizational success.

This study is motivated by the need to explore IC's impact within Taiwan's distinct industries and address the challenges faced by researchers and practitioners. By investigating the drivers of IC performance, this research aims to offer strategic insights to enhance operational and market outcomes for firms in Taiwan. The study systematically reviews existing literature to assess how IC components—human, structural, and relational capital—contribute to key performance outcomes such as financial success, innovation, and overall corporate value. Additionally, it evaluates the methodologies used to measure and analyze IC's impact, identifying gaps in current research and offering insights for better understanding and managing IC within various industrial contexts.

The key research questions guiding this study are:

1. How does human capital affect firm performance and innovation in Taiwan?
2. What is structural capital's impact on operational efficiency and market performance?
3. How does relational capital influence customer satisfaction and business partnerships?
4. What are effective methods for measuring intellectual capital's impact on firm performance?
5. How do Taiwanese industries utilize intellectual capital for competitive advantage?

The findings are expected to inform policymaking, guide corporate strategies, and contribute to the broader theoretical framework of IC. This study addresses the critical need for region-specific research and offers valuable lessons for other emerging economies seeking to leverage intellectual capital for sustainable growth and global competitiveness.

The rest of this study is structured as follows: Section 2 provides a comprehensive literature review, defining IC and its components of Human Capital (HC), Structural Capital (SC), and Relational Capital

(RC) and exploring their impact on firm performance across different sectors in Taiwan. Section 3 outlines the relevant theoretical frameworks, offering an introduction to key theories of IC and their application within the specific context of Taiwan's industries. Section 4 focuses on the empirical evidence regarding IC's impact on firm performance, with a detailed examination of how HC, SC, and RC contribute to firm success in manufacturing, technology, and service sectors. Section 5 outlines the methodologies for measuring IC, focusing on various measurement approaches. Section 5.3 discusses the impact of IC on firm performance and provides implications and contributions to the literature.

2. Literature Review

2.1. Definition of Intellectual Capital

Building on the foundational understanding of IC, its recognition as a key driver of organizational success has deepened. Early scholars like[3] and[4] emphasized the importance of intangible assets such as technology, brand image, and corporate culture, essential drivers of value creation, despite their lack of physical substance. As the concept of IC evolved, its structure became more refined. [5] categorized IC into the market, human-centred, intellectual property, and infrastructure assets. In contrast,[6] further defined IC as comprising human, organizational, and customer capital's framework widely adopted and expanded by others[7][8]. These frameworks underscore the diverse yet interconnected components of IC that collectively enhance competitive advantage.

The definition of IC remains complex due to its intangible nature and multidisciplinary scope. [9] described IC as the knowledge and capabilities within social collectives. At the same time, the International Accounting Standards Board (IASB) views it as non-monetary assets without physical substance, vital in production or service provision[10]. Modern discourse increasingly views IC as a dynamic resource within socioeconomic systems, crucial for value creation and competitive advantage at both organizational and national levels[11]. This evolving perspective highlights the importance of managing intangible assets such as human, managerial, and customer capital to drive innovation and sustain growth in a knowledge-driven economy.

2.2. Components of Intellectual Capital

IC is widely understood through its core components, HC, SC, and RC, which are crucial for analyzing how organizations leverage intangible assets to create value and sustain a competitive edge[8]. As

illustrated in Figure 1, *Human Capital* encompasses the collective knowledge, skills, and abilities of employees that directly influence organizational performance, while *Structural Capital* includes the processes, databases, organizational infrastructure, and systems that support employee productivity and preserve organizational knowledge. *Relational Capital* represents the value derived from relationships with external stakeholders, such as customers, suppliers, and partners. These components, foundational to modern IC theory[5][6], are particularly significant in the context of Taiwan's diverse industries—manufacturing, technology, and services, where effective management of intangible assets is essential for driving innovation and maintaining a competitive advantage. The following subsections provide a detailed examination of HC, SC, and RC, exploring their respective roles in enhancing organizational performance and competitiveness.

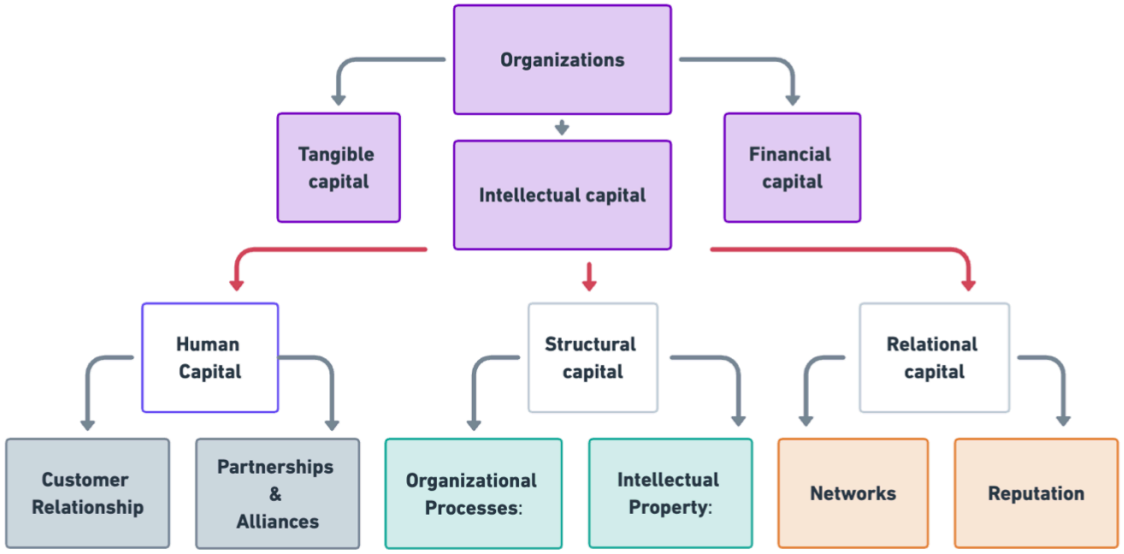

Figure 1. Intellectual Capital Components

2.2.1. Human Capital (HC)

HC is fundamental to the creation and sustenance of organizational value, encompassing the collective skills, knowledge, and expertise of employees. As defined by[12], HC represents the essential capabilities that drive innovation and organizational growth, making it a key component of competitive advantage within the Resource'Based View (RBV) framework[13]. In Taiwan, HC is particularly critical in high-tech and service industries, where a skilled workforce is crucial for maintaining a competitive edge in global markets[14]. Firms strategically investing in HC through

continuous learning and development initiatives consistently achieve superior financial performance and innovation outcomes, especially in sectors like semiconductors, where technological expertise is paramount[15][16].

By prioritizing HC development, Taiwanese firms enhance their capacity to innovate and adapt to market changes, fostering long-term growth and sustaining global competitiveness[17]. HC is integral to corporate value and firm performance in Taiwan, serving as a cornerstone of competitive advantage in the country's dynamic and increasingly globalized economy.

2.2.2. Structural Capital (SC)

SC is the essential framework underpinning an organization's ability to innovate, streamline processes, and safeguard intellectual property. Comprising critical non-human assets such as patents, technologies, and systemic processes, SC fosters a culture of experimentation and learning, thereby enhancing human capital productivity and driving corporate success[12][18]. In Taiwan's technology and manufacturing sectors, the efficient management of SC is crucial for maintaining competitiveness, as it provides the necessary infrastructure for knowledge acquisition, operational optimization, and cost reduction[19][20].

SC is particularly pivotal in fostering innovation within Taiwanese firms, especially in technology-driven sectors where continuous advancement is key to staying competitive[21]. Investments in SC have led to significant technological innovations and product developments, strengthening firms' innovative capacities. Moreover, SC offers a sustainable competitive advantage by enabling firms to differentiate themselves and respond agilely to market fluctuations and technological changes, particularly in sectors like banking that rely heavily on information and communication technologies (ICT)[22]. In Taiwanese firms, well-managed SC supports long-term growth and resilience, ensuring that companies remain competitive in a dynamic global marketplace[23][24].

2.2.3. Relational Capital (RC)

RC is the lifeblood of an organization's external connectivity, rooted in the intricate web of relationships with customers, suppliers, partners, and broader networks. It embodies the value derived from these interactions—such as customer loyalty, market reputation, strategic alliances, and brand equity—and plays a crucial role in enhancing competitive positioning by providing firms with access to insights, markets, and collaboration opportunities[24][25]. In Taiwan, RC is particularly

critical for firms in technology-driven sectors, where robust relational networks are essential for fostering innovation and maintaining a competitive edge. Effective management of RC involves building trust, fostering mutual understanding, and engaging continuously with external entities, allowing firms to swiftly adapt to shifts in consumer preferences, technological advancements, and economic fluctuations. This dynamic aspect of RC not only supports sustainable competitive advantage but also strengthens market positioning in Taiwan's rapidly evolving industries[14][19][26].

2.3. IC's Impact on Firm Performance

Firm performance is closely linked to IC, with strategic management of IC components being crucial for sustainable value creation and competitive advantage. Studies by[27][28] and[29] highlight how the integration of IC enhances operational efficiency and overall performance. However, existing research often overlooks the nuanced impact of distinct operational and cultural settings, such as those in the banking sector, on IC's effectiveness.

2.3.1. Market Based Performance Metrics

Market-based performance metrics, such as market share and stock performance, are significantly influenced by IC. IC is a key driver of economic value, particularly in banking. Using the VAIC model, [30] revealed IC's impact on financial and marketing metrics in Iranian banks, while[31] demonstrated IC's role in enhancing market value in Indonesian banks. In Islamic banking,[32] showed how well-managed IC can improve market performance, with profitability as a mediator. These studies collectively emphasize that human capital drives innovation, structural capital supports efficient operations, and relational capital fosters customer loyalty, all contributing to stronger market performance.

2.3.2. Financial Performance Metrics

The impact of IC on financial performance is well established, particularly in metrics such as Return on Assets (ROA), Return on Equity (ROE), and Earnings Per Share (EPS). Studies by[33] and[34] demonstrate IC's influence on key financial indicators in banking, while[35] highlight its effect on banks. Recent research, including[36] and[37], further underscores the strategic importance of IC in driving financial success across various sectors.

2.3.3. Operational Performance Metrics

IC significantly impacts operational performance metrics like efficiency, innovation capacity, and customer satisfaction.[38] highlighted IC's role in enhancing performance across Islamic and conventional banks in the GCC, especially in high-tech sectors. A study by[39] shows how IC components of HC, SC, and RC improve competencies, streamline operations, and enhance customer satisfaction.[40] and[37] further explore IC's influence on operational efficiency and management quality across various countries, demonstrating the importance of managing intellectual assets to achieve competitive advantage.

2.4. IC Impact on Firm Performance in Taiwan: Manufacturing Sector

IC plays a critical role in driving the performance of Taiwan's manufacturing sector, particularly in high-tech and advanced manufacturing industries. The integration of HC, SC, and RC within these firms has been pivotal in enhancing competitiveness, innovation, and operational efficiency. Taiwanese firms, especially in the electronics, machinery, and petrochemicals sectors, leverage IC to sustain their leadership in global markets. The adoption of Industry 4.0 technologies, including smart manufacturing, artificial intelligence, and the Internet of Things (IoT), has further underscored the importance of robust IC management in maintaining and advancing the sector's competitive edge[21] [41].

HC is central to innovation and productivity in Taiwan's manufacturing sector. Firms that invest heavily in employee development and training tend to see substantial improvements in operational efficiency and product quality. For instance, research in Taiwan's electronics industry has shown that companies with strong HC frameworks report significant gains in production speed and market competitiveness. The expertise in managing advanced manufacturing technologies enhances productivity and reduces operational costs, making HC a vital component of IC in driving firm success[21].

SC provides the necessary organizational infrastructure, processes, and intellectual property that support efficient operations and technological advancement. Taiwanese manufacturers, particularly in the semiconductor industry, benefit from well-developed SC, which includes automated production systems and proprietary technologies. These assets enable firms to optimize production, improve quality control, and protect their innovations through patents, thereby securing a competitive

advantage. The strategic accumulation and deployment of SC are thus essential for sustaining high levels of performance in Taiwan's manufacturing sector[20][41], as shown in various studies summarized in Table 1.

RC is equally critical, encompassing firms' networks and relationships with external stakeholders such as suppliers, customers, and partners. Strong RC enhances market share, supply chain efficiency, and customer satisfaction. Taiwanese manufacturing firms often leverage their relational networks to develop products and streamline operations, leading to improved coordination and reduced costs. This relational approach fosters innovation and strengthens customer loyalty, further driving firm performance in a highly competitive global environment[42].

The synergistic effect of HC, SC, and RC is evident in the superior performance metrics of Taiwanese manufacturing firms. Companies that effectively manage their IC tend to achieve higher profitability, greater market share, and enhanced innovation capabilities. These firms are better equipped to navigate market fluctuations and sustain long-term growth, maintaining their competitive edge in the global market. Empirical evidence from Taiwan's electronics and semiconductor industries, as highlighted in Table 1, demonstrates that robust IC frameworks significantly contribute to higher ROE and ROE, reinforcing the critical role of IC in the manufacturing sector's success[20][43].

Author	Date	IC Component	Performance Metric	Impact	Study Methodology	Industry	Region
[44]	2014	Relational Governance, Dynamic Capabilities	Innovation Performance	+	SEM, survey data from Taiwan	Manufacturing	Taiwan
[43]	2011	Relational Capital, Cognitive Capital, Structural Capital	OSS Development Performance	+	Field survey, empirical data from Taiwan	OSS	Taiwan
[14]	2020	R&D Intensity	Human Capital	+	Panel data analysis, empirical data	Semiconductor	Taiwan
[21]	2019	Intellectual Capital	VAIC	Non'linear (+/')	VAIC framework, regression analysis, empirical data from Taiwan	Semiconductor	Taiwan
[45]	2011	Innovation Capital	Financial Performance	+'	Pearson correlation, linear regression, empirical data	Semiconductor	Taiwan
[46]	2010	Advanced IT, Relationship Learning	Innovation Performance	+	SEM, survey data, empirical data from Taiwan	Electronics	Taiwan
[42]	2011	Information Sharing	Supply Chain Performance	+	Survey data, empirical data from Taiwan	Electronics	Taiwan

Table 1. Chronological Overview of Studies on Intellectual Capital and Firm Performance in Taiwan's Manufacturing Sector

Note: SEM ’ Structural Equation Modeling; VAIC ’ Value Added Intellectual Capital; GMM ’ Generalized Method of Moments; OSS ’ Open Source Software.

2.5. IC Impact on Firm Performance in Taiwan: Technology Sector

IC is integral to the performance of Taiwan’s technology sector, where HC, SC, and RC drive innovation, operational efficiency, and competitiveness. Continuous investment in HC, particularly in employee training and development, is prevalent among Taiwanese tech firms. Companies like TSMC and ASUS have implemented extensive training programs that enhance employees’ capabilities in managing advanced technologies, resulting in improved product quality and accelerated development cycles. These investments in HC are crucial for sustaining innovation and maintaining a competitive edge in a rapidly evolving technological landscape[29]. For instance, as shown in Table 2, studies like[17] highlight the nuanced impact of Human Capital and Innovation Capital on financial performance within Taiwan’s electronics industry, where the influence can vary depending on the context.

SC within Taiwan’s technology sector is exemplified by advanced technological infrastructure and optimized processes. The semiconductor industry, led by firms like TSMC, benefits from sophisticated SC, including state-of-the-art automated production systems and proprietary technologies, which contribute to high operational efficiency and low defect rates. These technological advancements, supported by substantial R&D investments, enable Taiwanese firms to maintain superior production standards and remain competitive in global markets[16][29]. This is further supported by research on knowledge productivity in the biotechnology sector[47], emphasizing the role of IC in optimizing operational outcomes, as detailed in Table 2.

RC plays a pivotal role in the success of Taiwan’s tech firms, with strong relationships established across supply chains, customers, and international partners. Companies like Acer and ASUS leverage these relationships to penetrate global markets, enhance market share, and drive innovation. Collaborative efforts with suppliers and customers are essential for developing new products and staying responsive to technological advancements, which are critical for maintaining competitiveness in a dynamic global market[16]. As shown in Table 2, studies such as[42] demonstrate how information sharing and relational learning within the electronics industry contribute significantly to supply chain performance and innovation.

Government initiatives in Taiwan further bolster the development and utilization of IC within the technology sector. Programs such as the Industrial Technology Research Institute (ITRI) and the Science and Technology Development Program provide essential support for R&D activities, fostering an environment conducive to innovation. Policies that encourage collaboration between academia and industry have also been instrumental in creating a robust innovation ecosystem, enabling firms to effectively leverage IC for global competitiveness[29].

Taiwanese technology firms also adopt unique strategies to maximize the value of their IC. Cross-disciplinary innovations that integrate technology with cultural content and creative marketing strategies enable these firms to differentiate their products and add significant value in global markets. This approach underscores the strategic importance of IC in achieving competitive advantage through innovation and differentiation[29].

Author	Date	IC Component	Performance Metric	Impact	Study Methodology	Industry	Region
[47]	2010	Intellectual Capital	Knowledge Productivity	+	Survey data, empirical data from Taiwan	Biotechnology	Taiwan
[17]	2022	Human Capital Innovation Capital	Financial Performance	+’	GMM, empirical data from Taiwan	Electronics	Taiwan
[46]	2010	Advanced IT Relationship Learning	Innovation Performance	+	Survey data, empirical data from Taiwan	Electronics	Taiwan
[42]	2011	Information Sharing	Supply Chain Performance	+	Survey data from Taiwan	Electronics	Taiwan
[21]	2019	Intellectual Capital	VAIC	Nonlinear (+/’)	VAIC framework, regression analysis, empirical data from Taiwan	Semiconductor	Taiwan
[45]	2011	Innovation Capital	Financial Performance	+’	Pearson correlation, linear regression, empirical data	Semiconductor	Taiwan

Table 2. Chronological Overview of Studies on Intellectual Capital and Firm Performance in Taiwan’s Technology Sector

Note: GMM ’ Generalized Method of Moments; VAIC ’ Value Added Intellectual Capital.

2.6. IC Impact on Firm Performance in Taiwan: Service Sector

IC is a crucial driver of performance in Taiwan’s service sector, where the effective utilization of HC, SC, and RC enhances innovation, operational efficiency, and competitiveness. Service firms in Taiwan prioritize HC through substantial investments in training and development, leading to improved customer satisfaction and service delivery efficiency. In sectors such as financial services and

hospitality, the emphasis on HC directly translates into superior customer interactions and loyalty, underscoring the critical role of a skilled workforce in maintaining a competitive edge[48][49].

Advanced information systems, robust service frameworks, and continuous process optimization mark SC in Taiwan's service sector. Firms that integrate digital technologies and automate processes demonstrate higher operational efficiency and innovation. For example, empirical studies in Taiwan's banking sector highlight how well-developed SC contributes to superior service delivery and customer retention, particularly in financial institutions that emphasize corporate governance and financial innovation[50][51].

RC plays a pivotal role in enhancing Taiwanese service firms' market share and profitability. Strong relationships with customers, suppliers, and strategic partners foster trust, loyalty, and repeat business. In the banking industry, relational capital significantly impacts overall bank performance and customer satisfaction[52].

Government initiatives and industry practices significantly shape the IC landscape in Taiwan's service sector. Programs supporting digital transformation and skill development have bolstered SC and HC, correlating with improved performance. Service firms that participate in these initiatives, along with those adhering to best practices promoted by industry associations, exhibit enhanced capabilities and competitiveness[41][48].

Taiwanese service firms also strategically integrate technology with human expertise, particularly in healthcare and financial services, where advanced digital tools are combined with personalized services. This approach boosts operational efficiency and elevates the customer experience, setting these firms apart in the market. Continuous improvement and innovation in service delivery are central to the strong performance of firms that invest in their HC and SC[14]. Table 3 summarizes key studies that underscore these strategic initiatives across various service industries, including banking, insurance, and internet services, highlighting the critical role of IC in driving firm success in Taiwan's service sector.

Author	Date	IC Component	Performance Metric	Impact	Study Methodology	Industry	Region
[53]	2011	Service Quality, Relationship Quality	Customer Loyalty	+	Survey, empirical data from Taiwan	Internet Banking	Taiwan
[54]	2013	Psychological Capital	Job Performance	+	Hierarchical regression, empirical data from Taiwan	Life Insurance	Taiwan
[20]	2010	High Performance Work Systems	Market Performance	+	Observational study, empirical data from Taiwan	Service	Taiwan
[55]	2014	Relational Capital	Export Performance	+	Observational study, empirical data from Taiwan	Various	Taiwan
[56]	2011	Knowledge Management	Innovation Firm Performance	+	SEM, survey data from Taiwan	Various	Taiwan
[50]	2022	Corporate Governance	Financial Innovation, Bank Performance	+	Panel data random effects model, empirical data from Taiwan	Banking	Taiwan
[51]	2020	Relational Capital	Overall Bank Performance	+	Mixed Network DEA models, empirical data from Taiwan	Banking	Taiwan
[52]	2018	Relational Benefits, Positive Moods	WOM Referrals	+	SEM, survey data from Taiwan	Banking	Taiwan
[57]	2011	CRM Implementation	Customer Satisfaction, Perceived Business Performance	+	Survey, empirical data from Taiwan	Banking	Taiwan
[58]	2014	Human Capital, Customer Capital	Corporate Performance	+’	PLS, empirical data from Taiwan	Banking	Taiwan

Author	Date	IC Component	Performance Metric	Impact	Study Methodology	Industry	Region
[59]	2012	Bank Firm Relationships	Relationship Closeness	+’	Not specified	Banking	Taiwan
[60]	2014	Financial Innovation	Bank Value	+	Panel data regression, empirical data from Taiwan	Banking	Taiwan
[59]	2012	Efficiency, Risk Management	Bank Performance	+	DEA methods, empirical data from Taiwan	Banking	Taiwan
[61]	2018	Service Recovery, Relational Selling Behavior	Trust, Satisfaction, Loyalty	+	SEM, survey data from Taiwan	Banking	Taiwan
[26]	2020	IT Practices, Relational Capital	Innovation Performance	+	SEM’PLS, fsQCA, survey data from Taiwan	Various	Taiwan
[62]	2020	Management Practices	Relational Governance	+’	Cross-sectional study, empirical data	Various	Taiwan
[63]	2017	Intragroup Conflict Social Capital	Team Performance	+’	Longitudinal study, empirical data from Taiwan	Various	Taiwan

Table 3. Chronological Overview of Studies on Intellectual Capital and Firm Performance in Taiwan’s Service Sector

Note: SEM ’ Structural Equation Modeling; DEA ’ Data Envelopment Analysis; WOM ’ Word of Mouth; PLS ’ Partial Least Squares; fsQCA ’ Fuzzy Set Qualitative Comparative Analysis.

2.7. Synergy of IC Components on Firm Performance

The synergistic interplay between HC, SC, and RC in Taiwan’s manufacturing sector significantly amplifies corporate value and firm performance. The true value of these IC components emerges from

their interactions, where the integration of HC with SC and RC has been essential in driving innovation and maintaining a competitive edge in global markets. For instance, when Taiwanese manufacturers invest heavily in employee training (HC), it enhances their ability to utilize advanced manufacturing technologies (SC), which, in turn, strengthens operational efficiency and reduces costs[21][41]. This synergy between HC and SC is further magnified when companies leverage strong relational networks (RC) to collaborate with suppliers and partners, leading to improved product development cycles and market responsiveness. However, research indicates that not all interactions yield universally positive results, as some combinations may adversely affect performance in specific sectors[64][65].

In Taiwan's semiconductor and machinery industries, the synergistic effect of integrating HC, SC, and RC has led to notable advancements in production capabilities and market positioning. For example, the combination of a well-trained workforce (HC) with advanced technological infrastructure (SC) enables firms to achieve higher production quality and efficiency. This advantage is compounded by strong relational ties (RC) with global suppliers and customers, facilitating knowledge transfer and innovation, and ultimately leading to enhanced market share and profitability[20][66]. Empirical evidence shows that companies with robust IC frameworks, where these components are effectively integrated, tend to outperform their peers in terms of ROA and ROE[43], reinforcing the critical role that the synergy of IC components plays in sustaining long-term growth and competitiveness in Taiwan's manufacturing sector.

3. Theoretical Frameworks

3.1. Introduction to Theories of Intellectual Capital

IC is grounded in key theoretical frameworks that emphasize its critical role in enhancing organizational performance. The RBV positions IC components such as human expertise, structural efficiencies, and relational networks as strategic resources essential for achieving competitive advantage[67]. Complementing this, the Knowledge-Based View (KBV) underscores the critical role of knowledge creation, sharing, and utilization in enhancing a firm's competitive edge, particularly in knowledge-intensive sectors like technology[68]. Human Capital Theory (HCT) further emphasizes the importance of workforce skills and experience in boosting productivity and economic value, a principle widely applied in the service sector[69]. Across sectors, these theories collectively illustrate how firms leverage their intangible resources to drive innovation, efficiency, and competitiveness[70].

Table 4 presents additional frameworks that enrich our understanding of IC reporting practices. Stakeholder Theory (STK) suggests that effective IC disclosure strengthens stakeholder relationships by reducing information asymmetry[23]. Legitimacy Theory (LT) posits that firms with substantial IC are more likely to disclose these assets to legitimize their market position, signalling operational excellence[71]. Signalling Theory (ST) highlights the benefits of IC disclosure in enhancing corporate image and attracting investors by reducing capital costs and stock volatility[72]. Finally, Agency Theory (AT) underscores the role of IC disclosure in mitigating agency problems and aligning management actions with shareholder interests, particularly in governance contexts[73]. These theories provide a comprehensive framework for understanding how IC is strategically managed and reported across different industries.

IC Reporting Theories	Acronym	Author	Findings
Agency Theory	AT	[73]	Highlights the need for IC disclosure to mitigate agency problems and align management with shareholder interests.
Human Capital Theory	HCT	[74]	Emphasizes investing in human skills and knowledge to enhance productivity and economic value.
Legitimacy Theory	LT	[71]	IC disclosure is used as a strategy to gain legitimacy and signal excellence in the market.
Resource Based View	RBV	[75][76]	Positions IC as a strategic resource for achieving competitive advantage and superior performance.
Signalling Theory	ST	[72]	IC signalling improves corporate image, attracts investors, and reduces capital costs.
Stakeholder Theory	STK	[23]	IC disclosure reduces information asymmetry and strengthens stakeholder relationships.

Table 4. Theories of Intellectual Capital Reporting

3.2. Application of Theories in Taiwan's Context

In Taiwan, theoretical frameworks like KBV, RBV, and HCT are applied to address the unique characteristics of the country's industries. In the tech sector, KBV is used to explore how firms manage and exploit knowledge resources to maintain global competitiveness, with a strong focus on continuous learning and innovation tailored to the fast-paced industry[48][77]. Similarly, in the manufacturing sector, RBV assesses how firms leverage advanced production technologies and supply chain efficiencies to sustain competitiveness in domestic and international markets[78][79].

In the service sector, HCT emphasizes the role of skilled labour in driving service excellence and customer satisfaction. Taiwanese service firms invest heavily in employee training and development, recognizing that a well-trained workforce is crucial for maintaining high service standards[80]. Additionally, the integration of RBV, KBV, and HCT in Taiwan often involves a cross-disciplinary approach, reflecting the complex and dynamic nature of the country's industries[81]. This holistic application underscores the adaptability of these frameworks to Taiwan's specific economic landscape.

4. Methodologies for Measuring Intellectual Capital

4.0.1 Measurement Approaches

IC is a pivotal asset for firms in Taiwan, particularly within the manufacturing, technology, and service sectors. Accurate measurement of IC is essential for assessing a firm's performance and maintaining competitiveness. Various methodologies have been developed globally to measure IC, focusing on different aspects such as human, structural, relational, and innovation capital.

As shown in Table 5, most methodologies prioritize human and structural capital, with some also emphasizing relational and innovation capital. For example,[82] and[83] include innovation as a key component, reflecting its significance in high-tech industries. Meanwhile, approaches by[84] and[6] focus on customer and organizational capital, which are crucial in service-oriented sectors where customer relationships and organizational culture drive performance. The diversity in these schemas highlights the varying importance of different IC components across industries, guiding firms in selecting the most relevant methodologies for their strategic goals.

Author	Human	Structural / Organizational	Relationship	Social	Customer	Innovation	Capital Employed
[6]	x	x					
[8][12][85]	x	x			x		
[24][65][86] [87][88]	x	x	x				
[89]	x		x	x			
[82]	x	x	x			x	
[90][91][92][93]	x	x	x				x
[94][95][96] [97][98]	x	x					x
[83]	x	x				x	

Table 5. Intellectual Capital Schema

5. Regional Comparison and Barriers to Effective IC Management

5.1. Comparative Analysis with Other Regions

In the manufacturing sectors across Taiwan and other regions such as China, South Korea, and Japan, IC is a critical driver of firm performance. The key components of IC (HC, SC, and RC) are widely recognized for their significant contributions to enhancing productivity, innovation, and overall competitiveness. In Taiwan, HC is particularly strong in high-tech manufacturing, where continuous investment in employee training and development directly correlates with improvements in product quality and production speed[99]. This mirrors practices in South Korea, where HC is crucial for sustaining competitiveness in industries such as electronics manufacturing. Additionally, Taiwanese banks underscore IC's role in driving firm value and efficiency, with HC, SC, and RC shaping competitive edge and operational efficiency[29].

SC in Taiwan's manufacturing sector is characterized by advanced technological infrastructure and well-defined processes. For example, Taiwanese semiconductor manufacturers leverage sophisticated SC, including automated production systems and proprietary technologies, to achieve high operational efficiency and low defect rates[100]. This focus on SC is similarly reflected in Singapore's banking sector, where strategic IC management, influenced by a tight regulatory framework, drives financial performance and competitive advantage[101]. While Taiwan's manufacturing sector focuses on integrating cultural content and creative branding into practices for added competitive value, China's approach contrasts with its aggressive adoption of Industry 4.0 technologies, utilizing smart machinery and artificial intelligence (AI) to upgrade manufacturing capabilities and enhance global supply chain participation[102][103].

RC significantly influences the performance of Taiwanese manufacturing firms through strong relationships with suppliers and customers, leading to improved supply chain efficiency and reduced costs[104]. This approach is also evident in Taiwan's banking sector, where RC fosters innovation and technology-forward strategies, contrasting with Singapore's emphasis on strategic RC management within a regulated environment to achieve resilience and robust financial performance[101]. While Taiwan shares several similarities with its regional counterparts, its manufacturing sector uniquely focuses on design and innovation to enhance value-added and international competitiveness, distinct from Japan's reliance on technological advancements and process optimization[105].

Moreover, Taiwanese SMEs employ cross-disciplinary innovations that integrate technology, cultural content, and marketing strategies, setting them apart from Japanese firms, which prioritize technological advancements and process optimization for manufacturing excellence[106]. Government policies and global collaborations also play a significant role in Taiwan's semiconductor manufacturing, where a multicultural workforce and supportive initiatives contrast with China's focus on large-scale infrastructure and technology investments. However, assessments of smart manufacturing readiness suggest that Taiwanese enterprises still have room to mature in their adoption of Industry 4.0 technologies, compared to Singapore, which is recognized as a leader in this area[107].

5.2. Barriers to Effective IC Management in Taiwan

In Taiwan, the effective management of IC faces significant barriers that hinder its potential to fully enhance organizational performance across various sectors. One of the primary challenges is the

insufficient integration of IC management practices within organizational strategies, particularly in the manufacturing and technology sectors. Although these industries have made strides in leveraging SC and HC to drive innovation, the lack of a cohesive strategy that aligns IC with long-term business objectives remains a critical issue. This is exacerbated by a persistent cultural resistance to change, where traditional hierarchical structures in Taiwanese firms can stifle the open communication and knowledge sharing essential for maximizing RC. Studies have shown that such resistance can significantly impede the development of a knowledge-sharing culture, ultimately undermining the potential benefits of IC management[108][109].

Another significant barrier is the challenge of measuring and quantifying IC, particularly in service-oriented industries where the value of intangible assets like customer relationships and brand reputation is less tangible and harder to assess. The absence of standardized metrics for evaluating IC components creates uncertainty and reluctance among managers to invest in IC initiatives, as they struggle to demonstrate clear returns on these investments. This issue is compounded by the lack of public and homogeneous data, which further hinders the ability to compare IC management practices and outcomes across firms and sectors[110]. Additionally, the rapid pace of technological change in Taiwan's technology sector introduces another layer of complexity, as firms must continually adapt their SC to keep up with new advancements while also ensuring that their workforce (HC) remains adequately trained and equipped to manage these changes. The failure to effectively address these barriers not only limits the strategic value of IC but also poses a risk to Taiwan's competitive position in global markets[111].

To overcome these barriers, it is essential for Taiwanese firms to develop more integrated IC management frameworks that align with their strategic goals and to foster a culture of continuous learning and adaptation. This includes adopting more flexible organizational structures that support knowledge sharing and collaboration across all levels of the company. Moreover, there is a critical need for the development of more robust and standardized IC measurement tools that can provide clearer insights into the value and impact of IC investments. Such advancements would enable firms to better justify IC initiatives and leverage these intangible assets more effectively to drive innovation, efficiency, and long-term growth[112]. By addressing these barriers, Taiwan can strengthen its IC management practices, enhancing its ability to sustain a competitive edge in regional and global markets.

5.3. Conclusion

This study provides compelling evidence of IC's critical role in driving firm performance across Taiwan's key sectors: manufacturing, technology, and service. The synergistic integration of HC, SC, and RC consistently leads to enhanced operational efficiency, innovation capabilities, and competitive advantage, though their specific manifestations and relative importance vary by sector. Our findings contribute significantly to the theoretical understanding of IC, reinforcing and extending the RBV, KBV, and HCT frameworks. The study demonstrates how these theories interplay in different sectoral contexts, providing a more nuanced understanding of IC's role in firm performance. In the manufacturing sector, the RBV explains how the combination of HC and SC drives innovation and efficiency. The KBV, particularly relevant in the technology sector, underscores the importance of integrating HC with SC to sustain knowledge creation and utilization. HCT highlights the role of workforce skills in driving productivity, with RC amplifying these effects across all sectors.

From a practical standpoint, our research emphasizes the need for tailored IC management strategies across different sectors. Companies in the technology sector should focus on consistent HC and SC investments to maintain global leadership. In contrast, those in the service sector should prioritize RC management to enhance customer satisfaction and loyalty. These sector-specific insights offer valuable guidance for practitioners developing IC management practices that align with their specific industrial contexts. Our findings also have important implications for policymakers. They suggest that government initiatives should focus on promoting R&D, fostering industry-academia collaboration, and driving digital transformation to strengthen Taiwan's IC ecosystem. Such efforts are crucial for maintaining and enhancing Taiwan's position in the global market.

Despite these contributions, this study has limitations that warrant consideration. The research primarily relies on existing literature and empirical analysis to assess the roles of HC, SC, and RC in driving financial success, innovation, and corporate value. However, it does not fully address the challenges associated with the classification and measurement of IC, particularly the intangible and non-physical nature of these assets. This limitation suggests that a more refined, theoretically grounded framework for categorizing and reporting IC components is needed. Additionally, while the study highlights the importance of IC in enhancing firm performance, it does not delve deeply into the complexities of developing robust IC reporting models that can accurately capture the value added by these intangible assets. The reliance on sector-specific analysis may also limit the generalizability of the findings to other contexts or industries. These limitations underscore the need for future research

to explore more comprehensive and theoretically driven approaches to IC classification, measurement, and reporting. Such studies could further refine our understanding of IC's role in value creation and competitive advantage, potentially leading to more accurate and universally applicable models for assessing and leveraging IC across various industries and economic contexts.

Notwithstanding these limitations, this study contributes significantly to the literature by providing a comprehensive, sector-specific analysis of IC's impact on firm performance in Taiwan. By emphasizing the varying roles of HC, SC, and RC across different industries, it offers a more nuanced understanding of how IC drives corporate value. This research enhances our theoretical understanding of IC and provides practical insights for managers and policymakers seeking to leverage IC for competitive advantage in an increasingly knowledge-driven global economy.

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