Revisiting the Intellectual Capital – Firm Performance Nexus: Evidence of Linear and Non-Linear Effects

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CERTIFICATE

This is to certify that this thesis entitled: **"Revisiting the Intellectual Capital – Firm Performance Nexus: Evidence of Linear and Non-Linear Effects"** submitted by **Ms. Hira Shahbaz** is accepted in its present form by the School of Economics, Pakistan Institute of Development Economics (PIDE), Islamabad as satisfying the requirements for partial fulfillment of the degree in Master of Philosophy in Economics and Finance.

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DEDICATION

This work is dedicated to my beloved parents and siblings for their unconditional love, prayers, sacrifices, and constant encouragement throughout my academic journey. I am equally grateful to my respected in-laws, especially my father-in-law, whose generous financial support, guidance, and moral encouragement played a vital role in the successful completion of this research. Without their patience, motivation, and unwavering belief in me, this accomplishment would not have been possible. May Allah (SWT) reward them abundantly for their kindness and support. Ameen.

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ABSTRACT

The study empirically test the effect of intellectual capital (IC) on the performance in the non-financial sector of Pakistan, considering both linear and non-linear specification. The analysis is based on an unbalanced panel data of 361 non-financial listed firms on Pakistan Stock Exchange with a 3,441 firm-years observations during the time-period of 2014-2023. Static panel and dynamic System GMM both techniques are utilized to enhance methodological rigor and control for endogeneity and persistence of the performance. The firm financial performance is the dependent variable and is proxied by Return on Assets (ROA). IC is the independent variable, measured using the Value Added Intellectual Coefficient (VAIC) framework and the core components of the IC are the Human Capital efficiency, Structural Capital efficiency and Capital Employed efficiency. The empirical evidence of linear model shows that the overall IC has a positive but insignificant contribution to the performance of the firm. Further on, the results of the non-linear estimation indicate that there is an inverted U-shaped IC-performance relationship, indicating the existence of an optimal level beyound which its marginal effects declines. Findings of the component level analysis illustrate that Human Capital Efficiency is the most prominent in explaining firm performance and demonstrate a U-shaped relationship. In contrast Structural capital and capital employed effficiency do not show significant non-linear effects. The dynamic panel analysis strengthens the findings and evidence a non-linear IC-performance association. Firm size, leaverage and liquidity positively affects performance and no strong persistence is observed. Cumulatively, the research provides a robust empirical evidence that support the Resource-Based View, Locus Human Capital, Endogenous Growth and Production Theory, as it focuses on the importance of intangible resources in the achievement of the firm performance. The results have important implications for managers and policymakers to enable development of knowledge-based growth and long term competitiveness in non-financial sector of Pakistan.

Keywords: Intellectual Capital, VAIC, Firm Performance, Human Capital Efficiency, Structural Capital Effiency and Capital Employed Effficiency, Non-linear Effects, System GMM

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LIST OF ABBREVIATIONS

IC	Intellectual Capital
VAIC	Value Added Intellectual Coefficient
HEC	Human Capital Efficiency
SCE	Structural Capital Efficiency
CEE	Capital Employed Efficiency
VA	Value Added
ROA	Return on Assets
EBIT	Earnings Before Interest and Taxes
EC	Employee Cost
D	Depreciation
A	Amortization
LEV	Leverage
LIQ	Liquidity
SIZE	Firm Size
AGE	Firm Age
RBV	Resource-Based View
FP	Firm Performance

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CHAPTER 1

INTRODUCTION

1.1 Background

Intellectual capital (IC) is a form of intangible resource in the modern world of knowledge-based global economies, which is one of the essential variable contributing to firms success. Since only the traditional sources like tangible or physical resources including financial capital, machinery and physical assets are insufficient in the attainment of sustainable competitive advantages of the firms (Sveiby, 1997). The world economy structure has changed in the recent decades, where industry oriented systems have been changed to knowledge driven-economies where sustainable firm performance is determined by the effectiveness of the organization in managing and utilizing knowledge (Godin, 2006). Companies that do well in managing their intellectual capital like skills and knowledge are usually high in terms of innovation and financial performance when compared with their competitors. The resultant change has led to knowledge management as a strategic discipline and IC as a concept of contemporary importance in the accounting, management and finance studies (Guthrie, 2001).

Due to its properties, which were identified as being valuable, unique and rare, intellectual capital has been identified as an important resource. This makes intangible assets more valuable than tangible ones since they are more likely to increase in value with time unlike tangible ones which lose value with time. The success of the businesses in the contemporary economic environment has become dependent on the intangible assets particularly the knowledge. The IC has also become critical to understand not only to researchers and policymakers but also for the purpose of value creation to enhance firm efficiency as well as living standard all over the world (Marr and Schiuma, 2001). The scholars have valued knowledge as a valuable resource. The intangible assets known as IC in the knowledge economy has the same significance as the physical and financial assets.

In general the term IC is used to refer to the collective knowledge, experience and intangible assets possessed by an organization that underpin its ability in creating value and sustaining long run performance (Advinsson and Malone, 1997). The most widely used definition of IC has the phrase of what is commonly referred to as knowledge that is valuable to a business. Based on this phrase

we can say that the aggregate of what is known or knowledge management leads to the creation of IC. Intellectual Capital has numerous definitions with many multifaceted meanings as well as the Interchangeably meaning with knowledge assets, intellectual assets and intellectual property. It can be understood as the aggregate of knowledge based capital that the business possesses. In line with this it can be the knowledge that is converted into intellectual assets of the firm or as well it can be the result of a knowledge transformation process. There is not one agreed definition of IC, but many perspectives have been shared to convey what it generally means. According to Edvinsson and Sullivan (1996) the definition of IC is the knowledge, experience applied, technology in an organization, customer and professional relationship, which gives a company a competitive advantage in the market. According to Bontis (1998), IC is knowledge that can be transformed into corporate value. All the unseen assets which are critical to the operations of a company are defined as IC as put forward by Brooking (1996).

According to Pulic (2000), IC refers to the efficiency with which a firm's physical and intangible assets create value, operationalized through the VAIC model. Value-Added Intellectual Coefficient (VAIC) model proposed by Pulic (1998, 2000), is the widely accepted model due to its simplicity and reliance on open source available financial data that operationalizes IC into three essential components. Human capital efficiency, structural capital efficiency, and capital employed efficiency are the three key elements that together define the most recognized intellectual capital framework, though there are many other components as well. Collectively as these three intellectual capital dimensions are interconnected, they significantly affect a firm's value and performance and provide a comprehensive view on how efficiently a firm converts its tangible and intangible resources into financial outcomes. Additionally, they represent the corporation's ability to outperform in competitive market.

Addressing the relationship of intellectual capital and corporate financial performance has become vital as corporations increasingly acknowledge the significance of intangible assets for obtaining competitive advantage. Traditionally, a lot of research has proposed a linear relationship, indicating that performance increases proportionately with a rise in intellectual capital (Ling, 2013; Asiaei and Jusoh, 2015; Nadeem et al., 2018). The research findings are primarily predicated on the linearity assumption, representing higher intellectual capital efficiency will reflect higher firm performance. Similarly, other studies (Chen et al. 2005; Firer & Williams, 2003; Tan et al. 2007) demonstrated that intellectual capital is key determinant behind variation in the firm performance.

According to these studies IC is increasingly acknowledged as a fundamental strategic asset in developed economies for maintaining sustainable competitive advantage and an essential contributor to shareholder value. Despite global acknowledgment of the importance of IC, it is still underexplored within the Pakistani context. Most of the firms in Pakistan concentrate on short term returns from tangible resources rather than investing in intangibles, long term resourcesand also the financial sectors of Pakistan have advanced in managing IC, whereas non-financial sector have shown limited adaptation of IC management practices.

To get a more complete picture of how intellectual capital affects firm performance, this research fills a key gap by examining both linear and nonlinear effects across various non-financial industries in Pakistan. It aims to determine whether companies are allocating too much or too little in IC and to identify the optimal investment level. The fundamental aim of this research is to provide useful information for both business executives and policymakers by addressing important questions regarding the association between intellectual capital and firm performance in Pakistan and whether this relationship is linear or nonlinear. To achieve this, the study uses the VAIC model which measures IC through human capital efficiency, structural capital efficiency and capital employed efficiency. This research analysis uses multi-year (panel) financial data from listed non-financial firms in Pakistan.

Resource-Based View, Human Capital Model, Romer Endogenous Growth Theory and Production Theory are the four major theories that build the theoretical framework of the analysis. According to Barney (1991), RBV suggest that firms achieve lasting competitive edge through resources that are valuable and non-substitutable. In line with the RBV framework, IC is regarded as a valuable strategic resource that help firms in achieving and maintaining value in the long run. Although existing literature provide meaningful perspectives, but it may oversimplify the complicated link between IC and firm performance. Concern have been raised in recent scholarly debates that IC and performance might not be strictly linear instead it might be non -linear, where the IC investment's effects shows diminishing marginal returns after a certain point. This idea is supported by Production Theory (Marshall, 1890), particularly the law of diminishing returns to scale, which also serve as a theoretical framework for the study. This concept suggests that excessive investment in IC beyond a certain point may result in decreasing gains. Emerging theoretical perspectives, notably the Human Capital Model by Lucas (1988) and Romer (1990) Endogenous Growth Theory, propose that knowledge and human capital can

lead to non-diminishig or even increasing returns due to spillovers, innovation, and learning-by-doing. Therefore, it is necessary to understand both linear and non-linear effects of IC for determining the optimal level of investment that leads to maximum results. However, recent findings (Asif et al., 2020; Kweh et al., 2022) point to a possible nonlinear IC-performance relationship, meaning that the effects of IC may vary depending on the level of investment. Such non-linear dynamics remains underexplored in developing countries, including Pakistan. These contrasting theoretical views call for re-examining the intellectual capital-performance nexus to assess whether IC yields linear, increasing, or diminishing returns in Pakistan's non-financial sector.

1.2 Motivation of the Study

Because of the theoretical and empirical developments, the IC-FP relationship has been back in the limelight of academic interest in recent years and, therefore, it is high time to consider this nexus again. Previous studies have mostly found the IC-performance relationship positive and linear; however, studies by emerging researchers challenge this aspect. Recent research has shown that the returns of IC are not quite uniform and proportional; rather, they are usually influenced by situational elements, industry variations and occasionally adhering to a non-linear dynamic (Kweh et al., 2022). The swift technological change, digital transformation and knowledge-based business models have dramatically altered value creation processes and this is an indicator that the traditional linear frameworks cannot adequately capture the dynamics of IC. In addition, there are more recent theoretical developments depending on diminishing returns, and non-diminishing or increasing returns, suggesting that over investment in certain components of the IC can lead to inefficiencies, higher coordination costs or decreased marginal productivity. These changes show that the previously established relationship between IC-performance has been changing with time and past results may become outdated in the modern economic environment. Therefore, there is a need to revisit this nexus and give updated empirical evidence so as to recognize non-linear mechanisms and reconnect IC research to contemporary business realities, particularly in emerging economies such as Pakistan where the application of IC practices within the various sectors is vastly different.

1.3 Problem Statement

The significance of intellectual capital is not a new discovery, although it remains unclear how simple or complex its impact on business performance is. The key problem addressed in this study is the lack of clarity about the nature and functional form of IC-performance relationship in Pakistan's listed non-financial firms. This uncertainty limits the ability of the firms to determine whether increasing IC will improve performance or its impact varies at different levels. As the functional form of IC-FP relationship is uncertain, this research paper sought to offer a better and more comprehensive description of the workings of IC in Pakistani firms by examining linear and non-linear effects of IC on the financial performance of firms. This ambiguity poses a problem since when Pakistani companies invest too much or too little in intellectual capital, they will face diminishing returns or possibly negative performance. Given the increasing level of prominence of knowledge-based assets and the paucity of empirical evidence, an extensive analysis of linear and nonlinear effects of IC, on firm performance has become critical. To be able to give more specific advice on how intellectual capital can best be invested, this paper examines whether the impact of intellectual capital on firm performance is linear at all tiers or the extent of this impact is dependent on the amount invested.

1.4 Research Questions

The study aims at evaluating two fundamental aspects of the intellectual capital-performance nexus. First, it investigates the role of IC in the performance of firms in different non-financial sectors in Pakistan, which has not extensively been covered in the literature and concentrated mainly on the financial sector. Second, the research evaluates the non-linear IC-performance correlation in order to identify the most preferable IC-investment level. Optimal level of IC, in this case refers to the point where the human, structural and capital utilized efficiencies cause the highest possible perfromance before the returns start to decrease or the minimum threshold level beyond which its positive impacts become stronger. This threshold has to be identified to make managerial decisions, especially in Pakistan, where companies misallocate investment in IC, which is not supported by empirical evidence.

According to the discussion above, the study analyzes the following questions:

1. Does IC affect financial-performance of listed non-financial firms in Pakistan across various sectors?
2. Does an optimal threshold level of IC investment exist for maximizing performance in Pakistan's non-financial sector?

1.5 Objective of the Study

1. To investigate the nature (linear or non-linear) of effect of IC on firm performance.
2. To identify whether an optimal threshold level of IC investment exist that maximizes firm performance.

1.6 Policy Context

The research provides valuable information on management practice, policy changes and scholarly writings in various aspects. It fills the empirical gap regarding the impact of components of IC on financial performance of companies in a developing nation. Since it is known globally that intellectual capital is a critical element of innovation and business development, the Pakistani policies have emphasized more on the transition of knowledge-based economies to enhance competitiveness of the firms. Through this research, there is an insight given on the role of IC investments to improve firm performance. Through the examination of both the linear and the non-linear relationship, the study demonstrates the existence of quantifiable returns of the targeted IC investments, which indicates the significance of effective corporate governance models. This study of the non-linear effects attempts to offer useful policies to the sector by establishing the best IC levels that can yield the best firm performance. The policy-makers can then utilize the results to inform balanced IC investment plans to boost productivity without becoming overly resourceful. Another aspect highlighted in the study is that strategic investment in intellectual property might be of value and thus may be used to develop policies or incentive to encourage sustainable, cost effective growth.

CHAPTER 2

LITERATURE REVIEW

In knowledge-based economy, Intellectual capital (IC) as an intangible asset (including knowledge, skills, organizational processes, and relationships between stakeholders) has now become one of the foundations of firm performance, and also has become more important driving force of value creation and the maintenance of competitive advantages than physical resources (Skhvediani et al., 2023). This research critically analyses the linear and non-linear, effects of IC on the firm's performance.

2.1 Theoretical Framework

The theoretical framework is a combination of four theories. These theories are the Resource-Based View (RBV), Human Capital Model, Romer Endogenous Growth Theory and the Production Theory. Relying on these four theories, this study will examine how IC effects the financial performance of Pakistani firms. Instead of simply providing context, these frameworks directly explain the selection of variables and underpin the use of both linear and non-linear model specifications in the study.

The **Resource-Based View (RBV)** will give conceptual insight into the study related to the association between intellectual capital and the financial performance of the firm (Riahi-Belkaoui, 2003). RBV theory was first conceptualized by Edith Penrose (1959) and emphasized the significance of the theory in the development and competitiveness of a firm due to resources they possess internally. Birger Wernerfelt (1984) further developed this theory as a concept of resource-based competitive advantage. Subsequently formulated by Jay Barney (1991), who added the concept of the VRIN criteria, Valuable, Rare, Inimitable, Non-substitutable, to rank the capacity of resources such that they can be used to sustain a competitive advantage. The RBV theory states that companies, which possess such resources as Intellectual Capital, may receive the competitive advantage that will result in their financial success (Wang et al, 2022; Riahi-Belkaoui, 2003). This theory explains that, not only the markets are making firms successful, but also the unique mixture of the resources and capabilities that they possess. According to RBV, the idea of sustainable

competitive advantage of companies is built on resources which can be characterized as valuable, rare, inimitable, and non-substitutable (Mubarik et al., 2021). When the firms create and manage such resources in an efficient manner, then there is the possibility of generating long term benefits which the competitor finds it hard to counter. Even though material resources like machinery or financial capital are crucial, RBV believes that the larger strategic role of the intangible resources, including knowledge, skills, and organizational culture, deliver an innovation and efficiency (Wernerfelt, 1984). In this regard, Intellectual Capital becomes one of the pillars of competitiveness since it incorporates the human, structural and capital used aspect, which contributes to influencing the firms to adapt, learn and improve with time. Recent studies have broadened the intellectual capital analysis to more than mere correlations with business performance.

RBV justifies the use of VAIC and its components as core explanatory variables and offers a theoretical foundation for expecting a positive IC-performance relationship. The VAIC model measures the efficiencies and provides a relatively measurable relationship between resource use and performance results and MVAIC is the model with the addition of CEE and RDE (Yin and Xu, 2024). In a case example, Clarke et al. (2011) favored the resource-based perspective using evidence that the efficiency of the human capital significantly enhances the performance of firms in Australia. RBV views IC as a dynamic capability that facilitates innovation, operational efficiency and market differentiation that directly influence such performance indicators as ROA, ROE and Tobin Q (Rana & Hossain, 2023). In essence, it reiterates the fact that the present economy survives on the capacity of the organizations to develop and access the internal capability to ensure high performance.

Production Theory formalised by Alfred Marshall (1890), puts forward the concept that, even though the initial investment may result in increased output but beyond a certain point no further investment of resources will yield the same returns. This law is very similar to the Law of Diminishing Returns (Jenssen and Greve, 2002; Munir and Li, 2018). Just as the Production Theory implies that firms that constantly invest in IC, reduces their returns when their marginal returns are less than their marginal costs. There are also a few studies of the past which indicate nonlinearity of correlation between IC and corporate performance (Kweh et al, 2022; Asif et al., 2020; McFadyen and Cannella Jr, 2004). Theoretically, this theory would mean that an increased

investment on the IC resources can be not profitable because the law of diminishing returns applies. Hence, the high returns on the IC investment can decrease beyond some,saturation level. Thus, production theory provides the basis for including squared terms (IC^2, HCE^2, SCE^2 and CEE^2) in the model to access the presence of non-linear (U-shaped or inverted U-shaped) IC-performance relationship.

Along with RBV, Production Theory views IC as a key driving force in the production equation that augments the traditional factors of production, e.g., labor and physical capital, to maximize production and efficiency and can be modeled through models of production, i.e., Cobb-Douglas or stochastic frontier (Dancakova and Glova, 2024). This theory puts the emphasis on the contribution of the IC in terms of enhancing marginal productivity based on transformation of the knowledge based inputs into the value added products according to economic theory of resource optimization. Production Theory describes how companies transform their available resources (labor, capital, and technology) into products and services at the most efficient level possible. It helps to know how the right combination and use of resources can increase the level of productivity and performance. Traditionally, this theory was occupied with physical and monetary resources, whereas in the present time, with the knowledge based economy, it has also recognized the rising importance of intangible resources like knowledge, skills and innovation.

According to the theory, the more successful the firms may be in terms of the efficient utilization of their resources in a production activity that is how different inputs are combined to make output (Cobb & Douglas, 1928). This has been applied in the current research where Intellectual Capital (IC) is added to the list of determinants of productivity and growth, namely human capital efficiency (HCE), structural capital efficiency (SCE), and capital employed efficiency (CEE). These factors can help firms transform the knowledge-based inputs into the measurable output, such as the return on assets (ROA), the return on equity (ROE), and the sales growth (SG) (Dancakova and Glova, 2024). The Production Theory entails the IC into the production function and HCE, SCE and CEE enhance the efficiency of the inputs to production that is converted to the output in terms of ROA, ROE and SG (Dancakova and Glova, 2024).

The model that was developed by (Pulic, 2000) and enhanced by the recent studies is the VAIC model which fuses the resource focus of RBV and the efficiency aspect of Production Theory by gauging the contribution of IC to value added (VA) to the output minus input excluding the cost

of labour. This model employs VAIC model that establishes the linear and non-linear, contributions of IC to the performance of firms in a holistic manner. RBV implements IC components (HC, SC, CE) as resources that enable differentiation and competitive advantage that create unique capabilities that are difficult to replicate by the competitors (Mubarik et al., 2021).

As one illustration, (Sharma and Weqar, 2025) apply VAIC to the Indian population sector enterprises and demonstrates that IC plays a vital role in resiliency in cases of economic shocks, which is justified by the fact that RBV focuses on the use of particular resources and Production Theory that focuses on the efficiency of transformations between inputs and outputs. In (Liu and Kweh, 2022), VAIC is used to research non-linear efficiencies of U.S. companies and relate theoretical synergies to the findings. The fact that BIG4 auditors improve the impact of IC is combined with the aspect of governance which is demonstrated by (Mohapatra and Pattanayak, 2024) and the fact that the uniqueness of the resources and the optimization of performance are connected. These articles lay stress on the transformational capacity of IC, but the moderators that are contextual, like the industry, size of a company, leverage, economic crises, and technological development, are critical in defining its performance.

In addition, the current growth models (like **the Human Capital Model**) of 1988 and the **Endogenous Growth Theory** of 1990 developed by Romer, suggest that human capital, innovation and knowledge show non-diminishing or increasing returns, which proves the idea of non-linear IC-performance dynamics. Thus, the empirical model reflects the underlying theoretical framework. The linear model test the RBV-based claim that IC-performance relationship is positive, whereas the quadratic model test the Lucas, Romer and Production Theory arguments that the relationship may be non-linear due to increasing returns, knowledge spillovers and diminishing marginal productivity.

Table 1: Theoretical linkages between Theories, Model Specification and Expected Effects

Theory	Model Link	Expected effect
Resource-Based View	VAIC, HCE, SCE, CEE	Positive linear effect on ROA
Human Capital Model	HCE and HCE^2	Human capital may generate increasing returns
Endogenous Growth Theory	$VAIC^2$, HCE^2, SCE^2	Knowledge and innovation may create non-linear/increasing returns
Production Theory	IC^2 and component squared terms	Possible diminishing returns or inverted U-shape

2.2 Intellectual Capital and Its Components

The model that was developed by (Pulic, 2000) and enhanced by the recent studies is the VAIC model which fuses the resource focus of RBV and the efficiency aspect of Production Theory by gauging the contribution of IC to value added (VA) to the output minus input excluding the cost of labour. This model employs VAIC model that establishes the linear and non-linear, contributions of IC to the performance of firms in a holistic manner. RBV implements IC components (HC, SC, CE) as resources that enable differentiation and competitive advantage that create unique capabilities that are difficult to replicate by the competitors (Mubarik et al., 2021). The Production Theory entails the IC into the production function and HCE, SCE and CEE enhance the efficiency of the inputs to production that is converted to the output in terms of ROA, ROE and SG (Dancakova and Glova, 2024). The VAIC model measures these efficiencies and provides a relatively measurable relationship between resource use and performance results and MVAIC is the model with the addition of CEE and RDE (Yin and Xu, 2024).

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2.3 Intellectual Capital and Firm Performance

The peculiarities of the business suggest a high degree of heterogeneity of the effect of IC. The physical capital (CEE) is more prone to prevail over the IC factors in the manufacturing industry due to the intensity of the asset base; (Skhvediani et al., 2023) found that CEE generated the highest positive ROA in the Russian manufacturing sector. On the other hand, high-tech and service industries are concerned with HCE and SCE to enhance innovation and efficient operation. As shown in the ecological industry (Yin and Xu, 2024), CE had a positive effect on performance in the pre-COVID-19 period of time, but was not significant in the period during the pandemic due to the interrupted chain of stakeholders and a lack of cooperation. The outcomes of the public sector firms are mixed because (Sharma and Weqar, 2025) discovered that VAIC had a positive impact on SG in SG-based Indian central public sector enterprises (CPSEs), but negative in 2008 and following the financial crisis, therefore a temporal moderating impact of economic conditions. The improved IC influences of companies that are certified according to the European Foundation of Quality Management (EFQM) model can be explained by the structuring of the knowledge management practices and the optimization of the processes (Mubarik et al., 2021).

The adverse aspects of the IC investment are observable in the environment with resource limits or crisis, so that the gains can be ruined by the high cost or the lack of compatibility with the strategy of the firm. As (Ahmed and Hussin, 2023) explain, the non-financial companies in Pakistan have the short-run profitability decline linked to the unnecessary IC investment which is primarily in HC and SC due to the high costs of implementation and a delayed payback. It has

been found that political risks and heavy leverage have adverse implications on the performance of IC investment, which is irrelevant or negative in the emerging markets (Nguyen and Vo, 2023). During the economic crisis, as it was in the case of the COVID-19, the efficiency of CE is typically low due to disturbed networks as (Yin and Xu, 2024) experienced in the example of the Chinese companies. These findings not only suggest relevance of contextual factors, which include economic stability, quality of governance, technological infrastructure and characteristics of the industry on effectiveness of IC but also establish that strategic alignment can play upon the opportunities presented by contextual factors to the fullest extent.

2.4 Linear and Non-Linear Relationships

2.4.1 Linear Findings

The positive linear relationship between IC and firm performance is supported by some studies which is in line with the arguments of RBV that incremental investments in unique resources yield corresponding incremental returns in the form of competitive advantage. Using the VAIC model, (Dancakova and Glova, 2024) have also found out that the SCE and CEE positively impact ROE and ROA in the European industries but the impact by the CEE is the most effective since it has a tangible asset base. (Mubarak et al., 2021) tested the hypothesis that HCE, SCE, and CEE are positively correlated with ROA in Czech firms that are certified under the EFQM model and discovered that this was explained by the well-organized knowledge management and excellence of the processes. In the emerging markets, (Sharma and Weqar, 2025) discovered that VAIC has a positive impact on SG of Indian public enterprises, whereas HCE and SCE, which enhance the efficiency and responsiveness of the operations to the market, substantially impact them. The same linear outcomes were also found in non-financial companies of Bangladesh, and the primary predictor of ROA is HCE due to the presence of a qualified labor force (Rana and Hossain, 2023). The connection between IC and performance as a concept in MNEs founded on digital platforms was also driven by the exchange of knowledge on digital platforms by (Mariani et al., 2023) and the significance of CE in network expansion. The careful examination of 48 studies in the ASEAN region, Korea, and other destinations revealed that positive linear relationships are dominant in the knowledge-intensive industries where IC directly and positively influences profitability, efficiency, and growth (Ahmed and Hussin, 2023).

Based on the research conducted by (Musali and Ismail, 2021), IC efficiency has a positive and a linear relationship with corporate success in emerging countries in Africa where the HCE and SCE have the most significant impact on the financial performance indicators such as ROE. Similar results were observed by (Buallay et al., 2021) in the Gulf Cooperation Council (GCC) banks, where the efficiency of the IC is associated with the enhanced financial performance, particularly through the totality of the customer relations implemented on the CE. The role of the governance was found (Cahyono et al., 2024) to be a significant moderator of the linear IC-performance relationships in Indonesia-based companies, which is underpinned by political connections. Based on these studies, companies are advised to be alert on the high stability of returns of IC investments in stable economic systems with good governance structures and appropriate resource supply.

There are studies that provide a positive correlation between intellectual capital (IC) and the performance of the firm, which implies that intellectual capital is a contributor to higher performance. Investigation of 150 Taiwanese firms by (Chen et al., 2005) based on the Value Added Intellectual Coefficient (VAIC) model revealed that the elements of IC, which include human capital, structural capital, and capital employed have an overwhelming positive impact on profitability of firm in terms of ROA. Equally, (Tan et al., 2007) studied 200 Singapore based firms by using VAIC and discovered that IC effectiveness is directly correlated with financial performance with particular reference to human and structural capital contribution to growth of revenue. This linear tendency was also explained in (Youseaf et al., 2022) a sample of 120 Pakistani manufacturing companies, by stating that the IC, which is represented by VAIC, has a positive impact on the performance of the company, and the efficiency of human capital was the highest factor of operational performance. Unanimity in different Asian environments underscores the effectiveness of linear models, but the scale of the impact varies depending on industry and the scale of the establishment, which implies the presence of contextual moderators, which should be explored in the future.

2.4.2 Non-Linear Findings

Different theoretical perspectives suggest U-shaped (increasing returns), inverted U-shaped (diminishing returns) and S-shaped (dynamic growth phases) IC-FP relationship. At early stages of IC development firms may not see immediate performance benefits, as investment in HC,

knowledge infrastructure and organizational system involve a time lag before becoming productive. While at higher levels of IC firms begin to benefit and become more pronounced, leading to increasing returns. Therefore, the IC-FP relationship may follow a **U-shaped pattern,** where the effect becomes stronger after a certain point.

At moderate levels, IC contributes to better performance through enhanced productivity, innovation and competitive advantage. However, after a certain threshold, more investment in IC may result inefficiencies because of higher cost or overstaffing etc. so the marginal contribution of IC decreases and performance may declines at higher levels as a result. Thus, IC-FP relationship may follow an **Inverted U-shaped** relationship that is consistent with Production Theory.

The **S-curve** relationship illustrate three phases of IC development. In the initial phase, firms encounter slow performance growth due to high learning cost and limited capabilities in utilizing IC. While in the growth stage, firms achieve higher performance because IC becomes integrated into organizational structures and knowledge spillovers. And finally in maturity phase, firms experience slower growthdue to saturation effects, resource limitation and diminishing marginal contribution of additional IC.

Recent literature is beginning to suggest non-linear relationships, in most cases inverted U-shaped curves, as the benefits of IC have optimal limits beyond which the returns become negative due to the coordination costs, knowledge overload or misallocation of resources. Inverted U-shaped relationship between VAIC, HCE and CEE and financial performance (EBIT and ROA) in Russian manufacturing companies was discovered as (Skhvediani et al., 2023) the highest performance occurred between 1012 values of VAIC. Beyond this, excessive IC invested created inefficiencies, such as bureaucratic idle time in SC or overtraining in HC, which increased the cost and did not benefit it. The two values, which were found to shift concave-up and inflexibly upward by (Liu and Kweh, 2022), respectively, HCE (increasing marginal benefits to a point) and an inflected upward trend in the efficiency scores of U.S. firms, which shows non-linear dynamics in knowledge-intensive industries whereby the starting gains and plateauing trend in innovation drive SCE and CEE, respectively. According to (Yin and Xu, 2024), overall IC and HCE exhibited an inverted U-shaped relationship on ROA in Chinese ecological firms, and physical capital exhibited a U-shaped relationship, and stimulating high or low investments had a decreasing or negative value of returns on resources. A non-linear perspective was described by Duodu and Rowlinson

(2019), who indicated that the IC and innovation outcomes might have a quadratic relationship. Taken altogether, these studies prove that the impact of IC on the corporate outcomes is context-dependent, and it might vary across industries and economies.

In Ghana (Boateng et al., 2025), non-linear productivity action was observed to be present in the state-owned organizations with IC showing negative impact below certain thresholds and positive impact above these negative impacts with stronger impacts in the partly-owned firms where the flexibility of governance enhances the use of IC. The relationship between moderate investing in IC and the optimal performance was backed up inverted U-shaped in European companies, where moderate investing in IC leads to the optimum cost, such as staff burnout or rigid organizational procedures, with no gains in proportional amounts (Zhang et al., 2023). Such non-linear findings refute the linear assumptions of the preceding RBV-based research, and the results suggest that the firm must be able to balance the IC investments plan wise to wipe out the inefficiency. An illustration of this its over-investment may result in the redundancy of knowledge or the demotivation of employees and over-developed SC may introduce bureaucratic inefficiencies that hinder agility (Nguyen and Vo, 2023). The importance of these studies has been to find the optimum IC investment level in offering optimal performance at the lowest possible cost more so in dynamic or resource-constrained environments.

The panel data approach (Asif et al., 2020) has examined the relationship of 90 Malaysian firms and found an inverted U-shaped pattern this way that average amount of IC investment leads to the peak performance of the company, whereas high amount of investment leads to diminishing returns due to coordination expenses and overlaps. Using a cubic S-curve model, (Kweh et al., 2022) assessed 200 Taiwanese technology companies and discovered the non-linear impact of IC efficiency on productivity, where in the first stage, it positively influences productivity, but in the optimal point, the efficiency then goes down because of the over-reliance on intellectual capital and the inability to have corresponding physical capital to sustain the growing dependency. (Xu and Zhang, 2021) explored 150 Chinese shipping companies and discovered a reversed U-shaped curve when using VAIC; the large numbers of IC above a certain level reduced the financial performance due to the complexity of the operations. These findings do not support linear hypotheses, which means that the advantages of IC are related to optimal level of investment, and it is determined by industry-specific parameters and strategies of resource allocation. This non-

linear perspective is in line with the Production Theory, which aims at aligning IC to other inputs in order to realize the highest efficiency, particularly in dynamic sectors.

However, in some cases, negative or weak relationships are created and this happens mainly in a period of economic crisis, where the environment is resource constrained or where the IC investments do not fit to the strategies of the firms. As noted (Sharma and Weqar, 2025), the relationship between VAIC and the ROA in the Indian CPSEs was not vital following the 2008 financial crisis, which carries an implication that economic crises impair the efficacy of IC. It indicates that high leverage and political risks reduce effectiveness of the IC investments and provoke the consequences of the failure of performance in the emerging markets or even adverse outcomes (Nguyen and Vo, 2023). As stated by (Ahmed and Hussin, 2023), negative returns have been made by SC investments due to the high cost of implementation or concentration on the strategy of the firm with low or no absorptive capacity in non-financial sectors. Incidentally, excessive communication of the complexity of the organizational systems may lead to inefficiencies in case the firms lack the infrastructure to make those systems effective.

2.5 Intellectual Capital-Firm Performance Nexus in Pakistan

Ket al. (2015) explored IC among the Pakistani electrical, and electronics SMEs based on survey information on 247 companies, and regression models. Their findings revealed that the intellectual capital in general positively affects performance, whereas human capital does not produce any significant effect. Arslan and Zaman (2024) consider the case of intellectual capital efficiency in Pakistans oil and gas companies during the year 2007-2011 according to the VAIC framework (HCE, SCE, CEE) and evaluate its influence on financial indicators, such as ROE, ROI and EPS. The paper concludes that overall IC efficiency positively affects financial performance that is made up of substantial contributions made by human and structural capital efficiencies, showing the value of IC in the Pakistani oil and gas industry. In his study, Mushtaq (2021) examines the role of IC through the VAIC model, with the industry being the textile sector, and the results indicate a positive correlation with the performance of the industry, providing valuable industry-specific information on the IC-performance nexus. Yao et al. (2019) are based on an inverted U-shaped pattern of the impact of IC on profitablity and productivity in 2007-2018 on 111 financial institutions in Pakistan through VAIC and MVAIC and find that human capital is the primary

driver of these results. Hussain and Mehar (2021) also report a conflicting effect of an IC; CEE and CCE has a positive influence, but SCE makes performance worse. In addition, political uncertainty is a major moderator of the performance of IC. Rehman et al (2011) study applies VAIC model to measure IC in modaraba sector in Pakistan and report that existence of a strong positive relationship between the efficiency of IC and the overall performance of the firm, indicating the non-linear pattern or threshold effects have not been taken into consideration. Therefore, the pakistani literature is not clear about the existence of a non-linear relationship between IC and the performance of the firms. This study will aim at fulfilling this gap by analyzing possible quadratic effects in PSX-listed non-financial companies.

Table 2: Overview of IC-FP Literature in Pakistan

Author/ Year	Country/ Context	Methodology	Key Findings	Gaps / Limitations
Khalique et al. (2015)	Pakistan, SMEs	Survey + regression	IC improves performance; HCE insignificant	Sector-specific, linear analysis only
Mushtaq (2021)	Pakistan, Textile	VAIC, regression	IC possitively affects performance	Industry specific, linear analysis only
Yao et al. (2019)	Pakistan-financial institutions	VAIC, MVAIC	Inverted U-shaped nexus; human capital drives effect	Non-financial firms not studied
Arslan & Zaman (2024)	Pakistan oil & gas	VAIC, panel data	IC efficiency boosts ROE, ROI, EPS	Linear approach only; ignore curvature
Rehman et al. (2011)	Pakistan, modaraba	VAIC, regression	IC possitively linked to performance	Linear, SME focused

2.6 Research Gap

The role of IC on the performance of companies is widely examined, but there are still gaps in research, particularly non-linear interaction and emerging economies such as Pakistan. Most of the available research in Pakistan or globally provides mixed findings, with most studies primarily assumed the existence of a linear relationship, implying that increased levels of IC result proportionately in the improvement of performance. There is an emerging global evidence that the association between IC and the financial performance of a firm is sometimes non-linear with inverted U-shaped or U-shaped format where performance rises with IC to a specific point than falls due to diminishing marginal returns. Nonetheless, the research evidence on whether the relationship between IC-performance is linear or non-linear is not provided in the context of non-financial sectors of Pakistan. Therefore the main gap of the study is the unresolved nature (linear or non-linear) of the IC-FP relationship, which has not been tested comprehensively using both aggregate and component-wise measures within a dynamic panel frameworks in the non-financial sector of Pakistan. The is also a lack of consensus among competing theories (RBV, Engogenous Growth, Locau Human Capital and Production Theory) regarding the nature of IC-FP relationship, in addition to the empirical, methodological and contextual gaps. Most of the studies focus on advanced economies (e.g., Europe, U.S.) or large emerging markets (e.g., China, India), and little is given to South Asian nations, where institutional weaknesses and resources as well as cultural factors can alter IC dynamics (Boateng et al., 2025). linear influences, and non-linear relationships, including the cases of inverted U-shaped curves, need to be examined deeper in order to identify optimal IC investment thresholds in different industries (Yin and Xu, 2024). This research bridges the literature gap using VAIC method to achieve sustainable performance in non-financial sector.

2.7 Hypothesis Development

Based on the empirical literature and theoretical framework, this study develops the following hypothesis regarding the IC-FP relationship. The RBV theory suggests that IC increases firm performance; therefore, a positive relationship of IC and its components is expected.

H1: IC has a positive and significant effect on firm financial performance.

H2: Human Capital efficiency, Structural Capital efficiency and Capital Employed efficiency have a positive and significant effect on performance.

However, recent empirical and theoretical evidence (Human Capital Theory and Endogenous Growth Theory) suggests that IC-FP relationship may not be strictly linear, rather increasing returns may occcur at higher levels of IC. While production theory implies that the marginal impact of inputs may not be uniform and can vary with scale.

H3: There exists a non-linear relationship between IC and firm performance.

H4: There exists a non-linear relationship between IC components (HCE, SCE and CEE) and firm performance.

Furthermore, firm performance may persist over time, which provides a rational for employing dynamic panel models.

H5: Firm performance is dynamically persistent, such that past performance significantly affects current performance.

2.8 Summary

This study's theoretical framework (Resource-Based View, Locus Human Capital, Endogenous Growth and Production Theory) integrates contrasting perspectives to capture the complexity of the IC-performance relationship. RBV emphasize the role of IC as a strategic knowledge resource that contributes to higher productivity, innovation and competitive advantage, suggesting that a positive IC-performance relationship and provide the basis for linear hypothesis of the study. In contrast, production theory, Human Capital and Endogenous Growth theory collectively indicates that the contribution of IC may differ at different levels as a result of diminishing or increasing returns highlighting that IC may exhibit non-linear patterns. By combining these theoretical insights, the study posits that IC may initially have a limited impact on performance but can generate stronger effects after effectively utilized, while also the framework allow for the possibility of diminishing returns at higher levels. Therefore, the integration of these theories directly informs the development of both linear and non-linear hypotheses, which are empirically tested using aggregate and component-wise measures of IC within the econometric framework. By using VAIC model, the study reveals the overall positive or non-linear way of influence of IC on financial performance of listed non-financial firms. Practically, the companies should strategically plan the IC investments to enhance competitiveness, sustainability, and long-term resiliency of the emerging markets.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Conceptual Framework

Conceptual framework of this study, represented in figure 1, is aimed at investigating the relationship that exists between IC-performance through the incorporation of a linear relationship and a non-linear relationship. The framework is based on four key theories that, in turn, reflect the strategic contribution of intangible resources to organizational performance. Generally, the conceptual framework introduces a cohesive analytical framework that connects the IC elements with both linear and non-linear functionality and including the firm-level attributes. This framework directs the empirical modeling approach and provide a systematic foundation to test the hypothesized IC-performance relationship in the non-financial sector of Pakistan.

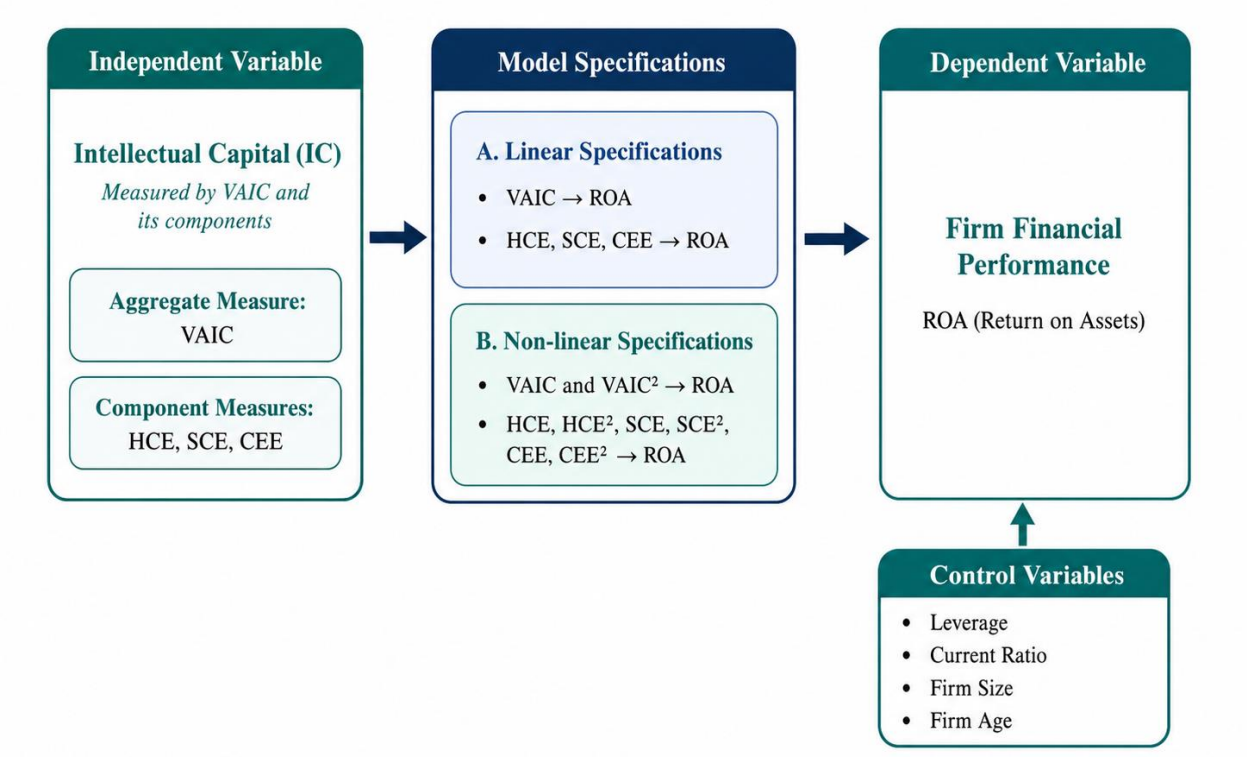

Figure 1: Conceptual Framework

3.2 Theoretical Framework

In Diagram 2, four theories are presented and they all underline the significance of knowledge-based resources, employee capabilities, organizational efficiency and productivity in determining the success of firms. Based on the theoretical framework developed in Chapter 2, the study estimates both linear and non-linear models in order to explain the variations in marginal returns to intellectual capital. The linear specification is justified by RBV theory, which explains IC as a strategic resource that enhances performance. The quadratic model is supported by Lucas Human Capital, Endogenous Growth and Production Theory, suggesting that the effect of IC may vary depending on its level as a result of increasing or diminishing marginal returns. Therefore, the framework suggests that intellectual capital that is quantified by Human Capital Efficiency, Structural Capital Efficiency, and Capital Employed Efficiency may have a direct or non-linear effect on firm financial performance. To further regulate the performance, firm-specific control variables are also included to ensure that the differences do not have an independent influence on performance. In general, this theoretical framework provides a powerful conceptual base of the empirical analysis.

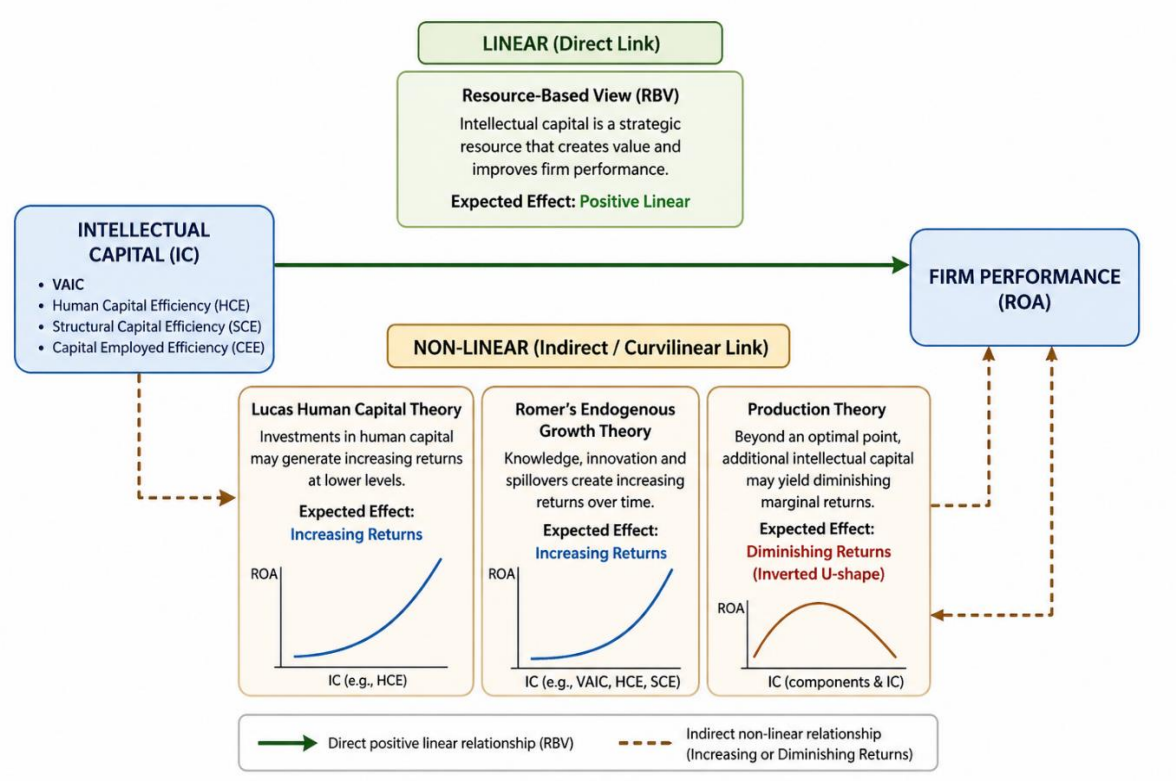

Figure 2: Theoretical Framework

3.3 Sample and Data

This research unravels the dynamic relation between IC and performance, with an indication of how intangible assets can lead to value creation. Our sample includes 361 non-financial companies that are listed on PXS, representing the entire population of non-financial companies that have accessible annual financial information throughout the period of 2014 to 2023. The research is done on non-financial firms to assure the homogeneity and commparability of the measurement of IC in those companies. Conversely, IC-performance literature has already covered the financial sector, both nationally and internationally. In addition, the financial sector has different regulatory frameworks, different capital structures, and they have sector specific reporting practices, therefore their financial ratios and IC elements cannot be compared with non-financial companies. The data is a broad mix of industries, including textile, sugar, food & Personal Care Products, engineering / manufacturing, mining & mineral products, cement, oil & gas / fuel & energy, electrical machinery & equipment, chemical products & pharmaceuticals, paper & board, Automobile & Parts and information & communication services. The firms are sampled using IC and components disclosure of the firms in their financial statements. With the inclusion of companies operating in various sectors, the study increases the generalizability of the results as well as the capability of the analysis to represent the differences in how IC increases the performance of firms, in the key industrial areas of Pakistan. The analyzed data is provided by the annual reports of the listed non-financial firms, PXS data portal and financial analysis report of State bank of Pakistan websites.

Table 3: Sector-wise Distribution of Sample Firms

Sr. No.	Sector Name	No. of firms
1.	Textile	124
2.	Sugar	28
3.	Food & Personal Care Products	20
4.	Engineering / Manufacturing	35
5.	Cement	16
6.	Mining & Minerals	9
7.	Oil & Gas / Fuel & Energy	33
8.	Chemicals & Pharmaceuticals	46
9.	Paper & Board	8
10.	Electrical Machinery & Equipment	7
11.	Automobile & Parts	20
12.	Information & Communication Services	15
	Total firms	**361**

3.4 Variables and Measures

3.4.1 Dependent Variable

Dependent variable in this research is firm financial performance (FP). Return on asset (ROA) is employed as a proxy indicator of firm performance. Other indicators such as ROE and Tobin's Q measures used to assess FP, but ROA is the prefered indicator (Jonnius and Almatius, 2021). The characteristics of ROA make it a better proxy compared to others because it is not influenced by accounting manipulations and financial risk while assessing financial analysis of a firm (Core, Guay & Rusticus 2006). ROA is a sound indicator which gives more steady basis of cross firm and cross industry comparisons. ROA has a way of reflecting actual operating performance because it is calculated as a result of net income divided by total assets and hence reflects the efficiency of the firm with which the total assets are used to create its profit.

3.4.2 Independent Variables

In this research, IC and its significant elements are used as the independent variables. Since the lack of an agreed method among scholars for calculating intellectual capital has led to development of various methods. Value-Added Intellectual Coefficient (VAIC) model is one of them that has become widely used in theoretical and empirical research to measure IC (Smriti and Das 2018). The index through which an Intellectual capital is calculated in this study is VAIC model proposed by Pulic in 1998. This model does not give subjective weights, but it determines IC using three efficiency-based components (HCE, SCE, CEE) derived from financial statements of firms that measures the overall efficiency of a firm and its IC efficiency. The VAIC model uses objective accounting information and standardized formulas therefore, offers a clear, comparable and methodologically sound approach in determining the role of intellectual capital in firm performance. In addition, the model is based on two major assumptions which are (1) the value generation of a firm is the result of the efficient utilization of its physical and intellectual resources (2) the value generated is a measure of the total efficiency of a firm. VAIC has been used in a large number of studies, indicating the value added by IC (Joshi et al., 2013; Purohit and Tandon, 2015).

$$VAIC = HCE + SCE + CEE \quad (3.1)$$

VAIC is the sum of HCE, SCE and CEE. Where VAIC stands for Value-Added Intellectual Coefficient, HCE as human capital efficiency, SCE stands for structural capital efficiency and CEE refers to capital employed efficiency. The VAIC model consists of multiple steps to calculate IC and it starts from calculating value added (VA).

$$VA = output - input$$

$$or\ VA = EBIT + EC + D + A \quad (3.2)$$

Here VA represents Value Added, EBIT is earning before interest and taxes, EC represents employees cost, D indicates depreciation and A stands for amortization. VA is evaluated by subtracting input from output. Here output refers to overall profits from goods and services, whereas input include all costs such as depreciation and amortization yet excluding expenses related to employees, interest, dividends and taxation (Soetanto and Liem; 2019).

Human Capital Efficiency: HC relates to the economic contribution of employee's abilities, experiences, knowledge, skills, competences and attitudes of the workforce, which collectively

enhance efficiency and stimulate growth (Mayilyan, F., & Yedigaryan, K. 2022). People are the main source of new ideas, knowledge and innovation. HCE reflects how efficiently a company transform its employee's skills, education, experience into value generation. HCE is calculated as dividing VA by cost of employees (HC).

$$HCE = VA / HC \tag{3.3}$$

Structural Capital Efficiency: Basically it includes all the non-human assets like infrastructures, processes, procedures, databases, and information that help employees to perform intellectually (Maddocks & Beaney,2002). SCE measures how effectively a company transform its systems, processes, patents and databases to value creation. SC is derived by subtracting HC from VA and SCE is determined as the ratio of SC to VA. Unlike HCE and CEE, SCE is calculated as SC divided by VA because SC is derived from VA after deducting HC cost. Thus SCE indicates the degree to which VA is maintained through organizational systems, internal processes and structural resources. This follows Pulic's VAIC methodology, where SC is measured as a residual portion of VA instead of being considered a direct input factor.

$$SCE = SC / VA \tag{3.4}$$

$$SC = VA - HC \tag{3.5}$$

Capital Employed Efficiency: It represents the net capital that a company uses to produce profit. It is measured either by adding equity and long term liabilities or total assets minus current liabilities. CEE reflects how effectively a company uses its CE to create value. It is calculated as the ratio of VA to CE.

$$CEE = VA / CE \tag{3.6}$$

$$CE = Equity + Non\text{-}Current\ Liabilities \tag{3.7}$$

3.4.3 Value Added Intellectual Coefficient VAIC / Ante Pulic

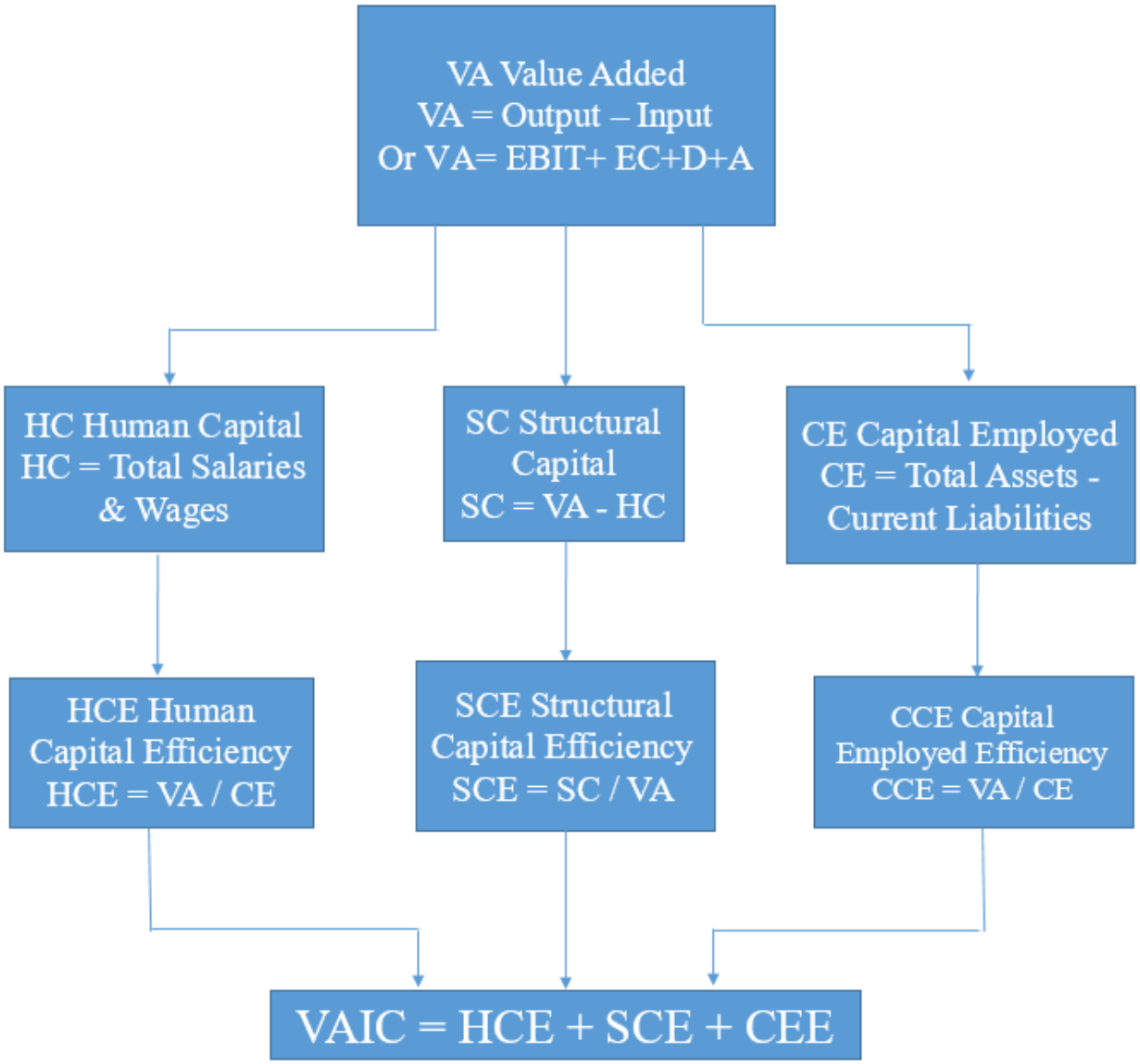

Figure 3: VAIC Framework

3.4.4 Control variables

To ensure the IC-performance relationship is not distorted by firm-specific factors, a number of control variables are incorporated in the model. The control variables employed in this research to mitigate the effect of changes in financial structure, firm maturity and liquidity are leverage, firm age, firm size and current ratio, all of which were adequately specified in the literature as having an effect on firm performance. Leverage represents the proportion of debt to total assets, capturing financial risk and decisions regarding capital structure. In the analysis of IC-performance, Zeghal and Maaloul (2010) considered leverage as a control variable since it has a significant impact on profitability and value creation. Current ratio is a basic measure of liquidity as it indicates the ability of a corporation to cover short-term debts using short-term assets. It is calculated as the ratio of current assets to current obligations, thus it has been incorporated in the study to manage the liquidity effects on performance. The firm age is determined by natural logarithm of the number of years that firm has been listed on the Pakistan Stock Exchange. According to Raymond and St-Pierre (2010), it negatively impacts performance since older firms usually possessed high level of inertia. Natural logarithm of total assets also provides the firm size, which will be controlled for since larger firms normally accrue high profits compared to smaller ones (Bayoud and Kavanagh, 2012).

Table 4: Variable Description and Sources

Variables	Proxy	Measurement Method	Data Sources
Dependent Variable			
Firm Financial Performance	ROA	Net Income / Total assets	Annual financial reports
Independent Variables			
Intellectual Capital	VAIC™	VAIC = HCE+SCE+CEE	Annual financial reports
Human Capital Efficiency	HCE = VA / HC	VA = Output – Input HC = Total salaries & wages	Annual financial reports
Structural Capital Efficiency	SCE = SC / VA	SC = VA - HC	Annual financial reports
Capital Employed Efficiency	CEE = VA / CE	CE = Equity + Non-Current Liabilities	Annual financial reports
Control Variables			
Financial Leaverage	Leverage Ratio	Total Debt / Total Assets	Financial reports
Current Ratio	Current Ratio	Current Asstes / Current liabilities	Financial reports
Firm Size	Total Assets	Natural log of Total Assets	Financial reports
Firm Age	Age	Natural log of No. of years of firm since Incorporation	Financial reports

3.5 Research Model

Past literature has also investigated the impact of IC on the performance of the firms through Ordinary Least Squares (OLS) estimation (Nuhoglu, Parlak, and Erdogaan, 2021). OLS can create biased and inconsistent estimates because it does not consider unobserved heterogeneity and potential endogeneity problems of a panel data (Wooldridge, 2010). Pooled OLS estimator was applied as an initial approach. Although pooled OLS provides a baseline estimation but this approach is not considered as reliable as it assumes homogeneity across firms while ignoring heterogeneity (firm specific and time specific effects). Moreover, the estimation with OLS presupposes the cross-sectional nature of the data and does not take into account the longitudinal nature. In both linear and non-linear ways, panel data econometric framework is applied to assess the IC-FP relationship. The panel data gives more detailed information as compared to other methods since it would be beneficial to note fluctuations in firms and time series changes across years. There are different estimators to deal with different econometric problems, because no single estimator can deal with all the econometric issues that is the reason why this research adopted more than one model to ensure the strength and validity of results.

3.7 Random Effects Model

This framework in panel data analysis relies on the assumption that unobserved heterogeneity is randomly distributed across firms and does not correlate with explanatory variables, utilizing both within firm and between firm variations (Gujarati, D. N., & Porter, D. C. 2009; Greene 2012). RE model differs from FE in that it views the unobserved firm specific effects are random outcomes drawn from probability distribution (commonly normal distribution), rather than as a fixed intercept. This model assumes that μ_i does not correlate with explanatory variables (Hsiao, 2003). If this holds, RE approach will provide efficient and unbiased estimates; if not, the FE method is more reliable and appropriate.

3.8 Fixed Effects Model

This model is useful because it especially takes into consideration within firm variation, and it regulates heterogeneity between firms that would otherwise give rise to biased coefficient estimates (Greene, 2012; Baltagi, 2008). This model produces more similar and objective results when it is compared to pooled OLS because it emphasises on within firm differences over time as

it considers unobserved heterogeneity that could be correlated with the explanatory variables (Baltagi, B. H. 2005). FE model also possess limitations because it absorbs all time invariant factors so the direct estimates of such variables as industry classification or ownership type are forbidden. In addition, it may also become inefficient in case there is majority of the variation in the dataset is between the firms and not within the firms.

The first model estimates the overall effect of IC efficiency on firm financial performance and is expressed as:

Model 1:

$$FFP_{it} = \beta_0 + \beta_1 IC_{it} + \gamma X_{it} + \varepsilon_{it} \quad (3.8)$$

Where FFP_{it} represents firm financial performance (ROA) for firm i in year t, IC_{it} indicates intellectual capital of firm i in year t, X_{it} represents set of control variables (x_1……, x_k) and ε_{it} is the error term.

The second linear model evaluates the individual contribution of IC components by disaggregating IC into human, structural and capital emplyed efficiency:

Model 2:

$$FFP_{it} = \beta_0 + \beta_1 HCE_{it} + \beta_2 SCE_{it} + \beta_3 CEE_{it} + \gamma X_{it} + \varepsilon_{it} \quad (3.9)$$

Where

HCE_{it} = Human Capital Efficiency

SCE_{it} = Structural Capital Efficiency

CEE_{it} = Capital Employed Efficiency

The model introduces a squared term of IC to capture non-linear effects. A positive squared term coefficient suggest accelerating returns, whereas a negative coeeficient implies diminishing returns to IC investment.

Model 3:

$$FFP_{it} = \beta_0 + \beta_1 IC_{it} + \beta_2 IC^2_{it} + \gamma X_{it} + \varepsilon_{it} \quad (3.10)$$

To further evaluate component wise non-linear behavior, squared term of individual IC components are included:

Model 4:

$$FFP_{it} = \beta_0 + \beta_1 HCEi_{it} + \beta_2 HCE^2_{it} + \beta_3 SCE_{it} + \beta_4 SCE^2_{it} + \beta_5 CEE_{it} + \beta_6 CEE^2_{it} + \gamma X_{it} + \varepsilon_{it} \quad (3.11)$$

This specification identifies threshold effects and non-linear productivity patterns linked to each IC component, thereby providing deeper insights into optimal resource allocation strategies.

3.9 Hausman Test (Model Selection)

This diagnosis tool was applied to evaluate whether the FE or the RE model is more credible to the analysis of this panel data (Hausman, 1978). The null hypothesis H_0 implies that RE model produces estimates efficient and unbiased because it presupposes that there is no connection between unobserved firm specific random effects (μi) and repressors. In the alternative hypothesis H_1 the RE model does not give consistent results because μi is correlated with at least one or more independent variables. This will contribute to biased outcomes hence FE model is a more appropriate one to analyze. Basically Hausman Test is the comparison of the estimates of the coefficient of both models (FE and RE). It will indicate that RE model cannot be used in case the test statistic is significant ($p < 0.05$) and thus use the FE model in the analysis. And in the case that the outcome is not significant as ($p > 0.05$) then RE model will be adopted.

3.10 Dynamic Panel Model

Even after the use of traditions estimators (pooled OLS, FE and RE) potential endogeneity problems remained that might led to biased and inconsistent parameters as a result of correlation of explanatory variables and error term. The majority of the previous studies had not identified the need to deal with endogeneity and its implications when investigating the impact of IC on firm performance but nowadays numerous studies are highlighting its significance (Nadeem, Gan, and Nguyen 2017; Sardo, Serrasqueiro, and Alves, 2018; Ul Rehman et al. 2023). In this study firm performance is a dependent variable and it is likely to follow a path where the past performance is likely to impact the current performance. By adding the lagged value of dependent variable (ROA), the model not only accounts for its past influence but it will also address the possibility of omitted variable bias that is also a major source of endogeneity and could be caused by absence of variables among the control variables (Nadeem, Gan, and Nguyen 2017; Lin, 2022).

System GMM estimator developed by Blundell & Bond (1998) that was later found by Roodman (2009) is a more robust than one step GMM method. Arellano & Bond (1991) and Hansen both test are employed to check the validity of system GMM as offered by Roodman (2009). Such tests possess their own features since Arellano and Bond (1991) is applied to test whether there is a

second order serial correspondence in the error term or not; and the Hansen test is used in testing whether correlation between error and instrumental variable exist or not. It is the preferred approach with respect to endogeneity since it combines the differences instruments and lagged levels, state that the system GMM provides consistent and non-bias results as compared to other methods such as OLS, FE and others. In addition to this, system GMM also solves some autocorrelation and heteroscedasticity (Roodman D, 2009).

Model 5:

$$FFP_{it} = \beta_0 + \lambda_t + \phi\, FFP_{i,t-1} + \beta_1 IC_{it} + \gamma\, X_{it} + \varepsilon_{it} \quad (3.12)$$

Model 6:

$$FFP_{it} = \beta_0 + \lambda_t + \phi\, FFP_{i,t-1} + \beta_1 HCE_{it} + \beta_2\, SCE_{it} + \beta_3 CEE_{it} + \gamma\, X_{it} + \varepsilon_{it} \quad (3.13)$$

Model 7:

$$FFP_{it} = \beta_0 + \lambda_t + \phi\, FFP_{i,t-1} + \beta_1\, IC_{it} + \beta_2\, IC^2_{it} + \gamma\, X_{it} + \varepsilon_{it} \quad (3.14)$$

Model 8:

$$FFP_{it} = \beta_0 + \lambda_t + \phi\, FFP_{i,t-1} + \beta_1 HCEi_{it} + \beta_2 HCE^2_{it} + \beta_3 SCE_{it} + \beta_4\, SCE^2_{it} + \beta_5 CEE_{it} + \beta_6 CEE^2_{it} + \gamma\, X_{it} + \varepsilon_{it} \quad (3.15)$$

Here λ_t shows time effects and $\phi\, FFP_{i,t-1}$ represents lagged dependent variable that captures persistence. IC_{it} and IC^2_{it} indicates intellectual capital and its non-linear term. X_{it} captures vector of control variables. Although this method has a lot of advantages but it also has some limitations that should be highlighted as careful instrument choice is necessary because misspecification can distort outcomes. Also in this method a large number of instruments are used that may lead to bias estimates.

3.11 Non-Linear Model Specification

In order to assume potential non-linear relationships between intellectual capital and performance nexus, this study employed the quadratic (polynomial) regression model. The new literature indicates that the effect of IC is not necessarily proportional to performance improvement, but instead, it may have a more diminishing or increasing marginal effect (Asif and Ting, 2020; Kweh et al., 2022). Although there are other non-linear models, including the Threshold models, GAM (Genera1ized Additive Models), non-parametric Kernel Regressions, Ramsay RESET test, the quadratic approach is commonly applied in IC literature due to its simplicity, effective calculation and ability to process panel datasset (Xu and Zhang, 2021; Ruiz-Fernandez, Marco-Lajara, and Seva-Larrosa, 2024; Asif and Ting, 2020). Quadratic approach allows testing of U-shaped or inverted U-shaped effects by adding squared IC terms, and allows an easy and useful way to test non-linear effect in the nexus of IC-performance. In order to minimize multicolinearity between linear and squared terms, all variables were mean-centered prior to squaring.

CHAPTER 4

DISCUSSION OF RESULTS

4.1 Introduction

In this chapter, the empirical study shows the relationship between intellectual capital and financial performance of organizations in the non-financial sector of Pakistan. The present study is done on an unbalanced set of panel data that has 3,441 firm-years observations of non-financial firms listed on PSX between the year 2014 and 2023. The study takes into consideration both the firm specific discrepancies and time varying trends in the efficiency of intellectual apital and performance dynamics using longitudinal firm level data. The analysis uses both static panel estimation and the dynamic panel methodology (system GMM) to improve robustness and methodological rigor. The relationship between IC and performance at a specific time is studied in the case of the static models and the control of the possible endogeneity, reverse causality and performance persistence is the case of dynamic models. The estimates of linear and non-linear model specifications are made to explain possible asymmetries and non-linearities in the IC-performance relationship.

4.2 Descriptive Statistics

Descriptive statistic is used as a preliminary measure to give a summary of central tendency and dispersion of the variables used in the study. This is necessary in finding out the major characteristics of the dataset and determining the variability of the firm and time periods. The table 5 indicates the mean, standard deviation, minimum and maximum of measures of intellectual capital, firm performance and control variables. The average of HCE is 3.25 which implies that companies make high value out of investments on employees, but the high standard deviation indicates large dispersion among companies. The average scores of SCE and CEE are 0.70 and 0.39, respectively, which means that both companies are moderately efficient in using physical capital and organizational facilities. An average IC value of 4.33 underscores the overall significance of intellectual capital in generation of value. The average ROA is 0.031, which indicates an average return of 3.1 percent on the total assets. In control variables, the average leverage ratio is 0.89 , indicates a high reliance on debt financing among firms, whereas the

average current ratio stands at 1.67 indicating a stable liquidity standing. The average age of a firm is about 39 years and the mean size of firms is 15.48 which indicates that the sample is composed of mature and relatively large firms.

Table 5: Descriptive Statistics of the Variables

Variable	Observation	Mean	Std. dev.	Min	Max
HCE	3,441	3.25	29.78	-1338.47	695.98
SCE	3,441	0.70	7.11	-296.34	168.24
CEE	3,441	0.39	2.10	-44.17	84.41
IC	3,441	4.33	30.68	-1337.92	693.40
ROA	3,441	0.031	0.155	-1.60	3.38
LEV	3,441	0.89	0.31	0.00	1.00
LIQ	3,441	1.67	3.96	0.00	138.53
SIZE	3,441	15.48	1.91	7.44	21.08
AGE	3,441	38.94	17.12	2.00	162

Note: ROA= Return on Assets, HCE= Human Capital Efficiency, SCE= Structural Capital Efficiency, CEE= Capital Employed Efficiency, IC= Intellectual Capital(VAIC), LEV = Financial Leverage, LIQ = Liquidity Ratio, SIZE = Firm Size, AGE = Firm Age.

4.3 Correlation

Table 6 shows the Pearson correlation format of the study variables that gives the direction and strength of relationship between the variables before regression estimates. As the findings show, ROA is positively and significantly correlated with HCE ($r = 0.27$, $p < 0.01$) and IC ($r = 0.26$, $p < 0.01$), indicating that companies with greater HCE are more likely to become profitable. This underscores the presence of knowledge based resources in enhancing performance. The positive correlation (0.97) between HCE and IC is very high which shows that IC is a composite index made up of its core components. In addition, all the correlation coefficients are less than the critical value of 0.80, which demonstrates the non-existence of a severe problem of multicollinearity in the regression estimates.

Table 6: Correlation Matrix

	ROA	HCE	SCE	CEE	IC	LEV	LIQ	SIZE	AGE
ROA	1.00								
HCE	0.27***	1.00							
SCE	-0.03*	0.00	1.00						
CEE	0.01	0.00	-0.00	1.00					
IC	0.26***	0.97***	0.23***	0.06***	1.00				
LEV	0.21***	0.03**	-0.01	0.02	0.03*	1.00			
LIQ	0.06***	0.01	-0.00	-0.01	0.01	-0.01	1.00		
SIZE	0.20***	0.03*	0.02	0.03**	0.04**	0.01	-0.07***	1.00	
AGE	0.04**	-0.02	0.00	0.00	-0.02	-0.00	-0.01	0.05**	1.00

Note: ***, **, and * indicate significance at the 1%, 5% and 10% levels respectively.

4.4 Static Panel Results

Before conducting the dynamic panel estimation, the pooled OLS, fixed effects and random effects were conducted, considering the roubustness and unobservable firm-specific heterogeneity. Since the primary estimation technique of the project is not the static panel estimations, the findings can be found in the appendix section. Hausman test results show that FE is preferable for model 1 and model 4, indicating that firm-pecific effects are correlated with the explanatory variables. While RE method is approriate for model 2 and 3, suggesting that RE assumption is valid as Hausman Test is statistically insignificant. The FE results for model 1 indicate that IC has a positive and significant effect on performance, suggesting that IC acts as a valuable strategic resource that enhances profitability. Liquidity also positively and significantly influence performance, while firm age and size are insignificant, indicating that these variables do not have meaningful impact on performance in this model. While leverage has a positive and weakly significant effect on perfromance.

The RE results for model 2 show that HCE has a positive and highly significant impact on performance, while SCE and CEE exhibit negative and insignificant effect on performance. Liquidity and firm size and leverage positively and significantly influence performance, whereas firm age is not significant. The results of RE for model 3 indicate that IC and also its squared term are positive and statistically significant, suggesting a U-shaped IC-performance relationship,

indicate that the positive impact of IC increases at higher levels. Liquidity, leverage and firm size have positive and significant affects, while firm age remains insignificant. The FE result for model 4 indicates a significant U-shaped relationship between HCE and performance as HCE and its squared term both have positive and significant effect on performance, while SCE and its squared term are statistically insignifiacnt. CEE linear term show negative but weakly significant effect, while CEE^2 is insignifiacnt, suggesting that CEE does not show a consistent non-linear relationship. Liquidity, leverage, and firm size positively influence firm performance, whereas firm age remains insignificant. The overall findings of FE and RE indicate that there is a positive relation between HC-performance. The mixed effect of SCE nad CEE implies that they rely on the situation affecting firms. Findings of the non-linear FE specificanions give further support to the IC-performance processes and the importance of the most optimal levels of knowledge investment. The R-squared values of FE indicates greater explanatory power compared to pooled OLS, which shows that the firm-specific controls have greater explanatory power on profitability. Judging by the results of the Hausman test, FE model is appropriate for model 1and 4, while RE is suitable for model 2 and 3 in our case, and therefore more attention is paid to the dynamic System GMM findings to final interference.

4.5 GMM Estimation Results – Linear Effects

Table 7 presents the System GMM estimation of the linear specifications of firm performance and IC. Profitability is a dynamic construct and this fact is reflected by incorporating ROA (t -1) as a lagged dependent variable. Although we get positive coefficients in both models, the coefficient of lagged ROA is statistically insignificant meaning that past firm performance does not significantly influence current firm performance. Model 1, which uses the aggregate measure of IC, has a positive but insignificant coefficient and this significance indicates that the overall impact of IC on performance may be non-linear or may have component level effects. In model 2, the coefficient of SCE shows that it is negative and statistically significant at the 1% level which reflects that holding other variables constant, a one-unit increase in SC is associated with a decrease in performance by approximately 0.0016. In comparison, HCE and CEE show positive but insignificant correlation to ROA which implies that their direct linear impact on profitability is not much when it is controlled by consideration of endogeneity and dynamic effects. Therefore,

In the component-wise analysis, SCE demostrate a significant negative impact on performance while HCE and CEE results are statistically insignificant.

As far as the control variables are concerned, the findings indicate that the variable of size of the firm has a strong and significant positive impact in the two models, indicating that larger firms have economies of scale and operational efficiency. Leverage has also a positive and significant effect on performance, suggesting that firns benefit from the effective use for debt. Liquidity has a positive but insignificant relationship with performance whereby companies with better short-term financial positions leads to increased profitability, while firm age remains insignificant. The usefulness of the model estimations is proven by diagnostic results, where the significant AR(1) and low AR(2) statictics show the non-existence of the second-order serial correlation. Contrarily the p-values of the Hansen test verify the soundness of the set of instruments. All in all, the findings are strong indications of dynamism, suggesting that a linear model may not fully capture the dynamics of the relationship.

Table 7: One-Step System GMM Results for Linear Models

	Model 1		**Model 2**	
Variables	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**
Intercept	-0.2295***	-6.31	-0.2281***	-6.52
ROA(t-1)	0.1191	1.48	0.1142	1.42
HCE			0.0013	1.59
SCE			-0.0016***	-3.69
CEE			0.0004	0.20
IC	0.0013	1.60		
LEV	0.0686***	4.18	0.06560***	4.16
LIQ	0.0029	1.72	0.0029	1.71
SIZE	0.0149***	5.71	0.0150***	7.57
AGE	0.0003	1.25	0.0003	1.37
	AR(1) p-value 0.001		AR(1) p-value 0.001	
	AR(2) p-value 0.314		AR(2) p-value 0.308	
	Hansen Test (p) 0.831		Hansen Test (p) 0.830	
	No. of Instruments 9		No. of Instruments 11	
	Observations 3,081		Observations 3,081	

4.6 GMM Estimation Results – Non-Linear Effects

Table 8 displays the System GMM estimation of the non-linear specifications of firm performance and IC. The lagged ROA measure reflects dynamics on profitability but its positive but insignificant coefficient means that it does not have strong persistence of performance over time. In model 3, the coefficient of IC is positive and very significant, whereas the IC^2 is negative and statistically significant which indicate non-linear IC- performance relationship. This trend is a good indication of a inverted U-shaped relationship, with an increase in initial investments in IC to increase profitability due to efficiency and innovation benefits (Kweh et al., 2022). This is because additional investment above the optimum level can lead to high cost of coordination, management inefficiency and marginal returns which undermine increases in performance. Model 4 reveals that HCE exerts a positive and highly significant effect on ROA and a significant squared term supports non-linear productivity influences with human capital accumulation. HCE demonstrate U-shaped relationship, suggest that increasing results after a certain threshold level. The non-linear effect of SCE and CEE is poor and largely insignificant, meaning that their influence on the performance of a firm is less important compared to that of human capital.

Financial leverage and firm size are the control variables that have positive and significantly high effect in both models indicating that firms benefit from the effective use of debt financing and also larger firms tend to perform better. The findings also suggest that the liquidity is positively and significantly correlated with profitability which is a key aspect of financial stability in the short run. Conversely, the age of firms is not statistically significant. The test results of the diagnostic tests confirm the validity of estimation, AR(1) and AR(2) test result denote that there is no second-order serial correlation and the result of the Hansen test is that the instrument set is valid. Combined, the results support the lack of linearity in the role of IC on performance and the strategic importance of balanced investment in knowledge-based assets.

Table 8: One-Step System GMM Results for Non-Linear Models

	Model 3		Model 4	
Variables	**Coefficient**	**t-Stat**	**Coefficient**	**t-Stat**
Intercept	-0.2407***	-6.38	-0.2377***	-6.64
ROA(t-1)	0.1176	1.49	0.1100	1.40
IC	0.0021***	3.52		
IC^2	-0.0000014***	3.21		
HCE			0.0023***	3.82
HCE^2			0.0000015***	3.54
SCE			-0.0025	-2.38
SCE^2			0.0000080	1.10
CEE			0.0025	0.66
CEE^2			-0.000045	-0.57
LEV	0.07946***	4.87	0.07516***	4.91
LIQ	0.0030*	1.73	0.0030*	1.73
SIZE	0.0152***	5.70	0.0153***	7.46
AGE	0.0004	1.49	0.0004	1.51
	AR(1) p-value	0.004	AR(1) p-value	0.003
	AR(2) p-value	0.288	AR(2) p-value	0.280
	Hansen Test (p)	0.833	Hansen Test (p)	0.834
	No. of Instruments	14	No. of Instruments	10
	Observations	3,081	Observations	3,081

4.7 Threshold Analysis

To fulfill the second objective of the study, the threshold or turning points of IC and its components are estimated by employing a quadratic model specification of the system GMM model.

$$Turning\ Point = -\beta_1 / \beta_2 \quad (3.16)$$

This formula identifies the level of IC where the marginal impact on performance changes direction. According to the results, the coefficient of IC is positive and significant, whereas the coefficient of IC^2 is negative and significant, confirming the presence of inverted U-shaped IC-FP relationship. As the figure 4 represents, the turning point value of IC (750) indicates the optimal threshold at which firm performance is maximized. After exceeding this level, the marginal contribution of IC diminishes, reflecting diminishing returns or excessive investment. At the component-level, the result shows that HCE and HCE^2 both have positive and significant coefficients, suggesting a U-shaped IC-FP relationship.

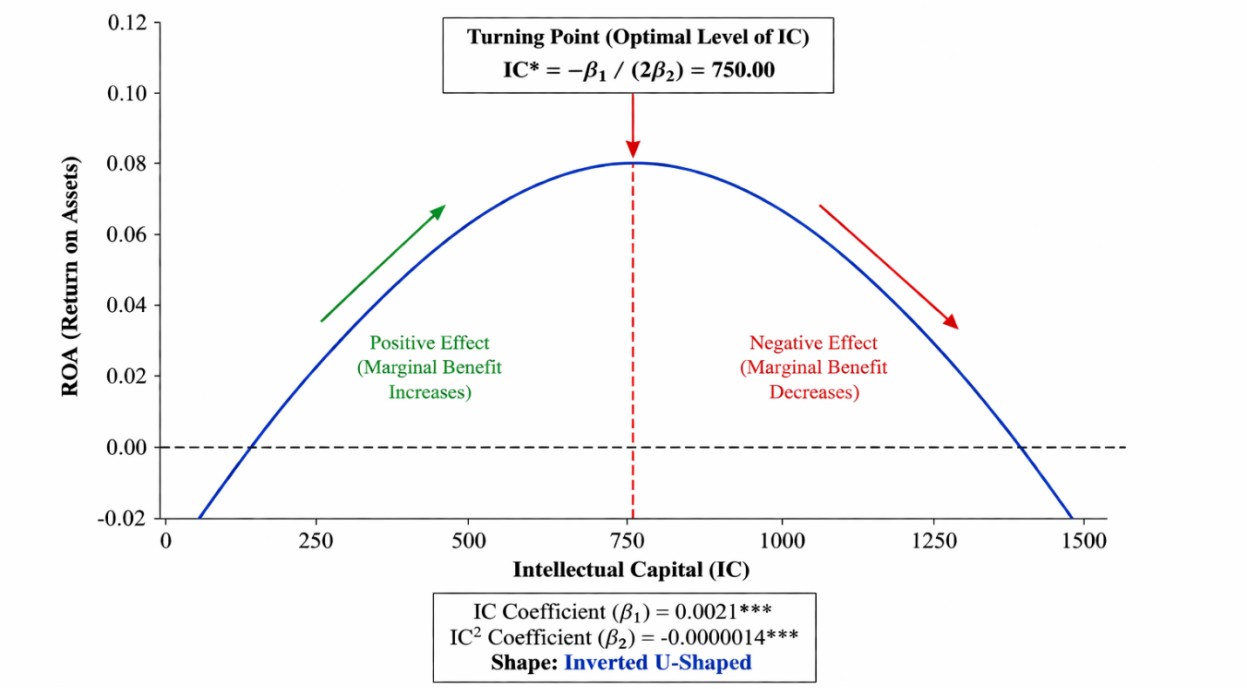

Figure 4: Inverted U-Shaped IC-FP Relationship

At the component-level, the result shows that HCE and HCE^2 both have positive and significant coefficients, suggesting a U-shaped IC-FP relationship. Figure 5 represents, the estimated turning point for HCE is (-766). This value lies outside the range of observed data and does not represent a practical threshold within the sample. This means that firms continue to benefit from higher levels of HCE without experiencing a decrease within the observed range. Since the estimation of turning point relies on the significant quadratic term, calculating threshold level for SCE and CEE is neigher appropriate nor reliable.

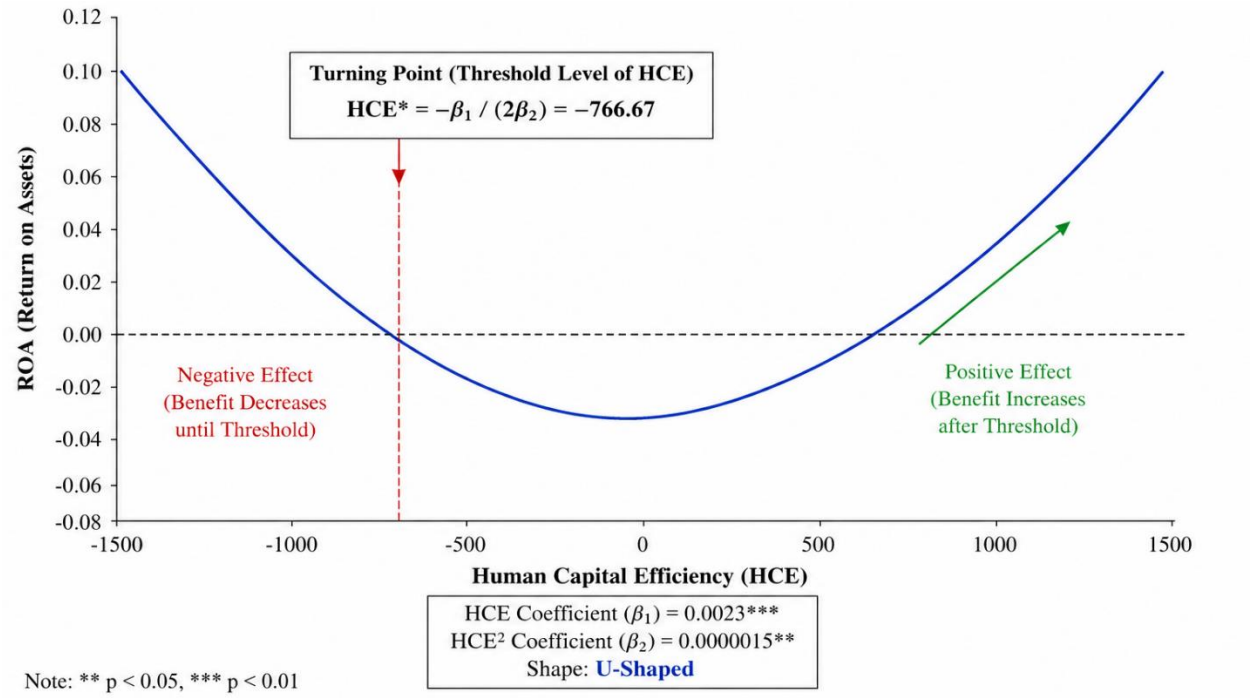

Figure 5: U-Shaped HCE-FP Relationship

CHAPTER 5

CONCLUSION AND POLICY RECOMMENDATION

5.1 Conclusion

Panel data analysis is utilized in the research on the nexus of IC- performance of non-financial sector in Pakistan. The research employed both, the static and dynamic econometric approaches to explain the non-linear effect of IC-components on profitability besides its direct effect. The empirical findings of system GMM method provide strong evidence that overall IC positively and insignificantly effects profitability, suggesting that IC does not have a strong direct impact on performance when considered in a linear model.

According to the findings of pooled OLS, FE and RE techniques HCE is determined to be the most important aspect of IC. This observation underlines the importance of knowledge based skills, skilled workers, and productivity of employees in improving business performance (Bontis, 1998; Pulic, 2000). Firms that invest in human resource training, career growth and employee retention programs usually fare better financially since such investments enhance operational efficiency and innovation ability (Chen & Hwang, 2005; Nawaz and Haniffa, 2017). But according to the system GMM findings HCE is positively but insignificantly effects performance.

As we have found, SCE does not add any positive contribution to the performance and, in the majority of models, it is negatively correlated with profitability. This implies that organizational operations or technology in Pakistani non financial companies might not be well aligned with performance based objectives (Bontis, 2001). Besides, this analysis indicates that there is positive and statistically not-significant CEE among the estimated models, implying that the utilization of the traditional physical and financial resources may not be adequate in stimulating high-performance. In the case of the emerging markets such as Pakistan, the inefficiencies in resource allocation, the availability of older production technologies and less efficiency in innovation can decrease the CE and hence result in negligible performance output. In general, our empirical comparative findings concerning HCE and other elements of the IC point to the fact that the knowledge and skills of the employees are more important to the profitability compared to structural and tangible capital in the non-financial sector of Pakistan.

The other important result of our research is that the IC-performance nexus is non-linear, i.e. its benefits vary throughout the various levels of investment (Romer, 1990; Chang et al, 2024). The empirical findings of the study show the presence of both increasing and diminishing returns in the IC-FP nexus. The aggregate measure of IC exhibits an inverted U-shaped association, indicating that while IC initially increases performance but declines after a certain optimal level. This result is consistent with Production Theory, indicating diminishing marginal returns to input. In contrast, the result of HCE represents U-shaped (non-diminishing / increasing return) relationship, suggesting that marginal marginal contribution of HC increases at higher levels. This result Locas Human Capital and Endogenous Growth Theory, highlighting the role of learning effects, knowledge accumulation and spillovers. Collectively, the findings reveal that IC-FP is not homogenous and differs across both components and levels of IC, underscoring the critical role of balancing IC investments to obtain optimal performance.

Therefore, this observation fits well with our theoretical model because the outcome supports Endogenous Growth Theory, Lucas Human Capital Model, RBV and Production Theory, where investment in HC and knowledge is a propulsive factor to sustained growth due to cumulative learning and positive spillover effects. The size of firms and liquidity and leverage are also among the important control variables that were found to have a positive influence on the performance of firms. The size of the firm comes with cost efficiencies in terms of scale benefits, greater access to financial sources and better market positions where access to sufficient liquidity facilitates firms in meeting short run commitments and investing in growth opportunities. Leverage positively influences performance, suggesting that firms benefit from efficient use of debt financing.

In general, the reliability of the results is improved by the similarity of the results provided by various estimation methods. In a broader context, our results will address a knowledge gap in the literature, offering empirical results in a developing economy where intellectual capital studies are scarce particularly in the non-linear viewpoint. The research results can be useful to managers, policymakers, and investors who want to know why intangible resources are important in strategic performance improvement by firms.

5.2 Policy Recommendation

Based on the findings of the study, several policy implications can be offered to the policymakers, as well as corporate decision-makers. Most importantly, companies must strive to develop human capital base. The companies are encouraged to invest in formal training, the ongoing skills development, and the reward systems based on merit. The practices create a learning environment that favours innovation and enhances firm performance. This process can be facilitated by providing tax breaks or subsidies to corporate training and professional development programs by policy makers.

Second, the organizations must increase their SC by reinforcing the digital infrastructure and knowledge management practices. Operation efficiency can be enhanced by the implementation of advanced technologies and data-based decision-making tools. The non-linear IC-performance curve supports the significance of ensuring that the long-term strategic orientation is embraced in comparison to the short-term cost-cutting measures. Investment in innovation and R&D, can be long-term in commitment, but has performance returns over the long term. Government organisations may be supportive by reinforcing innovation systems, granting research funding, and promoting industry-academia partnership. Lastly, companies ought to use IC indicators in their performance measurement and reporting systems. IC components can be measured and monitored to enable managers to make strategies that are not only well informed but also enhance competitiveness in the long run.

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APPENDIX

Table 9: FEM Results for Model 1

Variable	Coefficient	Std. Error	t-Stat	P-Value
IC	0.00124***	0.00124***	16.33	0.000
LEV	0.02409	0.01438	1.68	0.094
LIQ	0.00307***	0.00307***	4.27	0.000
SIZE	0.00414	0.00414	0.42	0.674
AGE	0.00048	0.00048	0.74	0.459
Constant	-0.0666	0.07964	-0.84	0.403
F(5, 3075) = 58.27				R-squared= 0.0865
Prob > F = 0.0000				

Table 10: REM Results for Model 2

Variable	Coefficient	Std. Error	z-Stat	P-Value
HCE	0.00134***	0.00008	17.64	0.000
SCE	-0.00024	0.00032	-0.76	0.446
CEE	-0.00088	0.00108	-0.81	0.416
LEV	0.05429***	0.01085	5.00	0.000
LIQ	0.00302***	0.00066	4.59	0.000
SIZE	0.01440***	0.00213	6.75	0.000
AGE	0.00032	0.00025	1.31	0.190
Constant	-0.21495***	0.03382	-6.35	0.000
Wald χ^2 (7) = 380.89				R-squared= 0.1148
Prob > χ^2 = 0.0000				

Table 11: REM Results for Model 3

Variable	Coefficient	Std. Error	z-Stat	P-Value
IC	0.00214***	0.00009	24.60	0.000
IC^2	0.00000145***	0.00000008	17.61	0.000
LEV	0.058787***	0.010599	5.55	0.000
LIQ	0.00307***	0.00063	4.84	0.000
SIZE	0.01527***	0.00216	7.06	0.000
AGE	0.00031	0.00025	1.23	0.219
Constant	-0.23482***	0.03422	-6.86	0.000
Wald χ^2 (6) = 688.73				R-squared= 0.1619
		Prob > χ^2 = 0.0000		

Table 12: FEM Results for Models 4

Variable	Coefficient	Std. Error	t-Stat	P-Value
HCE	0.00237***	0.00009	25.79	0.000
HCE^2	0.00000159***	0.00000008	18.83	0.000
SCE	-0.00015	0.00034	-0.45	0.668
SCE^2	-0.00000122	0.00000146	-0.84	0.445
CEE	-0.00223*	0.00134	-1.66	0.082
CEE^2	0.000025	0.000021	1.17	0.189
LEV	0.022744*	0.01363	1.68	0.095
LIQ	0.00308***	0.00067	4.58	0.000
SIZE	0.01499**	0.00563	2.66	0.019
AGE	-0.00057	0.00085	-0.67	0.644
Constant	-0.1928**	0.0755	-2.55	0.011
F(10, 3070) = 70.98				R-squared= 0.1878
		Prob > F = 0.0000		