

**Social capital
and industry 4.0 readiness:
Role of innovative capability,
industry 4.0 efficacy,
and knowledge
based dynamic capabilities**

Najam Ul Zia, Ph.D.

Doctoral Thesis Summary



Tomas Bata University in Zlín
Faculty of Management and Economics

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Social capital and industry 4.0 readiness: Role of innovative capability, industry 4.0 efficacy, and knowledge based dynamic capabilities

Sociální kapitál a připravenost průmyslu 4.0: Úloha inovativních schopností, účinnost průmyslu 4.0 a dynamické schopnosti založené na znalostech

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ABSTRACT

In this digital age, organizations are confronting the cusp of the fourth industrial revolution. Developed economies have already created new strategic options for the industry 4.0 (i4.0) strategy, however, due to institutional voids, firms in developing economies still rely on developed economies to extract knowledge and buy new technology. Firms in developing economies must use social capital (SC) to obtain knowledge, information, trust, and support from developed economies to show industry 4.0 readiness. Research on industry 4.0 mainly focuses on technical aspects, however, there is less scholarly attention on the management issues of industry 4.0, and most of the studies emphasise developed economies. Particularly, how the firms of developing economies become ready to face the fourth industrial revolution, and how developing economies get industry 4.0 competencies is still scarce in the existing literature.

The presented thesis seeks to establish the role of social capital dimensions to enhance industry 4.0 readiness in selected manufacturing firms in Pakistan. It also fills the missing gap of the mediating roles of innovative capability, knowledge-based dynamic capabilities, and industry 4.0 efficacy between the relationship of social capital and industry 4.0 readiness.

The goal of the study is achieved by using a mixed-method research design. The study first uses the quantitative approach and empirically examines the association of three dimensions of social capital and industry 4.0 readiness of manufacturing firms with the mediating roles of innovative capability, knowledge-based dynamic capabilities, and industry 4.0 efficacy. For the quantitative study, data collection was performed through survey strategy, questionnaire design and cross-sectional technique. Quantitative data analysis is conducted by employing structural equation modelling. There are a total of 320 valid responses that represent 81 manufacturing firms in Pakistan. These responses are analysed through SmartPLS and SPSS. The findings of the quantitative approach are then explained through interviews with top industry specialists. The results of the study are analysed and discussed in detail. The results show that structural social capital, relational social capital, and cognitive social capital are positively related with industry 4.0 readiness, and innovative capability, knowledge-based dynamic capabilities (KBDCs), and industry 4.0 efficacy mediate this relationship.

The thesis theoretically contributes to the existing knowledge of understanding industry 4.0 readiness and offers valuable insights for firms in developing economies to improve their social capital with the firms in developed economies during the industry 4.0 era. This study likewise reveals the significance of industry 4.0 efficacy, KBDCs, and innovative capability to facilitate the relationship of social capital and industry 4.0 readiness between the firms of developing economies and developed economies. Practical implications, limitations and future research directions are also emphasised.

ABSTRAKT

V současném digitálním věku organizace čelí výzvam čtvrté průmyslové revoluce. Vyspělé ekonomiky již vytvořily nové přístupy ke strategii průmyslu 4.0, avšak v rozvojových ekonomikách stále, kvůli institucionálním nedostatkům, se firmy spoléhají na rozvinuté ekonomiky k získání znalosti a nových technologií. Firmy v rozvojových ekonomikách musí využívat sociální kapitál k získávání znalostí, informací, důvěry a podpory od rozvinutých ekonomik, aby prokázaly připravenost na průmysl 4.0. Výzkum Průmyslu 4.0 se zaměřuje především na technické aspekty, problematice řízení Průmyslu 4.0 je věnována menší pozornost a většina studií klade důraz na vyspělé ekonomiky. Zejména to, jak se firmy z rozvojových ekonomik připravují čelit čtvrté průmyslové revoluci a jak rozvojové ekonomiky získávají kompetence Průmyslu 4.0, je v dostupné literatuře stále vzácné.

Předkládaná práce se snaží zjistit roli dimenzí sociálního kapitálu pro zvýšení připravenosti na Průmysl 4.0 ve vybraných výrobních firmách Pákistánu. Zaplňuje také chybějící mezeru ve zprostředkujících rolích inovačních schopností, dynamických schopností založených na znalostech a účinnosti průmyslu 4.0; mezi vztahem sociálního kapitálu a připraveností na Průmysl 4.0.

Cíle studie je dosaženo smíšenými metody výzkumu; vychází z kvantitativního přístupu a empiricky zkoumá spojení tří dimenzí sociálního kapitálu a připravenosti výrobních firem na průmysl 4.0 se zprostředkujícími rolemi inovačních schopností, dynamických schopností založených na znalostech a účinnosti průmyslu 4.0. Pro cíle kvantitativního výzkumu byl uskutečněn sběr dat na základě strategie průzkumu, návrhu dotazníků a průřezové techniky. Kvantitativní analýza dat se provádí pomocí modelování strukturních rovnic. Získáno bylo celkem 320 platných odpovědí z 81 výrobních firem v Pákistánu. Tato data jsou analyzována pomocí SmartPLS a SPSS. Zjištění kvantitativního přístupu jsou získána prostřednictvím rozhovorů se špičkovými oborovými specialisty. Výsledky studie jsou podrobně analyzovány a diskutovány. Výsledky ukazují, že strukturální sociální kapitál, vztahový sociální kapitál a kognitivní sociální kapitál jsou pozitivně spojeny s připraveností na průmysl 4.0 a inovační schopnosti, dynamické schopnosti založené na znalostech a účinnost průmyslu 4.0 tento vztah zprostředkovávají.

Práce teoreticky přispívá k dosavadním znalostem porozumění připravenosti na průmysl 4.0 a nabízí cenné poznatky pro firmy v rozvíjející se ekonomice, aby zlepšily svůj sociální kapitál s firmami ve vyspělých ekonomikách v době průmyslu 4.0. Studie rovněž představuje význam efektivitu průmyslu 4.0, dynamické schopnosti založené na znalostech a inovační schopnosti pro usnadnění vztahu sociálního kapitálu a připravenosti na průmysl 4.0 mezi firmami v rozvíjejících se ekonomikách a rozvinutých ekonomikách. Zdůrazněny jsou také praktické důsledky, omezení a budoucí směry výzkumu.

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LIST OF ABBREVIATIONS USED

AI	Artificial intelligence
CCA	Confirmatory Composite Analysis
CFA	Confirmatory Factor Analysis
CPS	Cyber physical systems
DC	Dynamic capabilities
EFA	Exploratory Factor Analysis
IoTs	Internet of things
KBDCs	Knowledge based dynamic capabilities
LGM	Latent Growth Modelling
PA	Path Analysis
PLS-SEM	Partial least square and structural equation modelling
PSX	Pakistan stock exchange
RBV	Resource based view
SMEDA	Small and Medium Enterprise Development Authority

1. INTRODUCTION

1.1. Motivation and need for the study

In this digital era, the adoption of digital technologies is the main requirement for manufacturing companies to embrace the industry 4.0 (i4.0) strategy (de Assis Dornelles et al., 2022; Ghobakhloo, 2020). The concept of i4.0 has become prevalent in businesses because it improves the productivity of business activities through an advanced level of computerisation and automation (Kolberg & Zühlke, 2015; Stock & Seliger, 2016). To automate production processes, companies use IOTs and CPS, where IOTs are known as Internet of Things (IOTs) and CPS is referred to cyber-physical systems (CPS). Nevertheless, this transformation of adopting CPS and IOTs is not an easy task, and companies face various challenges to implant these technologies in different processes of businesses (S. Chen et al., 2014; Hussain et al., 2021; I. Lee & Lee, 2015; Qian & Wang, 2012). Companies pursue showing i4.0 readiness, but indicate lack of plan and digital maturity for implementing i4.0 (Antonsson, 2017). To maximize the benefits of this strategy, it is essential to evaluate and pinpoint the elements that can help firms become more ready for i4.0.

In the existing literature, most studies emphasize technical aspects of the fourth industrial revolution, and studies in the management perspective of i4.0 are scarce (Shamim et al., 2016a; Zia et al., 2022), and these studies cover mainly the context of industrialized economies (Grabowska, 2020). However, less scholarly attention has been received in the context of developing economies. Particularly, how developing economies are prepared to deal with the fourth industrial revolution and how they are acquiring capabilities related to i4.0 is still in its infancy stage of investigation. Khan et al. (2019) highlight that the developing economies face the concern of institutional voids, which refers to the shortage of assistance from home organizations regarding the creation of knowledge and innovations. This situation brings the importance of external sources of knowledge, that is customers, the network of suppliers, and partners. In particular, those firms in developing economies that carry out relationship connections with firms in developed and digitally advanced economies can extract knowledge and information from these firms (Khan et al., 2019) in order to boost i4.0 readiness. Social capital theory becomes a relevant lens when the discussion lies to extracting knowledge, resources, and support due to networks of relationships. The current literature supports that social capital (SC) is implicitly related to i4.0 readiness through innovative capabilities. However, previous studies have not examined this relationship. The current study fills this gap by analytically researching the relationship between SC, innovation capability, and i4.0 readiness.

This study argues that the acquisition of knowledge and support through SC with foreign firms boosts the confidence in the firm's ability to achieve the desired outcomes, which is taken as i4.0 readiness in the specific context of this study. This phenomenon is also relevant to the concept of efficacy (Bandura, 1977). There is shreds of evidence in the literature that confidence in one's ability to achieve the

desired outcomes enhances the probability of achieving desired outcomes (Shamim, Cang, & Yu, 2017), which is i4.0 readiness in this context. It is argued that generating, acquiring, and combining all knowledge resources is based on the firm's knowledge-based dynamic capabilities (KBDCs) to improve i4.0 readiness. This study also investigates the mediating role of KBDCs in the relationship between the dimensions of SC and the readiness for I4.0.

As the context of this study is developing economies, therefore, this study chooses Pakistan to explore the above-mentioned issues. Pakistan becomes an appropriate context for a developing economy and also faces the problem of institutional voids (Khan et al., 2019). Moreover, Pakistan has recently started the adoption of digitization (Nizam et al., 2020) and its firms primarily depend on developed and industrialized economies to acquire industrial and hi-tech products (Malik & Kotabe, 2009)

This research adds to the corpus of knowledge in several ways. The current literature primarily discusses i4.0 in technological aspects; however, research on i4.0 management issues is still in the infancy stage and scarce in the literature. This study contributes to the theory of SC by examining and associating it with i4.0 readiness. The study also contributes its originality by investigating the mediating role of innovative capability, knowledge-based dynamic capabilities, and i4.0 efficacy in the relationship of SC dimensions and i4.0 readiness. Moreover, it is one of the rare studies that discuss the i4.0 readiness phenomenon from a cross-country perspective. Investigating these issues in Pakistan is an empirical contribution of this study, as Pakistan is considered a developing economies context; most of the current studies on the topic of i4.0 have been performed in the context of western and developed economies.

1.1.1. Research Questions

Based on research gaps, the study addresses following research questions to fulfil the research gap in the current literature.

RQ1: Do SC dimensions play its role in influencing i4.0 readiness?

RQ2: Does innovative capability mediate the relationship between SC (structural, relational, and cognitive) and i4.0 readiness?

RQ3: Does i4.0 efficacy mediate the relationship between SC (structural, relational, and cognitive) and i4.0 readiness?

RQ4: Do knowledge-based dynamic capabilities (KBDCs) mediate the linkage between SC dimensions (structural, relational, and cognitive) and i4.0 readiness?

The hypotheses needed for the conceptual model are described in the following chapters.

1.2. Research Problems and Objectives

The impact of SC dimensions on i4.0 readiness in the framework of developing economies is not currently covered in the literature. Another area that needs more research is the role of knowledge-based dynamic capacities, i4.0 efficacy, and innovative capability as mediators in the interaction between the three dimensions of SC and i4.0 readiness. Therefore, the goal of this study's research is to better understand how SC dimensions—structural SC, relational SC, and cognitive SC—affect manufacturing businesses' readiness for i4.0 in the framework of developing economies.

1.2.1. Research Objectives

The major goal of this study is to determine the impact of all three SC dimensions on i4.0 readiness and to look into the role of innovative capability, i4.0 self-efficacy, and KBDCs in mediating the relationship between SC and i4.0 readiness of manufacturing companies in developing economies context. Research objectives are as follows:

RO1: To identify the role of SC (structural, relational, and cognitive SC) in influencing i4.0 readiness.

RO2: To identify the mediating role of innovative capability between SC (structural, relational, and cognitive) and i4.0 readiness.

RO3: To identify the mediating role of i4.0 efficacy towards the linkage between SC (structural, relational, and cognitive) and i4.0 readiness.

RO4: To identify the mediating role of knowledge-based dynamic capabilities (KBDC) towards the linkage between SC (structural, relational, and cognitive) and i4.0 readiness.

2. THEORETICAL FRAMEWORK

2.1. Social capital

The social capital (SC) theory discusses value creation via the network of connections (Nahapiet et al., 1998). It also refers to the level at which information and network implanted resources are shared in the relationship network (Wang & Ho, 2017). Organizational innovation is also triggered by strong SC (H. J. Lee et al., 2020; Sánchez et al., 2015). The theory of SC indicates that sociability is an essential and vital prerequisite for the valued resource. It suggests that all interactions between organizational representatives and outside participants represent crucial requirements for knowledge creation, innovation, and information sharing (Ozanne et al., 2022; Zhang & Peterson, 2011). Organizations can perform better after having access to resources and information, which is caused by SC (Johnson et al., 2013). Nahapiet et al. (1998) mentioned three aspects of SC, named structural social, relational, and cognitive social capital, which are well used and explained in this thesis.

The first dimension is known as structural SC, which describes who will be responsible for building relationships and what are the ways to attain these relations

(Chow & Chan, 2008). Relational SC implies to assets generated by the relationships networks that are based on friendship, and interpersonal trust (Cabrera & Cabrera, 2005). This dimension shows the quality of a relationship that develops through a history of connections with other parties or with each other (Lefebvre et al., 2016). Cognitive SC is the third dimension of SC, which indicates the vision, values, shared goals, and language of organizational members (Wasko & Faraj, 2005). Sharing codes and language become the basics of communication for this dimension of SC (Gooderham, 2007).

2.2. Innovative Capability

The ability of a company to develop new and distinct goods, services and markets, as well as improve existing ones, is referred as innovative capability (March, 1991). Innovative capability facilitates the creation of new processes, new products, and new ideas within an organization (Hult et al., 2004). Innovative capabilities can help a company gain a long-term competitive advantage (Liu et al., 2019; March, 1991; Puspita et al., 2020). In this era of the fourth industrial revolution, competitive advantage depends on the readiness of firms towards i4.0 (Shamim et al., 2016), and i4.0 readiness relies on the innovative capability of firms (Agostini & Filippini, 2019; Lasi et al., 2014; Zia et al., 2022). One of the well-established predictors of inventiveness is SC (Maurer et al., 2011). Sheng & Hartmann (2019) claimed that SC's structural and relational dimensions have an impact on how innovative enterprises engaged in global commercial operations. A recent study by Zia et al. (2022) argued the importance of all three dimensions of SC in enhancing innovation capability and i4.0 readiness. As exploring and exploiting knowledge is prerequisites of innovativeness (Donate & Sánchez de Pablo, 2015) , therefore the existence of network ties (Inkpen & Tsang, 2005; Zia et al., 2022) due to structural SC provides greater access to knowledge. Sheng & Hartmann (2019) argued that accessing this knowledge provides a much better innovation (Sheng & Hartmann, 2019). On the other hand, relational SC refers to the relationships based on the trust (Andrews, 2010) and such relationships prompt easily exchange of knowledge between different actors in networks. Sheng & Hartmann (2019) also discussed that trust can improve the learning ability of firms to create a wider scope of knowledge that can build and reconfigure sources of innovation. Relational capital, which is built on confidence, can also give you access to different perspectives (Rowley et al., 2000). Trust motivates companies to seek a variety of information opportunities and helps them try new things, enhancing their ability to innovate (Grillitsch & Nilsson, 2022; Sheng & Hartmann, 2019). The third dimension of SC is cognitive SC, which represents the shared vision, values, languages, codes, and goals, and it enables tacit knowledge sharing (Alguezaui & Filieri, 2010) that is a leading and renowned predictor of innovation (Kim and Lee, 2013). Ganguly et al. (2019) discussed that all these dimensions of SC play a crucial role in developing and improving a firm innovation capability.

2.3. Knowledge-Based Dynamic Capabilities

The resource-based view (RBV) of the firms states that enterprises should utilize their strategic resources in order to get a competitive advantage. (Barney, 1991). The dynamic capabilities (DCs) view is an extension of the resource-based view (RBV), which contends that businesses should be able to adjust their competencies in response to shifting business environments rather than relying solely on strategic resources for competitive advantage (Teece, 2007; Teece et al., 1997). KBDCs further extend DCs and argue that knowledge is the main strategic resource of any organization, and the main purpose of an organization is to transform knowledge into commercial outcomes. Therefore, according to KBDCs, knowledge is the main source of DCs (Zhang et al., 2011). Knowledge plays a crucial role for any organization while dealing with various issues, i.e. survival, organizational performance, and business outcomes (Barton, 1995; Parayitam et al., 2022). Teece et al. (1997) discussed that organizations can become more compatible when they start renewing both tangible and intangible assets. The KBDCs view is an expansion of DCs (Shamim, Zeng, Choksy, et al., 2019) and accentuates the ability of any organization to acquire, generate, and combine internal and external sources of knowledge to address environmental dynamics (Zhang & Peterson, 2011). Knowledge is the main ingredient of KBDCs (Zhang et al., 2011), and knowledge extraction is heavily based on the SC of firms. SC at the firm level enables knowledge extraction, trust, and support from the relationship networks. Existing studies also used KBDCs as theoretical lens in the context of digital transformation (Shamim et al 2019b). Scholars have highlighted the application of KBDC e.g. J.-C. Lee and Chen, (2019) examined knowledge absorption as outcome of KBDC. Chen, Stewart, and Panuwatwanich, (2013) examined the learning capacities in industrial manufacturing operations by using KBDC as a theoretical lens and found innovation as outcome of intellectual capital which comes from KBDCs. Cheng, Yang, and Sheu (2016) investigated innovation development and evaluated the influence of KBDC. The current literature strengthens the view that organizations in developing economies obtain knowledge from developed economies through their relationship networks in order to enhance innovation (Khan et al., 2019; Malik & Kotabe, 2009; Zia et al., 2022), which is i4.0 in the context of this study.

2.4. Industry 4.0 efficacy

Efficacy plays an important role in the motivation and outcomes of the work, adopting a projecting role related to different sides of work activity (Judge et al., 2007). Ideally, self-efficacy falls under the framework of social cognitive theory and is stated as beliefs about one's abilities and skills to plan and execute the necessary courses of action in order to obtain desired goals (Bandura, 1977). Efficacy can better be observed in a particular domain (Bandura, 2012), dealing with this in a way that a more effective domain may lead to more determining self-efficacy (Azanza et al., 2013). Shamim et al. (2017) discussed self-efficacy in the context of creativity and

termed it creative-efficacy. Eastin & LaRose (2000) discussed internet-efficacy to measure the belief of respondents that how confident they are to use the internet. Siregar and Chang (2020) examined the efficacy of cybersecurity incident detection. Therefore, it is important to measure the efficacy in its specific context like in the industry or organizational field rather than to measure it in general (Salanova et al., 2005). This study contextualizes organizational-level efficacy in terms of i4.0 efficacy. This study defines the efficacy of i4.0 as an organization's judgment of its sense of confidence in accepting i4.0.

Scholars have highlighted the relationship of SC with organizational level and collective efficacy (C. R. Collins et al., 2014; Sulistyani & Suhariadi, 2022). Stanley and McDowell (2014) argue that inter-organizational SC can influence organizational efficacy. Collins & Clark (2003) supported the view that SC is positively related to collective efficacy in a given context. Siregar and Chang (2020) also reported the relationship between SC and team level efficacy. SC influences the desirability, intentions, and perceived efficacy of businesses (Hindle et al., 2009). When organizations access information through SC, they are more likely to implement with high organizational efficacy (Koçak et al., 2013).

2.5. Industry 4.0 readiness

I4.0 is closely linked to connecting the analogue, a physical and tangible world with the cybernetic, database or digital world (de Assis Dornelles et al., 2022; Quint et al., 2015). I4.0 is defined by Haddara & Elragal (2015) as the computerization of the industrial sector, where Cyber-Physical Systems (CPS) are recognized as a key component of it and industry experts as i4.0's technological drivers. To achieve competitive advantage and profitability over the long term with acceptable results, businesses must adopt the i4.0 strategy in the new digital economy (Drath & Horch, 2014). Because of this, businesses need to be prepared to meet this new competitive threat and demonstrate their readiness to adopt the new technology paradigm. (J. Lee et al., 2014).

It is important to assess an organization's digital readiness before implementing the fourth industrial paradigm, and doing so works with understanding an organization's strengths and shortcomings (Sony & Naik, 2019). Companies must therefore be ready to meet this new global challenge and change to the new technology paradigm (J. Lee et al., 2014). Before implementing this digital paradigm, the fundamental step toward i4.0 adoption is to monitor the organization's digital readiness and start to understand the current strengths and weaknesses (Geissbauer et al., 2016; Zia et al., 2022). The literature already in existence recognizes the significance of i4.0 readiness (Basl, 2018; Basl & Doucek, 2019; Stentoft et al., 2020; Zia et al., 2022). The argument over a methodology to evaluate an organization's i4.0 readiness was started by Pacchini et al. (2019), who also emphasized the dearth of recent research on the topic of determining an organization's i4.0 readiness level.

Organizations can check their i4.0 readiness using a variety of techniques (Rajnai & Kocsis, 2018). These tools are used as a standard to assess how effectively the

organization is moving toward digital transformation. Therefore, a successful i4.0 adaption can only be planned once an assessment of i4.0 readiness is made. The goal of evaluating the readiness of i4.0 is to recognize an organization's step toward digital transformation. After recognizing the current state of the organizational move towards digitization, management must have a specific strategic plan (Rajnai & Kocsis, 2018). Due to the growing value of knowledge, various evaluation models have been developed, using numerical readiness metrics and bundling these points into thematic classes. These indicators are used to obtain an outcome of the digital readiness of organizations by calculating the various measured indices (Rajnai & Kocsis, 2018).

3.0 THE SCOPE OF THE STUDY AND CONCEPTUAL FRAMEWORK

3.1 Theoretical underpinnings of the research

The thesis lay¹s its grounds on two composite theories. Particularly, SC theory and knowledge based dynamic capabilities.

- **Social capital theory:** Value creation through a network of relationships refer to the SC theory (Nahapiet et al., 1998). The degree to which people share information and other resources within their network of contacts is strongly related to SC (Wang & Ho, 2017). For the adoption and improvement of new technology, it is crucial to add resources into the structure of organizations (Parellada et al., 2011). SC plays a significant role in the innovation and presentation of organizations (Sánchez et al., 2015). The theory of SC discusses that sociability is a critical and necessary requirement for a valuable resource. SC theory also highlights the importance of relationships between members of organizations and outside players for knowledge creation, innovation, and information sharing (Zhang & Peterson, 2011).

The three types of SC that are employed and discussed in this study are structural SC, relational SC, and cognitive SC (Nahapiet et al., 1998). According to published research, less developed nations depend on industrialized nations for smart digital technologies. (Cockburn et al., 2000). Additionally, Khan et al. (2018) claimed that businesses in less developed economies go to outside sources for knowledge and assistance. When it comes to knowledge extraction, SC is one of the best theories to investigate this context (Maurer et al., 2011). As a result, SC provides a pertinent theoretical framework for this research.

1

- **Knowledge-Based Dynamic Capabilities:** According to the resource-based view of firms, businesses should employ strategic resources to gain a sustained competitive edge. (Barney, 1991). The dynamic capabilities (DCs) view of firms extends the resource-based view and argues that using the strategic resources is not enough and organizations should be able to create and reconfigure competencies according to changing business environment (Teece, 2007; Teece et al., 1997). According to the knowledge-based view, knowledge is the primary strategic resource of an organization, and the fundamental goal of companies is to translate knowledge into profitable results. The KBDCs' view argues that the main source of DCs is knowledge (Zhang et al., 2011). Knowledge is important in dealing with different issues regarding organizational performance, survival and business outcome (Barton, 1995). (Teece et al., 1997) explained that the organizations are more compatible when they start renewing tangible and intangible assets. The view of KBDCs view is an extension of DCs (Shamim, Zeng, Choksy, et al., 2019) and put emphasize on “ability to acquire, generate and combine internal and external knowledge resources to sense, explore, and address environment dynamics” (Zhang & Peterson, 2011).

The main ingredient of KBDCs is knowledge (Zhang et al., 2011) and is heavily based on SC. SC at the firm level ensures the provision of knowledge, trust, and support from the network of relationships. The literature supports the view that firms in less developed economies use their relationship network to extract knowledge to enhance innovations (Malik & Kotabe, 2009; Khan et al., 2019). Khan et al. (2019) examined this phenomenon in the context of Pakistani firms and argued that firms there rely on their external network to extract knowledge and their ability to absorb the knowledge plays a crucial role. Shamim, Zeng, Khan, & Zia (2020) examined this issue in the context of digital transformation and suggested that SC can enhance the KBDCs, and it can facilitate the digital transformations in a given context. Kim and Lee (2013) also suggested that SC facilitates the acquisition and dissemination of knowledge. Kim and Lee (2013) investigated the structural, relational, and cognitive dimensions of KBDCs and suggested that all of these dimensions are positively related to knowledge acquisition and dissemination, which are the basic elements of KBDCs. The resource-based view suggests that organizational capabilities are dependent on organizational resources, where structural, relational, and cognitive SC are important organizational resources influencing KBDCs (Kim & Lee, 2013).

3.2. Conceptual Framework

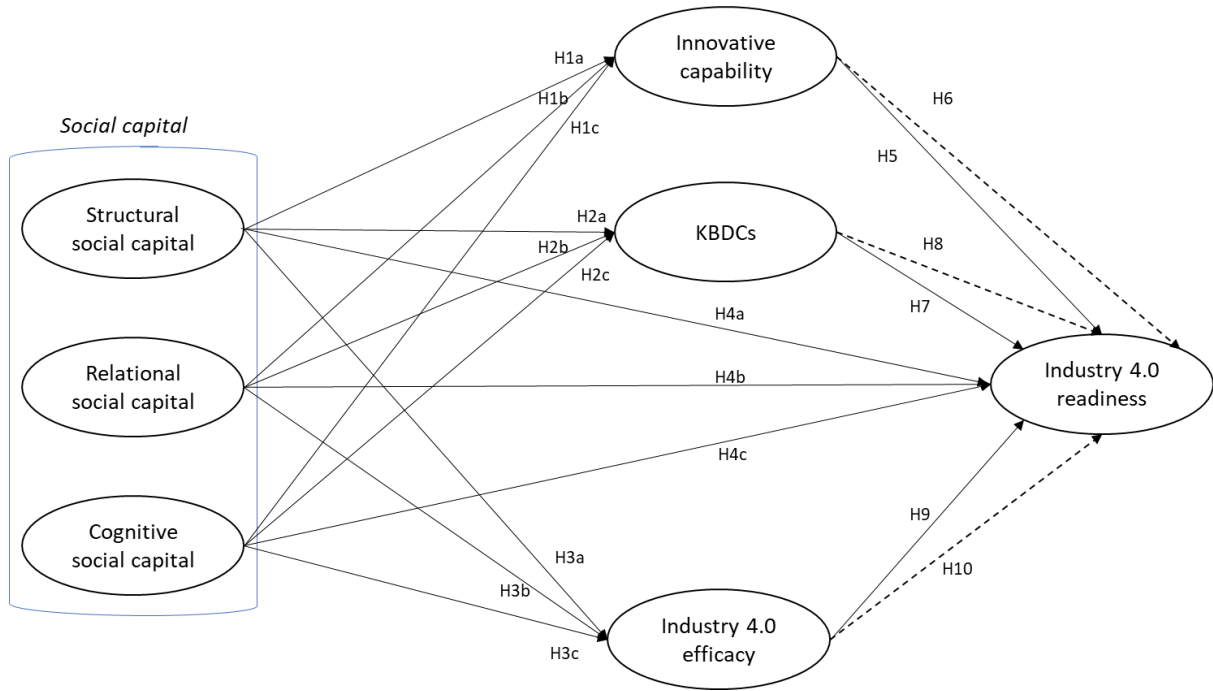


Figure 1 : Conceptual Framework (Source: Author's own)

3.3. Definition of constructs and literature sourced

Table 1: Definitions and summary of constructs (Source: author’s own)

S/N	Constructs	Definition	Literature adapted from
1	I4.0 readiness	Before implementing i4.0, the first step is to assess the organization's digital readiness, which begins with an awareness of its current strengths and weaknesses.	(Geissbauer et al., 2016)
2	I4.0 efficacy	I4.0 efficacy is an organization’s judgment of its sense of confidence in embracing i4.0.	(Azanza et al., 2013; Bandura, 2012; Eastin & LaRose, 2000; Salanova et al., 2005; Shamim et al., 2017; Siregar & Chang, 2020)

3	Structural SC	Who will interact in order to establish relationships and how these relationships will be achieved are explained by structural SC. This dimension includes elements like connectedness, hierarchy, network patterns, and density	(Chow & Chan, 2008; Nahapiet & Ghoshal, 1998)
4	Relational SC	Relational SC focuses on the type and degree of connections that can be made throughout the course of interactions with other people or other parties	(Cabrera & Cabrera, 2005; Davenport & Daellenbach, 2011; Lefebvre et al., 2016)
5	Cognitive SC	Cognitive SC comprises the members of the organization's shared values, vision, and objectives. Resources that provide common interpretations, means systems, and representations between participants are referred to as cognitive SC.	(Gooderham, 2007; Nahapiet & Ghoshal, 1998; Wasko & Faraj, 2005)
6	Knowledge based dynamic capabilities	KBDC is the grouping of two different aspects, dynamic capability refers to the renewing of resources in order to get operational enhancement, whereas knowledge creation aspect refers to the using of tacit knowledge by its transfer and use.	(Han & Li, 2015; Júnior et al., 2019)
7	Innovative capability	The ability of a company to develop new and distinct goods, services, and markets, as well as improve existing ones, is referred to as innovative capability	(March, 1991)
8	I4.0 efficacy	Organization's judgment about its sense of confidence to embrace i4.0 is called as i4.0 efficacy	(Bohn, 2010)

4. METHODOLOGY

4.1. Research Design

The study begins with theoretical research on “the effect of SC on i4.0 readiness of firms with the mediating role of innovative capability, i4.0 efficacy, and knowledge-based dynamic capabilities”. The conceptual framework developed earlier in the literature (see Figure 1) is applied based on the research design. The researcher uses to implement the objectives of the study that are presented in the methodological

procedure of the proposed research design. The literature review supports the proposed model with the theoretical concept of the study model. Deductive and inductive approaches have been implemented to achieve the overall objectives of the study.

The study follows a mixed-method approach and empirically examines the association of three dimensions of SC and i4.0 readiness of manufacturing firms with the mediating roles of innovative capability, i4.0 efficacy, and KBDCs. Then the findings of this quantitative approach are explained through qualitative approach by interviewing top industry specialists.

4.2. Sample, Demographics, Data Collection, and Analytic Technique

The population of this study comprises manufacturing companies in Pakistan. A questionnaire was developed in English based on the proposed model and then distributed among respondents. The questionnaire was created in Google forms and then shared with different levels of employees in manufacturing companies in Pakistan. A list of manufacturing firms in Pakistan was prepared using various resources, that is, the Small and Medium Enterprise Development Authority (SMEDA), the Pakistan Stock Exchange (PSX) and chambers of commerce in different cities. There are 391 large-scale manufacturing companies that are registered in PSX. While SMEDA is a Pakistani government organization that governs small and medium businesses. In SMEDA, there are more than 1,000 small businesses that have been registered so far. More than 500 firms were requested to participate in this survey by sharing the questionnaire link with a different level of managers through email and LinkedIn. A formal request was sent to the key people in the chamber of commerce of different cities to share the questionnaire with various registered firms. It is important to note that the analysis unit is an individual firm. A simple random sampling technique was applied to explore responses from respondents. This technique is more appropriate and effective, as it gives equal chances of sample selection to the understudying subject, and it also reduces the sample bias.

4.3. Measures of Variables

Three items from Nahapiet et al. (1998) and Chow & Chan (2008) are adapted to measure structural SC. Four items in total, drawn from Nahapiet & Ghoshal (1998) and Chow & Chan (2008), are used to assess relational SC. Three items are adapted from the study of Chow & Chan, (2008) to measure cognitive SC. Four items from the Sheng & Hartmann (2019) study are used to measure innovative capability. Four items from Shamim et al. (2017) are used to measure i4.0 efficacy, while four items from Zheng et al. (2011) are used to measure KBDCs. IBM developed a twelve-item scale to assess i4.0 readiness, which is freely accessible. IBM has given its formal consent for the use of the items for research purposes (see appendix). The elements related to SC dimensions, innovative capacity, i4.0 readiness, and KBDCs are rated

on a seven-point Likert scale that ranges from 1 ("strongly disagree") to 7 ("strongly agree").

5. QUANTITATIVE STUDY – Results

The approach of Fornell and Larcker (1981) is used to test the convergent and discriminant validity. The partial least squares method is used to test the hypothesis (PLS). The study carefully considered the benefits and drawbacks of PLS before choosing to utilize it. The literature, including Rönkkö & Evermann (2013), Chin et al. (2003), and Henseler et al. (2014) supports the use of PLS. Chin et al. (2003) claim that PLS has the capacity to concurrently take into account the structural model and measurement model. Testing the measurement of research variables and relatively complex interactions, such as a mediator and moderator, is possible with PLS. Given that this study includes mediators in addition to measuring variables using new scales, PLS is utilized to test the intricate and complex model (Henseler et al., 2014).

5.1. Construct reliability and validity

The construct reliability is measured through the Cronbach alpha. To establish reliability, the value of Cronbach's alpha should be more than 0.70 (George, 2011). The analysis results show that the Cronbach alpha value for each construct is greater than 0.70, indicating reliability and internal consistency. To establish convergent validity, the factor loading of each item needs to be greater than 0.70, the average variance extract (AVE) greater than 0.50 and the composite reliability value (CR) should also be greater than AVE (Donate & Sánchez de Pablo, 2015; Fornell & Larcker, 1981). The results in Table 2 show that all constructs met the requirement, i.e. factor loading for the construct of i4.0 readiness ranges from 0.74 to 0.89, innovative capability ranges from 0.76 to 0.86, i4.0 efficacy ranges from 0.84 to 0.88, structural SC ranges from 0.84 to 0.87, relational SC ranges from 0.75 to 0.82, and cognitive SC ranges from 0.82 to 0.90. Additionally, the value of AVE is greater than 0.50 and the CR value is also greater than the value of AVE, therefore, the convergent validity is established.

Table 2 : Reliability and Convergent Validity (Source: author's own)

Variables	Items	Factor loadings	AVE	CR	Cronbach's Alpha
Structural SC (SSC)	ssc1	0.873	0.728	0.889	0.814
	ssc2	0.840			
	ssc3	0.847			
Relational SC (RSC)	rsc1	0.769	0.627	0.871	0.802
	rsc2	0.828			

	rsc3	0.816			
	rsc4	0.753			
Cognitive SC (CSC)	csc1	0.827	0.740	0.895	0.824
	csc2	0.903			
	csc3	0.849			
Innovative capability (INOVCA)	Inovca2	0.783	0.649	0.847	0.728
	Inovca3	0.863			
	Inovca4	0.768			
Knowledge Based Dynamic Capabilities (KBDCs)	kbdc1	0.785	0.670	0.859	0.756
	kbdc2	0.818			
	kbdc3	0.851			
I4.0 efficacy (I4E)	I4e1	0.875	0.754	0.924	0.891
	I4e2	0.840			
	I4e3	0.876			
	I4e4	0.881			
I4.0 readiness (I4R)	i4r10	0.891	0.697	0.941	0.927
	i4r11	0.867			
	i4r12	0.745			
	i4r6	0.760			
	i4r7	0.807			
	i4r8	0.879			
	i4r9	0.883			

Fornell & Larcker have established the standards for determining discriminant validity (1981). Discriminant validity is demonstrated, in accordance with Fornell & Larcker (1981), when the AVE value is higher than the squared correlation between constructs. Table 3's findings demonstrate that the discriminant validity is confirmed. The squared correlation value is less than the value of AVE. The outcomes of the factor analysis, as well as the reliability and validity checks performed using Smart PLS and a variance based PLS technique, demonstrate the quality of the study model. The dependent variable's R² value is 0.73, which denotes a good model fit.

Table 3 : Discriminant validity (Source: author's own)

Factors	1	2	3	4	5	6	7
CSC	0.860						
I4E	0.482	0.868					
I4R	0.687	0.652	0.835				
INOVCA	0.469	0.344	0.541	0.805			
KBDCs	0.148	0.324	0.443	0.381	0.819		
RSC	0.645	0.397	0.687	0.369	0.319	0.792	
SSC	0.416	0.318	0.530	0.328	0.371	0.576	0.853

5.2. Path analysis and hypothesis testing

The Smart PLS 3.3.9 software version has been used to test hypotheses and path analysis using the structural equation model. We first investigated the direct link between the constructs, as shown in Table 7, and then we looked at the constructs' potential mediating effects. The findings show that cognitive SC ($\beta = 0.39$, $p < 0.001$) and structural SC ($\beta = 0.14$, $p < 0.05$) both positively and significantly affect innovative capability. The association between relational SC and innovative capability is not statistically significant ($\beta = 0.03$, $p > 0.05$). These results support the rejection of H1b and the acceptance of H1a and H1c. The outcomes also demonstrate the direct impact of all dimensions of SC on KBDCs. Structural SC and relational SC are positively and significantly related with KBDC, accepting H2a ($\beta = 0.28$, $p < 0.001$) and H2b ($\beta = 0.23$, $p < 0.05$). However, there is no significant relationship between cognitive SC and KBDC ($\beta = -0.12$, $p > 0.05$) and therefore H2c is rejected. There is no significant association of structural SC with i4.0 efficacy ($\beta = 0.10$, $p > 0.05$), and relational SC with i4.0 efficacy ($\beta = 0.09$, $p > 0.05$). These findings do not support H3a and H3b. On the other hand, cognitive SC is positively and significantly related to i4.0 efficacy ($\beta = 0.37$, $p < 0.001$), which supports H3c. Then, the direct effects of the SC dimension with i4.0 readiness are examined. The results indicate that the three dimensions of SC (structural SC ($\beta = 0.07$, $p < 0.05$), relation SC ($\beta = 0.26$, $p < 0.001$) and cognitive SC ($\beta = 0.24$, $p < 0.001$) are positively and significantly related with i4.0 readiness. These results support H4a, H4b, and H4c. The results also revealed that innovative capability is positively and significantly related to i4.0 readiness ($\beta = 0.14$, $p < 0.001$), the KBDCs are positively and significantly related with i4.0 readiness ($\beta = 0.13$, $p < 0.001$) and i4.0 efficacy is positively and significantly related to industry 4.0 readiness ($\beta = 0.31$, $p < 0.001$). These results support H5, H7, and H9.

Regarding mediating relationships, the results indicate that there is an indirect association of SC with i4.0 readiness through the mediation of innovative capability ($\beta = 0.072$, $p < 0.001$), KBDCs ($\beta = 0.037$, $p < 0.05$), and i4.0 efficacy ($\beta = 0.155$, $p < 0.001$). After entering the innovative capability, the KBDC and the effectiveness of i4.0 efficacy into the model, the direct relationship of SC with the readiness of i4.0

was reduced from $\beta = 0.768$ to $\beta = 0.504$. Partially mediation is demonstrated by the fact that the associations are still significant at $p < 0.05$. The results support H6, H8, and H10.

Table 4 : Path analysis and hypothesis testing (Source: author's own)

Path	Direct effect β (t-value)	Indirect effect β (t-value)	Total effect β (t-value)	Hypothesis	Result
SSC -> INOVCA	0.144**(2.08)		0.144**(2.08)	H1a	Failed to reject
RSC -> INOVCA	0.033(0.49)		0.033(0.49)	H1b	Rejected
CSC -> INOVCA	0.392***(6.06)		0.392***(6.06)	H1c	Failed to reject
SSC -> KBDCs	0.289***(4.59)		0.289***(4.59)	H2a	Failed to reject
RSC -> KBDCs	0.230**(2.98)		0.230**(2.98)	H2b	Failed to reject
CSC -> KBDCs	-0.123 (1.71)		-0.123 (1.71)	H2c	Rejected
SSC -> I4E	0.108(1.63)		0.108(1.63)	H3a	Rejected
RSC -> I4E	0.091(1.20)		0.091(1.20)	H3b	Rejected
CSC -> I4E	0.377***(5.74)		0.377***(5.74)	H3c	Failed to reject
SSC -> I4R	0.077**(2.18)		0.172***(3.27)	H4a	Failed to reject
RSC -> I4R	0.262***(4.80)		0.327***(5.02)	H4b	Failed to reject
CSC -> I4R	0.248***(4.80)		0.406***(7.61)	H4c	Failed to reject
INOVCA -> I4R	0.144***(3.55)		0.144***(3.55)	H5	Failed to reject
KBDCs -> I4R	0.138***(4.15)		0.138***(4.15)	H7	Failed to reject
I4E -> I4R	0.311***(7.75)		0.311***(7.75)	H9	Failed to reject
SC -> INOVCA -> I4R	0.504***(12.97)	0.072***(3.65)	0.768***(35.02)	H6	Failed to reject
SC -> KBDCs -> I4R		0.037**(2.96)		H8	Failed to reject
SC -> I4E -> I4R		0.155***(6.22)		H10	Failed to reject

Note: ** represents $p < 0.05$ and *** represents $p < 0.001$

6. QUALITATIVE STUDY – validation and explanation of results

The study uses qualitative methodology to validate and explain the findings of the quantitative study. To follow the method, semi-structured interviews are conducted from top industry experts. The findings are explained in more detail as follows.

6.1. Structural SC and innovative capability

Qualitative results that were based on semi-structured interviews with business professionals have confirmed the link between structural SC and innovative capability. Participants are asked to shed a light on how structural SC affects ability to innovative capability. For instance, one of the experts describes how his company's structural SC improves its capacity for innovation.

Another participant argues that

'The predefined social network structure is a key strength for firms to bring newness to products and services. We have introduced few rewards for those employees who are more active in building valuable relationships with foreign distributors and helping to bring innovation to the products [Informant ID #14]'

These arguments support the notion that strong social ties help the firms maintain innovation in their products. It also explains the role of solid network patterns of firms with other firms to enhance innovative capability.

6.2. Relational SC and innovative capability

The findings show that relational SC dimension is not positively associated to innovative capability. Although the previous literature has established relationship between the relational SC and innovative capability. For example, Zia et al. (2022) explained relationship of relational SC and innovative capability. However, semi-structured interviews confirmed and explained the findings of this study in their responses. One participant described that

“It is hard for employees to extract knowledge on basis of merely trust and friendship. The workers need various other kinds of relationships as well to come close to other companies’ knowledge infrastructure, and then these workers may become successful in obtaining the required information and technology [Informant ID #10]”

6.3. Cognitive SC and innovative capability

Semi-structured interviews of industry experts also explain and confirm the relationship between cognitive SC and innovative capability. Impact of SC on innovative capability is already established in the existing literature, however, the role of cognitive SC as a dimension of SC needs to be explored and is well explained during these interviews.

An industry expert explained the relationship. For example, the respondent described the relationship in a following statement.

'Sustainable growth can be achieved by sharing value. It could lead to higher business productivity by identifying and sharing common goals and values between business and society. Therefore, when the firm focuses first on social needs, it creates an innovative mindset throughout all organizational departments, and it leads to a more innovative organization [Informant ID #7]'

This statement and view match our quantitative findings and clearly reflect the influence of cognitive SC in developing the capability of the products to innovate.

6.4. Structural SC and KBDCs

Semi-structured interviews of industry experts reveal a positive relationship of structural SC with KBDCs. Most of the respondents report that due to the density of social networks, their employees were more successful in obtaining the desired knowledge and information. For example, one of the participants argued that

'While we receive knowledge from our company partners and the companies with which we have made contracts to send and receive information or knowledge, but the ability of our employees to interact with as many persons as possible plays a major role in obtaining key knowledge [Informant ID #2]'

This is how top industrial leaders motivate their companies to shape for a strong SC and carry valuable knowledge through these connections. These arguments explain the importance and positive effect of structural SC on KBDCs. Therefore, the structural SC dimension is well elucidated as an influencer to extract knowledge from valuable social networks.

6.5. Relational SC and KBDCs

Qualitative data analysis reveals the relationship between relational SC and KBDCs. Semi-structured interviews with industry professionals reinvestigate the importance of relational SC to enhance KBDCs, and the results validate and confirm the findings. For example, one of the respondents replied on how crucial the role of strong relational capital is in obtaining knowledge in the following way.

'Our relationships are a huge kind of notion that brings value to our lives. We believe that a typical person in a company keeps 100 and fifty important relationships, and our company encourages our employees to utilize a maximum portion of these relations to make our firms knowledgeably strong. The amount of money that we make due to our relationships is dramatic, and the same applies to the firms as well. The more we are friendly with our shareholders, the more value we will take from them in return [Informant ID #3]'

The above arguments support the quantitative findings of the study in which relational SC has a strong positive effect on KBDC. Our qualitative answers confirm and validate that relational SC is vital in enhancing knowledge-based dynamic capabilities of the companies.

6.6. Cognitive SC and KBDCs

The results show that cognitive SC dimension is not positively related to KBDCs. Semi-structured interviews further explained and confirmed the factors that may contribute to these findings. One participant explained that

“Ideally, sharing values and visions with other companies improves its ability to gain valuable knowledge. In Pakistan economy, the case looks a bit different. People can extend personal relationships and even exchange some knowledge as well, however, once they intend to exchange key norms or values, they face reluctant. It might be because of lack of previous practice. But I believe, once one company strengthens its relationships with other companies in developed world, both might be in position to share vision, norms, and key goals with each other [Informant ID #18]”

6.7. Structural SC, relational SC and industry 4.0 efficacy

The results of the quantitative data analysis indicate that structural and relational SC does not positively associate with i4.0 efficacy. The study conducted semi-structured interviews from industry experts and the interviewees described the results. One participant argued that,

“Only relations that are based on friendship cannot enable any company to show confidence in embracing industry 4.0 technology. Getting confidence towards industry 4.0 looks solely dependent on technical abilities. Companies achieve confidence for industry 4.0 when their employees are able to handle more technical jobs and when the employees are more innovative as compare to their competitors [Informant ID #07]”

6.8. Cognitive SC and industry 4.0 efficacy

The results of the quantitative data analysis show that cognitive SC is positively related to the efficacy of i4.0. This relationship was also explained through semi-structured interviews of key industry experts. The interviews enlightened the relationship between cognitive SC and i4.0 efficacy. One of the respondents elucidated that

'Discussing and sharing common languages or norms is often helpful for companies to advance their technologies. Same goes with the fourth industrial revolution. The more we are socially active; more we can obtain the relevant knowledge to support i4.0 environment [Informant ID #15]'

One respondent replies that

'The principles of shared values and shared vision encourage trust and transparency between the firm's business and society. Therefore, the firm for its profit and the society for its environmental benefits, both can coordinate together to induct new technology into the business that can be beneficial to business and society [Informant ID #4]'

These statements reflect that the positive role of cognitive SC plays a crucial role in knowledge creation that may lead to enhanced i4.0 efficacy.

6.9. Structural, relational, cognitive SC and industry 4.0 readiness

The quantitative finding of the study shows a positive relationship between all three dimensions of SC with i4.0 readiness. Semi-structured interviews explained the existence of an association between dimensions of SC (structural, relational, and cognitive) and i4.0 readiness. One of the interviewees stated the relationship of structural SC with i4.0 readiness in a statement below.

'We know that our employees can bring the knowledge that usually cannot be gained through our contractual partners. Personal relations of our employees always provide quality knowledge about the latest technology that is valuable to add to our existing infrastructure. This addition of technological and digital knowledge enables firms to be ready for the next steps of digitalization [Informant ID #8]'

Another participant stated that

'Having common values and languages can give more opportunities to share knowledge with each other. Our government has taken various steps to open language centers for entrepreneurs, and our firm has approved admission of

eleven top employees to learn languages such as Chinese, Dutch, and even French. This is not the first time; thought we have already produced dozens of employees who learned foreign languages and now they are leading our R&D projects. In our company, we have a strong belief that sharing knowledge supports innovation in new products, that make companies ready for the next technology challenge [Informant ID # 5]'

The results of the interviews confirm the quantitative findings that all three dimensions of SC have a strong impact on enhancing the i4.0 readiness of the firms.

7. DISCUSSION

This study examines the role of social capital (SC) of firms in developing economies to enhance i4.0 readiness. In this context, the SC of companies in Pakistan is measured and tested in relation to i4.0 readiness. Pakistan is considered a suitable context because the firms in Pakistan are in the primary stage of i4.0 technology adaptation (Nizam et al., 2020) and these firms primarily depend on bringing these technologies from the firms of developed economies (Malik & Kotabe, 2009). This study provides a rich direction of implication to the firms of developing countries, which are striving to adopt I4.0 strategy in this digital transition era. Due to institutional voids, the firms in developing countries need to endow their SC with the external actors to build strong ties with the firms in developed economies. The study examined the mediating role of innovative capability, KBDCs, and i4.0 efficacy in the relationship between SC and i4.0 readiness. The findings suggest that the SC of the firms of developing economies, i.e., Pakistan, with the firms of developed economies is a useful tool to improve the readiness of i4.0. The results show that structural SC and cognitive SC are positively related to innovative capability. In the context of this study, it means that firms in developing countries with strong personal people networks and a dense network link based on shared values and vision are better positioned to extract valuable knowledge from companies in developed economies to promote innovation. Furthermore, the results of the study show that the innovative capability of the firms is positively linked to the readiness for i4.0, which is consistent with the existing literature (Shamim et al., 2016b; Sheen & Yang, 2018). Innovative capability also mediates the relationship between SC and i4.0 readiness. In the context of this study, it means that companies in developing economies can be in a good position to gain knowledge through their strong SC that can gain the innovative capability to enhance i4.0 readiness. It also indicates that firms with strong social networks can increase knowledge sharing and contribute to product and service innovation (Pérez-Luño et al., 2011). Firms with

more ability to adapt to the changing environment through uninterrupted innovation, such as adapting the latest technology in the working environment and using big data in decision making, will become more equipped to incorporate i4.0 (Shamim, Zeng, Shariq, et al., 2019).

The results also show that structural SC and relational SC are positively related to KBDC. In the context of this study, it means that companies in developing countries having dense social ties, friendships, and trust are better positioned to acquire and disseminate knowledge from companies in developed economies, and this knowledge is the main foundation of KBDCs (Kim et al., 2013). The results further show that KBDCs are positively related with i4.0 readiness and KBDCs mediate the relationship between SC and i4.0 readiness. It means that firms with strong knowledge-based dynamic capabilities facilitate the knowledge flow from developing economies to the developed economies and enhance the ability of the firms to embrace i4.0 readiness.

The i4.0 efficacy of firms in less developed economies can be influenced by their SC with firms in industrialized and developed economies. The findings indicate that of the three dimensions of SC, only cognitive SC is positively related to i4.0 efficacy. In this context of the study, it means that firms in developing economies with a strong organizational structure of shared norms, values, and languages are in a better position to acquire the desired technical knowledge from firms in developed economies. This knowledge becomes a foundation for these firms to increase their confidence in i4.0 technology. The results also show that i4.0 efficacy is positively related with i4.0 readiness, and it also mediates the relationship between SC and i4.0 readiness. It means that firms in developing countries gain more confidence to embrace i4.0 technology through their shared norms and values with firms in developed economies, which can enhance their readiness to embrace i4.0 technology.

7.1. Academic contribution to theory and knowledge

This study contributes to theory and knowledge in several ways. Examination of the SC of firms in developing economies with developed economies is rare in the existing literature. Research in i4.0 readiness is an under researched area, and most of the studies are conducted on the technological aspect of i4.0; however, the studies on the management issues of i4.0 are scarce. The perspective of capability development with regard to i4.0 is also an overlooked research area. This study also contributes to the theory of SC and the theory of efficacy by determining that SC improves the efficacy of i4.0. This study uses efficacy as i4.0 efficacy that would consider it the first study to introduce efficacy in the context of i4.0. However, the existing literature only discusses i4.0 in the context of industrialized and developed economies, however; how less developed economies prepare and prepare to embrace the i4.0 strategy is still not addressed in the current literature. This study fills this gap by examining the role of SC to

enhance i4.0 readiness in Pakistan, which is considered a well-established context for developing economies. Examining the mediation of innovative capability, KBDCs, and i4.0 efficacy in the relationship between SC and i4.0 readiness is also a novel contribution. Overall, this study presents a very different line of inquiry in the context of i4.0

7.2. Contribution to practice

Pakistan is in the infancy stage of developing and adapting technologies for i4.0 (Nizam et al., 2020) and primarily depends on importing such technologies from developed countries (Malik & Kotabe, 2009). This research activity examines the mediating role of innovative capability, KBDCs, and I4.0 efficacy in the liaison of SC and i4.0 readiness. The expected results can indicate that SC can be a useful tool for developing countries like Pakistan to extract knowledge from developed countries and prepare for the i4.0 paradigm. Furthermore, the role of innovative capability, KBDCs, and i4.0 efficacy are also crucial. SC is frequently considered a forerunner of innovation and transformation (Maurer et al., 2011), and i4.0 readiness plays a vital role in triggering a digital transformation in organizations and economies as a whole. The investigation of SC role towards i4.0 readiness means that firms in developing economies can be in a good position to embrace i4.0 technology by effectively using SC. Furthermore, the mediation examination of innovative capability, i4.0 efficacy, and KBDCs in the relationship of SC and i4.0 readiness mean that firms of developing economies with strong SC can be in a good position to improve innovative capability, develop i4.0 confidence, and gain KBDCs which can enhance i4.0 readiness.

This study suggests connotations for companies in developing economies, especially those companies that are in the phase of the digital transformation process and are struggling to adapt to the i4.0 strategy. Due to institutional gaps, firms in less developed economies must depend on SC of firms in developed and industrialized economies. SC is a valuable tool for extracting effective knowledge from firms in developed economies by using intra-organizational ties to accelerate the process of innovation (Maurer et al., 2011).

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LIST OF PUBLICATIONS BY THE AUTHOR

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Published articles

1. **UI Zia, N.**, Burita, L. & Yang, Y. (2022) Inter-organizational social capital of firms in developing economies and industry 4.0 readiness: the role of innovative capability and absorptive capacity. **Review of Managerial Science**. DOI: [10.1007/s11846-022-00539-3](https://doi.org/10.1007/s11846-022-00539-3)

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3. Shamim, S., Yang, Y., **Zia, N. U.**, & Shah, M. H. (2021). Big data management capabilities in the hospitality sector: Service innovation and customer generated online quality ratings. **Computers in Human Behavior**. DOI: [10.1016/j.chb.2021.106777](https://doi.org/10.1016/j.chb.2021.106777)

4. **Zia, N. U.** (2020). Knowledge-oriented leadership, knowledge management behaviour and innovation performance in project-based SMEs. The moderating role of goal orientations. **Journal of Knowledge Management**. DOI: [10.1108/JKM-02-2020-0127](https://doi.org/10.1108/JKM-02-2020-0127)

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7. Avoiding crisis-driven business failure through digital dynamic capabilities. A case of B2B distribution firms. **Journal Name: Industrial Marketing Management**.

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9. Building blocks of cognitive trust in artificial intelligence and its integration into business strategy. **Journal Name: Information Technology and People**

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