



Network-based Intellectual Capital and knowledge discovery of innovative Start-ups: Big Data Analytics Perspective

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Received: 18/09/2025

Accepted: 01/12/2025

Published: 25/12/2025

Abstract:

This paper seeks to elucidate how network-based intellectual capital influences the products of innovative start-ups by utilizing knowledge discovery through big data analytics technology. The study employs a qualitative approach, utilizing an illustrative method that incorporates bibliographic and documentary research. The author presents a conceptual-theoretical model and states three research propositions that highlight the relationships between constructs, ultimately supporting the sustainability of innovative start-up products. The proposed model indicates that cooperation and knowledge sharing among network-based intellectual capital components generate more value of network-based IC for innovative start-ups within social networks, thus enabling the discovery of new knowledge through big data analytics to foster sustainable innovation. The findings underscore the data scientists' role in the knowledge discovery process.

Keywords: Network-based Intellectual Capital; Innovative Start-ups; knowledge sharing; Big Data Analytics; Knowledge discovery.

Jel Classification Codes: M 13, L 86, M 15, O 32.

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1. Introduction

Social network research originated from the concept of social capital (Chen et al., 2019, p. 167021; Dehbi & Bessaid, 2023). Furthermore, it became a hot topic in intellectual capital (IC) studies (Nahapiet & Goshal, 1998, p. 252), who proposed that “the fundamental proposition of social capital theory is that network ties provide access to resources,” which leads to linking and sharing knowledge among members of social networks (Ramadan et al., 2017, p. 444). Accordingly, (Nahapiet & Goshal, 1998, p. 245) suggested that ‘social relationships and the social capital therein have an important influence on the development of IC.

The importance of the network-based intellectual capital “network-based IC” concept has been recognized (Dehbi, 2021; Dehbi & Chennouf, 2021; Vătămănescu et al., 2016) when presenting the usefulness of the social network approach to examine the fourth stage of IC (Dumay & Garanina, 2013, p. 21) and its ability to enhance the role of network-based IC by expanding the communication process between members, such as people and knowledge (Vătămănescu et al., 2016, p. 606).

Furthermore, (Secundo et al., 2020, p. 19) observed that IC leverages digital collaborative platforms to facilitate knowledge sharing and harnesses the advantages of big data technology to stimulate product innovation (De Santis & Presti, 2018, p. 374). Consequently, the author offers a comprehensive perspective for start-up network managers by proposing a theoretical-conceptual model that elucidates the connections between network-based IC and innovative start-up products through three propositions.

Several studies of knowledge management (Iqbal et al., 2018; Ramadan et al., 2017) have focused on how the processes of creating, using, and sharing knowledge affect IC. While (Cabrilo & Dahms,

2018) explored the impact of IC components on innovation, they did not delve into the mediating relationships among these constructs. Furthermore, only a few extant studies have investigated knowledge discovery from small- and medium-sized enterprises (SMEs) and start-ups networks using a theoretical-conceptual model method or case study approach, as well as a literature review technique (Jordão & Novas, 2017).

Moreover, (Dehbi & Chennouf, 2021) identify opportunities for big data analytics from organizations' databases. Yet, the challenge of understanding IC and big data to promote innovation in the context of start-up networks remains a gap yet to be explored in depth. To the best of the author's knowledge, this study is the first to propose a theoretical-conceptual model to explain how network-based IC can foster the innovation role for start-up networks, both locally and internationally, by interpreting knowledge discovered from databases. This study aimed to address the following research question:

To what extent does knowledge derived from network-based IC affect the innovative products of start-ups from a big data analytics perspective?

This paper seeks to address this question by examining the significance of IC components within start-ups networks. In particular, it emphasizes the role of knowledge sharing as a crucial asset for business longevity and advocates the formation of strategic alliances with firms in the same or different industries. Additionally, this research underscores the importance of data scientists in knowledge discovery, drawing the attention of entrepreneurs to this role. The study also aims to alert governments and entrepreneurs in developing countries, such as Algeria, to consider adopting the theoretical-conceptual model when launching innovative start-ups, which could eventually grow into large companies.

2. Literature Review

2.1 Network-based intellectual capital, knowledge sharing, and discovery: conceptual aspects

Management literature has used the concept of IC to understand how knowledge functions as a fundamental asset of value for organizations. (Allameh, 2018) considered that knowledge sharing enhances individual and organizational skills, and nurtures the organization's IC. (Chang & Chuang, 2011) stated that network organizations provide individuals with opportunities to interact and build relationships. Knowledge is accumulated through the integration of information, experience, and theoretical insights. This can be achieved through technological or structured approaches. Individuals are more likely to participate in network organizations to share or exchange knowledge if they believe that personal benefits outweigh the potential loss of valuable knowledge. Scholars' conceptualizations of IC refer to its development and utilization as an intangible, knowledge-based asset generated by an organization's collective "brainpower" in ways that create value and enhance performance (Bontis, 2001). In other words, researchers have provided various definitions of IC; three main dimensions are widely accepted: human capital (HC), structural capital (SC), and relational capital (RC). These relate to the knowledge embedded in individuals' minds, organizational structures, processes, systems, relationships, and networks (Nahapiet & Goshal, 1998; Subramaniam & Youdnt, 2005).

The emergence of organizational networks (Marchiori & Franco, 2020) has radically changed the diversity and structure of employee relationships, resulting in the formation of network organizations. Therefore, (Vătămănescu et al., 2016, p. 498) have advanced a new concept of network-based IC implying a dyadic purpose: the individual's goal to learn, to have access to the network's resources for self-improvement and organizational competitiveness through cross-organizational networking." As (Dehbi, 2024, p. 20- 21)"a combination of knowledge assets that an organization

possesses such as the wealth of ideas, talents, and infrastructures in form of organizational technology in terms of information and communication technology, knowledge management processes, intellectual property, as well as knowledge generated from the organization's relationships and cooperation with its external environment such as stakeholders.”

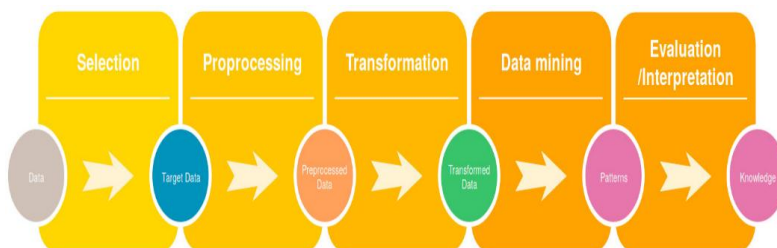
(Jordão & Novas, 2017) concluded that network organizations further empowered all participants to share knowledge and improve IC practices between SMEs, as well as start-ups (incubators and incubated companies) (Franco et al., 2021). (Berbache & Nadir, 2024, p. 149- 150) defined Start-ups as " small businesses that develop a new idea or offer an innovative product within a specific market. They seek to grow and scale their businesses, often relying on advanced technologies or innovative business models to achieve this goal. Startups are characterized by their ability to quickly adapt to changes in the market, making them a catalyst for continuous investment and innovation."

Overall, knowledge and IC were closely related. The former is not only a component of the latter but also a consequence of it, since IC itself consists of knowledge that enables the achievement of organizational goals (Jordão & Novas, 2017). Many empirical studies have explored the impact of dynamic knowledge processes and activities on IC (Buenechea-Elberdin et al., 2018; Hayaeian et al., 2022; Iqbal et al., 2018). Prior studies indicate a paucity of research establishing a causal relationship between IC and the process of knowledge extraction/discovery, which is particularly challenging to theorize. However, the efficacy of networks becomes evident in this context, as they facilitate dialogue and collective thinking, thereby rendering tacit knowledge explicit (Dehbi, 2023; Secundo et al., 2016); thus, the knowledge discovery process within start-up networks (Franco et al., 2021). In light of the dependence on technology that allows researchers and practitioners to capture data with greater volume, velocity, to attain its potential benefits, this paper explains the

author's perspective regarding exploring knowledge as a consequence of network-based IC through big data analytics technology innovation. Therefore, three research propositions are developed, and the hypothesized relationships between the research variables are clarified in the context of start-ups, as most studies conducted on this concept have focused on large companies.

2.2 Big Data Analytics and Innovation

(Vanani & Emamat, 2019, p. 61) defined knowledge discovery as “a significant extraction of previously unknown and useful information from data”. Data Mining is part of the knowledge discovery process by data scientists. In line with this, knowledge discovery in databases refers to “the process of extracting previously unknown information and understandable hidden patterns in data.”(Safhi et al., 2019, p. 30). It consists of five steps, as shown in Fig. 1: selection, pre-processing, transformation, data mining, and interpretation/evaluation. Previous work by (Dehbi, 2021) has implied the role of data scientists in describing the quality of data that can be used, illustrating the effects of network-based IC through network-based structural capital, where the author argued that both knowledge technology processes and data scientists and new knowledge can be discovered from databases. As mentioned by IBM, “the data scientist apart is strong business acumen, coupled with the ability to communicate findings to both business and IT leaders in a way that can influence how an organization approaches a business challenge”(Del Vecchio et al., 2018, p. 17)

Fig.1. Knowledge discovery process

Source: (Safhi et al., 2019, p. 30).

Several studies have investigated the relationship between IC and innovation in large corporations (Buenechea-Elberdin et al., 2018; Subramaniam & Youndt, 2005). Furthermore, in the recent phase of IC research, researchers demonstrated network-based IC in start-ups' networks, as this promotes the creation, sharing of knowledge, and collaboration (Franco et al., 2021), which are important for open innovation in start-ups (Franco et al., 2021; Hayaeian et al., 2022).

There is a diverse range of definitions for innovation, and the type of innovation created varies from products and services to production processes or business models. (Lu & Sexton, 2006, p. 1276) have defined knowledge-based innovation as the useful production and practical implementation of a new idea that can improve an organization's overall performance through IC. Most studies have focused on the knowledge traditionally extracted from IC stock in innovation. For example, (Hayaeian et al., 2022, p. 790) have recommended that SME managers could invest in fostering interconnected HC interrelationships, such as face-to-face interaction, group activities, and creating a collaborative and friendly work environment in SMEs, as this is conducive to sharing tacit knowledge and encouraging superior innovations. (Dehbi & Bessaid, 2023) highlighted the significance of enterprises' social networks in facilitating knowledge creation between knowledge seekers and contributors within the innovation process in social practice. While the

importance of big data in discussions on innovation outcomes cannot be overlooked, these outcomes arise from elements that enhance effectiveness through internal and external knowledge flows (Dahlander & Gann, 2010).

In this context, (Del Vecchio et al., 2018) noted that big data analytics tends to be more effective for large corporations than start-ups, as the latter typically have smaller economies, and expanding a company's scale necessitates greater investment and increased expenses. However, the indispensability of social networks, along with their structural, cognitive, and relational components, influencing start-ups' network development, strategic alliances, and relationships between human and relational capital, cannot be neglected. (Yasir et al., 2011) emphasized that start-ups need to operate within networks to exchange IC, improve their competitive abilities, streamline their operations with larger companies, integrate IC and innovation strategies (Jordão & Novas, 2017; Yasir et al., 2011), and stimulate trust between partners because it is the most important factor in the relational component of the social network (Holste & Fields, 2010). Therefore, three research propositions are developed, and the hypothesized relationships between the research constructs are clarified in the context of start-ups, as most studies conducted on this concept have focused on large companies.

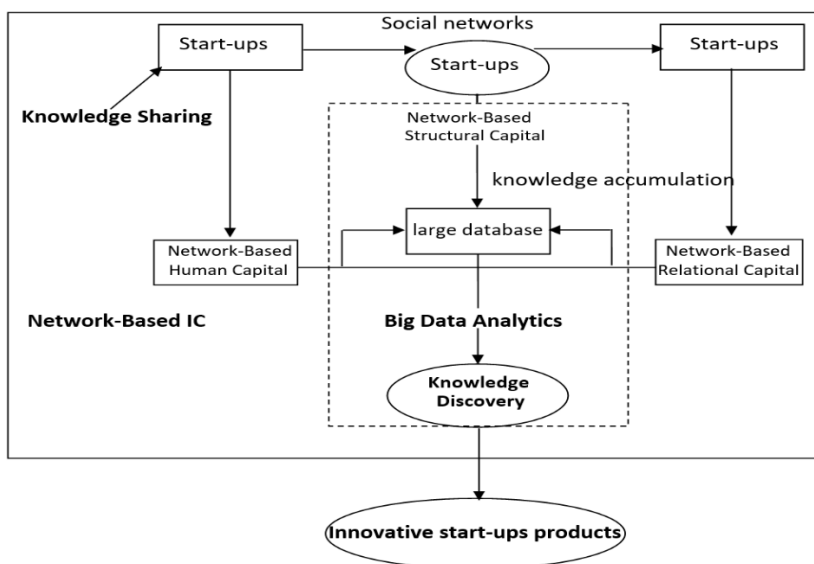
3. Research Methodology

This study adopts a qualitative methodology and employs an illustrative approach that utilizes bibliographic and documentary research (Tranfield et al., 2003). This study is explanatory since it seeks to investigate a topic in a little-explored field of research and establish, through inferences, an explanation of the correlations identified between the phenomena studied. This type emphasizes the development of a conceptual framework and the relationships between concepts (Rowe, 2014). To do this, this paper discusses documentary research, which enables us to identify and evaluate the current

intellectual landscape while choosing search terms, research gap, and research question. This approach aims to develop existing knowledge further (Rowe, 2014). The author seeks to explain the theoretical-conceptual proposed model and conduct an analysis of the correlation between the components of network-based IC, knowledge sharing, and big data analytics, resulting in start-ups' innovative products, as recommended (Del Vecchio et al., 2018), to make a connection between Big Data analytics and open innovation. This demonstrates the growing recognition and evaluation of qualitative research, making it imperative to conduct it rigorously and systematically to achieve useful and meaningful results based on previous research insights, recommendations, and findings.

4. Conception and Analysis of the Theoretical-Conceptual Model

Previous studies (e.g., Dehbi & Chennouf, 2021; Franco et al., 2021) have stressed the importance of Network-based IC management within networks. In line with (Del Vecchio et al., 2018) recommendation, which refers to companies' agility, it can become a powerful tool for (SMEs) to remain in the market of the digital era for big data analytics and innovation. The author adapted this idea to start-ups networks. For a more complete understanding of the discovery of new knowledge from databases, the author adapted this idea to start-ups networks, in which the proposed model clarifies the configuration of start-ups within social networks and how to strengthen the innovation process through three propositions.

Fig.2. Theoretical-Conceptual Model Development

Source: Author's own work.

Proposition 1. Social networks and knowledge sharing

Social network research has emphasized network relationships between individuals, teams, organizations, and communities that possess social resources (Inkpen & Tsang, 2005). In this case, (Barão et al., 2017, p. 738) considered the organization as “a social network that is made up of many smaller networks and organizational memories, and typically, the knowledge is dispersed throughout the network.” In addition, (Inkpen & Tsang, 2005) suggested that networks include various models, such as business units within companies, strategic alliances, customer-supplier relationships, and business groups.

The social capital theory has emerged as a crucial approach for evaluating social networks (Chen et al., 2019). (Chen et al., 2017; Nahapiet & Goshal, 1998) summarized social capital and divided it into three dimensions: structural, relational, and cognitive. Structural

capital encompasses networks that pertain to the comprehensive relationships among the actors with whom an organization is affiliated and their connections to other organizations, yielding advantages at both the organizational and individual levels, such as enhancing frequent interactions. In this regard, (Chen et al., 2017) have indicated that “ the structural dimension of the social network primarily provides opportunities for knowledge exchange and interaction frequency.

Relational dimension concerns the nature of the relationships between individuals and encompasses respect, friendship, trust, engagement, reciprocity, norm regulations, identification, cooperation, and obligations(Chang & Chuang, 2011; Nahapiet & Goshal, 1998). Trust is the most important factor in relational social networks(Holste & Fields, 2010). Regarding the cognitive dimension, cognitive social networks influence three aspects of knowledge sharing: shared culture, language, and shared goals, which increase collaboration when network members share the same goals (Inkpen & Tsang, 2005; Nahapiet & Goshal, 1998).

Knowledge sharing enables the formation of new relationships within networks, providing insight into how network-based IC facilitates its expansion within network society. In this way,(Nahapiet & Goshal, 1998, p. 245) suggests that “social relationships and the social capital therein have an important influence on the development of IC through interactions within and with organizations (Jordão & Novas, 2017). At least two parties are involved in the knowledge sharing and discovery process in organizations (i.e., the components of network-based IC in this paper). Interactions occur among network-based human capital, network-based structural capital, and network-based relational capital of the same or different start-ups.

It is recognized that innovative start-ups endeavor to integrate into networks to mitigate the constraints associated with their size, thereby forming alliances and collaborative partnerships with

companies (Jordão & Novas, 2017). According to Van Wijk et al., (2008), relational capital, especially trust, is crucial for knowledge sharing both within and between organizations (Van Wijk et al., 2008). However, different cultures can impede knowledge sharing across units within a company (Van Wijk et al., 2008). On the other hand, (Dehbi, 2023)'s study, involving 302 IT managers from three organizational levels (senior managers, mid-level managers, and junior managers) within the same company across various provinces, showed that collaboration and knowledge flow between managers within the network is not hindered by functional, geographical, or cultural distances. Furthermore, (Hayaeian et al., 2022) have investigated the moderating role of knowledge management on IC in the innovation evolution of 170 Iranian Start-ups. The outcomes highlighted the high level of IC correlation with innovation. Based on this line of thinking, the author proposes that start-ups build their network-based IC through collaboration and knowledge sharing within social networks.

Proposition 2. Network-based intellectual capital configuration

In today's world, the interaction between networks and the knowledge society offers a worldwide view on how businesses evolve into network organizations. As noted by (Dehbi, 2021), the emergence of the network-based IC concept is confronted with a fiercely competitive business landscape that is digital, virtual, and interconnected.

- **Network-Based Structural Capital**

ICT, as an element of structural capital, presents opportunities for IC (Dehbi & Chennouf, 2021). As noted by (Stephens et al., 2016), the structural processes that shape the network framework of employees enable a platform to gather data on employees' interactions. Besides, the organization's structural capital plays a key role in the intellectual output derived from collaborations between human capital and relational capital (Dost et al., 2016). Accordingly, structural

capital backs the accumulation of Knowledge resources in companies' structures, databases, and embedding knowledge in internal and external network relations (Buenechea-Elberdin et al., 2018). In this regard, the author argues that the structural dimension of social networks provides a platform for network-based structural capital for knowledge sharing among the components of network-based IC, establishing knowledge networks through infrastructure processes (Barão et al., 2017, p. 738), which generates an effect on both the same and other start-ups.

- **Network-Based Human Capital**

Network links refer to the specific ways in which actors are connected (Inkpen & Tsang, 2005). Thus, the diversity of different network-based human capital relationships impacts the dissimilarity ties, and these groups form "network teams." These relationships constitute an important aspect of social relations (Nahapiet & Goshal, 1998), and may be critical for network-based human capital diversity. Based on (Newman et al., 2020), the results demonstrated the effectiveness of leader communication in a large company with virtual teams from diverse cultural and geographic backgrounds. Matter most, the role of social capital has been explored in terms of knowledge networks in large-scale software development projects (Chen et al., 2017; Šmite et al., 2017).

(Šmite et al., 2017) focused on the team knowledge networks within two major companies. Their research revealed that social capital and networks play a crucial role for both new and established teams in tackling complex tasks. Additionally, the size of these networks is influenced by the company's level of experience and the team's culture regarding interactions. This study was adapted from the work of (Jordão & Novas, 2017), which broadens the understanding of how knowledge networks are formed and how knowledge is shared and discovered through social networks. Consequently, the author suggests that managers of innovative start-ups should encourage

network-based human capital to facilitate communication and collaboration across social networks to enhance data accumulation.

Network-based relational capital

In a similar vein, network-based relational capital assumes a pivotal role within start-ups' networks, akin to the influence of network-based human capital. Consequently, (Franco et al., 2021) mainly focused on the fundamental tenet of network existence in the development of collaborative networks are thus frequently employed by start-ups to ensure survival and enhance performance growth. Furthermore, network formation offers opportunities for knowledge sharing and discovery that benefit all participants (e.g., incubators and incubated firms). Thus, a social perspective for start-ups will help improve relationships with suppliers, customers, and competitors. This would make tacit knowledge explicit through dialogue and collective thinking (Dehbi, 2023; Secundo et al., 2016). As a result, start-ups in the same sector will develop exploitative and exploratory activities while improving the innovation process of their products, which determine market trends.

Proposition 3. Big Data Analytics and Knowledge Discovery

Start-ups often have a low hierarchy, which can stimulate originality and innovation. (Jha & Basu, 2025) Conducted a systematic review of the literature, which shows that innovative start-up entrepreneurs integrate external knowledge, such as that from stakeholders, through the knowledge acquisition process to drive innovation. The emergence of new digital infrastructures (e.g., big data analytics) has radically restructured the nature, ways, structure, and processes of doing business; thus, start-ups need to recognize the substantial role of interactions among network-based IC components for data storage in databases.

(Buenechea-Elberdin et al., 2018) argued that structural capital plays a substantial role in supporting the accumulation of knowledge

resources in corporate structures, databases, and knowledge embedded in internal and external networks. For these reasons, (Dehbi & Chennouf, 2021) highlighted the future of network-based IC in the era of big data, which enables data to be accessed from network-based human and relational capital.

The author highlights the importance for managers of innovative start-ups in Algeria's economy to leverage network-based IC and knowledge management. Given that Algeria is a nascent environment for such organizations, the main challenge lies in the expertise needed to handle big data, which is particularly significant for start-ups due to the limited availability and high expense of these skills (Del Vecchio et al., 2018). In this context, the involvement of IT managers and data scientists is essential for knowledge discovery (Dehbi, 2021).

However, the impact of big data analytics on innovation (Del Vecchio et al., 2018) and the role of IC and knowledge management in achieving innovation (Hayaeian et al., 2022). The author proposes that innovative start-up managers need to carefully consider big data analytics for knowledge discovery, leading to sustainable innovation.

5. Final Remarks

Past studies have identified the integration of IC, knowledge management, and innovation in SMEs or start-ups. However, to the best of the researcher's knowledge, this study is the first broad overview of the topic of network-based IC to enhance innovative start-ups products from a big data analytics perspective. The author reviewed the main academic works that addressed the aforementioned constructs (Barão et al., 2017; Dehbi, 2021; Dehbi & Chennouf, 2021; Del Vecchio et al., 2018; Franco et al., 2021; Jordão & Novas, 2017) from which the three propositions were derived and applied to start-ups.

First, the propositions demonstrate why knowledge networks are necessary for the generation of network-based IC through interactions

both inside and outside start-ups, that is, knowledge-sharing contributions between network-based human capital, network-based relational capital, and teams. Here, the structural and relational dimensions are handled to exert the trust factor that defines the relational context of social networks. The author explains the benefits of structural dimensions at the organizational level as innovative startups become part of networks to overcome size constraints by forming collaborative partnerships.

Second, we build on the findings of previous empirical studies (Newman et al., 2020; Šmite et al., 2017; Vătămănescu et al., 2016) to posit that the structural dimension of social networks provides a platform for structural capital to IC for knowledge sharing between network-based IC components, which stimulates tacit knowledge discovery of start-up networks (Dehbi, 2023; Jordão & Novas, 2017). Thus, social capital and networks are essential for both emerging and mature teams (Šmite et al., 2017). Therefore, startup managers should encourage human capital to use the network (Berbache & Nadir, 2024, p. 157) and strengthen relationships with suppliers, customers, and competitors (stakeholders); this can make tacit knowledge explicit through dialogue and collective thinking (Dehbi, 2024; Secundo et al., 2016).

Third, after reviewing the most relevant theoretical and empirical studies in the context, the author noted the absence of research that encompasses the constructs included in the original research proposed model, whether in the context of start-ups or network-based IC. Therefore, since interrelations between the network-based IC components and knowledge accumulation, we proposed relying on big data analytics for knowledge discovery, as IC research has reached the ‘fourth stage’ of research (Dehbi & Chennouf, 2021; Secundo et al., 2020) instead of traditionally extracting tacit knowledge within networks (Dehbi, 2023). Here, start-ups managers should pay attention to IT managers and data scientists within social networks (Barão et al., 2017; Dehbi, 2021), especially

since the substantial role of start-ups is innovation (Berbache & Nadir, 2024).

5.1 Limitations and Future Research

The discussion suggests that future research could explore the proposed model and conduct empirical studies through individual or comparative case studies or sector studies. First, the author holds that this validation could not be fruitful for every country due to diverse cultural or market environments. Instead, local start-up networks may configure an international network either through incubated corporations or multinational corporations.

Second, the current study focused generally on social networks as a communication medium for network-based IC components. Although future researchers may investigate how network-based IC components share knowledge across different social network platforms, such as Twitter, Facebook, and Instagram, scholars should also pay attention to network-based human capital, especially social network analysts and IT managers serving as virtual team leaders.

Third, another important issue requires further investigation. Start-ups often encounter difficulties in growing their network size; here, the incubator should establish long-term relationships with the incubated start-ups by structural dimensions of social network to expand network members, in turn forming new virtual teams.

The research provided future research of this subject, particularly promoting collaboration among businesses, governments, and researchers engaged in joint initiatives to develop new business models and services that benefit both customers and stakeholders.

6. Conclusion

On a theoretical level, the paper's findings enrich the existing body of knowledge and address a gap in studies concerning network-based IC and innovative start-up products. While previous literature often regarded IC as a static stock of knowledge, this study uncovers

the link between network-based IC and knowledge discovery, viewing the digital infrastructures of big data analytics as a dynamic capability within start-up networks. Particularly, the proposed model highlights how sharing knowledge dynamically of IC components within innovative start-up networks leads to the discovery of new knowledge for sustainable innovation.

For business practitioners, this study offers important practical insights for start-up entrepreneurs seeking to understand the innovation process within social networks better. The paper highlights the necessity of integrating network-based IC with a big data analytics approach to enhance knowledge discovery, emphasizing the data scientist's role. This study could be of value to start-up managers, as it helps them foster virtual interactions among IC components (e.g., customers and stakeholders) to facilitate knowledge collection and sharing. Consequently, governments must provide funding to lower the costs associated with acquiring big data analytics technology for these emerging companies.

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