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Embracing Technological Advancements: Blockchain as a Driver for Innovation and Dynamic Capability Development

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1. INTRODUCTION

The success of national economies is largely determined by the application of innovative technologies and countries' propensity to be at the forefront of technological progress that ensures the more efficient production of goods and services. It is widely accepted that technologies are the key drivers of the economic growth of cities, regions, and countries. Therefore, a clear understanding of the role of novel technologies is required, as such technologies are challenging the current status quo of organisations, reshaping the behaviour of many businesses and industries (Franco et al., 2009; Frolov, 2021), and enabling the creation of new ventures (von Briel et al., 2018; Chalmers et al., 2021). Technological advances embedded in the development of products affect the competitiveness of firms. Technologies provide an opportunity for smaller companies to exploit specific needs and challenge market leaders in well-defined niche areas by creating new products and processes.

Recent research has increasingly focused on the organisational implications of blockchain technology. This body of work has concentrated on various aspects, including comprehending how blockchain affects business practices, as exemplified by Frizzo-Barker et al. (2020) and Tönnissen et al. (2020), its impact on business models (Morkunas et al., 2019; Weking et al., 2020), its influence on entrepreneurship and innovation (Chalmers et al., 2021; Chen, 2018), and its effects on the capabilities of enterprises, as explored in studies by Gupta et al. (2023), Meier et al. (2023), Pattanayak et al. (2023), and Quayson et al. (2023). However, studies have yet to investigate the direct effects of blockchain technology on the capabilities of startups. In this dissertation, my purpose is to bridge the gap in innovation research pertaining to the managerial aspects of technology implications, particularly within the context of early-stage businesses.

This dissertation is organised as follows: To begin, I outline the rationale for selecting the topic and its socio-economic significance, followed by an overview of the articles that constitute this dissertation. Further, I establish the conceptual foundations by reviewing the relevant literature on blockchain technology and dynamic capability theory. In this review, I emphasise the open opportunities within the academic literature that this research aims to address. Following this, I provide an explanation of the methodology used in the presented articles and elucidate the procedures for data collection and analysis. Afterward, I present the main findings. Lastly, I elaborate on the contributions of the findings to blockchain-related literature, entrepreneurship, dynamic

capabilities, and research concerning the interplay between technology adoption and dynamic capabilities in young entrepreneurial firms. I also discuss the practical implications of research for individuals involved in the establishment and management of early-stage ventures, for the executives of incumbent organisations, and for policymakers.

1.1. Rationale for choice of the topic

At the beginning of my doctoral studies, I had the opportunity to participate in the research project "*Corporate technology management and dynamic capabilities*" within the framework of the EFOP-3.6.3-VEKOP-16-2017-00007 project "From talent to young researcher – supporting career in research activities in higher education" (spring semester 2020). In the framework of this project, I worked with Dr. Szabolcs Szilárd Sebrek (my supervisor), Israa Qutishat (an MBA student), Evelin Regina Szász, Endre Kende Kocsis, and Fedor Bence (bachelor students) to study the adoption of blockchain technology and use cases across a number of industries. It was a time when the hype and speculative fervour of the early years had subsided and the blockchain space had matured by the beginning of 2020, with a greater focus on real-world applications, regulatory clarity and compliance, leading to a more sustainable and long-term approach to blockchain innovation.

We collected information on the value propositions, competitive advantages, and distinctive capabilities of the companies that adopted blockchain technology. The initial findings of the study were discussed in the undergraduate theses and the publication titled *"New industrial fields, innovativeness, and firms' competitive advantage: the birth of the Hungarian blockchain ecosystem,"* co-authored with Israa Qutishat and Dr. Szabolcs Sebrek. This paper was presented at the 2nd International Conference on Applied Research in Business, Management, and Economics and published in the conference proceedings in September 2020.

Parallel to my involvement in the research project, I was taking an academic course on organisation theory with Prof. Primecz Henriett. Upon completing the course, I wrote a course paper on the adoption of blockchain technology through the lens of organisational theories. This paper underwent further development and was subsequently published in the Hungarian journal "*Vezetéstudomány/Budapest Management Review*". Additionally, I performed a comprehensive review of the existing literature pertaining to blockchain technology and its application within industries, with a specific focus on blockchain-driven entrepreneurship. This review

involved categorising and classifying the available literature sources. Through this research, I delved into the factors that support the establishment and expansion of businesses within the emerging blockchain industry. The research outcomes were showcased at the New Horizons in Business and Management Studies conference held by Corvinus University, and the solo-authored paper titled "*Entry dynamics of startup companies and the drivers of their growth in the nascent blockchain industry"* was included in the conference proceedings.

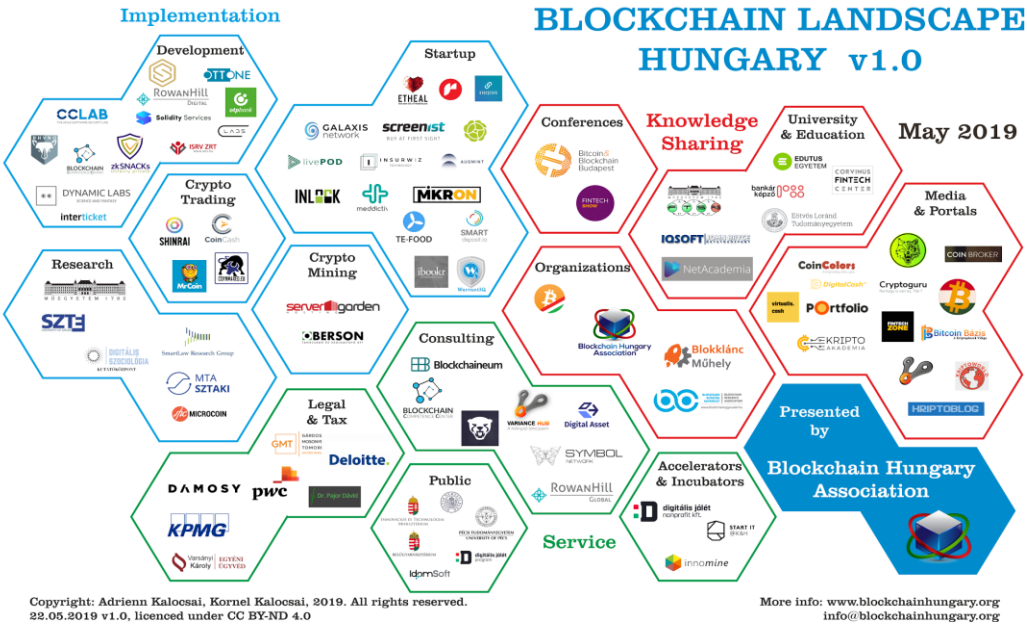
Thus, the decision to select my dissertation topic originates from the research endeavours initiated during my first and second years, where I consistently observed the profound impact of blockchain technology in enabling the establishment of new businesses as well as products and processes. In particular, I was fascinated by the transformative potential of technologies, including blockchain. Hence, my determination to further explore the domain of technology and its impact was a natural evolution of my experiences and an aspiration to enhance an understanding of its role in fostering innovation and entrepreneurship. In the forthcoming section, I delve into the socio-economic relevance of the selected topic.

1.2. The socio-economic relevance of the chosen topic

Between 2017 and 2019, the blockchain space saw the emergence of numerous blockchain startups and blockchain-themed conferences and events (for instance, the Blockchaineum conference, B-DAY conference, or Bitcoin Budapest Meetup). Universities responded to the rising interest in blockchain and distributed ledger technology by introducing courses and degree programmes in the field. For instance, Corvinus University was among the first to offer a course on the business aspect of blockchain technologies and applications, while the Budapest University of Technology and Economics focused on the technical aspects. Established companies and major corporations (e.g., IBM and Auchan Hungary) have started exploring blockchain solutions for various use cases. These initiatives attracted attention and fostered a sense of legitimacy for blockchain technology. The Blockchain Hungary Association, a not-for-profit organisation, was created in September 2018 (Blockchain Hungary Association, 2020) with the aim to educate interested stakeholders about technology applications and build the legal foundations for the successful functioning of blockchain ecosystem members. The organisation published a map of the Hungarian blockchain landscape to illustrate that there are around 100 active participants and entities in the

ecosystem that are trusted and well-known and to strengthen communication channels among the Hungarian stakeholders (see Figure 1).

Figure 1. Map of blockchain landscape in Hungary.



Source: Kalocsai and Kalocsai (2019)

The examination of the participants depicted on the map and detailed on the conference websites made it evident that blockchain's applicability extends well beyond the realm of finance. It encompasses areas like healthcare, supply chain management, identity verification, and energy, which in turn heightened the attention and discussions regarding its potential. There was a growing shift towards a more mature and realistic understanding of blockchain's capabilities and limitations. This technology has presented smaller companies with a chance to address specific customer demands and compete with established industry leaders in clearly defined specialised sectors through the development of innovative products and processes.

The evolution of blockchain technologies has led to the creation of a multitude of products and the establishment of new firms, marked by continuous entries and exits in the field. Recognising the temporal dimensions of competitive advantage is essential for organisations (Orlikowski and Yates, 2002). An understanding of temporality assists in evaluating the durability of a competitive advantage and in identifying when adjustments to capabilities become essential. The limited research on how blockchain technologies impact early-stage companies and their capabilities could potentially result in overlooked growth opportunities for various market participants and contribute to an innovation deficit in early-stage ventures. Additionally, entrepreneurs might develop blockchain-based startups without a comprehensive understanding of market needs and

dynamics, leading to ineffective business models. Allocating resources to blockchain projects without a solid research foundation can result in the mismanagement of time, capital, and resources. Thus, examining new technologies and the development of dynamic capabilities within organisations can provide valuable insights into the strategies these companies employ to create innovative solutions. This is not only essential for their individual success but also for fostering innovation within the wider business environment.

1.3. Content of the dissertation

As the culmination of my doctoral studies, I have composed an article-based dissertation that comprises a collection of related papers. Three articles have been published in peer-reviewed journals, and one paper has been submitted to a peer-reviewed journal. Table 1 exhibits the papers that have been incorporated into the dissertation as its main chapters.

Table 1. Overview of the papers and the journals' rankings.

Article / Year of publication	Title	Journal	MTA[1]	WoS indexed journal	SJR[2]
Article 1 (2020)	Technology adoption theories in examining the uptake of blockchain technology in the framework of functionalist and interpretive paradigms.	Vezetéstudomány / Budapest Management Review[3]	B	-	-
Article 2 (2023)	Exploring the profile of innovative enterprises in high-tech manufacturing sectors: The case of the regions of Madrid and Catalonia in 2016.	Regional Statistics		ESCI[4]	Q1/D1 (0.65)
Article 3 (2023)	The interaction of actor-independent and actor-dependent factors in new venture formation: The case of blockchain-enabled entrepreneurial firms.	Acta Oeconomica	C	Economics SSCI[5] (Q4) Impact Factor: 0.939	Q3 (0.23)
Article 4	Blockchain technology and the evolution of dynamic capabilities in early-stage ventures.	Journal of Business Research *(submitted to the journal*)		Business SSCI(Q1) Impact Factor: 11.3	Q1 (3.13)

[1] In the list of the competent committee of Section IX of the Hungarian Academy of Sciences (MTA).
[2] The SCImago Journal Rank.
[3] Rating A is valid from the 1st of June 2023.
[4] The Emerging Sources Citation Index (ESCI) includes high-quality, peer-reviewed publications of regional importance and in emerging scientific fields.
[5] Social Sciences Citation Index (SSCI).

The introductory article was published as a single-authored article in the November 2020 edition (Volume 51, Issue 11, pp. 26–38) of the Hungarian journal

"Vezetéstudomány/Budapest Management Review" under the title "*Technology adoption theories in examining the uptake of blockchain technology in the framework of functionalist and interpretive paradigms.*" In this paper, I examine the adoption process of emerging technologies using the example of blockchain. The theoretical analysis of blockchain acceptance and its consequences is examined through the lens of technology adoption theories as well as functionalist and interpretive paradigms. These theoretical frameworks aid in comprehending how end-users (e.g., supply chain practitioners) perceive the technology and promote its adoption across enterprises. The findings of the literature review revealed a lack of empirical research studies and underscored the necessity for more comprehensive theoretical development to expedite the adoption process within organisations.

The second article was prepared with Dr. Betsabé Pérez Garrido and Dr. Szabolcs Szilárd Sebrek, and it was published in January 2023 in the international Q2-ranked journal of *Regional Statistics* (Volume 13, Issue 1, pp. 119–148). In this article titled "*Exploring the profile of innovative enterprises in high-tech manufacturing sectors: The case of the regions of Madrid and Catalonia in 2016,*" we analysed the profile of innovative Spanish companies in terms of the degree of novelty in the high-tech manufacturing sector. The objective was to explore the likelihood of product innovation with respect to both the geographical location of firms and their specific characteristics (e.g., R&D expenses, size, researchers' salaries, and technological development) through the application of discrete choice models. Within the scope of this dissertation, I will emphasise the research results relevant to its topic. Companies that allocate an above-average level of funding to technological development tend to favour the creation of radical innovation (i.e., new to the market) as opposed to non-innovation or incremental innovation (i.e., new to the firm). Given the significance of high-tech manufacturing sectors and the resulting high-value-added production, it is essential to provide support to enterprises that are actively involved in innovative activities in order to further promote innovation in advanced manufacturing.

The third article was published in the *Acta Oeconomica* journal (2023, Volume 73, Issue 4, pp. 537–559) under the title "*The interaction of actor-independent and actor-dependent factors in new venture formation: The case of blockchain-enabled entrepreneurial firms*," co-authored with Dr. Szabolcs Szilárd Sebrek, Dr. Betsabé Pérez Garrido, Andrea Katona, and Dr. Gábor Michalkó. In this paper, we investigated how blockchain technology fosters the generation of new ideas for business ventures while also scrutinising the roles of founders and entrepreneurial teams in shaping those

ideas. We explained the interaction of actor-independent and actor-dependent factors in the process of new firm formation through the adoption of such theoretical frameworks as external enabler theory, dynamic capabilities, and dynamic managerial capabilities. A qualitative study was conducted to analyse four Hungarian blockchain start-ups. These companies span various sectors, including financial services, cryptocurrency trading, crypto asset management, energy, information technology, and identity industries, and they develop high-value-added and cross-industrial solutions for domestic and international markets. As the outcome of this research, three interconnected external enablers have been identified, and the role of entrepreneurs' capabilities and sensing and seizing activities in discovering and shaping these enablers has been discussed.

The last article, entitled "*Blockchain technology and the evolution of dynamic capabilities in early-stage ventures*," was submitted to the *Journal of Business Research* in spring 2024. This article was co-authored with Dr. Szabolcs Szilárd Sebrek and Dr. Philip T. Roundy (the Mary Harris Distinguished Associate Professor at the University of Tennessee at Chattanooga). The preliminary findings of this research were presented at the *DRUID 2021* and *EURAM 2023* conferences. We received constructive comments from the following well-known researchers: Prof. Peter Maskell from Copenhagen Business School, Prof. Russell Seidle from Suffolk University in Boston, Prof. Llewellyn D.W. Thomas from IESE Business School, Prof. Katharina Cepa from the Free University of Amsterdam, Prof. Patrick Mikalef from Norwegian University of Science and Technology, and others. To illustrate, Professor Patrick Mikalef provided feedback on our initial draft, expressing, "*I like your differentiation of dynamic capabilities into the three processes of sensing, seizing, and transforming*," and advising to elucidate how the technology under investigation either enables or enhances dynamic capabilities. Valuable insights and recommendations provided by esteemed scholars were thoughtfully incorporated into the final manuscript.

In the submitted manuscript, we integrated the theory of dynamic capability into the context of early-stage firms to demonstrate the impact of blockchain technology on the micro-level actions that constitute the temporal processes of dynamic capability development. Employing an exploratory, longitudinal, and inductive research approach based on case studies of five blockchain-enabled Hungarian companies, we focused on studying the long-term effects of blockchain applications and the technology's temporal and contextual dynamics as young organisations evolve. We have found that the incorporation of blockchain stimulates the adoption of the essential practices required for capability development in early-stage companies. Additionally, we have identified

eight underlying micro-level processes intricately linked to the sensing, seizing, and reconfiguring capabilities as well as formulated several propositions and developed the conceptual model. Our study, along with its theoretical and empirical insights, enriches the body of knowledge regarding the development of dynamic capabilities in early-stage enterprises and the ways in which new technologies play a facilitative role in this process.

The research questions and aims outlined in each article within the dissertation framework contribute significantly to the main research objective of bridging the gap in innovation research, specifically focusing on the managerial aspects of technology implications within early-stage businesses. In the first article, by reviewing technology adoption models and exploring the adoption process of blockchain technology in supply chains, the research addresses crucial aspects of technology integration within managerial contexts. The second article's investigation into innovation behaviour and performance associated with geographic location and firm-specific factors offers insights into the complex interplay between variables affecting innovation within enterprises. This knowledge is essential for developing tailored strategies to enhance innovation outcomes. The third article's examination of actor-independent and actor-dependent factors in new firm formation, using the dynamic capabilities framework, contributes to understanding the multifaceted nature of venture creation and provides practical guidance for entrepreneurs and managers navigating the startup process. Lastly, the fourth article's exploration of blockchain technology's role in business development and its impact on dynamic capability development in early-stage firms fills a critical gap in understanding how emerging technologies can drive organisational growth and adaptability, aligning closely with the overarching research objective. Overall, each article's research questions and aims offer valuable insights and contribute significantly to advancing knowledge in innovation management.

2. THEORETICAL FOUNDATIONS

The theoretical foundation of my doctoral dissertation is established through a review of the literature on blockchain technology and innovation, in conjunction with the theory of dynamic capabilities.

2.1. Uncovering blockchain's intrinsic features and its impact on entrepreneurship

2.1.1. Overview of blockchain technology and its key characteristics

The elementary unit of blockchain technology is a single transaction containing one or more entities. Several transactions are integrated into one single block, which is verified by the miners who reallocate computer resources. Given that the block is successfully validated, it is added to the chain of the previous blocks. Because the blocks are combined, transactions on the blockchain cannot be removed or modified (Narayanan et al., 2016). The entire process of validating transactions and appending blocks to a public blockchain is completely distributed, thus excluding the need for a single controlling authority (Nakamoto, 2008). Blockchain is basically a decentralised and distributed ledger enabling more efficient and transparent transactions (e.g., payment processes or transfers of information) where the need for a trusted intermediary is eliminated through consensus-based record validation (Nowiński and Kozma, 2017; Schmidt and Wagner, 2019). Blockchains are characterised by their resistance to data modification and their higher level of trust.

Blockchain technology has been widely exploited in the operations of financial institutions; meanwhile, a blockchain-based system can be used across all industries and organisations due to its key characteristics such as decentralisation of decision making, peer-to-peer transmission, reliability, immutability of data, distributed processing, automaticity, speed, low transaction fees, and transparency (Iansiti and Lakhani, 2017; Nakamoto, 2008; Narayanan et al., 2016). Blockchain technology enables the existence of cryptocurrencies (e.g., Bitcoin, Ethereum) and smart contracts. Cryptocurrencies can be used both as a means of payment and as a broader class of financial assets (cryptoassets), for which ownership and transfers of ownership are guaranteed by cryptographic decentralised technology (Giudici et al., 2020). In the case of smart contracts that are executable codes running on top of blockchain, such digital contracts are capable of imitating some functional properties of legal contracts, and their enforcement does not require any third party as implementations of contractual obligations are executed on the basis of consensus (Khan et al., 2021; Pesch and Ishmaev, 2019).

The technology of blockchain ensures transaction security, mitigates the risks of errors, fraud, and hacking attacks, lowers costs through the elimination of intermediaries and shortens implementation time (Rymarczyk, 2020), limits opportunistic behaviour, and facilitates contractual flexibility (Schmidt and Wagner, 2019). In the banking sector, Cucari et al. (2021) discovered that the adoption of blockchain led to a significant reduction in operational risk, greater transparency and visibility of data, and faster execution of transactions. Blockchain offers such promises as cost reductions, increases in productivity, integration of business processes, and the creation of customised services (Treiblmaier, 2018). Blockchain supports novel forms of economic organisations and institutions such as initial coin offerings (ICOs) and decentralised autonomous organisations (DAOs). The implementation of new technologies can cause new challenges and opportunities, elicit different forms of specialisation, create new rules and patterns of interaction, and have implications for commercial activity behaviour (Chalmers et al., 2021). The technology facilitates better decision-making and allows for transparent transactions (Schmidt and Wagner, 2019); namely, the complexity of transactions, information asymmetry, and contractual incompleteness are mitigated by the introduction of blockchain.

2.1.2. The application of blockchain technology in early-stage businesses

Research on the adoption of new technologies has primarily focused on large companies, with small, early-stage businesses receiving limited consideration (Eggers and Park, 2018; Stranieri et al., 2021). Meanwhile, the advent of new technologies has simplified the process for early-stage companies to reach customers beyond their local markets, equalised opportunities, allowing early-stage ventures to compete on a global scale, streamline innovation, and establish sustainable operations (Aspelund et al., 2005; Del Giudice et al., 2023; Nambisan, 2017; Zahra et al., 2023). In this context, the emerging technology of blockchain has increasingly been garnering attention for its potential to empower and improve the performance of young businesses. The unique characteristics of blockchain technology make it possible for small enterprises to become part of larger organisations' value chains, while also creating opportunities for the emergence of disruptive new firms that can challenge established market leaders (Chalmers et al., 2021; Koh et al., 2020; Morkunas et al., 2019; Wan et al., 2022).

Blockchain, as a novel external enabler (Davidson et al., 2018), encourages the exploration of entrepreneurial opportunities as it empowers companies to establish new market segments, develop new applications, and attract new customers (Chen, 2018;

Franco et al., 2009; Larios-Hernandez, 2017). Blockchain enables entrepreneurs to sense previously overlooked opportunities, seize them by adapting their business processes, and enhance their companies' positioning within a specific market segment (Baiyere et al., 2020; Pattanayak et al., 2023; Pérez-Sánchez et al., 2021). Despite the notable advancements in early studies that have explored the intersection of blockchain and entrepreneurship, there remains a significant gap in understanding the utilisation of blockchain for generating value in the context of early-stage ventures. There is a scarcity of both empirical and theoretical work on this topic to provide guidance to scholars and practitioners (Frizzo-Barker et al., 2020; Treiblmaier, 2019). Consequently, existing research has not been able to provide insight into how blockchain technology influences the dynamic capabilities of young organisations.

2.2. The interplay of technology and the development of dynamic capabilities in entrepreneurial firms

Dynamic capabilities theory is a cornerstone of strategic management that provides a conceptual framework for understanding how companies identify opportunities and match their resources to market demands in order to gain a competitive advantage (Arndt et al., 2022; Eisenhardt and Martin, 2000; Helfat and Peteraf, 2003; Schilke et al., 2018; Teece et al., 1997; Teece, 2007, 2022). Despite the predominant focus of dynamic capabilities research on the management of established companies, it is worth highlighting that insights from entrepreneurship research can also contribute to the development of capabilities. Entrepreneurship can be described as a process that requires the development of the essential capabilities to continuously sense, seize, and assess opportunities. It entails the adjustment of business models through the reevaluation of strategies and the reconfiguration of resources to establish successful ventures (Corner and Wu, 2011; Ma et al., 2015; Teece, 2012; Wu, 2007).

2.2.1. Conceptualisation of dynamic capabilities and their underlying microfoundations

A thorough description of dynamic capabilities includes its systematic approach to addressing challenges. This is fuelled by its ability to identify opportunities and threats, make timely decisions, and effectively implement strategic changes, ensuring alignment with the appropriate course of action (Ferreira et al., 2020; Helfat et al., 2007). The concept of dynamic capabilities is rooted in the resource-based view of the firm (Barney, 1991). Research on dynamic capabilities seeks to rectify the limitations of the resource-based view, which primarily focuses on strategies for leveraging pre-existing

firm-specific assets (Teece et al., 1997). Unlike the static approach of resource-based view, dynamic capabilities offer an alternative viewpoint for examining how firms create new capabilities to adapt to rapidly changing and dynamic markets.

Capabilities can be categorised as either ordinary or dynamic (Winter, 2003). The former (i.e., operational, administrative, and governance) capabilities are designed to maintain the current state and technical fitness, guaranteeing consistent processes at the same level. In contrast, dynamic capabilities support evolutionary fitness (Teece, 2014) and encompass more efficient methods that can potentially extend to support both existing and new processes, products, and services for current and prospective customers (Helfat and Winter, 2011). In a similar vein, dynamic capabilities are described as "a learned and stable pattern of collective activity through which the organisation systematically generates and modifies its operating routines" (Zollo and Winter, 2002, p. 340), all with the explicit aim of improving effectiveness.

The research on dynamic capabilities has significantly advanced through its subdivision into three capacities, or high-level dynamic capabilities: 1) to sense and shape opportunities and threats; 2) to seize such opportunities; and 3) to strengthen competitiveness through improvement and transformation (Arndt and Pierce, 2018; Helfat and Peteraf, 2015; Katkalo et al., 2010; Teece, 2007). These three clusters of activities are underpinned by microfoundations, encompassing the fundamental actions at both individual and group levels, distinct skills, processes, procedures, organisational arrangements, decision-making principles, and disciplines (Eisenhardt et al., 2010; Teece, 2007). These microfoundations are narrow-purpose activities or the smaller and more specific elements that support an organisation's capacity for innovation, adaptation of its competences and resources, and change response (Enkel and Sagmeister, 2020; Teece, 2022). To elucidate further, the microfoundational approach advances the dynamic capabilities framework (Arndt et al., 2022). It connects individual skills with organisational activities, facilitating the transformation of abstract dynamic capabilities into tangible, executable, and understandable actions (Schilke et al., 2018). Microfoundations clarify and solidify the conceptual nature and origin of dynamic capabilities by exploring the processes involved in the creation and evolution of dynamic capabilities within organisational settings (Arndt et al., 2022; Chen et al., 2023; Teece, 2007).

Sensing capabilities encompass a range of activities involving scanning, learning, and interpreting. To be more precise, sensing involves numerous aspects, including the "identification, development, codevelopment and assessment of

technological opportunities in relationship to customer needs" (Teece, 2014, p.332). These capabilities are supported by such microfoundations as the recognition of business opportunities, the identification of customer needs and latent demands, and the utilisation of advancements in external areas of science and technology (Teece, 2007; Teece, 2014). Furthermore, Teece (2007) proposes that companies should maintain an ongoing effort to seek out and investigate various technologies in both domestic and global markets. Building upon Teece's definition, Kump et al. (2019) assert that an organisation equipped with robust sensing capabilities consistently acquires strategically significant insights from its environment. This includes discerning market trends, adopting industry best practices, and monitoring competitors' actions.

Seizing implies successfully capitalising on market opportunities while effectively avoiding potential threats. These capabilities pertain to the set of activities concentrated on the implementation of an identified opportunity through the creation of new products, services, or processes. The ability to seize opportunities begins with a strategy that facilitates the identification of valuable knowledge. This evaluation relies on prior knowledge and concludes with the selection from several strategic options (Kump et al., 2019). Seizing entails the mobilisation of both internal and external resources and competencies that can enhance a firm's competitive advantage (Katkalo et al., 2010; Teece, 2014). Teece (2007) underscores that, for effective opportunity seizing, firms must demonstrate ability in making sound investment decisions, formulating appropriate business models, enhancing technological expertise, and maintaining assets.

Reconfiguring capabilities are predominantly rooted in a company's established routines. These routines play a central role in renewing and orchestrating resources and competences (Teece, 2007). Transforming entails operationalising decisions for new business models, products, or process innovations by establishing the necessary structures and routines, developing infrastructure, and ensuring the workforce possesses the requisite skills. Transforming is defined by the actual implementation of strategic renewal within the organisation, accomplished through the reconfiguration of resources, structures, and processes (Kump et al., 2019). A key microfoundation essential for managing transformation is the attainment of effective learning and effective integration of knowledge (Arndt and Pierce, 2018; Ellonen et al., 2009; Mazzucchelli et al., 2019; Teece, 2007). Reconfiguring activities follow an iterative pattern, and making slight modifications can be sufficient for capitalising on existing opportunities (Helfat et al.,

2007) and ensuring firms a sustained competitive advantage and continuous innovation in volatile environments (Felin and Powell, 2016).

Although dynamic capabilities may not guarantee superior performance in dynamic environments (Eisenhardt and Martin, 2000), their presence can influence firm growth and its overall performance, particularly as companies equipped with robust capabilities are better positioned to promptly address emerging challenges (Laaksonen and Peltoniemi, 2016; Lee, 2010; Pezeshkan et al., 2016; Zahra et al., 2006).

2.2.2. Dynamic capabilities and their microfoundations in the context of early-stage firms

Dynamic capabilities in the context of startups are defined by their ability to anticipate and spot new business opportunities, as well as to develop creative ideas and skills to enhance their business performance (Oliveira-Dias et al., 2022). When assessing the establishment or termination of businesses, it is crucial to investigate the evolution of their capabilities, as advocated by Helfat and Peteraf (2003). Emerging businesses frequently face a high failure rate in a rapidly evolving environment, highlighting the critical importance of adaptability and agility, not only for surviving but also for gaining a competitive edge (Oliveira-Dias et al., 2022; Zahra, 2021). Analysing the development of dynamic capabilities enables both researchers and entrepreneurs to pinpoint the elements that contribute to the survival and growth of these companies, especially young technology-based ventures (Corner and Wu, 2011). This understanding can be leveraged to increase the likelihood of achieving success.

There is existing literature available concerning dynamic capabilities in new ventures. Table 2 showcases a representation of the principal research papers on this topic. Those studies have suggested that a dynamic capability approach is useful for identifying the factors that affect the development of entrepreneurial firms. This theoretical perspective places greater importance on processes and activities, specifically on how resources are employed, as opposed to the mere presence of resources (Adam et al., 2018; Ambrosini and Bowman, 2009; Buccieri et al., 2021; Ma et al., 2020).

Table 2. Review of representative studies on dynamic capabilities (DCs) in early-stage firms.

Authors (year)	Journal	Type of study	Sample and methodology	Purpose	Key results / implications
Arthurs & Busenitz (2005)	*Journal of Business Venturing*	Empirical	422 firms in technology-based industries, statistical methods	To identify the value of venture capitalists (VCs) in their capacity to imbue new ventures with DCs	VC-backed ventures demonstrate greater DCs as they relate to product and management development
Newbert (2005)	*Journal of Small Business Management*	Empirical	A random sample of 817 American nascent entrepreneurs, regression analysis	To explore the process of new firm formation and identify the activities crucial for forming a successful new company	- Positioned the new firm formation process as a DC - The DCs of new firm formation is a process executed at the individual level, rather than at the firm level - Outlined a common set of gestation activities for successful nascent entrepreneurs
Sapienza et al. (2006)	*Academy of Management Review*	Conceptual	n.a.	To study the effects of early internationalisation on organisational processes	- Highlighted the importance of capability building as a major driver of new ventures' internationalisation and subsequent survival - Endogenous variables – organisational age, managerial experience, and resource fungibility – contribute to the development of new firm's DCs - Internationalisation may boost the firm's DCs
Zahra et al. (2006)	*Journal of Management Studies*	Conceptual	n.a.	To bring clarity to the notion of DCs and their relationships to the performance of new ventures and established companies	- Presented main differences between new and established companies in the use of their DCs - Highlighted the role of organisational learning in the evolution of capabilities
Wu (2007)	*Journal of Business Research*	Empirical	200 Taiwan's high-tech start-ups, path analysis	To improve understanding of start-up DCs	Proposed that DC is a mediating variable between start-up performance and resources. Start-up resources influence performance via DCs

Authors (year)	Journal	Type of study	Sample and methodology	Purpose	Key results / implications
McKelvie & Davidsson (2009)	*British Journal of Management*	Empirical	108 new firms in Sweden, regression analysis, longitudinal design	To understand the factors leading to the development of DCs in new firms	- Measured 4 DCs: *idea generation capabilities, market disruptiveness, new product development, new process development.* - Found that the nature and effect of resources employed in the development of these 4 DCs vary greatly
Corner & Wu (2011)	*International Small Business Journal*	Empirical	A technology-based venture from China, *longitudinal multi-case study* of focal events (i.e., customer creation episodes)	To explore DC formation in new venture examining technology commercialisation at the microlevel of entrepreneurs' actions and decisions	- Highlighted that DC development is an important sub-process in the overall venture creation process - Proposed the notion of dynamic entrepreneurial capabilities as a more fine-grained view of DCs at work in the new venture context
Evers (2011)	*Journal of Small Business and Enterprise Development*	Empirical	3 in-depth cases of highly export-dependent Irish seafood ventures, multiple case study and critical incident technique	To examine generating mechanisms and DC building processes in international ventures	- This study supports the DCs perspective in an entrepreneurship-networking context - The entrepreneurs' objective and subjective capabilities emerge as a key resource for strategically managing and developing the DCs of the firm - Highlighted the importance of the firms' capability to adapt and renew themselves via product diversification strategies for sustainable competitive advantage
Jiao et al. (2013)	*Journal of Engineering and Technology Management*	Empirical	115 new Chinese ventures, partial least squares structural equation modeling approach	To investigate the role of environmental dynamism in moderating the relationship between DCs and new venture performance	- Proved that DCs have a positive effect on new venture performance - A reconfiguration capability has the strongest impact on new venture performance, followed by an

Authors (year)	Journal	Type of study	Sample and methodology	Purpose	Key results / implications
					opportunity-sensing capability - Concluded that DCs are more effective in implementing organisational change at high degrees of environmental dynamism
Ma et al. (2015)	*Technology Analysis and Strategic Management*	Empirical	5 *longitudinal case studies* of technology start-ups, narrative analysis	To explore what DCs look like and how they emerge in technology start-ups	Found that sensing, seizing, and reconfiguring capabilities form a cycle for the development of DCs in a start-up, specifically: - capabilities of sensing opportunities are shaped by the entrepreneur's existing knowledge and past experience and adapted in response to external feedback - a start-up's capabilities of seizing opportunities rely on the mobilisation and orchestration of external complementary resources - a start-up is more agile in reconfiguring internal resources and external contacts to embrace opportunities and address threats
Feng et al. (2019)	*Journal of Engineering and Technology Management*	Empirical	An automobile startup company in China, *an exploratory case study*	To explore the evolutionary mechanism of an innovation ecosystem by investigating how the case startup develops to initiate and lead one	- Demonstrated that two main dimensions of DCs contribute to the resource renewal process: DCs about market (i.e. market-sensing capability) and DCs about technology (integrating, coordinating, and learning capabilities) - During the evolution, the social capital is a focused antecedent of DCs - Developed a holistic evolution framework for a startup to be an innovation ecosystem

Authors (year)	Journal	Type of study	Sample and methodology	Purpose	Key results / implications
					leader based on its DCs
Arora et al. (2020)	*Journal of Technology Transfer*	Empirical	A sample of 223 US-based green goods small manufacturers and their archived website data, an exploratory econometric analysis	To explore the relationship between strategic change and the growth of innovative small manufacturing firms	- Developed a measure of strategic change by quantifying the evolution in firm website topics - Greater activity in sensing via investment and engagement in R&D is likely to lead to improved small firm performance - Strategic change (or seizing), as measured by firm website topical change over time, has a curvilinear, inverse U-shaped relationship with sales growth
Ma et al. (2020)	*Management Decision*	Conceptual	A systematic review of the literature on enterprise capability, the content analysis approach	To develop a deeper understanding of enterprise capability	- Compared the capability levels of startups and mature enterprises - Developed a conceptual model for the dynamic evolution of enterprise capability levels, namely the three dimensions of improvisational, dynamic, and operational capabilities
Buccieri et al. (2021)	*Int Small Business Journal*	Empirical	286 Indian INVs from high-technology industries, the structural equation model	To examine the role of an international entrepreneurial culture (IEC) in shaping DCs and international performance	- Provided support for IEC as a core antecedent of the DCs of emerging market INVs - INVs utilise IEC to project and shape future trends to uncover profitable opportunities. IEC enable to equip these new ventures to better navigate and lead unpredictable and volatile environments

Dynamic capabilities in early-stage ventures are often conceptualised as being embedded in single entrepreneurs and small founding teams and are tied to entrepreneurs' leadership skills (Corner and Wu, 2011; Evers, 2011; Newbert, 2005; Teece, 2012) rather than standardised organisational routines and processes. In the

context of start-ups, Ma et al. (2015) suggest that the capabilities of sensing opportunities are formed by the entrepreneur's knowledge and prior experience; the capabilities of seizing opportunities depend on mobilising and coordinating external complementary resources; and that startup companies are more flexible in reconfiguring internal resources and external contacts to embrace opportunities and address threats (Ma et al., 2015). Earlier, Jiao et al. (2013) found that new ventures operating in more dynamic environments improve their performance by pursuing opportunity-sensing and reconfiguring capabilities.

In this dissertation, an effort is undertaken to make a timely contribution to both theoretical research (Ma et al., 2020; Sapienza et al., 2006; Zahra et al., 2006) and empirical studies (Arora et al., 2020; Corner and Wu, 2011; Ma et al., 2015; McKelvie and Davidsson, 2009; Wu, 2007) regarding the capability development of early-stage firms.

2.2.3. Facilitating dynamic capabilities through the integration of blockchain

Past research (Mikalef and Pateli, 2017; Parida et al., 2016; Steininger et al., 2022) offers empirical support for the notion that emerging technologies enhance internal processes, enhance agility in market positioning, and strengthen the dynamic capabilities of organisations. New theoretical avenues for microfoundations research have been opened up by emerging technologies (Conboy et al., 2019; Mikalef et al., 2021). As an illustration, Conboy et al. (2019) identified the microfoundations of dynamic capabilities empowered by business analytics, whereas Mikalef et al. (2021) identified the microfoundations of dynamic capabilities specific to artificial intelligence within marketing operations.

Pattanayak et al. (2023) have demonstrated that blockchain technology holds the potential to enhance sensing, seizing, and reconfiguring capabilities. Furthermore, Quayson et al. (2023) validated the effectiveness of constructing blockchain-driven sensing, seizing, and reconfiguring capabilities for enhancing circular supply chain development. Most of the existing studies that investigate the effect of blockchain on dynamic capabilities have primarily been carried out within the field of supply chain management, with a focus on established companies (Gupta et al., 2023; Meier et al., 2023; Pattanayak et al., 2023; Quayson et al., 2023).

Previous research indicates that the strategic adoption of technologies has a positive effect on capability development (Conboy et al., 2019; Mikalef et al., 2021). Yet, the impact of blockchain's unique characteristics on dynamic capabilities and their

underlying microfoundations remains uncertain in the context of early-stage firms. Hence, the aims are to acquire a deeper understanding of how the rapid advancement of emerging technologies opens doors for entrepreneurial opportunities (Bailey et al., 2019; Nambisan, 2017; Steininger, 2018) and to investigate the role of technologies in triggering dynamic capabilities (Cetindamar et al., 2009; Conboy et al., 2019; Franco et al., 2009; Parida et al., 2016; Steininger et al., 2022).

Due to the absence of comprehensive empirical support for the microfoundations that underpin dynamic capabilities (Chen et al., 2023; Kay et al., 2018), I investigate the potential of blockchain in enabling the microfoundational processes (Helfat and Peteraf, 2003; Teece, 2007) that form the basis for the sensing, seizing, and transforming activities integral to the temporal process of developing dynamic capabilities in early-stage technology-oriented companies.

2.3. Problem statement and research gaps

This section is dedicated to elucidating the problems and research gaps that were the subject of investigation in this dissertation. Table 3 presents a summary of the research aims and questions delineated in the examined papers.

Table 3. Summary table of research aims and questions.

	Research aims	Research questions
Article 1	**RA$_1$** To review the technology adoption models being recently applied in relation to blockchain technology implementation in supply chains. **RA$_2$** To explore the adoption process of blockchain technology and the main factors influencing the adoption behaviour of supply chain practitioners and compare the results of existing studies on blockchain acceptance with academic works carried out within the functionalist and interpretive paradigms.	**RQ$_1$** *What major technology adoption theories and models have been applied in relation to blockchain technology?* **RQ$_2$** *How do they contribute to explaining the adoption process of blockchain?*
Article 2	**RA$_1$** To investigate the innovation behaviour and degrees of innovation performance (i.e., radical, continuous, or no product innovation) associated with the geographic location of enterprises and firm-specific factors such as size, technological development, R&D expenses, and researcher wages. **RA$_2$** To examine the profile of innovative companies from the high-tech manufacturing sector through the application of two types of discrete choice models: a mixed-logit model and a multinomial logit model.	**RQ$_1$** *How do firm attributes affect the degree of product innovation performance in high-tech manufacturing companies located in two distinct Spanish regions?* **RQ$_2$** *What is the difference between the research results obtained using the multinomial logit and mixed logit models?*
Article 3	**RA$_1$** To understand the interaction of actor-independent and actor-dependent factors in the process of new firm formation. **RA$_2$** To examine activities that constitute the	**RQ$_1$** *How do entrepreneurial agents make use of the potential provided by external enablers?* **RQ$_2$** *What are the key microprocesses*

	shaping of external enablers and new venture ideas by applying the DCs framework.	*that are associated with integrating those enablers into developing new businesses?*
Article 4	**RA$_1$** To explore the use of blockchain technology for promoting business development. **RA$_2$** To analyse the impact of blockchain on micro-level actions that constitute the process of dynamic capability development in the context of early-stage firms.	**RQ$_1$** *How do early-stage firms leverage blockchain technology to support their activities in dynamic and uncertain environments?* **RQ$_2$** *What effect does blockchain have on early-stage firms' dynamic capabilities in generating business value?*

New technologies have been recognised as an objective factor that exerts a significant influence on innovation, entrepreneurial opportunities, actions, and results (Nambisan, 2017). Technologies open up opportunities for innovation activities in traditional sectors and offer new avenues for startup companies (Chen, 2018; Massey et al., 2017). Meanwhile, knowledge on new technologies is often vague and hard to quantify; this is applicable to blockchain technology, whose value remains uncertain for business and society (Frizzo-Barker et al., 2020). Academics have been investigating the various facets and uses of blockchain technology since 2014 (Casino et al., 2019; Frizzo-Barker et al., 2020; Ozdagoglu et al., 2020; Wamba and Queiroz, 2020). However, the ramifications of this technology for businesses and organisations have yet to be fully investigated.

In the first article, the primary objective was to examine the process of adopting blockchain technology and the key factors that impact the adoption behaviour of supply chain professionals. Given that earlier research on blockchain applications has primarily centred on the domain of supply chain management (Hughes et al., 2019; Wamba and Queiroz, 2020), I conducted a literature review to ascertain the organisational theories that have been recently applied in the implementation of blockchain technology in supply chain contexts. As highlighted by Baum and Haveman (2020), organisational theories can play a substantial role in enhancing our comprehension of emerging phenomena. Hence, the subsequent research questions have been devised: *What major technology adoption theories and models have been applied in relation to blockchain technology? How do they contribute to explaining the adoption process of blockchain?* to gain insight into how the organisations harnesses blockchain technology.

The second article presented a literature review on the various types of innovation, specifically focusing on product innovation with varying levels of novelty. We explored the profile of innovative firms in terms of the degree of novelty in the high-tech manufacturing sector. Our examination focused on the likelihood of product innovation in relation to firms' geographic location and specific characteristics,

including R&D expenditures, technological development, company size, and researcher compensation. Hence, the following research questions have been raised: *How do firm attributes affect the degree of product innovation performance in high-tech manufacturing companies located in two distinct Spanish regions? What is the difference between the research results obtained using the multinomial logit and mixed logit models?* Since innovation performance is shaped by various contributing factors, our objective was to address the knowledge gap related to the limited understanding of how firm attributes impact firms' innovation output.

As revealed in the first article, the existing studies on blockchain technology have predominantly focused on large corporations, especially within the context of established supply chains (Kamble et al., 2019; Koh et al., 2020; Kumar et al., 2022; Pattanayak et al., 2023). However, a wide range of technologies, including blockchain, have stimulated discussion about how the latter phenomenon facilitates entrepreneurial activities and outcomes. Despite the fact that blockchain presents advantages for early-stage ventures, there is a shortage of research addressing the long-term consequences of blockchain implementations and the technology's evolution within different temporal and contextual settings (Holm et al., 2020). Hence, both the third and fourth articles are focused on studying the implementation of blockchain in early-stage firms.

In the third article, we found that there is a gap in entrepreneurial literature regarding the examination of how entrepreneurs identify external enablers and the role of entrepreneurs' knowledge, experience, and networks in recognising and harnessing the mechanisms of external enablers across the entire venture creation process. Our aim was to acquire a better understanding of how blockchain technology has the potential to trigger the creation of new ventures and explore the activities of founders and entrepreneurial teams in this process. This research extends the scope of the dynamic capability perspective to the realm of small business management. We have combined the existing literature on external enablers, blockchain technologies, and dynamic capabilities to examine the following questions: *How do entrepreneurial agents make use of the potential provided by external enablers? And what are the key microprocesses that are associated with integrating those enablers into developing new businesses?* This study adds to the relatively narrow research stream (Corner and Wu, 2011; Newbert, 2005; Sapienza et al., 2006) that is dedicated to the investigation of dynamic capabilities and dynamic managerial capabilities in the context of emerging ventures and contributes to the body of literature on the commercial applications of blockchain technologies.

The utilisation of blockchain technologies in entrepreneurial practices is the central theme of an emerging, yet expanding, body of research (Chalmers et al., 2021; Kher et al., 2020; Park et al., 2020). Amidst uncertainty, volatile conditions, and fierce competition for survival, early-stage enterprises, as they expand, must cultivate dynamic capabilities that empower them to strategically align their resources with shifting market needs. Nevertheless, the processes through which young firms acquire these dynamic capabilities and how emerging technologies can facilitate their development remain uncertain.

In the fourth article, we delve into the examination of how blockchain technologies contribute to the enhancement of dynamic capabilities in early-stage, high-tech ventures. The objective was to investigate the impact of blockchain on the capabilities and development of Hungarian early-stage blockchain-based companies while addressing two questions: *How do early-stage firms leverage blockchain technology to support their activities in dynamic and uncertain environments? What effect does blockchain have on early-stage firms' dynamic capabilities in generating business value?* As we examine these questions, we contribute to the growing body of research related to the microfoundations of dynamic capabilities, as articulated by Teece (2007), exploring the fundamental processes by which blockchain technologies are utilised to promote the development of sensing, seizing, and transforming capabilities that add value to startup operations. Analysing the microfoundations of the dynamic capabilities of startups is still a big research gap. Startups, as new and fast-growing organisations, often face rapid changes and uncertainty in their markets and need to develop their dynamic capabilities to stay ahead of the competition and achieve success.

To sum up, the examination of blockchain technology in the fields of innovation, entrepreneurship, strategic management, and organisational dynamics highlights its crucial impact on contemporary business environments. Despite recognition of blockchain's transformative potential in existing literature, significant research gaps persist. Identifying these gaps underscores the necessity for further exploration into the intricate relationships between technology adoption, innovation, and organisational processes. By delving into these intersections, we attempt to elucidate how nascent technologies such as blockchain drive the development of dynamic capabilities in fledgling companies. As we study these unexplored realms, we not only contribute to academic discourse but also offer practical insights essential for guiding businesses towards sustainable growth and competitive advantage in the digital age.

3. METHODOLOGY

Table 4 provides a summary of the research methodology, data collection, and data analysis conducted in all four papers.

Table 4. Research methodology used in each article.

	Data collection	Sampling	Data analysis
Article 1	**Qualitative methodology:** systematic literature review. Two citation databases: Web of Science and Scopus. The search terms: "*blockchain*" AND "*adoption theory*" AND "*supply chain*".	Eight publications out of twenty were selected for further analysis. *Exclusion criteria*: the application of economic or informatic theories; articles that explored other fields rather than the supply chain area; articles without full availability, duplicate papers, or articles published in low-ranked journals.	Literature review analysis. Grouping of the data according to the theories and paradigms applied.
Article 2	**Quantitative methodology:** two discrete choice models: a logit model and a mixed logit model. Data source: the Technological Innovation Panel (*PITEC*) database constructed by the Spanish National Statistics Institute.	Data from 2016 (the last year of the database), containing 12,849 firms. *Two filters* were used: 1) firms from high-tech manufacturing sectors in **Spain**, reducing our sample to 323 firms, 2) firms with corporate headquarters located in Madrid or Catalonia, reducing our final sample to 212 firms.	2 methodological approaches for analysis: *a multinomial logit model and a mixed logit model.* The application of the mlogit package in the statistical software R.
Article 3	**Qualitative methodology:** case study method. Data sources: semi-structured interviews and archival resources (e.g., white papers, social media posts, press announcements).	Four **Hungary**-based start-ups from the financial services, cryptocurrency trading, crypto asset management, energy, information technology, and identity industries.	Analysis of each individual case, followed by comparison across cases.
Article 4	**Qualitative methodology:** multiple case study method. Data sources: semi-structured interviews, archival data (e.g., white papers, presentations, firms' websites, YouTube interviews, media articles, and news sources), and direct observation. Data collection: January 2020 – January 2023	Five **Hungary**-based start-ups from the urban farming, energy, insurance, information technology and services, and health industries.	Thematic analysis using ATLAS.ti. During the coding process, we used pre-established codes.

In the first article, a systematic literature review methodology was employed, as it proved effective in extracting valuable insights and revealing practical implementation and conceptual frameworks within available sources (Hart, 1998). The article centres on an analysis of the literature concerning various technology adoption theories related to how users perceive and apply blockchain technology within the

context of supply chains. In June 2020, relevant research studies were sought in two prominent and competitive citation databases, namely Web of Science and Scopus. The search criteria employed in these databases included the terms “blockchain” AND “adoption theory” AND “supply chain” to retrieve the available publications. As a result of the search, a total of eight high-quality publications were identified for in-depth analysis. This selection comprised seven papers that employed at least one of the technology adoption theories and one article that applied the sensemaking theory. The data extracted from these articles was organised according to the theories employed, the core constructs were scrutinised, and the results were consolidated.

In the second article, quantitative research was conducted to study the innovation profiles of Spanish high-tech manufacturing enterprises. Our data comes from the Technological Innovation Panel (PITEC) database created by the Spanish National Statistics Institute. The data includes a large sample of Spanish companies and offers details on their innovation-related activities, characteristics, and developmental indicators. In this study, 12,849 companies were represented by data from 2016, the database’s last year, and two filters were applied. First, we narrowed down our sample to 323 companies by choosing businesses from high-tech manufacturing industries. Second, we limited our final sample to 212 companies by selecting those having corporate headquarters in Madrid or Catalonia. Catalonia and the Madrid area, two of Spain’s strongest economic centres, have a sizable representation of high-tech manufacturing companies.

We employed two discrete choice models (Cao, 2021; McFadden and Train, 2000; Train, 2003) to describe organisational behaviour. Discrete choice models are the most effective method for determining how a firm’s innovation decisions affect innovation novelty (Barbosa et al., 2013). The process of decision-making involves the selection of the best alternative among a set of discrete alternatives. The multinomial logit model, in contrast to the mixed logit model, assumes that all organisations have homogenous preferences for each attribute, failing to account for the heterogeneity across businesses. Mathematically, it means the estimation of fixed effect parameters in the model. The mixed logit model overcomes the three limitations of standard logit models by permitting random taste variation, unlimited substitution patterns, and correlations in unobserved factors over time (Train, 2003). This flexible computational approach allows for the simultaneous capture of homogeneous (via fixed effects) and heterogeneous (via random effects) preferences. We believed it was crucial to

investigate both models since the behaviour of enterprises cannot be predicted in advance.

As suggested by Train (2003), a given variable is specified as a fixed or random parameter at the researcher's discretion. Previous studies found that organisational size (Greve, 2011; Li et al., 2020; Rothaermel and Deeds, 2004) and the scientific activities of the research team (Giarratana, 2004; Lazerson, 1988; Sebrek, 2020; Spithoven et al., 2010) had a significant impact on the firm's performance. In regard to the earlier findings, we defined research salary and firm size as random variables. The performance of product innovation at the selected enterprises is represented by the dependent variable. PITEC data report whether a company developed no new products, undertook incremental innovation involving novelty exclusive to the firm, or engaged in radical innovation, indicating the firm's ability to create products new to the global market (Laursen and Salter, 2006) and therefore demonstrating the highest degree of performance.

In the third and fourth articles, an exploratory qualitative research design that was grounded in the case study approach was adopted. Table 5 provides details about the blockchain-based companies investigated in the third and fourth articles. Qualitative data is especially well-suited for analysing the complex processes involved in the development of dynamic capabilities because of its depth and flexibility (Graebner et al., 2012; Ozcan and Gurses, 2018). The utilisation of the case study method aligns with our research objectives as it enables a thorough exploration of processes within a context that is rich in detail and complexity (Ozcan et al., 2017). Recent research indicates that the case study methodology is highly appropriate for identifying the factors that drive entrepreneurial businesses to adopt blockchain technology, understanding the roles that this technology plays, and examining the processes involved in the development of capabilities within new ventures (Kouhizadeh et al., 2019; Treiblmaier, 2019).

Table 5. Sample of the blockchain-driven companies examined in the third and fourth articles.

Firm / Founding year	Offerings	No. of founders	No. of staff
Article 3			
b-cube.ai 2018	R&D startup in AI and blockchain, cryptocurrency trading bots, educational courses, webinars, and consultancy	2	12
CoinCash Payments 2017	fintech start-up specialising in cryptocurrency exchange, online transfer services (buy or sell more than 50 cryptocurrencies for local currency),	2	12

	ATM network (16 ATMs) with bi-directional functionality		
Enerhash Technologies 2019	building and connecting mobile data centres, which provide fixed consumption and extra flexibility, to power plants	2	20
Internet of People (IOP) Ventures 2018	building the IOP technology stack and related infrastructure, cloud and support services	1	18
Article 4			
Firm A 2018	producing microgreens, edible flowers, herbs, and leafy greens for chefs and local specialty stores, R&D in service and on demand	2	7
Firm B 2019	building and connecting mobile data centres, which provide fixed consumption and extra flexibility, to power plants	2	20
Firm C 2019	web and mobile application development, system integrations, front-end/back-end and blockchain-based services, digital document solution	3	8
Firm D 2018	innovative parametric microinsurance products: ski and flight delay insurance, 2 products are coming: weather insurance and catastrophe insurance	3	7
Firm E 2018	healthcare trading platform where tissue banks are linked to healthcare professionals (manufacturers, hospitals, and universities), consultancy services, developing tissue banking related courses and blockchain specialised training programme for the universities	2	4

In the third article, our sample comprises four companies from various sectors, such as financial services, cryptocurrency trading and crypto asset management, energy, information technology, and identity industries. These firms develop high-value-added and cross-industrial offerings for Hungarian and foreign markets. The primary data source was semi-structured interviews conducted with representatives of the chosen companies. We aimed to maintain consistency in the interview structure and ensure that the results obtained from each interview were comparable. Additionally, we collected and analysed archival sources, including companies' white papers and official websites, social media posts, press announcements, and other online resources.

The initial phase of data analysis involved creating individual case stories focused on addressing the research questions. The objective was to uncover the key external factors that catalysed the establishment of the examined companies and to delve into the microfoundations of the dynamic capabilities linked to each case. Subsequently, we conducted a cross-case analysis in which we compared patterns in each case to those in other cases to establish consistency (following the approach outlined by Eisenhardt and Graebner, 2007). This process allowed us to define the key external enablers and dynamic capabilities of the new ventures.

It is important to note that the empirical findings of this research should be considered in the context of their limitations. The data in this study was self-reported by key individuals within the chosen firms. Although we supplemented the interview data with additional secondary sources, it is essential to acknowledge that this approach may not eliminate the possibility of informant bias.

In the fourth article, an exploratory, longitudinal, and inductive research design based on case studies of five young blockchain-enabled companies has been adopted. Inductive approaches are suitable when there is a lack of existing theoretical and empirical knowledge regarding a phenomenon. These approaches frequently make use of data that is rich in context to construct and enhance theoretical models, thereby propelling the advancement of a particular field (Eisenhardt and Graebner, 2007; Graebner et al., 2012). We employed the multiple case study approach, which involves the joint analysis of several cases (Yin, 2014). This approach helps us explore the reasons behind the emergence, development, growth, or termination of phenomena over time (Langley et al., 2013). To address our research questions, our approach involved the use of the analytical method known as "theory elaboration" (Eisenhardt, 1989; Lee et al., 1999). This approach includes researchers using preexisting conceptual ideas or a preliminary model to guide the design of the study. Theory elaboration aims to enhance existing theories, making them better at explaining real-world observations. In this process, researchers analyse and evaluate how the data gathered in an empirical context aligns with an established theory and explore ways to modify and improve aspects of the theory to better fit the observed data.

Five case studies within the context of Hungarian early-stage blockchain-based ventures were analysed. Initially, we chose seven early-stage ventures to be the subjects of our case studies, but two out of the seven ventures discontinued their operations. The remaining five ventures from urban farming, energy, insurance, health, information technology and services industries exhibited consistent growth and/or achieved profitability, making them the primary focus of our study. The data regarding the selected case study ventures was collected through a simultaneous and combined approach involving three sources: semi-structured interviews, archival data, and direct observation. Further, we performed thematic analysis on the gathered data (Miles et al., 2014) with the use of a qualitative research software programme, ATLAS.ti. To maintain the robustness of our analysis, we applied predefined codes. In the initial phase, we scrutinised the data for recurring patterns and distinctions in how respondents

described the impact of blockchain on startup operations and capability development. Subsequently, we associated related concepts within each case and linked them to emerging themes. Although we had some guiding theoretical concepts, we also allowed for the discovery of other patterns from the raw data. In the final step, we linked these emerging themes and concepts with existing literature, adopting an iterative approach to explore and clarify our findings.

4. RESEARCH FINDINGS

This chapter provides an overview of the primary research findings, which are condensed and presented in Table 6. The key insights from the articles are summarised, and their respective research questions are addressed.

Table 6. Findings.

Research questions (RQ)	Findings (F)
ARTICLE 1	
RQ_1 *What major technology adoption theories and models have been applied in relation to blockchain technology?*	**F_1** The diffusion of innovation theory, the technology acceptance model, the unified theory of acceptance and use of technology, the technology – organisation – environment framework, and the interorganisational system adoption theory are the widely used theories regarding blockchain use in the supply chain area.
RQ_2 *How do they contribute to explaining the adoption process of blockchain?*	**F_2** They help to analyse behavioural intention and behavioural expectation in adopting blockchain and understand the perception and intentions of supply chain professionals about adopting technology.
ARTICLE 2	
RQ_1 *How do firm attributes affect the degree of product innovation performance in high-tech manufacturing companies located in two distinct Spanish regions?*	**F_1** We found major differences between the samples from Madrid and Catalonia through descriptive statistics: compared to Catalonia, Madrid-headquartered enterprises are bigger and devote a greater portion of their current budgets to paying researcher wages.
	F_2 Better productivity and innovation performance are strongly correlated with wages.
RQ_2 *What is the difference between the research results obtained using the multinomial logit and mixed logit models?*	**F_3** In terms of analysing the profile of innovative firms in our regional sample, the mixed logit model proved to be more effective and flexible than the multinomial logit approach since it helps disclose more variables with statistically significant explanatory power and interpret their real impact.
ARTICLE 3	
RQ_1 *How do entrepreneurial agents make use of the potential provided by external enablers?*	**F_1** Identification of three interconnected external enablers of new venture ideas in the context of blockchain-based firms: - *market volatility associated with the growing popularity of cryptocurrencies and the underlying blockchain technology,* - *the characteristics of blockchain,* - *the ideology behind technology.*
RQ_2 *What are*	**F_2** Key microfoundations of sensing activities: - *problem and opportunity identification,*

the key microprocesses that are associated with integrating those enablers into developing new businesses?	- *market analysis and technology monitoring,* - *research and development process.* and seizing activities: - *creation of new products, processes, and business models,* - *building a customer base and establishing partnerships,* - *dissemination and legitimising work.* **F3** The dynamic managerial capabilities (DMCs) of the entrepreneurs played a decisive role in activating the external enablers. A firm's dynamic capabilities reside in founders and/or small entrepreneurial teams at the early stages of firm formation. **F4** Development of the model that illustrates the combination of external enablers, DMCs, and sensing and seizing capabilities that led to the formation and development of new ventures.
ARTICLE 4	
RQ1 *How do early-stage firms leverage blockchain technology to support their activities in dynamic and uncertain environments?* **RQ2** *What effect does blockchain have on early-stage firms' dynamic capabilities in generating business value?*	**F1** One of the main drivers of blockchain adoption is its capacity to securely verify, monitor, and share transactions using transparent and encrypted records. Additionally, startups used blockchain infrastructure to increase the reliability and sustainability of their offers as well as to strengthen their market position. **F2** Blockchain allows larger companies to integrate innovative solutions from startups, sustaining competitiveness and mitigating the risk of obsolescence. **F3** Eight underlying microfoundations of dynamic capabilities enhanced by blockchain are identified. Blockchain-driven sensing capabilities: - *blockchain-driven recognition of inefficiencies in the incumbents' business processes,* - *identification of customer needs for sustainable products,* - *discovery of latent demand and niche solutions*. Blockchain-driven seizing capabilities: - *designing mechanisms to capture value,* - *the enhancement of customer relationships,* - *partner development and collaborative capabilities.* Blockchain-driven reconfiguring capabilities: - *renewal of business models and expansion of the customer base,* - *knowledge-sharing and integrating procedures.* **F4** Two main propositions and three supporting sub-propositions are formulated: P1: *Early-stage companies can gain a competitive edge by integrating blockchain technology into their operations*. P2: *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced dynamic capabilities*. P2(a): *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced sensing capabilities*. P2(b): *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced seizing capabilities*. P2(c): *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced transforming capabilities*. **F5** Development of the conceptual framework that illustrates how early-stage companies benefit from blockchain-enhanced dynamic capabilities, strengthening their operations and ensuring competitiveness.

In the first article, when addressing the first research question concerning the major technology adoption theories and models used in the context of blockchain technology, it was determined that the diffusion of innovation theory (Kshetri, 2018),

the technology acceptance model (Kamble et al., 2019; Queiroz and Wamba, 2019), the unified theory of acceptance and use of technology (Queiroz and Wamba, 2019; Wong et al., 2020b), the technology–organisation–environment framework (Clohessy et al., 2019; Wong et al., 2020a), and interorganisational system adoption theory (Sternberg et al., 2020) were the most frequently utilised theories when studying the field of supply chain in relation to blockchain technology.

Regarding the second research question concerning the contributions of these theories to elucidating the adoption process of blockchain, it was revealed that these theories could assist in pinpointing the constructs and variables that influence the choice to embrace blockchain technology. Furthermore, they can facilitate an understanding of the behavioural intentions and expectations of supply chain professionals regarding the adoption of this technology. The examined studies suggest that the implementation of this complex technology should be a gradual and phased process (Kamble et al., 2019; Wang et al., 2019; Wong et al., 2020a). To ensure the successful integration of technology in supply chain management, several essential factors were highlighted, including the presence of the appropriate infrastructure and resources, employee awareness and knowledge (as emphasised by Wong et al., 2020b), and the crucial support of top management and external network members, as underlined in the studies by Wong et al. (2020a and 2020b).

In the second article, we examined the degree of firm innovation categorised into three groups: firms without innovative products and firms that launch novel products at either firm or market levels. Enterprises headquartered in two Spanish economic hubs—Madrid and Catalonia—and operating in the advanced manufacturing sectors were compared with the application of novel-to-the-topic methodology (i.e., the multinomial logit and mixed logit models) that allows for estimating the probability of a firm's innovation choices on innovation novelty. The profiles of the selected enterprises were analysed considering such characteristics as innovation expenditures dedicated to internal and external R&D activities, the proportion of internal R&D expenditures allocated to researcher salaries, technological development, and firm size. A considerable variation in innovation activity across regions was discovered.

The first question in this study sought to determine the innovation behaviour of the selected high-tech manufacturing companies located at Madrid and Catalonia in relation to firm-specific factors. The effect of these factors was analysed with the application of two discrete choice models. The first method indicated that the evaluated

firms shared homogeneous preferences for each of the listed attributes. There is a moderately positive correlation between the wages of researchers and innovation expenditures allocated to internal R&D, as well as between the wages of researchers and technological development in the firm profiles of Madrid and Catalonia. In the case of Madrid, market-level company innovation is influenced by such characteristics as firm size and external R&D spending, whereas firm-level innovation is mostly determined by researcher compensation. As the amount of firm spending devoted to researchers grows, businesses become more innovative in Madrid. As regards firm size, larger companies in Madrid are more likely to deliver radical innovations than incremental ones.

Catalan enterprises become more innovative as they advance technologically. A higher degree of technological development was noticed across enterprises with firm- or market-level innovations. In Catalonia, businesses that produce market-level innovations pay their researchers more. Generally, the findings demonstrated that enterprises with innovative products dedicated more funds to internal R&D projects than enterprises without innovative products. Businesses that successfully launched novel products to the market had greater sizes and higher proportions of innovation expenditures dedicated to external R&D activities.

In the second method, we included random effect parameters—in our instance, researcher salaries and firm size—under the premise that the firms have heterogeneous preferences. In Madrid's innovative enterprises, the random effect associated with firm size was significant at all levels of firm innovation, whereas in Catalonian enterprises without innovative products and those with innovative products at the market level, the random effects associated with researcher salaries and firm size were significant.

According to the mixed logit model, Catalonia's internal R&D funding has little impact on innovation, while having more resources for internal R&D decreases the probability of radical product innovation in the Madrid sample. Enterprises with headquarters in Madrid prioritise radical over incremental innovation. The impact of external R&D is substantially more significant for enterprises situated in Madrid than for those in Catalonia, yet the situation is the opposite when it comes to spending on technological development. Catalan firms become more innovative as their degree of technological development rises, whereas businesses in Madrid are less likely to introduce incremental product innovations when they allocate a larger share of their costs to technical development.

In both Spanish regions, the amount of the researchers' salaries is an important factor for firm innovation. Radical innovation over incremental innovation and non-innovation is preferred in Madrid, while the likelihood of both product innovation outcomes is about equal in Catalonia. Firm size demonstrates itself to be a significant random variable in connection to innovation performance in Madrid and Catalonia. Larger businesses in Madrid favour radical innovation over incremental innovation, whereas businesses in Catalonia place equal value on both. Firm size is related to equal preferences for incremental innovation and no product innovation in the Madrid sample, despite the absence of a significant effect in Catalonia. Our findings are consistent with those of Buesa et al. (2006) and Jaumandreu (2009), who found that Catalonia and Madrid operate differently in terms of innovative spending and associated activities.

Returning to the second question posed at the beginning of the study (see Tables 3 and 6), we conclude based on a comparison of the findings obtained from the application of two methodological approaches that the mixed logit model, as opposed to the conventional multinomial logit model, allows for a more comprehensive and detailed evaluation of the profile of innovative firms in both regions. The main function of the mixed logit model is to expose the diverse features of the sampled entities, which means that core variables with both fixed and random effects become significant at the same time. As a result of our analysis, we recommend using discrete choice models for similar works in the field of regional statistics. The practical advantage of adapting such a flexible computational approach as the mixed logit specification is its ability to facilitate the simultaneous estimation of fixed- and random-effect parameters in the models and enable the identification of more variables with statistically significant explanatory power. Consequently, additional insights can be obtained regarding the attributes of the studied phenomena.

In the third article, in response to the first research question, the three main external enablers of blockchain-based firms were identified, followed by an explanation of how new ventures use the potential of external enablers. The creation of new ventures was triggered by a combination of actor-independent factors, including the growing popularity of cryptocurrencies associated with the underlying blockchain technology, the characteristics of the technology itself, and ideology. These factors were the driving force for the founders of the mentioned companies to identify potential applications and commence the development of blockchain-based solutions aimed at addressing various customer issues. The mere emergence of the technology alone did

not guarantee the company's successful development; instead, this was primarily facilitated by the founders' efforts and capabilities. Our findings align with earlier research (Corner and Wu, 2011; Newbert, 2005; Zahra et al., 2006) that has similarly emphasised the significant role of the entrepreneur in a firm's dynamic capabilities. We noted that the dynamic managerial capabilities of entrepreneurs (human capital, social capital, and managerial cognition) played a crucial role in the activation of these external enablers.

Addressing the second research question, the dynamic capability framework was applied to explore the activities that comprise the shaping of external enablers and new venture ideas. Three microfoundations of sensing activities (i.e., *problem and opportunity identification, market analysis and technology monitoring, research and development process*) and three microfoundations of seizing activities (i.e., *creation of new products, processes, and business models, building a customer base and establishing partnerships, dissemination and legitimising work*) were identified. Those microprocesses are the most prominent in terms of incorporating these enablers into the development of new business concepts and the subsequent establishment of ventures. Despite the relatively young age of these firms, we observed certain characteristics of transformative activities. These took the form of product development, changes in business models, transitioning from a movement to a formal company structure, and an expansion of services and projects. In the end, we developed a model to show the relationship between external enablers, entrepreneurs' dynamic managerial capabilities, entrepreneurs' activities, and new venture ideas.

The fourth article was designed to determine the role of blockchain technology in facilitating early-stage firms' dynamic capabilities, which encompass sensing, seizing, and transforming capacities undergirded by their microfoundations. With respect to the first research question on how early-stage firms leverage blockchain technology to support their activities, our analysis reveals that the primary motivation behind the adoption of blockchain technology in early-stage businesses was to improve reliability, ensure the long-term viability of their products, and bolster their position in a particular market niche.

In answering the second research question, which concerns what effect blockchain has on early-stage firms' dynamic capabilities in generating business value, we discovered that blockchain serves as a powerful tool for promoting capability-development in young organisations, namely enhancing the sensing and seizing

capabilities of young firms and facilitating their ongoing transformation. Additionally, eight underlying micro-level processes intricately linked to the sensing, seizing, and reconfiguring capabilities were identified. Having synthesised the findings across the cases, we presented a set of propositions to guide future research and introduced the conceptual framework. The model illustrates how dynamic capabilities, enhanced by blockchain technology, bolster the operations of early-stage companies, thereby ensuring their competitive advantage. This study, along with its theoretical and empirical insights, enriches the body of knowledge regarding the development of dynamic capabilities in early-stage enterprises and the ways in which new technologies play a facilitative role in this process.

In summary, these articles collectively enhance our comprehension of how organisations navigate technological advancements, innovation processes, and dynamic capabilities in various contexts. They underscore the significance of harnessing strategic management and organisational theories, contextual factors, entrepreneurial skills, and emerging technologies to support value creation and organisational growth in an ever-evolving business environment.

5. THEORETICAL AND PRACTICAL IMPLICATIONS

5.1. Theoretical implications

The findings presented in this dissertation lead to a number of significant contributions within the domains of blockchain research, innovation management, and the microfoundations of dynamic capabilities. The initial contribution centres on rectifying a critical gap in innovation research by illuminating the less-explored managerial dynamics and the potential consequences associated with the adoption of blockchain technology. Blockchain technology, being a recent development, opens up numerous unexplored avenues for research, as emphasised by Seebacher et al. (2021). Scholars acknowledge its importance for future applications (Iansiti and Lakhani, 2017; Kher et al., 2020). A key objective was to provide insights into the creation and capture of value through the integration of blockchain and to offer strategies for the development of more secure and efficient products and services empowered by blockchain.

Second, this research enhances scholarly comprehension of the intricate connections between emerging technologies and organisations (Bailey et al., 2019; Steininger, 2018) by showcasing the long-term effects of implementing blockchain

technology in early-stage entrepreneurial firms operating across a variety of sectors. The demonstration reveals that incorporating blockchain technologies can enhance capability development in early-stage firms. The implications of blockchain for the firms under examination contribute to the existing body of knowledge in blockchain-related entrepreneurship research (Chalmers et al., 2021; Ilbiz and Durst, 2019; Morkunas et al., 2019; Park et al., 2020; Weking et al., 2020). This contribution involves uncovering the reasons entrepreneurial firms adopt blockchain technology and elucidating its particular roles within firms' value chains.

Third, the analysis of the chosen blockchain-enabled companies contributed to the external enabler theory (Davidsson et al., 2020). This contribution stems from our investigation into the microfoundational activities conducted by entrepreneurs and entrepreneurial teams within these firms. The dynamic managerial capability perspective (Adner and Helfat, 2003) provided an explanation for how and why entrepreneurs were able to incorporate a variety of enablers into their new venture concepts. The examination of founders' managerial capabilities contributed to our understanding of the innovative ways in which entrepreneurs recognised and realised the potential mechanisms of external enablers during the venture-creation process. Hence, an actor-dependent view of external enablers was incorporated into the external enabler theory (Chalmers et al., 2021; Davidsson et al., 2020). Despite the conventional conception of enablers as objective and autonomous actors, our observations demonstrated that the actors actively contributed to shaping the development of the enablers they sought to employ.

Further, we expanded the perspective of dynamic capabilities to encompass new entrepreneurial firms, effectively bridging a research gap regarding the role of dynamic capabilities in entrepreneurial contexts, particularly during their foundational and developmental phases. This addresses a notable deficiency in the existing literature (Corner and Wu, 2011; Jiao et al., 2013; Newbert, 2005; Razmdoost et al., 2020; Wu, 2007; Zahra et al., 2006). Our study offers a comprehensive understanding of the role of dynamic capabilities in the establishment of new ventures by detailing the nature and function of these capabilities. The sensing and seizing activities undertaken by the selected firms played a crucial role in uncovering external enablers, developing them into novel business concepts, offerings, and products, and subsequently establishing their legitimacy. The establishment of new ventures in this setting, characterised by the technology's novelty, controversial nature, and constantly evolving environment, necessitated a high level of both sensing and seizing capabilities.

Lastly, a contribution was made to the research exploring how technologies influence the processes or foundations that lead to the formation of dynamic capabilities (Cetindamar et al., 2009; Conboy et al., 2019; Franco et al., 2009; Mikalef and Pateli, 2017; Mikalef et al., 2021; Parida et al., 2016) by elaborating on how blockchain enables the enhancement of sensing, seizing, and reconfiguring capabilities. This offers valuable insights into the operational significance of blockchain for early-stage ventures that must navigate resource limitations and adds to the existing knowledge base (e.g., Corner and Wu, 2011; Ma et al., 2015; Zahra et al., 2006) on the dynamic capabilities of emerging businesses. Table 7 outlines the summary of implications drawn from the compiled articles.

Table 7. Theoretical and practical implications.

Articles	Theoretical implications (TI)	Practical implications (PI)
ARTICLE 1	**TI_1** The findings show a lack of empirical research investigations and the need for greater theory elaboration to accelerate the adoption process within organisations. **TI_2** Organisation studies should be based on predefined research questions and not on paradigm assumptions, as there is no need for such works to be grounded in paradigm debates.	**PI_1** This review of studies on technology adoption theories may help organisations develop their strategies for new technology introduction and understand the attitude of their personnel toward blockchain and other novel technologies. **PI_2** The article raises awareness of how blockchain technology can support businesses.
ARTICLE 2	**TI_1** A comparative analysis of the innovative enterprises situated in different regions within the same country confirms earlier research that reported a significant variance in innovation activity among regions. **TI_2** The study's methodological approach, which uses the logit and mixed logit models, provides a powerful analytical tool for evaluating the likelihood of a firm's innovation decisions on innovation novelty. **TI_3** The findings add to a growing body of literature on product innovation and the impact of firm size and researcher salary on innovation outcomes.	**PI_1** Flexible computational approaches, including the mixed logit model, may be applied to the development of an innovation strategy that is specifically customised to the requirements of certain geographic areas. **PI_2** Given the dependency of high-tech manufacturing sectors on scientific research, businesses and policymakers are recommended to pay more attention to raising the salaries of research personnel, creating better working conditions, and providing additional benefits.
ARTICLE 3	**TI_1** The study adds to the theoretical development by integrating external enabler theory, the dynamic capability view, and the concept of dynamic managerial capabilities. **TI_2** According to our argument, venture creation cannot be well explained by a single external enabler. The study contributes to the limited research on the role of multiple enablers in shaping new venture ideas. External enabler theory is extended through the integration of an actor-dependent view of external enablers and the examination of the	**PI_1** The results of our research could encourage collaboration between established and new blockchain-enabled businesses. **PI_2** Our findings could facilitate the adoption of blockchain technology and the development of legal regulations for using this technology. **PI_3** Policymakers may adopt more effective supportive measures for startup companies and predict business responses to policy changes based on an examination of the microfoundations of firms' capabilities.

	microfoundational work conducted by entrepreneurs and entrepreneurial teams within these firms. **TI$_3$** We addressed the gap in research on the development of dynamic capabilities in a small business context by identifying core microprocesses that underlie the sensing and seizing capabilities.	
ARTICLE 4	**TI$_1$** Our research makes a theoretical contribution by filling a void in the innovation literature and the literature on blockchain-related entrepreneurship. We bring attention to the less-explored managerial dimensions associated with the impact of blockchain technology on a firm's capabilities. **TI$_2$** The key contribution of our study is the incorporation of dynamic capabilities as a theoretical framework. Our research makes a valuable addition to the area of study focused on improving our comprehension of how technologies influence the processes that contribute to the development of dynamic capabilities. **TI$_3$** We enriched the understanding of dynamic capabilities within early-stage businesses by shedding light on the progression of sensing, seizing, and reconfiguring capabilities, all of which are strengthened through the adoption of blockchain technology. **TI$_4$** Several propositions and a conceptual framework have been developed to direct future research and enhance the use and significance of blockchain in facilitating organisational dynamic capabilities.	**PI$_1$** The current study provides policymakers and practitioners with information about how new technologies are transforming conventional sectors, creating comprehensive innovative solutions, and giving rise to brand-new market niches, businesses, and consumer groups. **PI$_2$** Our research demonstrates how collaborating with startups can help established firms maintain their competitiveness in knowledge-intensive sectors. **PI$_3$** It is advisable for policymakers to channel additional efforts and resources into fostering a more conducive environment for entrepreneurship and the uptake of emerging technologies. These measures should facilitate the entry of new businesses into the market and support their seamless integration into the established organisations' value chains. **PI$_4$** Recommendations propose that policymakers engage with a range of stakeholders, including but not limited to blockchain developers, business leaders, and academic professionals, to gather input and ensure that policies align with real-world needs.

5.2. Practical implications

As widely acknowledged, there is a prevailing scepticism and negative discourse surrounding blockchain technology, motivating us to delve deeper into its intricacies. Our primary aim was to gain a comprehensive understanding of the implications of this technology and examine how emerging companies leverage its advantages in their day-to-day operations. We endeavoured to explore specific instances illustrating how businesses confront the hurdles linked to blockchain while effectively capitalising on its strengths. Furthermore, our focus extended to assessing its practical applications and potential influence across various sectors. Consequently, the study has the potential to provide valuable insights for policymakers and practitioners regarding the impact of new technologies on the transformation of traditional industries and the formation of new market niches, industries, and customer segments. The practical implications of the

research works included in this dissertation are particularly relevant for both emerging and established organisations. Analysing blockchain technology through the lenses of various organisational and strategic management theories can assist organisations in developing strategies for the introduction of new technologies and can enable them to gain a deeper understanding of their employees' viewpoints and attitudes regarding technology.

The results of the studies indicate that industry professionals would benefit from a thorough examination of the technological attributes shaping their processes of value creation and appropriation. Additionally, they should explore the potential opportunities that blockchain might offer within these processes. Entrepreneurs and managers should carefully consider the distinctive implications of blockchain technologies and their potential to impact micro-level activities that underpin sensing, seizing, and reconfiguring capabilities. The dynamic capabilities enhanced by blockchain play a crucial role in enabling companies to identify profitable niches or strategically reposition themselves in competitive environments.

The findings of this dissertation will be relevant to companies exploring the adoption of blockchain technology and to individuals who have identified specific areas where the integration of blockchain can effectively address and resolve issues. The case studies illustrated how collaboration between start-ups and established corporations could enhance the innovation activities of incumbents and their adoption of new technologies. Acknowledging the advantages of partnering with entrepreneurial firms in developing and implementing blockchain technologies should be considered by established organisations as a strategic approach to enhance their competitiveness in the market for knowledge-intensive products and services. Established companies are recommended to collaborate with blockchain start-ups to enhance their dynamic capabilities, leveraging the expertise of these emerging entities in the rapidly evolving fields of blockchain technologies. The research holds crucial implications for managers concerning how their organisations can effectively address increased environmental uncertainty and the subsequent challenges that arise.

In light of the research outcomes, the support of businesses that undertake innovative activities is required to further foster innovation in high-tech sectors and their high-value-added outputs. Policymakers should allocate resources to create environments conducive to entrepreneurial activities focused on the adoption of new technologies. These initiatives in building ecosystems can empower emerging businesses to enter the market, foster their capability development, and facilitate their

integration into the value chains of established organisations. The exploration of dynamic capabilities within new ventures has the potential to facilitate knowledge transfer to established companies. The insights acquired from these emerging ventures can be effectively applied to assist larger, well-established organisations in enhancing their agility and responsiveness to change. Further, in assessing the quality of start-up companies, it is essential to consider both the dynamic capabilities of the company and the dynamic managerial capabilities of its founders. The findings of our research hold relevance for policymakers, as a more profound comprehension of the origins and development of companies' capabilities can help anticipate probable business responses to shifts in policies.

6. LIST OF ARTICLES AND CONTRIBUTION REPORT

ARTICLES

1. Semenova, V. (2020). Technology adoption theories in examining the uptake of blockchain technology in the framework of functionalist and interpretive paradigms. *Vezetéstudomány / Budapest Management Review*, 51(11), 26–38. https://doi.org/10.14267/VEZTUD.2020.11.03

2. Garrido, B. P., Semenova, V., Sebrek, S. S. (2023). Exploring the profile of innovative enterprises in high-tech manufacturing sectors: The case of the regions of Madrid and Catalonia in 2016. *Regional Statistics*, 13(1), 119–148. https://doi.org/10.15196/rs130106

3. Semenova, V., Sebrek, S. S., Garrido, B. P., Katona, A., Michalkó, G. (2023). The interaction of actor-independent and actor-dependent factors in new venture formation: The case of blockchain-enabled entrepreneurial firms. *Acta Oeconomica*, 73(4), 537–559. https://doi.org/10.1556/032.2023.00001

4. Semenova, V., Sebrek, S. S., Roundy, P. T. (submitted to *Journal of Business Research*). Blockchain technology and the evolution of dynamic capabilities in early-stage ventures.

CONTRIBUTION REPORT

Article 1. Single author.

Article 2. Second author. Contributor to conceptualisation, literature review, manuscript draft, manuscript review, and editing.

Article 3. First author. Principal contributor to conceptualisation, methodology, literature review, data collection, formal analysis, manuscript draft, manuscript review, and editing.

Article 4. First author. Primary contributor to conceptualisation, methodology, literature review, data collection, formal analysis, manuscript draft, manuscript review and editing.

6.1. Chapter 1. Technology adoption theories in examining the uptake of blockchain technology in the framework of functionalist and interpretive paradigms

Viktoriia Semenova

Abstract

The purpose of this paper is to examine the adoption process of emerging technology on the example of blockchain. The theoretical interpretation of blockchain acceptance and its implications are discussed from the positions of technology adoption theories (diffusion of innovation theory, the technology acceptance model, the unified theory of acceptance and use of technology, the technology – organisation – environment framework) as well as sensemaking theory. These theoretical models help understand the perception among end-users (e.g. supply chain practitioners) and facilitate technology diffusion among enterprises. Due to the novelty of the research field, the analysis revealed that current studies were conducted within the functionalist paradigm; however, studies on blockchain implementation can be equally done in the interpretive paradigm. The results indicate a shortage of empirical research investigations and the need for greater theory elaboration to accelerate the adoption process within organisations.

Keywords: blockchain technology, functionalism, interpretivism, sensemaking

1. Introduction

Advances in new technologies have expanded the capacity of firms to disperse their activities geographically. The digital revolution and development of global supply chains have made possible the emergence of novel organisational forms and the upgrade of strategies and practices of business organisations (Baum & Haveman, 2020). These trends require powerful analytical tools to address the challenges posed by increasingly complex and rapidly changing organisations.

Blockchain technology (BT), along with its emergence, adoption, and exploitation, has generated many kinds of research in different fields ranging from purely technical to business topics. In general, Demeter and Losonci (2020) indicated the increasing interest of academia and professionals towards the adoption of new and innovative technologies as well as digitally enabled new business models. The adoption behaviour in relation to different novel technologies has been widely studied, among them the "Internet of things" (Gao & Bai, 2014), big data (Sun et al., 2018), cloud computing (Alkhater et al., 2018), and bitcoin (Folkinshteyn & Lennon, 2016).

The present study explores the main technology adoption theories and models which explain the benefits of blockchain for organisations and their processes and predict the further adoption process of the technology. The broader use of blockchain for business purposes has already been started by such leading companies as IBM, SAP, Microsoft, and Boeing (Saberi et al., 2018). Bearing the characteristics of a

decentralised trustless database, blockchain allows global-scale transactions and process disintermediation and decentralisation amongst various parties (Crosby et al., 2016). The technology can significantly reduce costs and improve operational efficiencies (Kshetri, 2018) as well as weaken the role of middlemen in the network by supporting peer-to-peer transactions (Saberi et al., 2018). Economically, diffusion of blockchain technology can benefit a firm and its supply chain from various business dimensions affecting economic performance (Saberi et al., 2018).

The significance of theories of economics, strategic management, and organisation for blockchain technology management is seen in the extant literature. In order to explain the phenomenon of blockchain and its strategic competitive advantage, such mainstream theories and views as transaction cost economics (Ahluwalia et al., 2020; Schmidt & Wagner, 2019; Treiblmaier, 2018); agency theory (Pan et al., 2020; Treiblmaier, 2018); network theory (Queiroz & Wamba, 2019; Somin et al., 2020; Treiblmaier, 2018); contract theory; the resource-based view (Treiblmaier, 2018); the diffusion of innovation (DOI) theory (Kshetri, 2018); the technology acceptance model (TAM) (Kamble et al., 2019); the unified theory of acceptance and use of technology (UTAUT) (Queiroz & Wamba, 2019; Wong et al., 2020a, 2020b); and the technological, organisational, and environmental framework (TOE) (Clohessy et al., 2019; Wong et al., 2020a) are extensively used by the scholars. Diffusion theory suggests that technology can have various levels of diffusion across diverse industries (Rogers, 1995). The TAM and UTAUT, derived from the original TAM constructs, explain the acceptance of technology based on behavioural intention, whereas the TOE suggests a more comprehensive view on the adoption of technology.

Regarding the multiplicity of theories and views, it is complicated to comprehend their connections. Moreover, the theoretical development is not fully elaborated because this technology is still in its early stage (Frizzo-Barker et al., 2020) and the number of enterprises that are developing and implementing it is constantly increasing each year (Puel et al., 2020). According to Baum and Haveman (2020), organisation theories can significantly assist in understanding new phenomena. So there is a need for more empirical research and greater theory elaboration for this interdisciplinary domain to better understand its potential and the adoption process among the network of enterprises.

Due to a considerable number of technology adoption theories related to the potential of blockchain and the radical changes blockchain can induce, the following research questions are formulated: *What major technology adoption theories and*

models have been applied in relation to blockchain technology? How do they contribute to explaining the adoption process of blockchain? The answer to these questions will be given by providing a review of the technology adoption models being recently applied in relation to blockchain technology implementation in supply chains. Papers conducted in the framework of the positivist/functionalist paradigm are analysed and compared to articles conducted within the interpretive paradigm that can be considered an alternative to them. The purpose of the study is to explore the adoption process of blockchain technology and the main factors influencing the adoption behaviour of supply chain practitioners.

The paper is organised in the following way. The second part outlines the research methodology. Section 3 introduces blockchain technology and provides a summary of the existing literature reviews on blockchain. Section 4 is devoted to multiparadigm inquiry and compares functionalist and interpretive paradigms. Section 5 consists of an analysis of the studies incorporating technology adoption theories and sensemaking theory and considers them under two paradigms. Conclusions, limitations, and further research directions are provided in the last section.

2. Literature review

2.1 Acquaintance with blockchain technology and its literature reviews

Blockchain was first introduced in the bitcoin protocol by using several existing technologies which allow the creation of a peer-to-peer version of electronic cash. BT is a protocol of open, transparent, and secure distributed ledger technology that eliminates the need for a trusted third party (Nakamoto, 2008). The interest in blockchain is due to its attributes that ensure security, anonymity, and data integrity without any third-party organisation controlling the transactions (Yli-Huumo et al., 2016). While some authors (Kane, 2017; Pilkington, 2016) have labelled blockchain as a radical disruptive innovation that has the characteristics of a general-purpose technology (GPT), Iansiti and Lakhani (2017) proposed a more relevant definition of BT, naming it a foundational technology that can create new foundations for social and economic systems. According to Iansiti and Lakhani (2017), blockchain has recently emerged as a critical technological advance. Clohessy et al. (2019) professed a belief in the dual mission of blockchain by stating that it will "put an end to traditional ways of doing things and usher in a new era for business and the world" (pp. 69 – 70). As the introduction of bitcoin in 2008 led to a paradigm shift in how transactions are processed around the world (Nakamoto, 2008), bitcoin's popularity generated broad interest in its

underpinning technology. It is said that blockchain technologies will disrupt a multitude of industries and transform existing business processes. For example, blockchain has a high potential to disrupt inefficient models and improve supply chain management (SCM) operations models (Queiroz & Wamba, 2019).

After the publication of Satoshi Nakamoto (2008) on the blockchain mechanism and main application, the technology of blockchain has gained wide public recognition and generated great research interest. The literature on blockchain predominantly has covered the technological aspects since Nakamoto's publication. In this regard, Yli-Huumo et al. (2016) located and mapped all papers on blockchain with its technical perspectives containing security, performance, data integrity, privacy, and scalability. The results indicate that most of the papers mentioned the seven technical challenges and limitations outlined by Swan (2015): throughput; latency; size and bandwidth; security; wasted resources; usability; and versioning, hard forks, and multiple chains (pp. 81 – 83). These challenges and privacy were used to classify and map the existing studies on blockchain, among which more than 80% of the works focused on the bitcoin system, and less than 20% dealt with other blockchain applications like smart contracts, voting, and property licensing (Yli-Huumo et al., 2016). Most of the research studies attempted to address the issues with blockchain's limitations from privacy and security perspectives.

Since 2014, business scholars have started to research blockchain's different aspects and business applications. Several systematic literature reviews (Casino et al., 2019; Frizzo-Barker et al., 2020; Ozdagoglu et al., 2020; Wamba & Queiroz, 2020) have already been performed. Casino et al. (2019) conducted a systematic literature review of blockchain-based applications across multiple fields to discover how specific characteristics of this disruptive technology can revolutionise business-as-usual practices. The authors presented a classification of the blockchain-enabled applications across diverse sectors based on a structured, systematic review and thematic content analysis of the literature. Frizzo-Barker et al. (2020) carried out a PRISMA guided systematic review of the blockchain research in the business literature from 2014 to 2018. According to the results of their research, blockchain remains an early-stage area of research in terms of theoretical foundation, methodology, and empirical work. Instead of technical aspects, Frizzo-Barker et al. (2020) explored the business and organisational implications of this nascent technology. Ozdagoglu et al. (2020) conducted a study to discover the current state of blockchain research by applying a scientometrics methodology, which is used in analysing data extracted from online

scientific databases, and the authors provided a holistic view of the blockchain-related literature.

Hughes et al. (2019) noted that blockchain applications have often been discussed in the context of logistics and SCM. In this context, it is relevant to refer to the study of Wamba and Queiroz (2020), in which the researchers aimed at understanding blockchain applications in operations and supply chain management (OSCM) and the way firms create and capture value with blockchain technologies. Wamba and Queiroz's bibliometric analysis demonstrated that blockchain applications in regard to OSCM still remain in the infant stage, and there is a need to explore the role of blockchain in terms of operations traceability, e-commerce, public services, agriculture, and other areas.

2.2 Multiparadigm inquiry: focus on the functionalist and interpretive paradigms

In order to stimulate further research on blockchain and blockchain-based enterprises, a brief multiparadigm review of the related literature is presented in this section. Multiparadigm reviews, along with multiparadigm research and metaparadigm theory building, are three approaches to multiparadigm inquiry which were described by Lewis and Grimes (1999). In multiparadigm reviews, two techniques assist reviewers: paradigm bracketing and bridging (Lewis & Grimes, 1999, p. 673). The first technique implies differentiating between diverse sets of assumptions and adds a critique of alternative views. Burrell and Morgan's typology of sociological paradigms serves as the most relevant framework for paradigm bracketing. The second technique reviews transition zones, attempting to integrate paradigms' theoretical perspectives and combine their similarities. Such transition zones allow researchers to grasp a variety of research strategies within different paradigms and thereby enrich the research outcomes. As noted by Lewis and Kelemen (2002), multiparadigm reviews help researchers to understand the assumptions of various paradigms and be aware of the differences in the obtained results.

Burrell and Morgan (1979) classified existing theories within their typology to show how opposing viewpoints are maintained by different assumptions. Within the Burrell and Morgan matrix, the politically conservative functionalist and interpretive paradigms are contrasted with the conflict-oriented radical structuralist and radical humanist viewpoints. In contrast, the functionalist and radical structuralist paradigms share a more objectivist scientific view, while the interpretive and radical humanist

paradigms adopt a more subjectivist position. Due to various characteristics, each of the four paradigms has its own approaches and analytical tool to conduct research.

The current study concentrates on comparing functionalist and interpretive perspectives because they are the dominant ones in organisation and management studies (Burrell & Morgan, 1979). For instance, they were applied in analysing the application of information technologies (IT) for knowledge management (Butler & Murphy, 2007), understanding the implementation of a new computer system in the workplace (Prasad & Prasad, 2000), and explaining the relationship between globalisation and IT (Ardalan, 2011). Functionalist studies tend to approach technology as a determinant of organisational structure (e.g. structural contingency theory) (Donaldson, 2003), while interpretative works treat it as a social object (Barley, 1986) that can alter the relations of production and organisational structure. Doing research within these two paradigms, it is possible to compare the subjectivist stance on a given topic with the more objectivist one. Before proceeding further, the main peculiarities of these two paradigms are briefly described.

The functionalist paradigm often employs refinement of theory. According to Donaldson (2003), functionalist research aims to generate general theories or control phenomena (Chia, 2003). The theory building is primarily implemented in a deductive manner, that is, the first step includes the literature review and the consideration of prior theories. As suggested by Gioia and Pitre (1990), the aims of hypotheses are threefold: the revision/extension/rejection of original theory in a new way, the attempt to close a research gap in the current state of knowledge, or the testing of competing interpretations for structural relationships. The formulation of hypotheses is based on the selected variables; therefore, in accordance with the formulated hypotheses, specific instruments are used to collect the necessary data and the required procedures are designed. The researchers stick to the consistency of variables and hypotheses throughout the whole theory-elaboration processes (Gioia & Pitre, 1990, p. 590).

By contrast, the theory-building process in the framework of the interpretive paradigm is mainly grounded in the inductive reasoning that may reveal structuring processes due to which actors construct social meanings and roles. Based on Cunliffe (2011), exploring narratives is an important characteristic but building theories is not. Gioia and Pitre (1990) emphasised that the researcher should tend to be a part of the studied phenomenon. One of the tasks of the researcher is to gather data that are important to the informants and convey their unique representations. The analysis of data starts simultaneously with the data collection and usually uses coding procedures.

Subsequently, analysis, theory generation, and further data collection are interrelated processes (Gioia & Pitre, 1990, p. 588).

Donaldson (2003) and Hatch and Yanow (2003) noted that the two paradigms possess differences in relation to the mode of analysis: interpretive analysis is associative whereas the functionalist paradigm operates in a causal mode. Furthermore, interpretivists consider the importance of culture and context for shaping phenomena, and they explain their findings in terms of emergent images and metaphors, while the functionalist or positivist paradigm adheres to the predefined and universal analytical framework, analysts operating under this paradigm tend to generalise things. As was mentioned, interpretive scholars, unlike positivists, use relatively low levels of deductive and higher levels of inductive reasoning.

As Donaldson (2003) stated, the organisation has to adapt to its environment by fitting its organisational structure into the contingencies, such as the size of organisation or technology. Studies conducted in the framework of the functionalist paradigm are analysed to understand how the organisation exploits or plans to employ emerging technologies. Here the researchers are acting as functionalists by following a quantitative and positivist approach, and they prefer such scientific research methods as statistics, questionnaires, and structured interviews. In contrast, interpretive researchers construe social reality through a sensemaking process and rely on qualitative data, mainly interviews. That is why, as an alternative view to positivist research, the work of Wang et al. (2019) was chosen as work that is done within the interpretive paradigm with the application of sensemaking theory. According to interpretivism, individuals are those who create society through their interactions. In this context, this sensemaking approach allows us to more deeply understand the perception and knowledge of supply chain (SC) experts about technology (Wang et al., 2019) and predict their future actions and the actions of other practitioners regarding its application.

3. Research methodology

As the technology of blockchain is applicable across various industries and for different applications, there are a number of adoption theories that are used to investigate the implications and acceptance of this new and complex technology. The method of systematic literature review is applied in this study as it generates useful information and identifies practical implementation and conceptual frameworks from available resources (Hart, 1998); additionally, it can result in more objective, transparent, and replicable reviews (Briner & Walshe, 2014). So this paper focuses on analysing the

existing literature on various technology adoption theories pertinent to blockchain technology's user perception and application in the context of supply chains. The fact that most of these studies were conducted using a positivist paradigm and are compared to the one interpretive study helps to more thoroughly explain the emerging phenomenon.

The relevant research studies were searched in June 2020 in the two world-leading and competing citation databases: Web of Science (WoS) and Scopus (Zhu & Liu, 2020). The search terms "*blockchain*" AND "*adoption theory*" AND "*supply chain*" were used within these databases to retrieve available publications. This specific search yielded similar papers in both databases; namely, around 20 articles were identified. Each of the papers retrieved by the search was reviewed for quality and relevance. As advised by Kitchenham and Brereton (2013), the search and data collection process followed a three-stage process – search, select, and validate the literature. Both conceptual and empirical studies were analysed. Some articles were excluded for the following reasons: application of economic or informatic theories which did not correspond to the subject of the paper; articles which explored other fields (e.g., cryptocurrencies, token economics) rather than the supply chain area; and articles without full availability, duplicate papers, or articles published in low-ranked journals and conference proceedings. In the end, 8 high-quality publications were collected, including 7 papers using at least one of the technology adoption theories and prepared within the functionalist paradigm and one article with the application of sensemaking theory and conducted within the interpretive paradigm. The data on these articles were grouped according to the theories applied, the main constructs were analysed, and the results were compiled, as shown in Table 1. The reviewed articles were primarily published in such high-impact Q1 journals as *the International Journal of Information Management, International Journal of Production Research, International Journal of Production Economics, and the Journal of Business Logistics*.

4. Analysis of works done under functionalist and interpretive paradigms

4.1 Technology adoption theories

A number of research studies have been conducted to assess the blockchain effect on organisational activities and examine the adoption process of blockchain technologies across various industries (Grover et al., 2019). As a matter of fact, the majority of such studies have been done in the framework of the functionalist paradigm and in relation to

SCM and logistics. According to Kshetri (2018), blockchain technology has a relative advantage in SC activities in comparison to the financial industry. The technology can result in SC disintermediation, leading to reductions in transaction costs and time and to a decrease in business waste in the supply chain (Saberi et al., 2018). The most widely applied models are the diffusion of innovation theory (Kshetri, 2018), the technology acceptance model (Kamble et al., 2019; Queiroz & Wamba, 2019), the unified theory of acceptance and use of technology (Queiroz & Wamba, 2019; Wong et al., 2020b), the technology–organisation–environment framework (Clohessy et al., 2019; Wong et al., 2020a), and interorganisational system (IOS) adoption theory (Sternberg et al., 2020). They serve to identify the constructs and factors which impact the decision to adopt technological innovation, in this case, blockchain technology (see Table 1), and to understand the behavioural intentions of adopting BT.

Table 1. **Papers based on application of technology adoption theories and models in relation to blockchain deployment**

Authors (Year)	Journal	Theories applied	Type of study	Sampling	Results
Kshetri (2018)	*International Journal of Information Management* (Q1)	DOI theory	Conceptual	11 case studies of blockchain projects; archival	- A relative advantage of BT in supply chain compared to finance industry - Blockchain-based SC products are more appropriate for the tech, auto, and garments industries and the oil trading sector, and the food industry is the most affected by blockchain
Kamble et al. (2019)	*International Journal of Production Research* (Q1)	TAM, TPB, TRI	Empirical	Online survey, 181 SC practitioners from 102 companies in India; archival	The validity of the proposed model based on the integration of TAM, TPB, and TRI: - Perceived usefulness, attitude, and perceived behaviour control—the most critical constructs that explain behavioural intention for BT adoption in SC - Discomfort and insecurity are not perceived as the inhibiting factors in the BT adoption process by SC experts - Low level of blockchain awareness among the SCM respondents

Queiroz and Wamba (2019)	*International Journal of Information Management* (Q1)	Network theory; TAMs with special focus on UTAUT	Empirical	Questionnaire, 344 & 394 SC professionals from India and the US, respectively; archival.	An altered version of the classical UTAUT with the integration of 2 new "constructs"—trust of SC stakeholders and blockchain transparency: - Performance expectancy influences behavioural intention - Behavioural intention influences behavioural expectation - Facilitating conditions was supported only in the US, while in developing countries (e.g., India) such conditions repulse the BT adoption - Trust between SC stakeholders does not affect BT adoption in both cases
Wong et al. (2020b)	*International Journal of Production Research* (Q1)	UTAUT + additional constructs of technology readiness, technology affinity, trust	Empirical	Questionnaire, 157 firms in Malaysia were asked regarding BT adoption in SCM; archival.	- Incapability of the UTAUT to predict the adoption of immature technologies, and the key role of environmental readiness in adopting BT - Low familiarity with the technology among respondents, uncertainty in blockchain use at their companies - Insignificance of trust
Clohessy et al. (2019)	In Treiblmaier & Beck	Innovation theory; TOE	Conceptual	Review of the BT literature (16 final research resources) conducted in 7 databases	- Important technological considerations: perceived benefits, complexity, and compatibility - Organisational considerations: organisational readiness, top management support, and organisational size - Environmental considerations: the regulatory environment and market dynamics - Important role of top management support in adopting BT
Wong et al. (2020a)	*International Journal of Information Management* (Q1)	TOE framework	Empirical	Questionnaire, 194 SMEs in Malaysia regarding BT adoption for OSCM	- The top 4 significant considerations: competitive pressure, complexity, cost, and relative advantage - Insignificant considerations: market dynamics, regulatory support and upper management support
Sternberg et al. (2020)	*Journal of Business Logistics* (Q1)	IOS adoption theory	Empirical	Single case study on the ReLog's vine supply chain	- Introduction of a synthesised model for BT interorganisational adoption in SC

					- Identification of positive (perceived benefits, external pressure, and organisational readiness) and negative IOS factors of adoption (perceived obstacles, external resistance, and organisational immaturity) - Specific phenomena of BT adoption in SC: the trust – investment paradox and the traceability – efficiency, visibility – privacy, and performance – commitment tensions

Source: author's compilation

Diffusion of innovation theory

The diffusion of innovation theory was developed by Rogers, who defined 5 main interrelated attributes for predicting future innovations' rate of adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers, 1995, p. 211).

Kshetri (2018) developed a framework to consider the contribution of blockchain to achieving the main SCM objectives through such mechanisms as validation of individuals' and assets' identities and incorporation of the IoT, which may "make tracking possible and more accurate" (p. 87). In this context, 11 case studies of blockchain projects at various stages of development were discussed: Maersk; Provenance; Alibaba; the largest defence contracting firm Lockheed Martin; San Francisco-based blockchain start-up Chronicled and life sciences supply chain consultancy LinkLab; the Swiss start-up Modum in cooperation with the University of Zurich; the London-based start-up Everledger; Walmart; Gemalto; Intel; and Denver-based start-up Bext360. The selected cases were used to compare BT adoption in a variety of industries such as the food, pharmaceutical, diamond, wine, and coffee industries and cybersecurity-related initiatives. Based on DOI theory and the analysis of cases, Kshetri (2018) revealed that blockchain will primarily transform the SC processes by addressing issues related to communication. The industry which will be significantly impacted by blockchain is the food industry. And the tech, auto, and garment industries as well as the oil-trading sector are the most suitable ones for blockchain-based SC products due to a smaller number of suppliers. So the examples derived from these case studies prove the ability of blockchain to reduce costs, eliminate manual paper-based processes, automate SC processes, and allocate the proper amount of resources (Kshetri, 2018, p. 86). Meanwhile, there are many challenges, for example,

the need for a high level of computerisation and the requirements for parties operating in the global SC to comply with diverse institutions, laws, and regulations.

TAM/TPB/TRI

Kamble et al. (2019) tried to understand the user perceptions of blockchain technology through the example of 181 SC practitioners in India by assimilating the constructs of three adoption theories—technology acceptance model, technology readiness index (TRI)—and the theory of planned behaviour (TPB). The TAM is the most widely used model in a diverse set of technologies and users. It measures the developing attitude towards the behavioural intention and the perceived ease of use and perceived usefulness (Davis, 1989). The TPB is the extended version of the theory of reasoned action (TRA), and it measures the impact of perceived behavioural control and subjective norms on the adoption process (Ajzen, 1991). And the TRI model contains four sub-dimensions: two motivators of the technology—optimism and innovativeness, and two inhibitors—discomfort and insecurity. The technology readiness index measures the perceived risks that inhibit general technology adoption (Parasuraman, 2000). Thus, Kamble et al. (2019) adopted the two TRI's constructs of discomfort and insecurity, which act as the inhibiting factors during blockchain adoption in supply chains. The results of the statistically validating model revealed the insignificant effect of the discomfort and insecurity constructs on the perceived ease of use and usefulness, while the perceived usefulness, attitude, and perceived behavioural control affect the behavioural intention and the subjective norms negligibly impact the behavioural intention. The findings indicated that SC practitioners perceive blockchain adoption to be free of effort and that their activities should concentrate on "making blockchain more user-friendly" and easier to use (Kamble et al., 2019, p. 2026). The authors advised the companies that have successfully implemented blockchain in SCs to share their stories and explain its benefits in comparison to traditional SCs.

UTAUT

The unified theory of acceptance and use of technology was proposed by Venkatesh et al. (2003) to research technology acceptance. The model is an extension of existing models, including the TAM, DOI, TRA, and TPB, whose limitations the UTAUT tries to address. Venkatesh et al. (2003) identified four constructs which are direct determinants of user acceptance and usage behaviour—performance and effort expectancy, social influence, and facilitating conditions—and the model is moderated

by gender, age, experience, and voluntariness (p. 447). This influential model has been employed in a number of studies on adopting new technology. Regarding blockchain adoption, the constructs of this framework and other main adoption theories have been tested by multiple authors (Kamble et al., 2019; Queiroz & Wamba, 2019; Wong et al., 2020a, 2020b).

To understand blockchain adoption behaviour in the SC management domain, Queiroz and Wamba (2019) proposed a model on a modified version of the classical unified theory of acceptance and use of technology with the integration of two new constructs: trust of SC stakeholders and blockchain transparency. The authors combined the extant literature on supply management and blockchain and, mainly, on network theory and the TAM, with particular attention on UTAUT and UTAUT2 (Venkatesh et al., 2003, 2012), and conducted cross-cultural research on adoption behaviours between India- and US-based professionals. Firstly, network theory aids in explaining the complexity of interfirm relationships and cooperation as well as the impact of external variables on technology adoption. Within SCM, blockchain can transform the relationships among network members, optimise transaction costs, and improve efficiency. The UTAUT allows a better understanding of employees' motivations for adopting blockchain (Queiroz & Wamba, 2019, p. 73). The results show that there are differences in blockchain adoption behaviour among SC professionals in India and the US, but both Indian and American respondents are reluctant to exchange data with their SC members.

In order to predict blockchain adoption intention in the SCM, Wong et al. (2020b) extended the UTAUT model by omitting the construct social influence (SI) and including the additional exogenous constructs of technology readiness, technology affinity, and trust as well as adopting regulatory support as the moderating variable instead of the UTAUT model's primary moderators. After statistically testing the proposed model based on data collected from 157 firms in Malaysia, the authors revealed the incapacity of the UTAUT to predict the adoption of immature technologies and the insignificance of trust but found the direct impact of such constructs as the facilitating conditions, technology readiness, and technology affinity on blockchain adoption in SCM. Therefore, following the meaning of these three determinants, the behavioural intention of the firm mainly depends on the right infrastructure and resources and the main personnel's propensity and interest in exploring new technologies as well as on external stakeholders' support in terms of regulatory authorities and safe practices (Wong et al., 2020b, p. 2114). The authors advocated the

need for integration of inter- and intra- organisational parties to adopt BT in SCM. The authors suggested that those companies planning to adopt blockchain technologies should increase the level of this technology's awareness and develop the required expertise, trust, and environment towards successful implementation.

The TOE framework

Clohessy et al. (2019) earlier revealed important technological, organisational, and environmental blockchain adoption considerations that can serve as a foundation for advancing research on the blockchain adoption in organisations. By applying innovation theory and the TOE framework, Clohessy et al. (2019) conducted a comprehensive review of the blockchain-related literature and identified the top three organisational considerations—organisational readiness, top management support, and organisational size—which were used as mediating concepts in the research. From the technological and environmental perspectives, several key considerations such as perceived benefits, complexity, and compatibility as well as the market dynamics and the regulatory environment were specified. One of the main findings was the important role of top management support in incrementally adopting this technology.

Due to disregard of the organisational and environmental factors by the UTAUT and the TAM, Wong et al. (2020a) adopted the technology, organisation, and environment framework to analyse the effects of relative advantage, complexity, upper management support, cost, market dynamics, competitive pressure, and regulatory support on blockchain adoption for OSCM among Malaysian small- and medium-sized enterprises. Based on the innovation adoption theory, the TOE framework was developed by Tornatzky et al. (1990) to consider the technological, environmental, and organisational factors that influence the decision to adopt technological innovations. Unlike the traditional models such as TAM, UTAUT, and DOI, Wong et al. (2020a) referred to the TOE framework by stressing the combination of human and non-human factors into a single framework, thereby offering a more holistic view of technology adoption among small and medium-sized enterprises. SMEs comprise a group of economic actors that lack resources for technological investments; meanwhile, they must also adhere to the same requirements for optimising the business process and effectively managing their resources. This is when blockchain may come into play to support SMEs' sustainability, owing to the technology's features of transparency, immutability, and security. According to the findings, constructs of the research model such as competitive pressure, complexity, cost, and relative advantage have significant

effects on behavioural intention, whereas market dynamics, upper management, and regulatory support are found to be insignificant predictors. Wong et al. (2020a) concluded that blockchain technology has the potential to solve many problems of enterprises, for example, via improving SC traceability. However, its adoption requires a gradual process through collaboration between various internal functional divisions and external members because of blockchain's complexity, uncertainty, and security concerns, as well as the higher costs inherent in implementing this technology.

The IOS adoption theory

Furthermore, Sternberg et al. (2020) also emphasised that blockchain technologies entail a network effect in supply chains. This means that the value of one organisation adopting blockchain is limited, as the technology yields benefits only when multiple members in a network—stakeholders and value chain partners—adopt this technology. In this research, blockchain was considered an interorganisational system; therefore, the adoption of blockchain in SCs was studied from the perspective of the IOS adoption theory proposed by Iacovou et al. (1995). The reasons for selecting and developing this IOS adoption model were due to its main determining factors such as perceived benefits, organisational readiness, and external pressure that are the positive IOS factors of adoption as well as its ability to address the negative IOS factors of adoption—perceived obstacles, external resistance, and organisational immaturity. Based on the single-case study on ReLog's vine supply chain, Sternberg et al. (2020) proposed an interorganisational adoption model and identified four specific phenomena of blockchain adoption between organisations in SCs: the trust–investment paradox and the traceability–efficiency, visibility–privacy, and performance–commitment tensions occurring between positive and negative IOS factors of adoption (p. 13). In conclusion, the authors highlighted the necessity to consider both the benefits and challenges that the adoption of blockchain causes in SCM. And from the human-centric view, they emphasised privacy concerns, especially among SC employees, as one of the greatest blockchain-related issues.

4.2 Comparison of studies on BT adoption conducted under interpretivist and positivist paradigms

The potential of blockchain to alter SCM and logistics is one of the fields which was studied from the lenses of different theories, including mainly transaction cost theory and principal-agent theory, but also other technology adoption theories (Ahluwalia et

al., 2020; Kamble et al., 2019; Queiroz & Wamba, 2019; Schmidt & Wagner, 2019; Treiblmaier, 2018; Wong et al., 2020a, 2020b) within the positivist paradigm. For instance, the study of Kamble et al. (2019) is a clear example of research conducted in the framework of the functionalist paradigm. The authors aimed to analyse the factors which affect the acceptance of blockchain in SCs. For this purpose, a unified research model integrating the different constructs of three adoption theories—TAM, TPB, and TRI and the related hypotheses—was tested by applying such quantitative techniques as confirmatory factor analysis and structural equation modelling (see Table 2). The target audience consisted of SC practitioners whose perception was studied to understand the adoption process of blockchain technology in the area of the SC. To examine the relationships among the proposed parameters, an online survey was conducted with the participation of 181 SC professionals representing 102 (manufacturing, technology, or logistics) companies from 4 major cities of India (Kamble et al., 2019).

This quite large sample size and the applied standardised measures, as well as the statistically validated model, corresponded to the requirements of research within the positivist paradigm. The findings revealed that the TRI constructs (insecurity and discomfort) had an insignificant effect on affecting the behavioural intentions of the SC practitioners, while the constructs of TAM and TPB—perceived usefulness, attitude, and perceived behaviour control—were the most critical ones in explaining behavioural intention for blockchain adoption in SCs. In general, perceived usefulness helped build the attitude towards blockchain adoption, which the SC practitioners perceived effortlessly. These practitioners were familiar with this technology; however, they lacked practical knowledge and experience regarding its further implementation that made them consider both the advantages and issues pertinent to introducing BT into SC.

In contrast, the interpretive paradigm is also well-suited to research a new and underinvestigated area. An alternative approach to examine the implications of blockchain in transforming the contemporary SC within the interpretive paradigm was provided by Wang et al. (2019). The authors applied a well-established sensemaking theory (Weick, 1990; Weick et al., 2005) in organisation and management studies to analyse how SC practitioners developed assumptions and knowledge about the technology of blockchain which later shaped their actions. The aim of Wang et al. (2019) was to interpret the future impact of blockchain technology on the SC domain by focusing on individual sensemaking of SC experts, that is, the way these practitioners made sense of the nascent technology. The data collection technique applied in this research was semi-structured interviews, which are common for qualitative research and

the interpretive paradigm. The data were gathered from 14 interviews, a small sample size that nevertheless is considered acceptable for conducting research under the interpretive paradigm. This example illustrates how the researchers interpreted the reality (blockchain adoption) from the perspectives of participants (14 subject matter experts) through a sensemaking process rather than a hypothesis testing process. Wang et al. (2019) were interested in local understandings of specific uses in a certain field. Based on the individual sensemaking and the practitioners' interpretations, the individual cognitive maps were constructed for every interviewee. After collecting and comparing all codes, they were grouped into such categories as benefits, applications, and challenges' frames, and the collective cognitive mapping was created as a data analysis technique. The narrative analysis was the second method of data analysis, which was an iterative process of moving back and forth between the collected data, the literature on blockchain, and Wang et al.'s emerging framework of sensemaking (Wang et al., 2019, pp. 226 – 228). The research demonstrated that the SC practitioners tended to first understand the usage of technology and then gradually implemented small-scale applications of blockchain rather than make radical changes.

Table 2. **Comparison of the adoption of blockchain technology in the context of supply chains within positivist and interpretive paradigms***

Characteristics of articles	**PARADIGMS**	
	Interpretive	**Functionalist**
Authors/Year/ Title	Wang et al. (2019): Making Sense of Blockchain Technology: How will it transform supply chains?	Kamble et al. (2019): Understanding the Blockchain Technology Adoption in Supply Chains-Indian Context.
Journal (country/rank)	*International Journal of Production Economics* (The Netherlands / Q1)	*International Journal of Production Research* (The UK / Q1)
Theoretical framework	- sensemaking theory	- TAM, TPB, TRI
Research type	- qualitative, explorative approach	- quantitative research
Aim	- explore how emerging BT technology may transform SC - examination of individual sensemaking of SC practitioners	- understand the blockchain adoption process in SCs - analyse the factors which affect the acceptance of BT in SCs
Data collection method	- semi-structured interviews	- online survey (to examine the relationship between constructs; 33 parameters proposed in the research model)
Sample size	- 14 SC experts: senior executives/ managers from the UK, Germany, Switzerland, Indonesia, Romania, and Portugal who had in-depth domain knowledge in SCM with a sufficient understanding of IT	- 181 SC professionals representing 102 companies (manufacturing, technology, and logistics) from 4 major cities of India (Mumbai, New Delhi, Bangalore, and Chennai)
Data analysis	- narrative analysis - cognitive mapping: individual maps—a collective strategic map - iterative process of moving back and forth	- model and hypotheses testing with confirmatory factor analysis - use of AMOS 21 to conduct structural equation modelling
Contribution	- extension of sensemaking theory:	- identification of the critical

	contribution to the emerging field of behavioural operations research by applying sensemaking theory to gain insights into how SC actors make sense of the emerging technology - preparation of industries' practitioners to adopting BT, which is disruptive technology for some of the domains - further insight for the stream of technology adoption studies	constructs for successful adoption of BT in SCs and the development of the SC practitioner's behavioural intentions on adopting BT - the study advances the literature of technology adoption and tests a unified model integrating the theories of TRI, TAM, and TPB

Source: Table created by the author based on Kamble et al. (2019) and Wang et al. (2019).

Thus, both research studies, carried out either in the positivist or interpretive paradigms and in the same time period, have considerable explanatory power in relation to blockchain technology adoption, and they aimed at preparing SC practitioners to implement this technology (Table 2). This indicates that the same phenomenon can be studied in the framework of different theoretical perspectives and paradigms. The analysed studies have mixed assumptions that can reinforce each other; however, this would need additional discussion.

5. Conclusion and future research directions

The academic works here were discussed through the lenses of technology adoption theories and sensemaking theory as an alternative option. Regarding the area of supply chain management, the studies analysed behavioural intention and behavioural expectation in adopting the technology of BT as well as the factors that influence the decision to incorporate this technological innovation.

The widely used theories regarding blockchain are the DOI, the TAM, the UTAUT, the TOE framework, and the IOS adoption theory that were frequently employed in examining the supply chain area. The analysis of academic papers reveals that some authors tended to integrate several theories and then propose and test the modified research models. For instance, Clohessy et al. (2019) combined innovation theory and the TOE framework, while Queiroz & Wamba (2019) integrated the constructs of the UTAUT and network theory to outline the complexity of intercompany relationships. Some researchers found that supply chain practitioners saw the adoption of blockchain as a process that requires little effort (Kamble et al., 2019), while others warned about the need to consider both benefits and challenges related to blockchain adoption (Sternberg et al., 2020). However, there was a consensus that this complicated technology should gradually be implemented (Kamble et al., 2019; Wang et al., 2019; Wong et al. 2020a). For the successful acceptance of technology in SCM, the right infrastructure and resources, awareness and knowledge among employees (Wong et al.,

2020b), and the support of top management and external network members (Wong et al., 2020a, 2020b) are required.

Following the position of Vegh and Primecz (2019), I tried to avoid being driven by the paradigm taxonomy, and instead the study was primarily guided by two research questions. The purpose of the article was to review the results of existing studies on BT acceptance and compare them with academic works carried out within the functionalist and interpretive paradigms. The findings showed that the majority of studies in the field of blockchain technology management had been done within the functionalist paradigm. Research studies completed in the framework of these two paradigms were the most appropriate for analysing the new opportunities created by blockchain and users' perception to it. Due to the multiparadigm reviews, a multiplicity of data collection and data analysis techniques as well as a cross-fertilisation of ideas might enrich the elaboration of the relatively new research field on blockchain technology incorporation.

The research outcomes support the argument of Vegh and Primecz (2019) that organisation studies should be based on predefined research questions and not on paradigm assumptions, as there is no need for such works to be grounded in the paradigm debates. This review of technology adoption theories may help organisations develop their strategies for new technology introduction and understand the attitude of their personnel to the technology.

Thus, because this research contains a review of blockchain from the lens of technology adoption theories and sensemaking theory, it is recommended that future research continue the analysis from the perspectives of other organisation theories and concepts and derive classifications of them. Given the infancy of blockchain technology, most studies have explored prior attitudes towards BT adoption, which is why further research can be devoted to studying the post-adoption process throughout multiple industries.

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6.2. Chapter 2. Exploring the profile of innovative enterprises in high-tech manufacturing sectors: The case of the regions of Madrid and Catalonia in 2016

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Abstract

This study explores the innovation profiles of Spanish enterprises operating in high-tech manufacturing sectors. Firms with corporate headquarters in one of two prominent regions are considered: Madrid or Catalonia. The innovation profiles describe a firm's capacity to engage in radical, continuous, or no product innovation and represent distinct degrees of innovation performance. They are elaborated by applying two types of discrete choice models: (a) a multinomial logit model, which permits only the estimation of fixed effect parameters, and (b) a flexible mixed-logit model that permits the simultaneous specification of fixed and random parameters. The mixed logit methodology indicates that internal research and development (R&D) funds play no role in innovation in Catalonia. Meanwhile, Madrid-headquartered enterprises are associated with a preference only for incremental rather than radical innovation. The impact of external R&D is significantly more important for Madrid-based firms than for Catalonian ones, but the situation with expenses dedicated to technological development is the reverse. The size of researchers' salaries plays a relevant role in innovation in both regions: in Madrid, radical innovation over incremental innovation and non-innovation are unanimous preferences. However, there are roughly equal chances for both product innovation outcomes in Catalonia. Firm size proves to be a meaningful random variable in relation to innovation performance in both Spanish regions. Concerning its association with the radical/'no innovation' outcome, the results are the same in the focal regions, which display an equal preference for the two choices. Larger size induces Madrid firms to prefer radical innovation to incremental innovation, while Catalonian enterprises consider the latter equally important. Although there is no significant effect in Catalonia, firm size in the Madrid sample is associated with equal preferences for incremental innovation and no product innovation. This study describes firm attributes that enhance product innovation performance in high-tech manufacturing sectors in two distinct regions with above-average within-country per capita GDP. Methodologically, this shows the importance of using enriched alternative computational approaches, where a mixed logit specification along the multinomial one allows for the simultaneous estimation of fixed- and random-effect parameters in the model, generating additional insight into enterprise attributes regarding the innovation performance phenomena under analysis.

Keywords: innovation performance, product innovations, regional implications, discrete choice models, fixed and random parameters

1. Introduction and literature review

This study's main purpose is to deepen our understanding of the innovation behaviour and performance of Spanish enterprises operating in high-tech manufacturing sectors. In the literature, innovation performance is measured by the propensity of firms to generate product or process innovation (Cohen–Klepper 1996, Klepper–Simmons 2000, Kraft 1990). Regarding innovation performance, we focus on product innovation. The importance of this type of innovation has been acknowledged in many pieces of

academic work. March (1991) considers product innovation activity a means of organisational learning, while Danneels (2002) believes that such activities contribute to developing firm competencies. Scholars have insisted that product innovation facilitates firm renewal and enables firms to gain competitive advantage (Danneels 2002, De Jong–Vermeulen 2006, Klepper–Simmons 2000, March 1991). Product innovation enhances the quality and variety of goods and offers opportunities for enterprise growth in terms of larger quantities and higher prices (Vaona–Pianta 2008). Moreover, researchers have found that introducing product innovation drives process innovation, and that these types of innovation are interdependent (Martinez-Ros 2000, Pisano 1997, Reichstein–Salter 2006). Product innovation is more likely to occur among firms involved in research activities and invest capital in innovation (Roper et al. 2010).

Regarding degrees of novelty, product innovation can be classified into three categories: non-innovation, incremental, and radical innovation. Incremental and radical innovations describe innovation with a low (high) degree of novelty, respectively (Garcia–Calantone 2002, Henderson–Clark 1990, Laursen–Salter 2006). Incremental innovation is a more common phenomenon than radical innovation, perhaps because the latter is riskier and demands more resources (Barbosa et al. 2013). In previous studies (Barbosa et al. 2013, Laursen–Salter 2006), measures of incremental and radical innovation have been constructed based on the distinction between products ‘new to the firm’ (i.e. introduced by a firm for the first time but not new to the market) and ‘new to the market’ (i.e., new to the firm and the market). Therefore, our study explores innovation novelty with respect to whether it involves products new to the firm or new to the market (incremental versus radical innovation).

Innovation performance is a result of multiple influencing factors. According to Segarra-Blasco (2010), the probability that a company will engage in product innovation increases with its R&D input (i.e., expenditure), size, and contracting of research staff. As regards input into the innovation process, prior studies have demonstrated the positive influence of R&D investment on product and process innovation (Anzola-Roman et al. 2018, Bhattacharya–Bloch 2004). R&D activities are the most consistent drivers of product innovation and play a critical role in facilitating incremental and radical innovation (Barbosa et al. 2013). As suggested by Jaumandreu (2009), cumulative R&D expenditure determines a major part of productivity and, thereby, the cost advantage of firms.

Santamaría et al. (2009) point out exaggerated attention to the role of R&D activities in innovation studies. The author claims that innovation behaviour also

depends on other sources and activities. Various studies have provided evidence that process and product innovation are determined by wages (Flaig–Stadler 1994, Martínez-Ros 2001). Bester and Petrakis (2003) reported that wage rate defines firms' engagement in labour productivity, which affects process innovation. Salaries are positively related to workforce skills and the introduction of new technologies (Bester–Petrakis 2003). Lerner and Wulf (2007) investigate the association between innovation and shifts in the compensation of managers responsible for corporate R&D. Their findings demonstrate that more long-term incentives are associated with frequent awards, heavily cited patents, and patents of greater originality (Lerner–Wulf 2007). Hence, offering long-term incentives to corporate R&D executives leads them to decide better, thereby increasing the productivity of R&D efforts. Shao et al. (2020) found that firms with CEOs who had formerly been engaged in universities or research institutions had better innovation output and performance. Considering the decisive role of research staff in the output of knowledge-based products (Dietz–Bozeman 2005) and the positive connection between salaries and labour productivity (Bester–Petrakis 2003), we aim to investigate the relationship between compensation for researchers and firm innovation. Therefore, we attempt to fill the knowledge gap concerning the lack of understanding of the impact of researchers' salaries on firms' innovation output.

The literature offers mixed findings in terms of firm size and innovation performance. The discussion on the effect of firm size on the effectiveness of innovation is ongoing and requires further elaboration. Several researchers have observed the positive impact of firm size on innovation output (Bhattacharya–Bloch 2004, Cohen–Klepper 1996, Klepper–Simmons 2000), especially in high-technology manufacturing industries associated with a larger share of firms engaged in innovation activity (Minguela-Rata et al. 2014, Santamaría et al. 2009, Segarra-Blasco 2010). The authors suggest that large firms are more inclined to carry out R&D (Arbussá–Coenders 2007) and innovate (Rogers 2004). It is also reported that mostly large incumbent companies engage in major product and process innovation (Klepper–Simmons 2000) owing to their tendency to possess stronger resources and capabilities to dedicate to the innovation process (Barney–Clark 2007). In such companies, there may also be complementarities between R&D and other non-manufacturing activities (Minguela-Rata et al. 2014, Rogers 2004) that help maintain large and diversified innovation portfolios (Van de Vrande et al. 2009) and create value for the R&D pipeline through cooperation with entrepreneurs and suppliers (Brunswicker–Chesbrough 2018).

Firm size appears to be an important determinant of incremental innovation, whereas radical innovation is not affected by firm size (Laursen–Salter 2006). According to the literature (Laursen–Salter 2004, Lee et al. 2010), larger firms are not necessarily better than small and medium-sized enterprises in radical innovation. Large incumbent firms have standardised procedures and routines, whereas small firms tend to be more flexible and creative, especially in highly innovative industries (Audretsch 1995, Giarratana 2004). Small firms often identify business opportunities faster (Harison–Koski 2010), and their key employees can devote more time to innovation-related tasks because of a less rigid management structure (Rogers 2004). In contrast, innovation processes are typically more structured and professionalised in large firms (Van de Vrande et al. 2009). The latter have stronger cash flows dedicated to funding innovation and better access to a wider spectrum of knowledge and human capital skills (Minguela-Rata et al. 2014, Rogers 2004). Hence, the contradictory results documented in innovation literature motivate us to examine the effect of company size on innovation activity.

The propensity to implement any innovation activity varies across sectors, although the link between innovation and science is explicit and direct in some industries (e.g., biotechnology and pharmaceuticals). Firms operating in knowledge- and technology-intensive industries are more likely to actively undertake R&D than firms in low-technology and service sectors (Arbussá–Coenders 2007). As Van de Vrande (2009) noted, manufacturing firms are more technology-intensive and invest significantly in R&D.

Some authors have found that major product innovations are likely to emerge in manufacturing companies located in larger cities (Shearmur 2011, Van de Vrande 2009). An early study found that enterprises require a larger and denser regional environment for product development (Karlsson–Olsson 1998). Alcácer (2006) argued that agglomeration stimulates R&D activities due to knowledge spillovers. For example, organisational proximity is the most important determinant of multinational enterprises' co-location across high research-intensive and science-based industries. Companies can benefit from collaboration and knowledge sharing (Le Duc–Lindeque 2018). Different regions may have different traits regarding their populations' innovation habits (Kourtit et al. 2012). Moreover, the regional industry structure plays a moderating role in the association between R&D investment and innovation performance (Aarstad–Kvitastein 2019). Many studies on innovation have addressed the innovation patterns of firms in different countries (Alcácer 2006, Páthy 2017, Roper et al. 2010, Sebrek 2020,

Zdanowska et al. 2020), although considerable variation in innovation activity can occur among regions within the same country (Almeida–Kogut 1999, Buesa et al. 2006, Páthy 2017). Therefore, we argue that location may affect firms' innovation behaviour. The relationships between specific areas within a single country and the innovation profiles of enterprises should be studied further.

We restricted our analysis to firms in the high-technology manufacturing sector in Spain. This country offers a large sample of such firms and provides interesting research setting as one of the countries of the European Union with greater regional diversity (European Commission 2013). Spanish regions have diverse economies with varying degrees of innovation performance. Regional authorities have developed their scientific, technological, and innovation policies associated with significant budgets for financing and promoting R&D and innovation (Cruz-Castro et al. 2018). As the separation of samples can enable a more fine-grained analysis of innovation determinants (as opposed to a single sample), we select two major industrial regions in Spain: Madrid and Catalonia.

Madrid was chosen because it has a complete innovation system than other regions (Buesa et al. 2006). The capital city of Spain, Madrid, is one of the most economically dynamic cities in the region, with a vibrant community of engineering professionals and supporting occupational institutions (Rama et al. 2003). The geographical proximity of firms in Madrid facilitates industrial, scientific, and technical cooperation (Sánchez Moral 2009). The commitment of Catalan firms to R&D activities has been stronger than in the rest of Spain (Segarra-Blasco 2010), and its manufacturing base is substantial in (relative) regional and national comparisons (Roper et al. 2010), with a remarkable share of high-technology products (Directorate-General for Economic Analysis 2020). Catalonia has an outstanding research infrastructure and hosts the most innovative companies in Spain.

In summary, we investigated the profile of innovative firms in terms of the degree of novelty in the high-tech manufacturing sector. The aim was to explore the propensity for product innovation in relation to firms' geographical location and firm-specific characteristics (e.g., R&D expenses, size, and researchers' salaries). The methodological approach used in this study was to apply two discrete choice models: a logit model and a mixed logit model (Cao 2021, McFadden–Train 2000, Train 2003). As Barbosa et al. (2013) noted, discrete choice models are the best approach to assess the impact of a firm's innovation choices on innovation novelty. Researchers may be able to conduct methodologically more effective studies in regional statistics using these

models. They can adapt flexible computational approaches, such as the mixed logit specification, which facilitates the simultaneous estimation of fixed- and random-effect parameters in their models. Consequently, additional insights can be obtained regarding the attributes of the studied phenomena.

The remainder of this paper is organised as follows. The next section provides a detailed description of the Spanish dataset used in the investigation, the two regions examined, and the variables incorporated into the analyses. The third section discusses the notion of discrete choice models, focusing on multinomial and mixed logit models. The following section reports empirical evidence on firm innovation performance in the two regions, given the distinct methodologies. The final section summarises the main conclusions.

2. Dataset and variables

Our data are sourced from the Technological Innovation Panel (PITEC) database constructed by the Spanish National Statistics Institute (INE), which has been extensively exploited in computational-intensive articles (Barge–Gil 2010, Escribano et al. 2009, Sebrek–Pérez 2015). The data cover an extensive sample of Spanish enterprises, providing information about their innovation processes, attributes, and developmental indicators. This study used data from 2016 (the last year of the database), containing 12,849 firms. Two filters were used in the study. First, we selected firms from high-tech manufacturing sectors (variable in PITEC: *actin*), reducing our sample to 323 firms. Second, we selected firms with corporate headquarters located in Madrid or Catalonia (variable in PITEC: *sede*), reducing our final sample to 212 firms. The selected data are summarised in Table 1.

Table 1

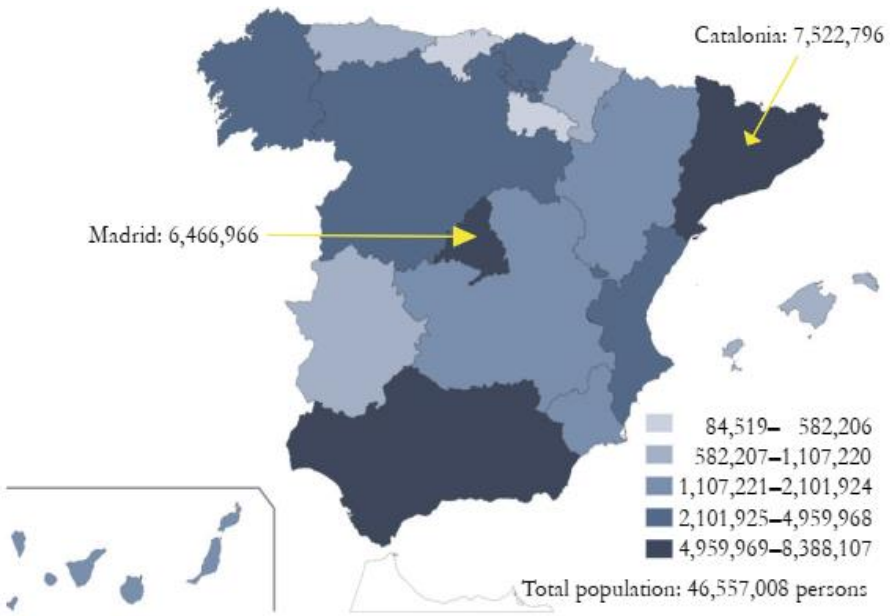
Data selection, 2016

PITEC (*actin*)	CNAE2009	Industry	Classification	Headquarters (*sede*) in Madrid	Headquarters (*sede*) in Catalonia
0011	21	manufacturing of pharmaceutical products	high-tech	33	71
0016	26	manufacturing of computer, electronic, and optical products	high-tech	49	55
0021	303	aeronautic and spatial construction	high-tech	4	0
			Subtotal	86	126
			Total sample	212	

Spain is divided into 17 autonomous communities that provide significant political and fiscal autonomy to regional governments (Cruz-Castro et al. 2018). Figure 1 displays the graphical location and total population of Madrid and Catalan's selected autonomous communities. Table 2 reveals the additional socioeconomic indicators for Spain and the target regions.

Figure 1

Total population in 2016: Madrid and Catalonia



Source: Spanish National Statistics Institute (INE).

Table 2

Socioeconomic indicators in 2016

Indicator	Spain	Madrid	Catalonia
Population (people)	46,557,008	6,466,996	7,522,596
Territory (km^2)	505,944	8,028	32,113
Population density (people per km^2)	92	806	234
GDP (million euros)	1,232,570	211,673	212,704
Per capita GDP (euros)	26,474.4	32,731.3	28,275.3

Dependent variable

The dependent variable (DV) represents the sampled firms' product innovation performance. PITEC data report whether a firm created no new products, undertook incremental innovation involving novelty exclusive to the firm, or engaged in radical innovation, indicating the firm's ability to create products new to the world market, thus representing the highest level of performance (Laursen–Salter 2006). Prior studies have attempted to explore the different degrees of novelty attached to the innovation process

(Freeman–Soete 1997, Laursen–Salter 2006). Two major innovation types are differentiated (Garcia–Calantone 2002, Henderson–Clark 1990): incremental innovation (e.g. the release of a new version of a pre-existing software product) and radical innovation (e.g. fully electric Tesla cars with ample range).

The variable is created using two proxies, as listed in Table 3. In our research context, *novedademp* symbolises a firm's ability to engage in product innovation that is new to the firm and thus can be considered incremental innovation. *Novedad* indicates the ability of a firm to engage in radical innovation, defined as innovation embedded into a product that is new to the world market. Radical innovation has been deemed competence-destroying for incumbent companies and greatly alters patterns of competition within the respective industrial fields (Tushman–Anderson 1986, Anderson–Tushman 1990). In addition, radical innovation is less common than incremental innovation and generates greater rewards (Marsili–Salter 2005). Therefore, *novedad* implies greater innovation performance than *novedademp* (Laursen–Salter 2006). We constructed three categories, representing three levels of product innovation: firms without product innovation and firms that launched novel products at the firm or market level. Table 3 summarises the sources and construction of DV.

Table 3

Dependent variable representing the organisational level of innovation, 2016

Variable	Description	Details
novedademp (original)	if the product innovation is new to the firm	1 = yes, 0 = no
novedad (original)	if the product innovation is new to the market	1 = yes, 0 = no
noinn (created)	firms without product innovation	*novedademp* = 0 and *novedad* = 0
newtofirm (created)	firms with product innovation with novelty at firm level	*novedademp* = 1 and *novedad* = 0
newtomarket (created)	firms with product innovation with novelty at market level	*novedademp* = 1 and *novedad* = 1 or *novedademp* = 0 and *novedad* = 1

A multinomial logit model was selected because DV contains more than two categories. This permits a pairwise comparison of the three outcomes, requiring the three regression models to run. We compared *newtomarket* to *newtofirm* (Model 1), *noinn* to *newtofirm* (Model 2), and *newtomarket* to *noinn* (Model 3).

Independent variables

The profile of enterprises was explored based on five attributes or independent variables (IVs). The first two attributes are related to innovation expenditure. The first one (*intr&d*) shows the proportion of innovation expenditure dedicated to internal R&D activities. The second (*extr&d*) is the proportion assigned to external R&D activities. The third attribute (*ressalary*) reflects the proportion of internal R&D expenses dedicated to researchers' salaries. Fourth (*techdev*) measures technological development associated with the proportion of current expenses allocated to technological development activities by firm administration. Finally, the last attribute (*firmsize*) reflects firm size expressed by the number of employees. Table 4 summarises the IVs used in this study, aimed at capturing certain attributes of the sampled firms.

Table 4

List of independent variables

Name of variable	Original variable name in PITEC	Description	Details
intr&d	*gintid*	internal R&D expenditure	proportion of innovation expenditure dedicated to internal R&D activities
extr&d	*gextid*	external R&D expenditure	proportion of innovation expenditure dedicated to external R&D activities
ressalary	*reci*	salaries for researchers	proportion of internal R&D expenses dedicated to salaries for researchers
techdev	*destec*	technological development	measure of technological development
firmsize	*tamano*	firm size	integer value

3. Discrete choice models

This section presents the statistical background of the two selected discrete choice models: the multinomial logit model and mixed logit model. The last part of this section describes the underlying differences between the two approaches.

The multinomial logit model

Considering random utility theory, let us assume that firm *i* obtains a certain level of utility by choosing the level of innovation *a*, expressed as

$$U_{ia} = \boldsymbol{\beta}_i^T \boldsymbol{X}_{ia} + \varepsilon_{ia}, \quad i=1,..,I, \quad a = \{noinn, newtofirm, newtomarket\}, \qquad (1)$$

where $\boldsymbol{X}_{ia}$ is a (z × 1) vector of observed variables that captures the attributes of the firms denoted in our study as: *intr&d, extr&d, ressalary, techdev* and *firmsize*. $\boldsymbol{\beta}_z^T$ is a (1 × z) vector of the coefficients of these attributes and ε_{ia} is the random error. Under the assumption of firms' utility-maximisation behaviour, the probability that firm *i* will choose alternative *k* is given by:

$$\pi_{ik} = \text{Prob}(U_{ik} > U_{ia}, \text{ for all } a \neq k),$$

The expression above indicates that firm *i* selects the level of innovation *k* because this alternative provides the greatest utility. Thus, it can be rewritten as:

$$\pi_{ik} = \text{Prob}(\boldsymbol{\beta}_i^T \boldsymbol{X}_{ik} + \varepsilon_{ik} > \boldsymbol{\beta}_i^T \boldsymbol{X}_{ia} + \varepsilon_{ia}, \text{ for all } a \neq k),$$

$$= \text{Prob}(\varepsilon_{ia} - \varepsilon_{ik} < \boldsymbol{\beta}_i^T \boldsymbol{X}_{ik} - \boldsymbol{\beta}_i^T \boldsymbol{X}_{ia}, \text{ for all } a \neq k).$$

Note that the probability of choosing the level of innovation *k* is the cumulative probability that each random term $(\varepsilon_{ia} - \varepsilon_{ik})$ is less than the observed quantity $(\boldsymbol{\beta}_i^T \boldsymbol{X}_{ik} - \boldsymbol{\beta}_i^T \boldsymbol{X}_{ia})$.

Denoting the density function of the error term as $f(\varepsilon_i)$, the probability of choosing the level of innovation *k* can be written as

$$\pi_{ik} = \int_{\epsilon} I(\varepsilon_{ia} - \varepsilon_{ik} < \boldsymbol{\beta}_i^T \boldsymbol{X}_{ik} - \boldsymbol{\beta}_i^T \boldsymbol{X}_{ia}, \text{ for all } a \neq k) \cdot f(\varepsilon_i)\, \delta\varepsilon_i\,, \qquad (2)$$

where $I(\cdot)$ is the indicator function.

The multinomial logit model assumes that $\boldsymbol{\beta}$ does not vary across firms and that each error ε_i is independently and identically distributed following a Gumbel distribution (or type I extreme value). Under these assumptions, the resulting integral has a closed-form expression, and the probability of choosing the level of innovation *k* can be written as

$$\pi_{ik} = \frac{e^{\boldsymbol{\beta}^T \boldsymbol{X}_{ik}}}{\sum_{a=1}^{A} e^{\boldsymbol{\beta}^T \boldsymbol{X}_{ia}}} \qquad (3)$$

which is called the logit choice probability. The multinomial logit model permits the estimation of homogeneous preferences through fixed-effect parameters.

Mixed logit models

Mixed logit models can be derived in various ways, with each derivation providing a particular interpretation (Train 2003). This model is more flexible because it allows the simultaneous estimation of homogeneous preferences by introducing fixed effects to the model and the estimation of heterogeneous preferences via the introduction of random effect parameters in the model. Three main steps are involved in testing the significance of the random-effects parameters in the model. First, it is necessary to specify the potential distribution of random effects (e.g., normal distribution, lognormal distribution). Second, estimate the model including the proposed random effects. Third, verify whether the random effects are significant in the model.

For instance, consider the case of a mixed logit model with a single random effect β_z. In the first step, we specify the potential distribution of the random effect. For

example, we can assume that it follows a normal distribution, $\beta_z \sim N(\mu, \sigma^2)$. Second, we estimate the model, including the proposed random effect β_z. Third, we verify whether the proposed random effect β_z, is significant in the model. To do this, it is necessary to check whether the estimated standard deviation of the random effect $\hat{\sigma}$, is significant. If so, then the random effect β_z is significant in the model.

The interpretation of random effects provides useful information during the analysis. Considering our previous example, estimating the random effect $\hat{\beta}_z$ allows us to determine the proportion of firms with a positive (or negative) coefficient. For instance, if the estimated random effect is $\hat{\beta}_z \sim N(\hat{\mu}, \hat{\sigma}^2)$, then the share of firms with a negative coefficient (i.e., negative $\hat{\beta}_z$) can be calculated as

$$P(X \leq 0) = P\left(\frac{X-\hat{\mu}}{\hat{\sigma}} \leq -\frac{\hat{\mu}}{\hat{\sigma}}\right) = P\left(Z \leq -\frac{\hat{\mu}}{\hat{\sigma}}\right), \quad (4)$$

where Z is the standardised normal distribution. In contrast, the share of firms with a positive coefficient (i.e., positive $\hat{\beta}_z$) can be calculated as

$$P(X \geq 0) = 1 - P(X \leq 0). \quad (5)$$

Under the assumptions of this fixed-logit model, the probability of choosing alternative *k* is given by the following expression:

$$\pi_{ijk} = \int \left(\frac{e^{\boldsymbol{\beta}_z^T \boldsymbol{x}_{zijk}}}{\sum_{a=1}^{A} e^{\boldsymbol{\beta}_z^T \boldsymbol{x}_{zija}}}\right) f(\boldsymbol{\beta}|\theta)\, d\boldsymbol{\beta}, \quad (6)$$

where the integral does not have a closed form and must be approximated using numerical methods.

Goodness-of-fit tests

There are different measures to assess the goodness of fit of the logistic regression models. In this study, we used two of these methods. The first measure is the likelihood ratio test, defined as:

$$LR = 2\left(LL(0) - LL\left(\hat{\beta}\right)\right) \quad (7)$$

where $LL\left(\hat{\beta}\right)$ is the log-likelihood of the proposed model and $LL(0)$ is the log-likelihood of the model with only an intercept as a predictor (null model). If this difference is statistically significant, the proposed model performs significantly better than the null model does.

The second measure is the McFadden pseudo R^2, defined as

$$R^2_{\text{McFadden}} = 1 - \frac{LL(\hat{\beta})}{LL(0)} \quad (8)$$

According to McFadden (1979), if the resulting value ranges from 0.2 to 0.4, it indicates a good fit.

Comparison and limitations of both methodologies

There is an important difference between the multinomial logit model and the mixed logit model, arising from their capacity to capture the behaviour of firms. The multinomial logit model assumes that all firms share homogeneous preferences and captures these preferences through fixed effects parameters. Thus, an inherent limitation of this approach is that it cannot capture the possible heterogeneity among firms. However, the mixed logit model obviates the three limitations of standard logit models by allowing for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time (Train 2003). Moreover, it permits the simultaneous capture of homogeneous preferences (through fixed effects) and heterogeneous preferences (through random effects). Considering that the behaviour of firms is not known in advance, we considered it important to explore both approaches.

It is at the researcher's discretion to specify a given variable as a fixed or random parameter or decide upon the latter's distribution (Train 2003). A body of literature emphasises that the scientific activity of research staff (Giarratana 2004, Lazerson 1988, Sebrek 2020, Spithoven et al. 2010) and organisational size (Greve 2011, Li et al. 2020, Rothaermel–Deeds 2004) can contribute to firm success with regard to certain elements of strategic change. We decided to define *ressalary* and *firmsize* as random variables.

4. Findings and discussion

This section explores the profile of Spanish enterprises considering the location of their corporate headquarters, namely Madrid and Catalonia. Each profile was analysed using two methodological approaches: a multinomial logit model and a mixed logit model. The results of this study were obtained using the *mlogit* package in the statistical software *R* (Croissant 2020, R core team 2022).

Profile of enterprises in Madrid

The profile of enterprises located in Madrid was created on 86 firms. Table 5 presents the basic statistics of the IVs for the entire sample and distinct categories of DV.

Table 5

Descriptive statistics for firms in the Madrid sample, 2016

	Full sample		DV: *noinn*		DV: *newtofirm*		DV: *newtomarket*	
IVs	mean	sd	mean	sd	mean	sd	mean	sd
intr&d	60.35	41.87	41.81	46.54	72.77	39.23	68.54	33.69
extr&d	7.24	18.39	3.88	11.02	3.45	16.25	12.93	23.51
ressalary	32.98	32.43	10.98	17.81	44.67	37.35	44.82	29.15
techdev	35.01	41.85	19.57	35.67	39.13	44.94	46.18	41.79
firmsize	247	471.8	159.37	180.43	74.65	100.47	446.79	696.5

Note: sd: standard deviation.
Variable definition:
intr&d: proportion of innovation expenditure dedicated to internal R&D activity
extr&d: proportion of innovation expenditure dedicated to external R&D activity
ressalary: proportion of internal R&D expenses dedicated to salaries for researchers
techdev: measure of technological development
firmsize: size of firm

On average, the proportion of innovation expenditure dedicated to internal R&D activities (variable: *intr&d*) is smaller in firms without product innovation (41.81%) and larger in firms with product innovation at either the *newtofirm* or *newtomarket* level (72.77% and 68.54%, respectively). The proportion of innovation expenditure dedicated to external R&D activities (variable: *extr&d*) is larger in firms with product innovations at the *newtomarket* level (12.93%) contrasted with the other two DVs. Regarding the average proportion dedicated to salaries for researchers (variable: *ressalary*), this quantity is similar in firms with product innovation at either the *newtofirm* or *newtomarket* levels (44.67% and 44.82%, respectively), which proves to be much greater than the value of non-innovating enterprises. On average, technological development (*techdev*) increases as firms become more innovative. Finally, firm size (variable: *firmsize*) is prominently larger in firms with product innovations at the *newtomarket* level (on average, 447 employees) compared to the two other outcomes. Table 6 lists the correlation matrices of the IVs.

Table 6

Correlation matrix and basic statistics for firms in the Madrid sample, 2016

	intr&d	*extr&d*	*ressalary*	*techdev*	*firmsize*
intr&d	1				
extr&d	-0.19	1			
ressalary	0.56	-0.11	1		
techdev	0.48	-0.09	0.51	1	
firmsize	0.11	0.22	0.02	0.19	1
mean	60.35	7.24	32.98	35.01	247

sd	41.87	18.39	32.43	41.85	471.8
minimum	0	0	0	0	1
maximum	100	100	98.5	100	2764

Note: See Table 5 for a description of the variables.

Table 6 shows a moderate positive correlation between the attributes *ressalary* and *intr&d* (0.56) and the attributes *techdev* and *ressalary* (0.51). In the rest of the cases, the correlation is less than 0.5.

In the following section, we describe the profile of firms using two methodological approaches. The first approach involves using a multinomial logit model, wherein firms are assumed to share homogeneous preferences and capture them through the fixed effects parameters. Because the DV in our study contains three categories, it is necessary to estimate three models to compare these categories appropriately. Table 7 presents the results of the estimated multinomial logit model for the three models. First, we estimate Model 1 to compare *newtomarket* with *newtofirm* as a reference group category, while in Model 2, we compare *noinn* with *newtofirm* as the base category. Model 3 estimates *newtomarket* by applying the reference group category *noinn*.

Table 7

Profile of innovative enterprises in Madrid using the classical approach: multinomial logit model, 2016

	Model 1			Model 2			Model 3		
DV	***newtomarket***			***noinn***			***newtomarket***		
Reference group	*newtofirm*			*newtofirm*			*noinn*		
	estimate		sd	estimate		sd	estimate		sd
Fixed effects									
intercept	-0.768		0.78	**1.13**	*	0.55	**-1.897**	**	0.66
intr&d	-0.005		0.01	-0.006		0.01	0.001		0.01
extr&d	0.013		0.02	-0.019		0.03	**0.032**	†	0.02
ressalary	0.01		0.01	**-0.044**	*	0.02	**0.054**	**	0.02
techdev	0.002		0.01	0.004		0.01	-0.002		0.01
firmsize	**0.006**	*	0.00	0.004		0.00	0.001		0.01

Note: *** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05, † p-value < 0.1. Sd: standard deviation. See Table 5 for a description of the variables. McFadden R^2: 0.247. Likelihood ratio test: chisq = 46.223 (p-value = 1.307e-06).

The results show that the intercept is significant in Models 2 and 3, demonstrating firms' inertia regarding engagement in any product innovation. External R&D expenditure has a positive and 10% significant effect in Model 3. This means that an additional unit increases the probability by 0.032, thus enhancing the likelihood of firm innovation at the *newtomarket* level compared to the *noinn* level, indicating a clear preference for radical innovation rather than an inert innovation enterprise posture.

The expenditure dedicated to salaries for researchers (*ressalary*) is significant in Models 2 and 3. In both cases, the interpretation is that: firms become more innovative as the magnitude of enterprise expenses dedicated to researchers increases. In Model 2, it increases the probability at the *newtofirm* level compared to *noinn*, while in Model 3, it increases the probability of firms' classification as *newtomarket* vis-à-vis *noinn*. Finally, firm size has a positive significant effect in Model 1: each additional unit of *firmsize* increases the probability by 0.006, expressing the link between firm size and *newtomarket* status versus *newtofirm*. In other words, large firms are more likely to present radical innovations than incremental innovations. Regarding the significance of the multinomial logit model, the p-value of the likelihood ratio test is 1.3065e-06, indicating that the model is statistically significant. Similarly, the McFadden pseudo R^2 value indicated a good fit (0.247).

The second approach to exploring the profile of firms assumes heterogeneous preferences in one or more attributes, thereby specifying the random effects in the model. Table 8 presents the results of the mixed logit model and incorporates two random effects through the variables *ressalary* and *firmsize*.

Table 8

Profile of innovative enterprises in Madrid using the mixed logit model, 2016

		Model 1			Model 2			Model 3		
DV		***newtomarket***			***noinn***			***newtomarket***		
Reference group		*newtofirm*			*newtofirm*			*noinn*		
		estimate		sd	estimate		sd	estimate		sd
Fixed effects										
intercept		**-7.792**	***	1.23	2.304		3.10	**-4.210**	***	1.05
intr&d		**-0.157**	†	0.08	0.094		0.14	-0.164		0.11
extr&d		**0.233**	***	0.07	**-0.362**	*	0.15	0.224		0.40
techdev		0.016		0.05	**0.250**	*	0.11	-0.110		0.15
Random effects										
ressalary	mean	**0.393**	***	0.09	**-1.387**	*	0.58	**0.948**	*	**0.41**
	sd	0.565		0.42	0.396		0.89	-0.611		0.56
firmsize	mean	**0.221**	***	0.00	0.103		0.10	-0.031		0.05
	sd	**0.229**	***	0.00	**0.687**	***	0.12	**0.145**	*	**0.06**

Note: *** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05, † p-value < 0.1. Sd: standard deviation. See Table 5 for a description of the variables. McFadden R^2: 0.154. Likelihood ratio test: chisq = 28.737 (p-value = 0.011).

The first part of Table 8 estimates the fixed effect parameters. The intercept has a significant negative effect in Models 1 and 3, delineating a more nuanced picture than before. Firms in the Madrid sample refrain from innovating products new to the world

market and prefer either incremental innovation or not to be innovative. Internal R&D expenditure is negative and significant on the margin in Model 1; in this case, augmenting internal R&D decreases the probability by 0.157 that firms engage in *newtomarket* innovation compared to *newtofirm* innovation. In other words, possessing more resources for internal R&D increases the probability of less radical product innovation.

External R&D expenditures are significant in Models 1 and 2. In both cases, firms become more innovative as external R&D expenditures rise. In Model 1 (2), the variable increases the probability that a firm engages in *newtomarket* (*newtofirm*) innovation rather than *newtofirm (noinn*) innovation.

The measure of technological development is positive and significant in Model 2: adding one additional unit of *techdev* increases the relative log odds by 0.250, increasing the probability that firm innovation can be classified as *noinn* instead of *newtofirm*. The results suggest that when firms allocate a greater proportion of their current expenses to technological development, they are less likely to engage in incremental product innovation. We speculate that this is because of the need to avoid attentional overload during business administration.

Finally, the second part of Table 8 estimates the proposed random effects parameters *ressalary* and *firmsize*. We assume that they follow a normal distribution in both cases, delivering the estimation of $\hat{\beta}_{ressalary} \sim N(\hat{\mu}_{ressalary}, \hat{\sigma}^2{}_{ressalary})$ and $\hat{\beta}_{firmsize} \sim N(\hat{\mu}_{firmsize}, \hat{\sigma}^2{}_{firmsize})$, respectively.

In the case of the first random effect, $\hat{\beta}_{ressalary}$, the results show that only the mean, $\hat{\mu}_{ressalary}$, is significant in all models, meaning that there is no evidence that $\hat{\beta}_{ressalary}$ is a normally distributed random variable. More researchers on payroll indicate that radical innovation is preferred to incremental and no innovation and that incremental innovation is strictly preferred to no product innovation.

By contrast, concerning the second random effect, $\hat{\beta}_{firmsize}$, the standard deviation, $\hat{\sigma}_{firmsize}$, is significant in all models, meaning that there is statistical evidence that $\hat{\beta}_{firmsize}$ is a random effect normally distributed in every model. In Models 2 and 3, the estimated distributions were $\hat{\beta}_{firmsize} \sim N(\hat{\mu}_{firmsize} = 0, \hat{\sigma}^2{}_{firmsize} = 0.687^2)$ and $\hat{\beta}_{firmsize} \sim N(\hat{\mu}_{firmsize} = 0, \hat{\sigma}^2{}_{firmsize} = 0.145^2)$, respectively. In both cases, the centre of the distribution is zero ($\hat{\mu}_{firmsize} = 0$), meaning that for approximately 50% of the firms, the estimated coefficient $\hat{\beta}_{firmsize}$ is

positive, and for the rest (that is, 50% of the firms), it is negative. Using the random parameter *firmsize*, these results imply that firms in Madrid prefer incremental and no innovation (Model 2 in Table 8) and radical and no product innovation (Model 3 in Table 8) equally.

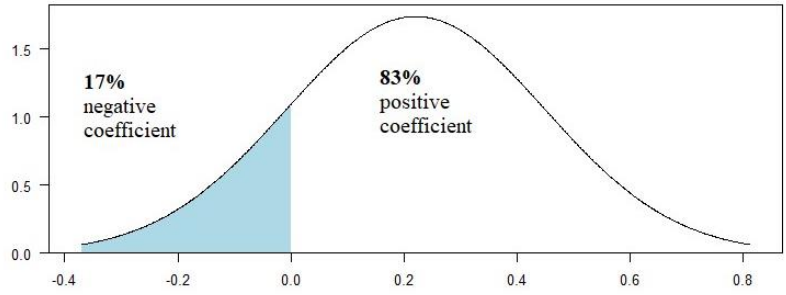
In Model 1, the estimated distribution is $\hat{\beta}_{firmsize} \sim N(\hat{\mu}_{firmsize} = 0.221, \hat{\sigma}^2{}_{firmsize} = 0.229^2)$. The distribution centre is different from zero ($\hat{\mu}_{tamano} = 0.221$), requiring an additional calculation to establish the proportion of firms with positive and negative coefficients. The following simple equation gives the proportion of firms with a negative coefficient:

$$P(X \leq 0) = P\left(\frac{X-0.221}{0.229} \leq -\frac{0.221}{0.229}\right) = P\left(Z \leq -\frac{0.221}{0.229}\right) = P(Z \leq -0.967) \approx 0.17.$$

For approximately 17% of firms, the effect of firm size, through the negative coefficient, increases the probability of innovation of the *newtofirm* type compared to *newtomarket*. For the remaining firms (i.e., 83%), it augments the probability (positive coefficient) of innovation at the *newtomarket* level compared to the *newtofirm* level. Consequently, one can conclude that the average-sized firm in Madrid unequivocally prefers radical innovation vis-à-vis incremental innovation. However, the preference is the reverse for almost one-fifth of the firm population. Figure 2 displays the distribution of the random effect $\hat{\beta}_{firmsize}$ in model 1.

Figure 2

Distribution of the random effect $\hat{\beta}_{firmsize}$ for the Madrid sample in 2016



Note: the random effect comes from Model 1 of Table 8.

Concerning the significance of the mixed logit model, the results show that the p-value of the likelihood ratio test is 0.011, meaning that the model is statistically significant, as confirmed by the McFadden pseudo R^2 (0.154), which indicates a good fit.

Regarding the two methodological approaches, we conclude that a mixed logit model provides a more thorough assessment of the profile of innovating enterprises than

a traditional multinomial logit model. This facilitates the identification of heterogeneous features through more variables that reach conventional significance levels in relation to fixed and random effects.

Profile of enterprises in Catalonia

In the case of Catalonia, firm profiles were analysed based on a sample of 126 firms. Table 9 presents the basic statistics of the IVs for the entire sample and the distinct categories of DV.

Table 9

Descriptive statistics for firms in the Catalonian sample, 2016

	Full sample		DV: *noinn*		DV: *newtofirm*		DV: *newtomarket*	
IVs	mean	sd	mean	sd	mean	sd	mean	sd
intr&d	54.84	41.63	36.85	43.75	62.23	41.31	68.61	32.40
extr&d	10.47	20.83	11.00	23.23	9.56	22.25	10.58	17.18
ressalary	30.17	29.53	24.16	32.60	30.53	27.49	36.30	26.72
techdev	32.35	38.27	12.23	27.93	40.97	37.52	47.49	39.66
firmsize	207.67	322.52	126.04	252.13	143.21	202.01	342.0	411.2

Note: sd: standard deviation. See Table 5 for a description of the variables.

On average, the proportion of innovation expenditure dedicated to internal R&D activities (variable: *intr&d*) increases as firms become more innovative. The proportion of innovation expenditure dedicated to external R&D activities (variable: *extr&d*) is similar in all categories, varying from 9.56% to 11%. On average, salaries dedicated to researchers (variable: *ressalary*) increase in terms of innovation performance and are the highest in firms with radical product innovation (36.30%). The measure of technological development (variable: *techdev*) grows with innovation performance, reaching a peak at *newtomarket* level (47.49%). The firm size covariate reaches its highest value with 'radical innovation' (342), substantially higher than its value for *noinn* (126.04) or *newtofirm* (143.21). One can identify major differences between the samples from Madrid and Catalonia through descriptive statistics: firms in Madrid allocate more of their current expenses to researchers' salaries for effective product innovation activity than those in Catalonia and are larger in size. Table 10 presents the correlation matrices of IVs.

Table 10

Correlation matrix and basic statistics for firms in the Catalonian sample, 2016

	intr&d	*extr&d*	*ressalary*	*techdev*	*firmsize*
intr&d	1				
extr&d	-0.14	1			
ressalary	0.64	0.07	1		

techdev	0.53	-0.11	0.34	1	
firmsize	0.06	0.25	0.01	0.06	1
mean	54.84	10.47	30.17	32.35	207.67
sd	41.63	20.83	29.53	38.27	322.52
minimum	0	0	0	0	1
maximum	100	100	97.1	100	1424

Note: See Table 5 for a description of the variables.

The correlation matrix shows a moderate positive correlation between the variables *ressalary* and *intr&d* (0.64), and between *techdev* and *intr&d* (0.53); for the rest, the correlation is less than 0.5.

Table 11 presents the first approach to exploring the profiles of firms, assuming that all share homogeneous preferences for every attribute. Similar to the Madrid case, this table presents the results of three models with the same construction.

Table 11

Profile of innovative enterprises in Catalonia using the classical approach: multinomial logit model, fixed effects in 2016

	Model 1			Model 2			Model 3		
DV	***newtomarket***			***noinn***			***newtomarket***		
Reference group	*newtofirm*			*newtofirm*			*noinn*		
	estimate		sd	estimate		sd	estimate		sd
Fixed effects									
intercept	-0.539		0.56	**1.153**	**	0.42	**-1.691**	***	0.49
intr&d	0.000		0.01	-0.012		0.01	0.012		0.01
extr&d	-0.005		0.01	-0.002		0.01	-0.004		0.01
ressalary	0.008		0.01	0.014		0.01	-0.007		0.01
techdev	0.003		0.01	**-0.022**	**	0.01	**0.025**	**	0.01
firmsize	**0.002**	*	0.00	0.000		0.00	**0.002**	*	0.00

Notes: *** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05, † p-value < 0.1. Sd: standard deviation. See Table 5 for a description of the variables. McFadden R^2: 0.148. Likelihood ratio test: chisq = 40.492 (p-value = 1.388e-05).

The results show that the intercept is significant in Models 2 and 3, demonstrating firms' inertia about managing any type of innovation, similar to the firms in the Madrid sample. The measure of technological development (*techdev*) was significant in Models 2 and 3. As Catalonian enterprises increased their technological development, they became more innovative in both cases. Specifically, in Model 2 (3), the variable increases the probability that incremental (radical) innovation will be selected compared with an inert innovation posture.

Finally, firm (*firmsize*) has a positive significant effect in Models 1 and 3. In both cases, firms become more innovative because of increased *firmsize*. Specifically, in Model 1, the variable increases the probability of firms adopting a *newtomarket*

innovation approach rather than a *newtofirm* one. In Model 3, *firmsize* strengthens the probability of selecting a *newtomarket* strategy rather than a *noinn* strategy. Hence, larger firms unilaterally prefer new-to-the-market innovations vis-à-vis new-to-the-firm ones or no innovation. The p-value of the likelihood ratio test (1.388e-05) and McFadden pseudo R^2 (0.148) indicate the significance of the multinomial logit model.

The last approach assumes heterogeneous preferences for one or more attributes (IVs). Table 12 presents the results of the mixed logit model for the Catalonian enterprise population, including two random effects: *ressalary* and *firmsize*.

Table 12

Profile of innovative enterprises in Catalonia using the mixed logit model, 2016

		Model 1			Model 2			Model 3		
DV		***newtomarket***			***noinn***			***newtomarket***		
Reference group		*newtofirm*			*newtofirm*			*noinn*		
		estimate		sd	estimate		sd	Estimate		sd
Fixed effects										
intercept		**-9.468**	†	5.07	**1.883**	*	0.90	**-10.844**	*	4.82
intr&d		-0.028		0.02	-0.004		0.04	-0.004		0.02
extr&d		-0.095		0.08	0.012		0.09	**-0.182**	***	0.04
techdev		**0.124**	***	0.03	-0.165		0.15	**0.179**	***	0.02
Random effects										
ressalary	mean	-0.046		0.06	0.172		0.18	**-0.067**	*	0.03
	Sd	**0.977**	***	0.18	0.193		0.22	**0.590**	†	0.35
firmsize	mean	0.006		0.01	0.020		0.03	**0.012**	*	0.01
	Sd	**0.380**	***	0.02	0.133		0.10	**0.400**	***	0.01

Note: *** p-value < 0.001, ** p-value < 0.01, * p-value < 0.05, † p-value < 0.1. Sd: standard deviation. See Table 5 for a description of the variables. McFadden R^2: 0.1359. Likelihood ratio test: chisq = 37.202 (p-value = 0.0006875).

Regarding the fixed effects in Table 12, the intercept is significant in all models, signifying that firms in each outcome pair do not engage in sophisticated innovation. External R&D expenditure is negative and significant in Model 3. Adding one additional unit decreases the probability of radical innovation by 0.182, whereby sufficiently non-incentivising the firms to select *newtomarket* vis-à-vis *noinn* level.

Technological development had a positive and significant effect in Models 1 and 3. In both cases, firms become more innovative as their degree of technological development increases. Specifically, the variable increases the probability that firms engage in *newtomarket-type innovation* compared to *newtofirm* and *noinn.* Hence, for firms that dedicate a greater than average amount of funds toward technological development, the creation of innovations with novelty in relation to the entire market is preferred over the two other outcomes.

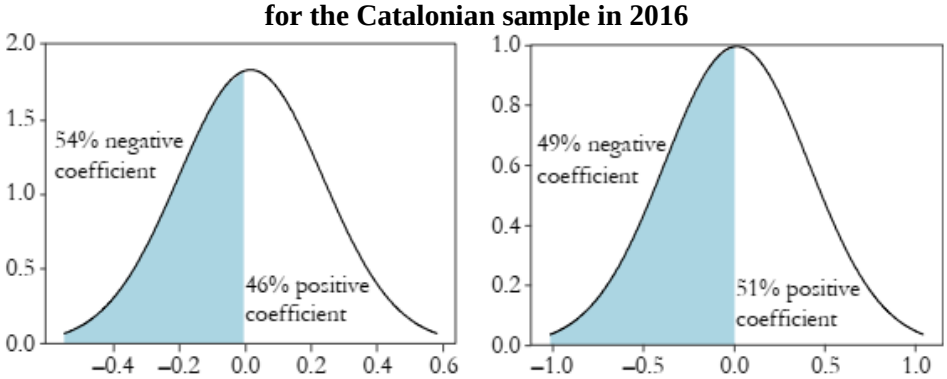
Following an examination of the random effects, similar to the case of firms from Madrid, we assume that both random effects – i.e., *ressalary* and *firmsize* – are normally distributed.

The first random effect, $\hat{\beta}_{ressalary}$, was significant in Models 1 and 3. In Model 1, the estimated distribution is $\hat{\beta}_{ressalary} \sim N(\hat{\mu}_{ressalary} = 0,\ \hat{\sigma}^2{}_{ressalary} = 0.977^2)$, meaning that for approximately 50% of firms, it increases the probability (positive coefficient), whereas it decreases for the rest. In other words, having an average salaried staff implies an equal probability that firms will engage in new-to-market and incremental innovation. In Model 3, the estimated distribution is $\hat{\beta}_{ressalary} \sim N(\hat{\mu}_{ressalary} = -0.067,\ \hat{\sigma}^2{}_{ressalary} = 0.590^2)$, meaning that, for approximately 46% of the sampled firms, the existence of salaried researchers increases the probability (positive value) of engaging in radical innovation, whereas for 56%, it does not make a vital contribution to product innovation.

Finally, the second random variable, $\hat{\beta}_{firmsize}$, is significant in Models 1 and 3. In Model 1, the estimated distribution is $\hat{\beta}_{firmsize} \sim N(\hat{\mu}_{firmsize} = 0,\ \hat{\sigma}^2{}_{firmsize} = 0.380^2)$, meaning that for approximately 50% of firms, the size covariate increases the probability of engaging in radical product innovation (positive value), whereas it decreases for the rest, incentivising them to engage in non-radical-type continuous innovation. In Model 3, the estimated distribution is $\hat{\beta}_{firmsize} \sim N(\hat{\mu}_{firmsize} = 0.012,\ \hat{\sigma}^2{}_{firmsize} = 0.400^2)$, meaning that for approximately 51% of firms, the probability of engaging in radical innovation with significant novelty in relation to the firm's respective market (positive coefficient) is increased, while for the remaining 49%, it is decreased (firms without any innovative products). Figure 3 displays the distribution of the random effects $\hat{\beta}_{ressalary}$ and $\hat{\beta}_{firmsize}$ in Model 3.

Figure 3

Distribution of the random effects $\hat{\beta}_{ressalary}$ (left) and $\hat{\beta}_{firmsize}$ (right) for the Catalonian sample in 2016



Note: the random effect comes from Model 3 of Table 12.

We draw the same conclusion for the Catalonian subsample as the Madrid one. The mixed logit model proved to be superior to the multinomial logit methodology in terms of analysing the profile of innovative enterprises in our regional sample because it helps reveal the real effects of more variables, whether fixed or random. Finally, concerning the significance of the mixed logit model fitted for Catalonia, the p-value of the likelihood ratio test was 0.0006875, meaning that the model was statistically significant. Moreover, the McFadden pseudo R^2 value of 0.1359 indicated an adequate fit.

5. Implications and conclusion

This study focused on the profile of Spanish enterprises in relation to three levels of innovation: firms without product innovation and firms that launch products at *newtofirm* or *newtomarket* levels. Two discrete choice models, a multinomial logit model and a mixed logit model, were used to analyse the profile of innovative enterprises operating in high-tech manufacturing sectors and are headquartered in Madrid and Catalonia, the two main economic hubs in Spain. The regional profiles of Spanish enterprises were analysed in relation to firm attributes such as innovation expenditure earmarked for internal and external R&D activities, expenditure dedicated to salaries for researchers, technological development, and firm size.

In the first approach, we assume that all enterprises share homogeneous preferences for each attribute, hence resorting to a multinomial logit model. In Madrid's case, external R&D expenditure was found to affect firms' propensity to engage in radical innovation instead of remaining inert (incremental innovation). In contrast, salaries for researchers proved to be a relevant factor in increasing innovation performance. In this geographically centrally located autonomous community, firms that pay higher salaries to researchers tend to create innovative products instead of resting on their laurels. The mixed logit specification proved to be much more flexible because we identified more variables with explanatory power. For example, internal R&D and technological development measures have become significant. The former finding suggests that more resources increase the probability of less-radical innovation. The latter indicates that firms do not necessarily prefer incremental innovation to no innovation, perhaps because of an administrative attention clash involving ongoing technological investments. Funds for external R&D now lead to different and more nuanced findings, as the possession of the latter is associated with enterprises opting for radical or incremental types of innovation vis-à-vis an inert posture. As far as the

random parameters go, our proxy for researchers' salary reflects earlier findings and highlights the prominence of radical innovation rather than incremental innovation. Because the standard deviation of the variable is not significant, it cannot be considered a real random parameter. This is not the case for firm size: the standard deviation is significant in all models, permitting us to compute the proportion of firms in each outcome pair: 83%-17% for radical-incremental innovation (the multinomial delivered here only a similarly positive significant effect); 50%-50% for the 'no' versus 'incremental', and the 'radical' versus 'no' innovation pairs. Thus, treating *firmsize* as a random parameter in the Madrid subsample adds to understanding its role in innovation performance compared with using the multinomial logit method.

In the case of multinomial specification applied to firms headquartered in Catalonia, technological development and firm size are two relevant factors that increase product innovation performance. In this eastern autonomous community, a high ratio of current expenses to technological development is associated with a firm preference for innovative products of any degree of novelty over an inert product innovation posture. In addition, larger enterprises tend to engage in radical innovation compared to 'new to the firm' and 'non-innovation' types. Using the mixed logit model again led to more variables in more models with a statistically significant explanatory power. Funds for external R&D do not necessarily encourage Catalonian firms to opt for incremental innovation (relative to inert product innovation behaviour). The results for technological development are partly similar to those from the multinomial method in how they highlight the choice of firms for radical innovation over none. However, there is also an added emphasis on a revealed preference for radical innovation over incremental innovation. We assumed that Catalonian enterprises display heterogeneous preferences regarding researchers' salaries and firm size as distinguishing attributes. Induced by the former, firms equally choose between radical and incremental innovation postures, and slightly fewer firms opt for radical innovation rather than no innovation (46%-54%). In theory, firm size is similarly depicted in the multinomial specification; we can now precisely specify that larger firms equally prefer radical and incremental innovation outcomes. Further, the size variable is positive and significant for the *newtomarket* and *noinn* pair, similar to the multinomial case. Nevertheless, our calculations reveal that radical innovation is only minimally preferred over non-innovation (a 51%-49% split).

Applying the mixed logit methodology allowed us to compare firms in two prominent Spanish regions. In both subsamples, firms display some sort of inertness in

terms of innovation rather than a more creative, innovative approach. Internal R&D funds play no role in Catalonian enterprises in fomenting product innovation, and in Madrid, it only elicits a preference for incremental over radical innovation. External R&D is a much more influential variable for firms headquartered in Madrid than those in Catalonia: former firms use such resources to increase innovative performance. The reverse scenario occurs in the case of expenses dedicated to technological development: there is no role for these expenses in Madrid, while firms in the eastern region use them to buttress radical innovation with beneficial effects on international markets. This is in accordance with prior observations that show the significance of R&D expenses (Anzola-Roman et al. 2018, Barbosa et al. 2013, Bhattacharya–Bloch 2004, Jaumandreu 2009). Salaries dedicated to researchers play a role in both regions; in Madrid, radical innovation over incremental innovation is the unanimous preference, but there is an equal chance of product innovation outcomes in Catalonia. The same pattern is revealed for the radical-no innovation pair: while in Madrid, the former is preferred, in Catalonia, there is a 46%-54% division between the outcomes. Additionally, the results related to the researcher's salaries show that Madrid-based enterprises opt for incremental innovation rather than an inert posture. However, for the Catalonian sample, there is no statistically significant effect. This outcome confirms that wages are positively associated with better innovation performance and productivity, as previously observed (Bester–Petrakis 2003, Lerner–Wulf 2007, Martínez-Ros 2001).

Further, firm size was considered a random variable in both subsamples. Concerning the radical-no innovation outcome, the results are the same for both samples, with equal preferences for both choices. However, Catalonian firms are split regarding the choice between radical and incremental product innovation. Nonetheless, Madrid-based enterprises clearly prefer radical product innovation, spurred by their sheer size. These findings contradict previous research (Laursen–Salter 2006), which indicated the importance of firm size for the incremental type of innovation and the smaller relevance of size for the radical type. An additional difference is that, while there is no significant effect in Catalonia, firm size is not associated with a clear preference for incremental or no product innovation for firms headquartered in Madrid. Overall, our results support the findings of Buesa et al. (2006) and Jaumandreu (2009) that Spanish regions, namely Catalonia and Madrid, differ in their implementation of innovative expenditure and related activities.

Our study contributes to the stream of research on product innovation and the ongoing debate on the effects of firm size and researcher salary on innovation outcomes.

The strengths of this study are its examination of the profiles of innovative enterprises through a regional lens and the application of two discrete choice models. A comparison of the results obtained from the two methodological approaches indicates that the mixed logit model facilitates a more thorough assessment of the profile of innovating enterprises in both regions compared with the use of a traditional multinomial logit model. The core feature of the former permits the heterogeneous features of the sampled entities to be revealed, meaning that core variables with fixed and random effects attain significance simultaneously. This agrees with Arbussá and Coenders' (2007) argument that the statistical methodology discussed can generate adequate inferences from complex sample designs.

The analysis built on the mixed logit method was especially capable of highlighting the relevance of examining crucial factors associated with a population of firms in each region that might be associated with greater innovation activity. Such differences are relevant when policymakers fine-tune industrial policies to boost the growth potential of regions. Considering the importance of high-tech manufacturing sectors and the concomitant high value-added production, support for enterprises pursuing innovative activities is needed to promote innovation in advanced manufacturing further. Our results permit us to derive policy implications associated with the prominent variables analysed herein. In our theory-driven research, greater organisational innovation performance is associated with radical innovation, followed by incremental innovation. Interestingly, funds for external R&D are more important for Madrid-headquartered firms than for Catalonian firms, while the reverse holds true in terms of expenses dedicated to technological development. Insofar as such sophisticated industries depend on scientific research, enterprises need to pay attention to increasing the salaries of research staff, perhaps accompanied by the provision of good working conditions and other perks, which economic policy should encourage. Therefore, as found to be relevant in both regions, firms should allocate more funds for such purposes, increasing firm innovativeness. Finally, based on the finding that larger firms are more likely to launch innovative products, the manufacturing industry will benefit from complex industrial policies that target business consolidation, helping enterprises create and market products with greater innovation.

This study was limited by the number of enterprises and variables available in the PITEC dataset. Although this study refers to Spanish enterprises and regions, we believe that a large proportion of the findings have explanatory potential and are transferrable to similar socioeconomic environments. Nevertheless, to create a properly

tailored innovation policy for specific regions, the repetition of this study is highly recommended. Future studies on the current topic should ideally incorporate a larger sample of enterprises, more firm attributes, and more regions to enhance the reliability of their conclusions.

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INTERNET SOURCES

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6.3. Chapter 3. The interaction of actor-independent and actor-dependent factors in new venture formation: The case of blockchain-enabled entrepreneurial firms

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Abstract

The present study seeks to explore how emergent blockchain technology enables the creation of new ideas for ventures and to examine the activities of founders and entrepreneurial teams in shaping those ideas. To achieve the research purpose, we adopted several theoretical frameworks – external enablers theory, dynamic capabilities (DCs), and dynamic managerial capabilities (DMCs) – to explain the interaction of actor-independent and actor-dependent factors in the process of new firm formation. We analysed four blockchain start-ups that operate across financial services, cryptocurrency trading, crypto asset management, energy, information technology, and identity industries and create high value-added and cross-industrial offerings for Hungarian and foreign markets. Using qualitative study research results, this study develops the model of external enablers, founders' and firm capabilities, and new venture creation. We identify three interconnected external enablers – namely, market volatility associated with the growing popularity of cryptocurrencies and the underlying blockchain technology, the properties of blockchain, and the ideology behind the technology – and discuss the role of entrepreneurs' DMCs and sensing and seizing activities in discovering and shaping these enablers into profitable business ideas.

Keywords: cryptocurrencies, dynamic capabilities, dynamic managerial capabilities, external enablers.
JEL classification indices: L20, L26, M10

1. INTRODUCTION

Digital technologies can enhance opportunities in the entrepreneurial process by enabling greater activity in terms of new venture formation (Boeker et al. 2021; Nambisan 2017). Technological characteristics can be used by entrepreneurial agents to create new value propositions. In the entrepreneurial literature, such technologies have been suggested to represent the actor-independent external enablers of new firms (Davidsson 2015; Davidsson et al. 2020). Scholars have studied the mechanisms through which digital technologies affect entrepreneurial outcomes (von Briel et al. 2018) and the daily organisational practices of entrepreneurial firms that have developed new digitally enabled venture ideas (Chalmers et al. 2021). However, there has been limited attention to understand the role of entrepreneurs' knowledge, experience, and contacts in identifying and capturing the mechanisms of external enablers throughout the venture-creation process.

The incorporation of an actor-dependent view of external enablers into external enabler theory has been suggested in prior research (Chalmers et al. 2021; Davidsson et al. 2020). We have referred to the concepts of *dynamic managerial capabilities* (DMCs) and *dynamic capabilities* (DCs) to understand the role of entrepreneurs and entrepreneurial teams in sensing the external enablers and shaping them into new venture ideas. Several authors (Corner – Wu 2011; Newbert 2005; Zahra et al. 2006) have examined DCs in the context of new ventures and reached some consensus that the DCs associated with new firm formation are executed at the individual level to meet uncertain and changing market needs. DCs reside originally in the several individuals that make up the entrepreneurial team but do not always exist throughout the organisation. So far, relatively little research has been carried out on DCs and DMCs in the context of technology-based small firms. Our research contributes to the limited research stream (Andersson – Evers 2015; Corner – Wu 2011; Newbert 2005; Razmdoost et al. 2020; Sapienza et al. 2006) that is devoted to the examination of DCs and DMCs in the context of new ventures.

In this study, we explore one of the most recent and most prominent new technologies. This is versatile blockchain technology, which is applicable to diverse fields by creating the means for customisation (Seebacher et al. 2021), and which facilitates fundamentally new ways of coordinating transactions and economic activities (Davidson et al. 2018; Frolov 2021). To date, the potential of blockchain technology and its performance and usage by customers have not been extensively studied. An empirical examination of successful blockchain applications is scarce (Schmidt – Wagner 2019), thus we contribute to the literature on the commercial applications of blockchain technologies. Due to the paucity of research on DCs in emerging ventures and on the use of blockchain, this study adopted a qualitative method based on interviews with start-ups' management and archival material.

The paper is organised as follows. The second section includes the literature review on external enablers of entrepreneurship, blockchain characteristics, and its implications, and describes the DCs in the context of new ventures. The third section explains the methodology and process of data collection and analysis. In the fourth section, we describe findings about the key external enablers and the role of entrepreneurs in enacting those enablers, and we identify the key microfoundations of sensing and seizing activities. The following section discusses the findings, as well as promising future research directions. Finally, concluding remarks complemented by policy and managerial implications are presented.

2. LITERATURE REVIEW

2.1. External enablers of entrepreneurship

Recent research on external enablers (Davidsson 2015; Davidsson et al. 2020) has contributed to the reconceptualisation of fundamental entrepreneurial processes. The external enablers approach integrates external conditions with fundamental aspects of entrepreneurial agency (Chalmers et al. 2021; Davidsson et al. 2020). The core of entrepreneurship lies in the formation of new ventures or new economic activity (Wiklnud et al. 2011; Davidsson et al. 2020) which is triggered by objective, external influences. Davidsson (2015) introduced external enablers as an aggregate-level construct for theorising about preexisting actor-independent opportunities. A study by von Briel et al. (2018) applied Davidsson's (2015) external enabler construct to determine how and when digital technologies enable entrepreneurial processes in the high-technology sector. Earlier, digital technologies were acknowledged as an objective factor that has a strong effect on entrepreneurial opportunities, actions, and outcomes (Nambisan 2017). The entrepreneurial literature lacks study of how enablers are discovered and further used in practice by entrepreneurs. Following Davidsson et al. (2020), we attempt to understand the impact of external factors in new venture development by examining the interaction of multiple enablers and the actions of entrepreneurs in shaping those enablers. Specifically, the study aims to obtain additional insight into how enablers relate to one another and to agents in deriving enabling mechanisms and contributing to venture creation.

2.2. Blockchain technology as an external enabler of entrepreneurship

Digital technologies have been used by scholars as one of the major factors for operationalising the construct of external enablers (Browder et al. 2019; von Briel et al. 2018). For example, a recent study on blockchain technology and entrepreneurship examined how blockchain was used to develop new venture ideas in the music industry (Chalmers et al. 2021). In our study, we seek to extend their research to new blockchain-enabled firms in different industries and to obtain insight into how this foundational technology may trigger the formation of new ventures.

The technology of blockchain and other types of distributed ledger technologies (DLTs) are regarded as one of the most important technological innovations. Blockchain is a decentralised and distributed ledger that enables more efficient and

transparent transactions (e.g., payment processes or transfers of information), while the need for a trusted intermediary is eliminated through consensus-based record validation (Nowiński – Kozma 2017; Schmidt – Wagner 2019). Blockchain-based systems can be used across all industries and organisations due to their key characteristics, such as the decentralisation of decision making, peer-to-peer transmission, reliability, privacy, immutability of data, speed, low transaction fees, and transparency (Grover et al. 2019; Iansiti – Lakhani 2017; Mnif et al. 2021; Nakamoto 2008).

The technology has led to the enhancement of existing activities, the expansion of the range of transactional services, as well as the creation of new economic activities (Frolov 2021). Blockchain supports new types of contracts and novel forms of economic institutions such as initial coin offering (ICO), which is a new way of fundraising, as well as decentralised autonomous organisations (DAOs). Blockchain technology enables the existence of digital currencies. On the one hand, cryptocurrencies meet a market need for faster and more secure payment and transaction systems. As alternative payment instruments, they facilitate international trade by reducing transaction costs. On the other hand, blockchain operation is very energy intensive; the bitcoin system in particular consumes an enormous level of electricity (Chang et al. 2020), which can cause a significant environmental burden (Kouhizadeh et al. 2019). The unstable value of cryptocurrencies makes them speculative investments. Cryptocurrency adoption is considered an economic incentive for illegal conduct, such as money laundering, financing terrorism, and tax evasion, due to weak capital controls (Kher et al. 2020). Cryptocurrencies are highly volatile, yet they add economic value and move financial markets forward in terms of efficiency and growth (Giudici et al. 2020).

2.3. Dynamic capabilities in the context of new ventures

The creation of new firms takes place through several phases which require entrepreneurial capability (Vohora et al. 2004). Entrepreneurs combine and reconfigure resources in new ways (Penrose 1959; Schumpeter 1934) and, as start-ups' resources are limited, they need to acquire them from sources outside the firms' boundaries (Stuart et al. 1999; Zahra – George 2002). Wu (2007) believes that entrepreneurial resources do not translate into performance without DCs (Arend 2014). Prior studies have mainly focused on incumbent companies and denied the existence of DCs at the founding stage (Eisenhardt – Martin 2000; Helfat – Peteraf 2003; Teece et al. 1997). In this study, we appeal to the research stream that views the development of DCs as a

crucial sub-process in venture creation (Corner – Wu 2011) and which argues that DCs can exist from the time of new venture formation (Arend 2014; Zahra et al. 2006).

Research on DCs has developed through the analysis of the microfoundations which underpin such capabilities. Teece (2007) introduced the microfoundations of the DCs which are the organisational and managerial processes and procedures underlying those capabilities. DCs may be conceptually subdivided into a firm's capacities to sense and shape opportunities, seize those opportunities, and reconfigure the firm's tangible and intangible assets. Scholars contend that the microprocesses within new ventures differ from those of incumbent firms because such processes are embodied in the entrepreneur and reflected in their actions and decisions (Corner – Wu 2011; Lanza – Passarelli 2013; Vohora et al. 2004). Zahra et al. (2006) add that entrepreneurial activities are important for the conception, development, configuration, and maintenance of DCs in both established organisations and new ventures. The concept of DMCs presented by Adner – Helfat (2003) provided a more granular understanding of DCs. DMCs reflect interactions between human capital, social capital, and managerial cognition (Adner – Helfat 2003; Helfat – Peteraf 2015; Razmdoost et al. 2020). In a small business context, DMCs transform entrepreneur's abilities into the organisational level and convert them into routines capable of implementing processes of innovation and change.

Thus, scholars have suggested that the DCs perspective represents a theoretical framework for understanding the process of new firm formation (Corner – Wu 2011; Newbert 2005; Wu 2007; Zahra et al. 2006). DCs can explain how new ventures create, discover, and exploit entrepreneurial opportunities in the search for the strategic matching of resources and market needs by means of using new technology (Jiao et al. 2013). Our study extends the DCs perspective to the small business management setting through the examination of blockchain innovation and commercialisation by entrepreneurial firms.

To sum up, we have integrated the literature on external enablers, blockchain technologies, and DCs to address the following questions: *How do entrepreneurial agents make use of the potential provided by external enablers? and What are the key microprocesses that are associated with integrating those enablers into developing new businesses?*

3. METHODOLOGY

To obtain insight into the uptake of blockchain technology in Hungary and the value this technology creates for organisations, we chose to engage with startup companies – namely, with innovative entrepreneurs who are developing blockchain-based solutions. Our sample consists of four firms derived from the financial services-, cryptocurrency trading and crypto asset management-, energy, information technology- and identity industries, working mainly in Hungary and abroad. This number of cases is enough to provide an accurate account in empirical research when the purpose of the latter is mainly explorative (Eisenhardt 1989). The main source of information was the semi-structured interviews which were conducted with the representatives of the selected companies (see Table 1). We sought to ensure similarity regarding the structure of each interview and the comparability of the corresponding results. All interviews were conducted online, and recorded and transcribed. They lasted between 75 and 100 minutes. To achieve the maximum variance and diversity, we selected cases associated with different combinations of sources, including companies' white papers and official websites, social media posts, press announcements, and other internet resources.

Data analysis started with constructing individual case stories through the lens of the research questions. The goal was to identify the main external enablers that triggered the formation of the firms under analysis and the microfoundations of the DCs associated with each case. Next, cross-case analysis was undertaken whereby patterns from each case were compared to patterns from other cases to develop consistency (Eisenhardt – Graebner 2007). As a result, the main external enablers and DCs in the new ventures could be defined, as discussed in the following sections. Note that the empirical results of this research should be interpreted in line with their limitations. As our data were self-reported by the key players from the selected firms, we complemented the interview data with additional secondary data. However, this cannot fully rule out informant bias.

Table 1. Overview of companies and data sources

FIRM INFORMATION (YEAR OF FOUNDATION, LOCATION, SIZE)	**SERVICES / PRODUCTS**	**PRIMARY DATA SOURCES**	**ADDITIONAL DATA SOURCES**
b-cube.ai *(R&D startup in AI and blockchain)*			
Acintya Global Holdings (parent company) 2017, France *b-cube.ai* 2018, France, Hungary	- Cryptocurrency trading bots - Educational courses, webinars, and consultancy	CEO interview, 100 mins White paper (2021, 50 pages)	Co-Founders (CEO, CTO, CMO) interviews with *ICOHOLDER*

Size: 12 employees Over $400 million worth of trading volume			
CoinCash Payments (*Fintech start-up specialising in cryptocurrency exchange*)			
2017, the UK, Hungary Size: 12 employees	- Online transfer services (buy or sell more than 50 cryptocurrencies for local currency) - ATM network (16 ATMs) with bi-directional functionality	CEO interview, 75 mins Blog articles	CEO interview with *Forbes Hungary* (November 2021)
Enerhash Data Centre Operator (*Energy tech company*)			
2019, Hungary Size: 20 employees	- Computer facilities management activities - Building data centres and renting out places inside them to power plants	CEO interview, 80 mins Articles about operations and key results (30 pages)	CEO interview for *Sesterce Group* on the topic of 'The European mining ecosystem' (July 2021) CEO and COO interviews given to *Kripto Akadémia* (August-September 2021) and to *Mandiner* (February 2022)
Internet of People (IOP) Ventures			
2018, 2 HQs: *IoP Ventures* (Budapest, Hungary) *IoP Divisions* (Karlsruhe, Germany) Size: 18 employees	- Building the IOP technology stack and related infrastructure - Cloud and support services	Product & Technical Coordinator interview, 80 mins White paper (2019, 42 pages)	Founder interview with *XT AMA channel* (June 2021), *SmartOptions.io* (November 2017), *LATOKEN* (2020)

4. FINDINGS

4.1. External enablers

Among the external enablers three enablers were identified: the unpredictable nature of blockchain technology development, the enabling mechanisms (i.e., characteristics) of the technology, and the ideology that boosts the emergence of new venture ideas (see Table 2).

Table 2. External enablers

MARKET VOLATILITY
Growing popularity of cryptoassets
b-cube.ai: *"From 2013, Erwan [CTO] started to pay Guruprasad [CEO] for yoga classes in Bitcoin. They started to get a lot of interest in cryptocurrencies and blockchain technology"* (White paper)
CoinCash: *"I just wanted to invest in Bitcoin. And it was a very painful process in 2016. There was no convenient player on the market"* (Interview with CEO)
Enerhash: *"At first I mined Bitcoin with an average mining machine in my apartment"* (Interview with CEO)
IOP: *"Maybe some of us remember the good old days in crypto, before the money craziness and all the institutions came in"* (Interview with CEO)
BLOCKCHAIN CHARACTERISTICS
Technological: Security, Efficiency, Trust, Immutability, Authentication, Faster speed **Strategic:** Transparency, Fraud

Economic: Reduced Cost
b-cube.ai: *"Our team is building a secure, efficient, and easy-to-use blockchain-based platform….If there was no smart contract, then there would be no trust between us to do business"* (Interview with CEO) CoinCash: *"We can carry out transactions with each other in an unalterable, irrevocable, and transparent manner"* (Interview with CEO) Enerhash: "*With blockchain you could transfer money immediately. With US dollars and euros, you need days.…It is completely transparent and much faster to make payments through cryptocurrency transactions"* (Interview with CEO) IOP: *"We ensure with the help of cryptography tied to timestamped proof on a blockchain that nobody can be de-platformed, or have their wallets frozen or identity eliminated"* (Interview with Core Developer)
Informational: Decentralisation, No intermediary
b-cube.ai: *"Feeling something unique in humankind's history was happening—a new way of transferring value, giving trust through decentralisation, bypassing banks and governments"* (White paper) CoinCash: *"With a smart contract you are able to lend or borrow a significant amount of money without intermediaries. I think the next big thing that will happen in blockchain and cryptocurrency will be decentralised finance"* (Interview with CEO) Enerhash: *"The banking system is so slow and not working well enough. I think we need a different type of payment structure"* (Interview with CEO) IOP: *"The reason why blockchain and cryptography were invented is to make people freer and change the power structure of the ownership of the data"* (Interview with CEO)
IDEOLOGY
b-cube.ai: *"Our ambition is to inaugurate a new financial industry era which is fair, transparent, and efficient"* (Interview with CTO) CoinCash: "*I really wanted to be part of that wave when we rebuild financial services*" (Interview with CEO) IOP: *"Many of our decisions are based on idealistic instincts…We always focus on how to make an impact on society"* (Interview with Core Developer) IOP: *"We want to make people freer and change who has the power over our data and how things work. We aim to build a real sharing economy"* (Interview with CEO)

Note: Quotations represent analytical codes.

4.1.1. Market volatility. The market hype around cryptocurrencies and their underlying blockchain technology triggered interest among the founders of the selected start-ups. As can be seen from the quotations in Table 2, all the founders were initially users of cryptocurrencies, the most well-known applications of blockchain. For instance, the founder of *IOP* bought his first Bitcoin as early as in 2011. *Enerhash*'s founder mined Bitcoin in his apartment. One of *b-cube.ai's* founders started to pay the other founder for yoga classes with Bitcoin, then they started to mine cryptocurrencies, and later invested these assets in a variety of ICOs. Most of those ICOs turned out to be scams, which is why the founders made it to their mission to help rid the crypto industry of scammers and began trading to compensate for their losses. *CoinCash's* co-founder wanted to invest in cryptocurrency before setting up the cryptocurrency exchange business. The growing popularity of digital assets and the technology behind them enabled diverse entrepreneurial endeavours – for instance, setting up cryptocurrency exchange businesses or consulting services.

4.1.2. Characteristics and functionalities of blockchain. The results of the qualitative analysis of interviews and additional sources revealed several key features of blockchain technology and its derivative innovations (e.g., cryptocurrencies and smart contracts), which the reviewed companies listed. In Table 2, we have categorised those features into technological, informational, strategic, and economic domains, as earlier suggested in the literature (Grover et al. 2019; Mnif et al. 2021). The findings show that the usefulness of blockchain is primarily perceived when it is used as an informational and technological instrument. These features of technology enabled the firms to solve different kinds of problems. Further, we have explained the specific purposes of using blockchain technology and other closely linked innovations by these firms. All the examined cases, supported by quotations extracted from the interviews, demonstrate how these companies utilise and test blockchain technology.

According to *b-cube.ai*'s CEO, blockchain technology is the basic building block of the business. The technology helped the company solve two main problems: one related to clients' lack of trust regarding sharing personal data; and another associated with improving transparency regarding the distribution of profits made from crypto trading. First, the company uses the blockchain application software for securely storing and encrypting the application program interface (API) key which is a code used to identify and authenticate a user. The application helps overcome clients' fear of sharing their unique IDs, as the company can only see encrypted API keys instead of the real keys. The CEO highlighted that *"this was a problem that we had now solved for some of the people who were scared of losing API keys."* Thus, instead of the company having custody of any funds, the use of the encrypted API key of the client helped the firm assure its clients that their money would not be taken away. Second, *b-cube.ai* created Ethereum-based smart contracts to be sure that the company would get a share of any profit. When a trade is completed, the smart contract automatically allocates 80% of the profits to the user, and 20% to *b-cube.ai*. Users can withdraw their funds at any time and *b-cube.ai* is authorised to withdraw its 20% of the profit. The CEO noted that smart contracts ensured accurate revenue-sharing and created trust between the company and their clients. The advantage of blockchain technology was emphasised by *b-cube.ai's* CEO: *"When there were no smart contracts, then there was no trust between us regarding doing business. But now it is possible because we have smart contracts. So, this is one of the biggest ways in which FinTech companies like us can benefit".* A similar opinion was expressed by *CoinCash's* CEO: *"With a smart contract you are able to lend or borrow a significant amount of money without intermediaries".*

This demonstrates that blockchain and its applications reduce the impact of opportunistic behaviour and behavioural uncertainty in transactional relationships and ensure greater transparency.

By ensuring the anonymity of transactions, cryptocurrencies create value that traditional currencies cannot. In comparison to bank transfers, cryptocurrencies allow donations to be made anonymously. To increase the spread and acceptance of cryptocurrencies and help the community, *CoinCash* undertook cryptoasset fundraising activities. The CEO of *CoinCash* explained: "*We believe that people can see that you can do a lot of good things with bitcoin and other cryptocurrencies; we wanted to show Hungarian people how you can help with Bitcoin".* In the case of *Enerhash,* due to its involvement in global operations, the firm uses cryptocurrencies to make payments quickly and avoid high overseas transaction fees. *Enerhash* benefits from higher transaction speed and lower transaction fees (Table 2). In our interview, *Enerhash's* CEO confirmed: *"We realised that cryptocurrency transactions are much faster"*. The *IOP*'s Core Developer stated that: *"Blockchain itself allows quite a lot of creative ways to build internal workflows for companies"*. He believes that *"decentralised solutions will come into the picture"* as companies and individuals seek to get rid of the centralised services provided by large corporations (e.g., Google and Facebook).

4.1.3. Ideology about social change. By using blockchain technologies, the interviewees want to reduce the power of a central authority and increase liberty and freedom for individuals. Their beliefs, which are related to the ownership of power in society, embody an ideology. Indeed, besides all the practical changes that blockchain-based solutions can offer in terms of the economy and businesses, blockchain has an ideological element (Huckle – White 2016).

Members of the management of the selected firms expressed both a negative assessment of current financial and banking systems and positive evaluations of systems that provide alternative future visions, including such systems based on cryptocurrencies, self-sovereignty, and decentralisation. The strongest intention to tackle social imbalances was manifested by the *IOP* company, which seeks to steer technological progress for people's benefit by reducing poverty, maximising freedom, protecting data, and enhancing security in relation to corporations and states. The *IOP*'s vision is to build a trusted, decentralised, global internet where everyone has control over their own data. Among the clients of *IOP* there are small and medium-sized enterprises that do not trust large technology companies (e.g., Facebook) which are

claimed to exploit user data. Blockchain is seen as an alternative to such organisations: "*There are mid-sized German companies that are frightened of using Google and Facebook… Big tech companies are not their friends, and as a result, decentralised solutions will come into the picture*" (Interview with Core Developer).

b-cube.ai and *CoinCash* aim at making the financial industry fairer, more transparent, and more efficient, which is believed to be possible with blockchain technology. Specifically, *b-cube.ai* aims at making trading in cryptocurrencies more transparent, secure, and automatic. The CTO of *b-cube.ai* explained the motive behind their project and the role of technology: *"Our mission is to bring efficient and innovative financial tools to the common man which were so far reserved for the super-rich. All this is possible thanks to the combined technology leap of blockchain, cryptocurrencies, and artificial intelligence (AI)"* (Interview with CTO). The CEO of *CoinCash* believe that the enthusiasts who are building a decentralised finance system are building a new world. The company's mission is to serve as a "gateway between traditional finance and the crypto economy" by transferring value between both worlds. One of *CoinCash*'s goals is to onboard more people to the new world.

Although the use of the technology and its application will not necessarily lead to social change, these advances can optimise many processes – for example, streamlining energy production (i.e., Enerhash). As an energy tech company, *Enerhash* acts as an intermediary between energy producers and blockchain server owners by taking part in load balancing. The firm's databox, which is a new form of technology for the energy industry, is an alternative to the energy storage units that help optimise the production of energy. Thus, the mission of *Enerhash* founders is to maximise the value of the excess capacity of energy producers and convert this into an additional source of revenue for clients.

4.2. The role of entrepreneurs in recognising and enacting external enablers

The properties of the external enabler cannot be activated by themselves, leading to venture formation. Entrepreneurs are at the forefront of blockchain-enabled firms. They were the first to learn about external enablers and to combine them into new venture ideas. The founders played a crucial role in the process of new venture formation, from the identification of new venture ideas and acquisition of resources to the establishment of their firms.

We found that the human capital (i.e., knowledge and skills) of the founders led to opportunity recognition and increased their confidence in terms of opportunity

evaluation. Regarding the backgrounds of the founders and co-founders, they were former founders of other start-ups (both founders of *b-cube.ai*, the CEOs of *CoinCash* and *IOP*, and the COO of *Enerhash*) and/or were employees or managers of large companies. For example, the CEO of *b-cube.ai* founded an investment management and advisory company at the age of 16 which became the most successful start-up and was profitably sold. The CEO had experience working for multinationals like Bosch as an industrial engineer and Morgan Stanley as an investment analyst. He was also an early investor in cryptocurrencies and an inventor of several unique strategies for successful trading and investing.

Further, the founders' social capital (i.e., social ties) enabled them to reach out to outside entities and establish strategic partnerships (e.g., *b-cube.ai* and *CentraleSupélec*), and to convince their former colleagues (e.g., *CoinCas*h) or relatives (e.g., *Enerhash*) to join them. For instance, the CTO of *b-cube.ai* graduated from the best French engineering university, which became the key partner in developing *b-cube.ai*'s project and products. The CEO of *Enerhash* persuaded his older brother, who had experience at building business models from scratch, to team up with him. Our findings demonstrate that founders' human and social capital (see Table 3) had a signalling effect on attracting financial and human resources and the external partners required for developing products and setting up a new venture.

Table 3. Characteristics of founders and key employees

FOUNDERS	PREVIOUS ENTREPRENEURIAL EXPERIENCE	EDUCATION	PREVIOUS WORK EXPERIENCE
b-cube.ai			
Co-founder & CEO	Yes	Bachelor of Engineering / Industrial Management	15+ years of experience in global equities and commodities as a fundamental and technical analyst (Bosch, Morgan Stanley)
Co-founder & CTO	Yes	Master of Engineering, Digital Engineering	15+ years of experience in software engineering
CoinCash Payments			
Co-founder & CEO	Yes	Bachelor of Business Studies, Master of Communication and Media Studies	20+ year multinational career (SONY Pictures, Telenor)
Founder & COO	No	N/A	5 years of experience in software development
Enerhash			
Founder & CEO	No	Bachelor of Business Administration and Management, Bachelor of International Administration	6+ years of experience as business analyst and gas wholesale expert (MET Group)

Co-founder & COO	Yes	Bachelor of Transportation Engineering	10+ years of experience in marketing, namely industrial marketing, management
IOP			
Founder & CEO	Yes	Electronic Engineering, Management	20+ years of experience in the IT field and FinTech sector
Product and Technical Coordinator, Core Developer	No	Master of Electrical and Electronics Engineering	20+ years of experience as a software engineer, lecturer

Founders managed to employ highly skilled employees and established a network of relationships thanks to their managerial cognition (i.e., beliefs and mental models). For example, the founder of *IOP* searches for smart people who share similar ideas. The founder talked about the team's commitment to the firm's ideas: *"My colleagues know what community is, and they live by the ideas of self-sovereignty and decentralisation. Everybody knows why they are part of the team and for what goal".* The *IOP* team is diverse; most of its employees have been working for many years in the IT field. One of the developers worked previously in a research lab at a Nokia company. The core developer is experienced at teaching programming and crypto; his expertise helps the firm to integrate young developers. Thus, through the entrepreneurs' knowledge and experience, their beliefs, and access to their network of relationships, they generated the firm's resources and capabilities that led to the formation of their firms.

4.3. Opportunity sensing and seizing

In this section we explain how the selected entrepreneurial firms incorporated and shaped the external enablers into new venture ideas. We found that the sensing capabilities of the entrepreneurial team helped them discover new opportunities and then address them through their seizing capabilities. We identified the key microfoundations of sensing and seizing activities (as presented in Table 4) which are most salient for nascent ventures. Despite the firms' young age, some traits of transforming activities at these companies were revealed in the form of the further development of their products, alteration of business models, restructuring from a movement to a company, or expansion of a range of services and projects.

Table 4. Sensing and seizing capabilities

Constructs	**Exemplar data**
Sensing activities	
Problem and opportunity	b-cube.ai: *"I worked for Morgan Stanley as an investment analyst and after that I was really thinking what I should do next as my venture. Then I came to Bitcoin. It was a*

identification	*little different from equities as it is so volatile"* (Interview with CEO) CoinCash: *"I had been following the technology of blockchain and Bitcoin for several years already when I decided to create my own start-up focusing on exchanging cryptocurrencies"* (Interview with COO) "*There was no convenient player on the market with which you could buy cryptocurrencies for Hungarian Forints*" (Interview with CEO) Enerhash: *"I was hedging options for electricity production, and I saw an opportunity regarding how to implement mining technology into the energy industry"* (Interview with CEO) IOP: *"I bought my first Bitcoin in 2011 and I have been involved in the blockchain industry since 2014"* (Interview with CEO)
Market analysis and technology monitoring	b-cube.ai: *"There is nothing like the 'best thing' in this business, the market always keeps changing. We always need different approaches"* (Interview with CEO) CoinCash: *"We are following all interesting developments regarding blockchain"* (Interview with CEO) Enerhash: *"I read a lot of articles and consultant stuff about blockchain"* (Interview with CEO) IOP: *"We are involved in monitoring news and innovations about blockchain start-ups. We check if there is something new that is worth adapting. Therefore, we have very deep knowledge about crypto space"* (Interview with CEO)
Research and development process	b-cube.ai: *"The university is exactly paired with the environment we belong to, and the ecosystem that provides us with a lot of infrastructure…"* (Interview with CEO) CoinCash: *"We did a lot of brainstorming, developed whatever we could and educated ourselves"* (Interview with CEO) Enerhash: *"I left my last job in 2018, after which I started working intensively on the idea of Enerhash. By mid-2019, every detail was crystallised"* (Interview with CEO) IOP: *"We have developed and advanced the decentralised technology stack over two years"* (Interview with CEO)
Seizing activities	
Creation of new products, processes, and business models	b-cube.ai: *"You pay only when you make a profit. There are no subscription fees, entry fees, exit fees or any management fees"* (White paper) CoinCash: *"We wanted to be a fully-fledged broker. We wanted to serve all possible ways where people can buy or sell cryptocurrencies"* (Interview with CEO) Enerhash: *"This is a trend in the energy sector – namely, the introduction of flexibility instruments. We are flexible with this, but with a unique, completely new solution"* (Interview with CEO) IOP: "*IOP removes the need for a central platform authority (e.g., Facebook). Cryptographically secured identifiers stored on blockchain allow users to control all aspects of their online identity*" (Interview with CEO)
Building customer base and establishing partnerships	b-cube.ai: *"Our customer base is mainly high net-worth investors. We make a monthly report for them and have face-to-face calls with our clients"* (Interview with CEO) CoinCash: *"Cryptocurrencies are still a short- or long-term investment vehicle for individuals"* (Interview with CEO) Enerhash: *"I made analyses and got in contact with 200 power plants. I sent emails, requests to talk"* (Interview with CEO) IOP: "*To secure the fast growth of the user base, we follow a highly scalable approach: We partner with universities*" (Interview with CEO)
Dissemination and legitimising work	b-cube.ai: *"We are willing to make a difference by delivering top-quality content that is most relevant for our community, and teaching our members"* (White paper) CoinCash: *"Starting a couple of years ago, you started to exchange your experience with others"* (Interview with CEO) CoinCash: *"We [Blockchain Working Group] are checking what the EU agenda is regarding blockchain and cryptocurrencies and what we can do or what the Hungarian government can do to facilitate this area to grow faster"* (Interview with CEO) Enerhash: *"I have already published articles on LinkedIn. I have another article about why it is good for a power plant to buy a container and implement it into production"* (Interview with CEO) Enerhash: *"When leading companies start treating data centres as an additional type of investment beside energy storage units, it will become an industry standard and a prerequisite of competitiveness"* (Website) IOP: *"This time the conference was semi-public, in an open-house environment. It*

	was not widely advertised, but people who heard about the conference were invited to join the sessions and mingle with the developers and ask questions" (Interview with CEO)

Note: Quotations that represent analytical codes.

4.3.1. Sensing activities. According to our findings, the sensing activities are made up of three primary categories:

4.3.1.1. Problem and opportunity identification. The identification of problems and opportunities presented by external enablers is mainly associated with the entrepreneurs. Their knowledge and professional experience have enabled them to identify the problems in the industries they worked in and to offer innovative solutions. The deep knowledge of trading, business, technology, and cryptocurrency mining and trading activities of *b-cube.ai's* founders allowed them to sense the potential of cryptocurrencies and blockchain technology as a new way of transferring value as well as the necessity of building transparency and trust in the crypto asset management industry. First, the founders registered the company *Acintya Global Holdings* in France and offered consulting services and e-commerce activities. Later, the *b-cube.ai* project was born out of this company to overcome challenges in the asset management industry – namely, non-transparent dealing, low returns, and fraud.

The founders of *CoinCash* sensed the potential of the evolving cryptocurrency market and the need for setting up a convenient and trusted cryptocurrency exchange company. The CEO explained how the opportunity of entering the cryptocurrency market was sensed: "*I realised that blockchain is doing much more than just revolutionising financial services, but it has lots of opportunities which one will have to discover in the forthcoming decade. I wanted to invest in Bitcoin, but it was a very painful process in 2016: there was no convenient player on the market with which you could buy Bitcoin or any other cryptocurrencies for Hungarian Forints. So, easy, convenient, and understandable services are needed on the market, and that is how the idea of CoinCash came up".*

Having experience both in the energy industry and Bitcoin mining, the founder of *Enerhash* sensed the opportunity of implementing cryptocurrency mining technology into the energy industry and creating benefits for both sides – power plants and cryptocurrency miners. Before starting to offer innovative solutions to the challenges of the energy sector and miners, the CEO of *Enerhash* worked as an energy trader in Switzerland and then Hungary, in parallel becoming interested in Bitcoin mining. This experience led him to understand how blockchain technologies work and can be used in the energy industry. As described by the CEO: *"I was hedging options for electricity*

production, and I saw an opportunity regarding how to implement mining technology into the energy industry because we could provide a fixed-price takeover option and a hedging option for gas deliveries and electricity prices".

Following his education as computer science expert, the founder of *IOP* studied electronic engineering. Subsequently, he attended Maastricht University to study knowledge engineering, cognitive psychology, and AI. At the end of his studies, the founder decided to establish an IT service company. In 2015, he wrote a thesis that defined a vision of a decentralised company. He identified problems related to users' privacy of information and sensed the potential of blockchain technology for digital identity management. The founder sketched out all necessary technological components and began to implement these with a team.

4.3.1.2. Market analysis and technology monitoring. All the companies we have discussed operate in emerging fields and thoroughly monitor the markets and their competitors to adopt best practices in their industries. They constantly tracked the developments of the blockchain world. The CEO of *CoinCash* noted: "*We want to be up to date with all of the news which is happening in blockchain and cryptocurrency ecosystem*". *IOP* has been monitoring the news and innovations in the blockchain industry since 2015. The accumulation of deep knowledge about the crypto space enables the *IOP* team to provide consulting services to other companies.

4.3.1.3. Research and development process. Before introducing the products, the selected firms invested a lot of time and effort into their development. Cooperation with universities and an incubator (*b-cube.ai*), legal and tax advisors (*CoinCash*), power plants (*Enerhash*) and another project of the founder (*IOP*) as well as the receipt of investment support facilitated the creation of the firms' offerings. In case of *b-cube.ai*, the collaboration with the university allowed the founders to obtain access to the required resources and infrastructure and helped in the development of *b-cube.ai's* technology, giving the project a better scientific grounding. The CEO of *b-cube.ai* said: *"We contacted the quantitative analysis lab and a mathematician whom we now have on our advisory team".* In October 2018, the founders started *b-cube.ai* as a research and development project in partnership with *CentraleSupélec*, a French graduate engineering school of Paris-Saclay University, of which the CTO is an alumnus. Later, it was also incubated at K&H StartIT (Hungary), as the CEO moved to Hungary where he continued developing the *b-cube.ai* project of their parent company. As a result, *b-cube.ai* developed a crypto-trading bot platform for trading cryptocurrencies.

Since its founding, *CoinCash* has striven to be a transparent and reliable tax-paying company; however, nobody was able to advise them on how to properly set up the company in Hungary due to the absence of laws and regulations related to blockchain and cryptocurrencies. As there was no legislation or regulation related to the crypto field in 2016, the company had to build its services in a very uncertain area. *CoinCash* managed to reach out to the UK's legal and tax advisors and get recommendations on how to build up their startup and comply with the regulations. London's good reputation for its fintech ecosystem and ongoing communication with local regulators were conducive to incorporating the *CoinCash* start-up in the UK. Transparency and compliance with regulations were extremely important to the company. It sought to engage with regulators through consultation with many legal advisors regarding how to set up the companies and how to comply with legislation and tax rules.

To develop the product (i.e., data centre) and the whole system, the founder of *Enerhash* left his job to work intensively on his ideas. He explained: *"I started working on the product first and developing the whole system. Then my brother joined me, and we had the first investment round that enabled us to build and test a prototype of a data centre and to work with power plants".* The research and development phase of the *IOP* project (the development of the technology stack), took over two years, then the team could present it to market. Within the framework of the *Libertaria* project, the founder and its team conducted research and developed protocols, networks, the backend, and standards.

4.3.2. Seizing activities. The seizing activities include the following three processes:

4.3.2.1. Creation of new products, processes, and business models. The firms seized the opportunities induced by blockchain via the creation of their products, processes, and business models. For example, *Enerhash*'s founder started developing the prototype of the mobile data centre, *IOP* built the open-source technology stack, and *b-cube.ai* developed the crypto trading bot platform after two years of product development work. *CoinCash* enables customers both to purchase and sell cryptocurrencies for local currency. The business model of *CoinCash* is centred around the commission fees it charges per transaction made online or via ATM. To build transparent and accountable services for its clients, *CoinCash* invented its own know-your-customer (KYC) procedures based on regulation and cryptocurrency best practices by asking for a picture ID, proof of source and address, selfie, and the like. The

company investigated international players (e.g., *Coinbase* and *Kraken*) to build its own system. As a result, when the related Hungarian legislation came into force, the company quickly adapted to KYC and anti-money laundering (AML) policies because they were already doing nearly everything that the new regulation required them to do. *Enerhash* is a pioneer locally and globally in connecting decentralised data centres to power generators. Server owners use the capacity of the server to execute high-performance computing operations based on blockchain networks. Power plants benefit from a predictable base load and a stable source of income. *IOP* believes that the centralised approach to personal data and the business practices of the centralised giants (e.g., Uber, Facebook, and Amazon) can be changed with a totally new business model which benefits both users and businesses. The CEO noted: *"We cannot fight the current system without working alternatives".* The company is building a modular technology stack that is expected to create a restructured version of the internet, whereby data is decentralised among users instead of being centralised on the platform they use.

4.3.2.2. Building a customer base and establishing partnerships. We found that all companies had managed to build relationships in new markets. *b-cube.ai* developed its offering in partnership with a French university that had the necessary infrastructure, researchers, and environment. While building its databoxes, *Enerhash* started to collaborate with power plants and work on mutual projects with them. The case of *Enerhash* demonstrates how the firm helped its clients (i.e., energy companies) to optimise their process development capabilities by adopting new technologies and applying them to preexisting processes. The *IOP* company partnered with a university in Mexico to develop a customised application for this organisation. *CoinCash* cooperated with its main competitor, *MrCoin*, and other companies to implement a fundraising project and later it acquired rival *MrCoin*.

In terms of customers, the primary focus of *b-cube.ai* is individual cryptocurrency traders. The firm seeks to reach broader markets and address newcomers due to its educational content and a community of over 9,000 people on social media. The company has received acknowledgment from various French and Hungarian organisations and won several awards for its innovations. The project received funding from *Block.IS*, a European-Union-funded blockchain acceleration program. This recognition adds a certain sense of respectability to *b-cube.ai's* operations. The target audience of *CoinCash* are experts and individuals who consider cryptocurrency to be a short- or long-term investment. The firm has managed to become a visible player on the

market. With its motto “Bitcoin made simple” and the largest bitcoin ATM network, *CoinCash* positions itself as the most trusted brand in terms of cryptocurrency exchange in Hungary. In the case of *Enerhash,* the founders first had to win the trust of power plants, as what they are doing is a new type of business in the energy industry. As the CEO noted: *“The energy sector is very traditional – people do not want big changes. If you want to convince investors, you need to prove that power plants are interested”.* The CEO had to get in contact with numerous power plants, arrange meetings with the power plants interested in implementing Bitcoin mining in their production, and explain the model to them. *Enerhash* has expanded its network of clients by cooperating with a variety of electricity companies from several countries. In an interview with the *Sesterce Group,* the CEO specified: *“We are present in New Zealand, Australia, Slovakia, and Bulgaria, and we are currently working on a project in Sweden as well. The goal is to work anywhere where we can offer a good solution to the power industry”.* In the case of *IOP*, partnerships with universities enable *IOP* to secure the fast growth of the user base. Each partner university can add several tens of thousands of users simultaneously, which makes it easy to develop a large user base.

***4.3.2.3. Dissemination and legitimising work*.** Due to the novelty of blockchain technology and blockchain-enabled services and products, all the companies analysed here were involved in disseminating knowledge about this technology and their respective markets. The management of the selected firms frequently give media interviews (e.g., *Forbes Hungary, Kripto Akadémia*), participate in conferences (e.g., *Blockchaineum conference, Blockchain Budapest*), and publish articles containing explanations of their business activities. The *b-cube.ai* company created the *BCUBE Academy* by providing training and sharing articles and news related to cryptocurrency trading. *IOP* organised the blockchain and crypto conferences in Berlin and Budapest. In the early stages, the *IOP* company represented a movement or DAO with its network of ambassadors from around 80 countries, the involvement of which pushed forward *IOP*’s development. Currently, the broad network of the *IOP* community is spread around the world and the firm keeps distributing its ideas about *IOP*’s decentralised solutions for identity management and its open-source technology through its growing community on social media. Additionally, formal (e.g., *Blockchain Working Group*) and informal groups (e.g., *Blokklánc Műhely/Blockchain Workshop*) have been created to facilitate blockchain development. The industry participants meet occasionally and exchange their experiences regarding the industry and discuss what happens at the

international level and how they should develop. The sharing of expertise and opinions about further developments in the blockchain industry and establishing strategic alliances with incumbents contribute to legitimising blockchain-enabled offerings and enhancing the credibility of the technology.

5. DISCUSSION

To answer the question how new ventures utilise the potential of external enablers, we first identified three main external enablers (Table 2) of new venture ideas in the context of blockchain-based firms. The combination of those actor-independent factors – namely, the growing popularity of cryptocurrencies associated with the underlying blockchain technology, the characteristics of the technology itself, and ideology – triggered the formation of new venture ideas. The major function of the discussed enablers was to entice potential entrepreneurs to create new ventures.

The rapid development of this technology together with ideology and market volatility were found to be the reason why the founders of the discussed companies discovered the potential applications and started building blockchain-based offerings which addressed different customer problems. The emergence of technology was not enough to ensure the successful development of the company, as this was mainly supported by the founders' activities and capacities. Our results reflect those of prior studies (Corner – Wu 2011; Newbert 2005; Zahra et al. 2006) that have also noted the important role of the entrepreneur in a firm's DCs. Those capabilities reside in individuals and/or small entrepreneurial teams at the early stages of firm formation. We observed that the DMCs of the entrepreneurial actors (i.e., entrepreneurs) played a decisive role in activating these external enablers. Further, we examined activities that constitute the shaping of external enablers and new venture ideas by applying the DCs framework. We identified the key microfoundations or microprocesses of sensing and seizing activities (Table 4) which are most salient for integrating the enablers into new business ideas and subsequent venture formation. To explain the relationship between external enablers, entrepreneurs and their activities, and new venture ideas, we developed the model in Figure 1. Our model demonstrates the combination of external enablers, DMCs, and sensing and seizing capabilities that led to the formation and development of new ventures.

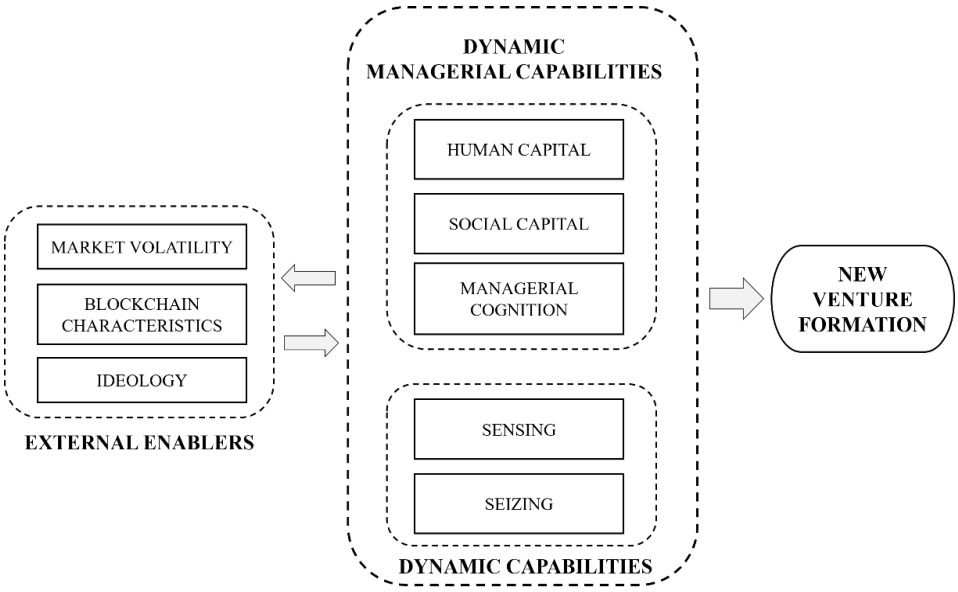

Fig.1 Model of external enablers, capabilities, and new venture formation

We contend that a single constituent of external enablers is not sufficient to explain venture formation, as investigated in a prior study (von Briel et al. 2018), and we address the authors' call to study the role of multiple enablers in shaping new venture ideas. Based on our analysis of the selected blockchain-enabled firms, we have contributed to external enabler theory (Davidsson et al. 2020) by examining the microfoundational work carried out by entrepreneurs and entrepreneurial teams within these companies. By applying the DMCs perspective (Adner – Helfat 2003), we explained how and why entrepreneurs learn about enablers and manage to integrate multiple enablers into new venture ideas. The analysis of founders' DMCs helped with understanding how entrepreneurs creatively identified and realised the potential mechanisms of external enablers in a variety of ways throughout the venture-creation process. Thus, we incorporated an actor-dependent view of external enablers into external enabler theory (Chalmers et al. 2021; Davidsson et al. 2020). Although the enablers are conceptualised as objective and actor-independent, we observed that the actors themselves actively contributed to the development of the enablers they aimed to activate.

Further, we extended the DCs perspective to the new entrepreneurial firms and addressed the gap in the research about the role of DCs in entrepreneurial settings, especially in their founding and development stages (Corner – Wu 2011; Jiao et al. 2013; Newbert 2005; Razmdoost et al. 2020; Wu 2007; Zahra et al. 2006). Our study elucidates the role of DCs in new venture formation by specifying these capabilities' nature and function. The sensing and seizing activities of the selected firms were instrumental for discovering the external enablers, shaping them into new business

ideas, offerings, and products, and their subsequent legitimisation. Due to the novelty of the technology, its controversial nature, and the dynamic environment a high level of both sensing and seizing capabilities was necessary for the formation of new ventures. Our investigated blockchain-enabled firms managed to establish partnerships with incumbents through cooperative methods such as personal contacts or strategic alliances between firms. Allying with universities and established companies helped new firms to access complementary resources and capabilities and signalled the latter's ability to develop valuable products, enhance their legitimacy, and attract customers. This finding supports previous research results (Stuart et al. 1999) about the benefits of cooperation with incumbents for young firms, which can reinforce the latter's market position. In line with the findings of Zahra – George (2002), we confirm that the network linkages embedded in new ventures' entrepreneurial teams also facilitated successful internationalisation processes.

The technology of blockchain as a new phenomenon offers many new areas for research (Seebacher et al. 2021). Scholars have agreed on its significance for future applications (Iansiti – Lakhani 2017; Kher et al. 2020). One of the objectives of this study was to explain how value could be created and captured through the incorporation of blockchain and how to build more secure and efficient blockchain-enabled products and services. For example, *Enerhash* has found a solution to addressing the problem of the high electricity consumption of the cryptocurrency mining industry (Chang et al. 2020). This is a win-win situation for energy producers and miners, as *Enerhash*'s data centres consume the excess capacity of power plants and make the production of renewable energy more efficient. Another objective of this study was to explain the role of ideology in the formation of entrepreneurial discourses and practices (Chalmers et al. 2021). Thus, we have attempted to understand the formation of blockchain-enabled ventures by combining the theory of external enablers, DCs and DMCs perspectives. Our results are in line with the view of Teece (2007) that entrepreneurship is about sensing and understanding opportunities and getting things started. Having specific knowledge, the participants we interviewed proved their ability to recognise, sense, and interpret information about external enablers and to shape them into new venture ideas. Due to the small sample size in our study, caution must be applied as the findings might not reflect all firms' capabilities. More study of the current topic is therefore recommended, and research can be undertaken to investigate the impact of the business environment on the DCs of new ventures. The conditions under which the external enablers might foster entrepreneurship should be also explored.

6. CONCLUSION

The paper shed light on the role of multiple external enablers in the formation of new ventures. First, we elaborated the enabling mechanisms of blockchain technology that has arisen as a new class of information technology infrastructure with numerous applications. Second, in terms of managerial implications, we indicated that entrepreneurs and entrepreneurial teams play a key role in shaping external enablers and developing the DCs of new ventures. The properties of the technology and its rapid development allowed the entrepreneurs at the discussed case companies to sense such opportunities, resulting in innovative offerings and business models and the shaping of emerging market demand for blockchain-based applications. Besides the creation of products/services, the firms seized these opportunities due to their observation and adoption of best practices, and the internationalisation and establishment of relations with different stakeholders.

Our results will be of interest to companies that are considering the implementation of blockchain technology, and to individuals who have identified areas where incorporating blockchain will help solve problems. We advise established companies to cooperate with blockchain start-ups in order to boost their DCs by utilising their expertise in fast-evolving blockchain and related DLTs. The study has important implications for managers regarding how their organisations can deal with a high degree of environmental uncertainty and ensuing challenges. A company's DCs and founders' DMCs should be considered relevant factors in any assessment of the quality of start-up companies. The outcomes of our research should be useful for policymakers, as a deeper understanding of the origins and evolution of companies' capabilities may assist in predicting likely business responses to policy changes. Policymakers should increase the sophistication of legal regulations to strengthen those fields which belong to the high value-added ICT services branch of diversified economies, with the option of better safeguarding them during downturns.

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6.4. Chapter 4. Blockchain technology and the evolution of dynamic capabilities in early-stage ventures

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Abstract

As new ventures scale, they must build dynamic capabilities that enable them to strategically match their resources with changing market demands. However, it is not clear how young firms develop dynamic capabilities and how emerging technologies can facilitate the evolution of their capabilities. In this study, we investigate how blockchain technologies enhance the dynamic capabilities of early-stage, high-tech ventures. Through an exploratory research design based on case studies of five blockchain-enabled companies, we study the impact of blockchain on the micro-level actions that constitute the processes of dynamic capability development. We find that the integration of blockchain encourages the practices necessary for capability development in early-stage firms and identify eight underlying micro-level processes involved in sensing, seizing, and reconfiguring capabilities. The insights from our study generate several propositions and a conceptual model that can guide future research and enhance the use and value of blockchain as a facilitator of organisational dynamic capabilities.

Keywords: case study method, dynamic capability theory, microfoundations, start-ups.

1. Introduction

Studies of new technology adoption have predominantly concentrated on large corporations, with limited attention given to small, early-stage businesses (Eggers & Park, 2018; Stranieri et al., 2021). However, in many contexts, the startup sector is one of the most rapidly expanding segments and young companies hold a crucial position due to their linkages with larger, established enterprises and their integral role in supply chains (Jamieson et al., 2012). New technologies have made it easier for early-stage firms to expand their customer base beyond their local contexts and have brought about transformative changes in emerging companies. New technologies have also levelled the playing field, enabling early-stage ventures to compete globally, innovate efficiently, and develop sustainable operations (Aspelund et al., 2005; Nambisan, 2017).

The significance of blockchain technologies (hereafter “blockchain”) for organisations is increasingly recognised (Goldsby & Hanisch, 2023; Murray et al., 2021). Blockchain is gaining particular traction as an emerging technology that can enhance young firms (Sreenivasan & Suresh, 2023). Blockchain is beneficial to early-stage ventures because its characteristics can create several advantages and opportunities. Ventures may benefit from the unique features of blockchain technology, such as traceability, transparency, immutability, tamper-proofness, security, automation, and disintermediation (Hasan et al., 2020; Yli-Huumo et al., 2016), which spur new organisational dynamics and promote sustainability (Friedman & Ormiston, 2022). For instance, the distinctive features of blockchain enable the integration of small

companies into the value chains of larger organisations as well as provide opportunities for the development of new firms that can disrupt established market leaders (Chalmers et al., 2021; Koh et al., 2020; Morkunas et al., 2019; Wan et al., 2022). Blockchain technology can also provide early-stage firms with the ability to identify and pursue opportunities through the creation of new customer segments. Blockchain can increase customer value by enabling access to previously unavailable products and markets (Chen, 2018; Larios-Hernandez, 2017). In addition, blockchain technology can facilitate peer-to-peer exchange of resources and allow direct transactions of digital assets (Morkunas et al., 2019). As an illustration, smart contracts, based on automated decision-making, reduce the impact of asymmetric information, which can boost organisational effectiveness (Hasan et al., 2020).

Despite the benefits of blockchain for early-stage ventures, there is limited research focused on the long-term effects of blockchain applications and the technology's temporal and contextual dynamics as young organisations evolve (Holm et al., 2020). The existing research on blockchain technology has predominantly concentrated on large corporations, particularly within the scope of established supply chains (Koh et al., 2020; Kumar et al., 2022; Pattanayak et al., 2023). However, the effects of blockchain vary by industry and the life cycle of organisations and are highly influenced by the context in which the technology is deployed. In this study, which focuses on early-stage firms, we endeavour to address the gap in innovation research pertaining to the managerial aspects of blockchain's implications, particularly in early-stage ventures. Our aim is to explore the effects of blockchain on early-stage companies' capabilities and development. To do so, we adopt an exploratory qualitative research design and utilise the case study approach (Yin, 2014) to address two closely related questions:

1) *How do early-stage firms leverage blockchain technology to support their activities in dynamic and uncertain environments?*
2) *What effect does blockchain have on early-stage firms' dynamic capabilities in generating business value?*

In pursuing these questions, we expand upon the growing body of research on the microfoundations of dynamic capabilities (Teece, 2007), delving into the underlying processes through which blockchain technologies are harnessed to facilitate the development of value-enhancing capabilities and solutions within startup operations. By analysing five case studies within the context of Hungarian early-stage blockchain-based ventures, we investigate how these companies employ and evolve blockchain

technology to facilitate their dynamic capabilities, which encompass sensing, seizing, and transforming capacities undergirded by their microfoundations. The microfoundations of dynamic capabilities refer to the individual- and group-level processes and actions that collectively contribute to a firm's ability to sense, seize, and transform opportunities in a rapidly evolving business landscape (Eisenhardt et al., 2010; Teece, 2007). In the context of early-stage firms, these microfoundations play a vital role in shaping how dynamic capabilities are nurtured and leveraged. The ability to develop dynamic capabilities provides a source of competitive advantage.

Through our analysis, we find that the main reason for the adoption of blockchain technology in early-stage firms was to enhance reliability, secure the long-term viability of companies' products, and enhance their position within a specific market segment. The case studies provide evidence that blockchain serves as an effective tool for advancing the sensing and seizing capabilities of young organisations and enabling their continued transformation.

Overall, our findings generate three contributions to research on blockchain, innovation management, and the microfoundations of dynamic capabilities. First, we address a critical omission in innovation research by shedding light on the underexplored managerial dynamics and implications of adopting blockchain technology. Second, our work advances scholarly understanding of the complex relationships between emerging technologies and organisations (Bailey et al., 2019; Steininger, 2018) through our demonstration of the long-term impacts of blockchain implementation in early-stage entrepreneurial firms across various sectors. Finally, we explain the role of blockchain in facilitating sensing, seizing, and reconfiguring dynamic capabilities, which provides insights into the role of blockchain at the operational level of early-stage ventures facing resource constraints.

The paper is organised as follows: First, we establish the conceptual foundations for our study by reviewing the relevant literature on blockchain technology and dynamic capabilities theory. In our review, we highlight the open opportunities in the literature that our study seeks to address. Next, we describe our methodology and how our data was collected and analysed. We then present the key findings. Through data analysis, several propositions are developed, alongside a conceptual framework, for future research endeavours. Finally, we unpack the contributions of our findings to research on the interaction between technology adoption and dynamic capabilities in young entrepreneurial firms and the implications of our research for practitioners creating and managing early-stage ventures.

2. Literature review and conceptual background

2.1. Blockchain adoption in the context of early-stage firms

The use of blockchain technologies in entrepreneurial processes and practices is the focus of a nascent, but growing, stream of research (Chalmers et al., 2021; Kher et al., 2020; Park et al., 2020). Early-stage businesses are often the ones to invent blockchain-based applications (Tönnissen et al., 2020). Young firms are increasingly present in the nascent blockchain ecosystem (Fiedler & Sandner, 2017; Ozcan & Unalan, 2022) and play an important role in new markets, which large companies often overlook or lack the capabilities to participate in. Yet, early-stage, blockchain-driven firms face distinct uncertainties about the efficiency of their products and operations and their fitness for the emerging blockchain market (Hite & Hesterly, 2001).

Blockchain provides new opportunities for creating and capturing value and developing marketable products (Ardito et al., 2020; Chalmers et al., 2021). Blockchain is one of the elements of the ongoing digital transformation and can help entrepreneurs to sense previously unidentified opportunities, seize those opportunities through modification of business processes, and improve the positioning of companies in a given market niche (Baiyere et al., 2020; Pérez-Sánchez et al., 2021). As a novel external enabler (Davidson et al., 2018), blockchain fosters the pursuit of entrepreneurial opportunities by allowing companies to create new market niches, applications, and customers (Chen, 2018; Franco et al., 2009; Larios-Hernandez, 2017).

Blockchain is an innovative blend of existing technologies, namely distributed databases and cryptography. Since the publication of the Bitcoin white paper (Nakamoto, 2008), blockchain technology has demonstrated several advantages and multiple areas of applicability (Larios-Hernández, 2017; Zhan et al., 2023). The benefits of blockchain, which include time and cost savings and increased trustworthiness and security in transactions, have caused a growing number of organisations to implement the technology (Rakshit et al., 2022). Blockchain is portrayed as a new form of technological infrastructure governing a wide range of transactions (Lumineau et al., 2021) and enabling innovations in a variety of business models and industries (Ilbiz & Durst, 2019; Ozcan & Unalan, 2022). Blockchain's wide range of applications originates from two specific features—machine-based automation and decentralised consensus—which enable such functionalities as the traceability of records, transparency, tamper-proofness, information immutability, reliability, autonomous enforcement of agreements, and disintermediation (Lumineau et al., 2021; Yli-Huumo et al., 2016). Two of the most common blockchain uses are cryptocurrencies and smart

contracts. The latter, which is based on if-then logic, are self-executing programmes containing the terms of an agreement between parties and allowing trusted transactions to be carried out among the anonymous parties (Vacca et al., 2021).

These features of blockchain can boost the efficiency of startup operations and diminish the risk of failure by promoting sustainable practices (Friedman & Ormiston, 2022; Sreenivasan & Suresh, 2023). In a fast-paced and ever-evolving business landscape, blockchain has the potential to enhance a firm's ability to sense and seize new opportunities and transform the company (Pattanayak et al., 2023). Although early studies focused on blockchain and entrepreneurship have made important strides, the use of blockchain technology and how it is applied to create value for early-stage ventures has not been thoroughly studied and there is a limited empirical and theoretical work on the topic to guide scholars or practitioners (Frizzo-Barker et al., 2020; Treiblmaier, 2019). As a result, extant research has not been able to demonstrate how blockchain technology affects the dynamic capabilities of young organisations. This creates a challenge for scholars (and entrepreneurs) as the paucity of research on the impact of blockchain technologies on early-stage companies and their capabilities could potentially result in overlooked growth opportunities for various market participants and contribute to an innovation deficit (Potts, 2009) in early-stage ventures.

2.2. Dynamic capabilities and microfoundations

Dynamic capabilities theory, as a cornerstone of strategic management, is a conceptual framework that helps to explain how firms establish a competitive advantage (Enkel & Sagmeister, 2020; Sapienza et al., 2006) through the discovery of business opportunities and the ability to strategically match resources with market demands and create new products and processes (Eisenhardt & Martin, 2000; Franco et al., 2009; Helfat & Peteraf, 2003; Jiao et al., 2013; Teece et al., 1997; Teece, 2007). Although most research on dynamic capabilities has focused on the strategic management of mature firms, entrepreneurship research can also inform capability development because entrepreneurship can be conceptualised as a process that involves cultivating the capabilities necessary to iteratively sense, seize, and test opportunities and adapt business models by redefining strategies and reconfiguring resources to create successful ventures (Corner & Wu, 2011; Ma et al., 2015; Wood & McKinley, 2010; Wu, 2007). Several studies have suggested that a dynamic capability approach is useful for identifying the factors that affect the development of entrepreneurial firms as this

theory places more emphasis on processes and activities (i.e., how resources are used) rather than resource availability (Adam et al., 2018; Ambrosini & Bowman, 2009; Buccieri et al., 2021; Ma et al., 2020).

Dynamic capabilities are analytically disaggregated into sensing, seizing, and transformational capacities (Teece, 2007). Sensing includes the identification and assessment of opportunities and threats through scanning and search across markets and technologies, by learning, filtering, and interpreting activities. Sensing entails the discovery of opportunities as well as the conceptualisation of new resource combinations and business strategies to capitalise on them (Teece, 2018). Seizing involves the mobilisation of resources to address opportunities and pursue them by investing in the development and commercialisation of activities. Transforming involves continuous renewal of existing business models and strategies (Teece, 2007). Acknowledging the temporal nature of industries and markets, organisations are more inclined to engage in strategic renewal activities involving dynamic capabilities to maintain their competitiveness.

The microfoundations of dynamic capabilities focus on the specific actions and processes of individuals and teams within the organisation as they build and creatively recombine capabilities (Eisenhardt et al., 2010; Teece, 2007; Winter, 2003). Building on Conboy et al. (2019) and Mikalef et al. (2021), we offer definitions for each facet of dynamic capabilities along with the associated processes and value creation outcomes in the context of early-stage firms (see Table 1). The microfoundations (Teece, 2007) of dynamic capabilities are the causal mechanisms that explain how capabilities are formed and lead to sustained enterprise performance and competitiveness (Salvato & Vassalo, 2017).

Table 1

Dynamic capabilities and underlying processes in early-stage firms.

	Sensing	**Seizing**	**Reconfiguring**	**Reference**
Definition	The identification and assessment of opportunities and threats	The mobilisation of resources to address an opportunity and to capture value from doing so	The maintenance of competitiveness through enhancing, combining, protecting, and reconfiguring the enterprise's intangible and tangible assets	Teece, 2007
Underlying processes	- Scanning and monitoring - Learning and interpretive activities - Assessing	- Designing mechanisms to capture value - Building competencies - Selecting partners and distribution channels - Forming alliances and	- Knowledge-sharing and integrating procedures - Renewing the business model and	Jiao et al., 2013; Katkalo et al., 2010; Teece, 2007; Wilden et al.,

	customer needs - Understanding latent demand and the structural evolution of industries and markets	joint ventures	strategy continuously	2013; Zahra et al., 2006
Value creation in the context of early-stage businesses	Determining entry timing	Transforming ideas and information into innovative products, services, and processes	Firm survival and renewal	Katkalo et al., 2010; Newbert, 2005; Sapienza et al., 2006; Teece, 2007

2.3. Enhancing dynamic capabilities through blockchain

Earlier studies provide evidence to support that new technologies improve internal operations, increase agility in market positioning, and reinforce organisations' dynamic capabilities (Mikalef & Pateli, 2017; Parida et al., 2016; Steininger et al., 2022). Emerging technologies have generated new theoretical opportunities for microfoundations research (Conboy et al., 2019; Mikalef et al., 2021). Conboy et al. (2019), for instance, identified business analytics-enabled microfoundations of dynamic capabilities, while Mikalef et al. (2021) identified the AI-specific microfoundations of dynamic capabilities for marketing operations.

Blockchain technology can enhance sensing, seizing, and reconfiguring capabilities (Pattanayak et al., 2023). Quayson et al. (2023) confirmed the effectiveness of building blockchain-driven sensing, seizing, and reconfiguring capabilities for circular supply chain development. In addition, in a study of the financial implications of blockchain technology in supply chains, Gupta and colleagues (2023) put forward the idea that blockchain can enhance and cultivate dynamic technological capabilities. According to these researchers, blockchain is now playing a more robust role in seizing opportunities (Gupta et al., 2023). These effects of blockchain are ascribed to its inherent ability to verify transactions and record all alterations in a transparent manner that is visible to all network participants.

The majority of available studies which embrace the impact of blockchain on dynamic capabilities have been conducted in supply chain management and focus on mature firms (Gupta et al., 2023; Meier et al., 2023; Pattanayak et al., 2023; Quayson et al., 2023). However, it is not clear how blockchain's distinctive features impact dynamic capabilities and the microfoundations that undergird these capabilities, particularly in the context of early-stage firms. Prior research states that the strategic use of technologies positively impacts capability development (Conboy et al., 2019;

Mikalef et al., 2021). This observation resonates with a recent call in the literature to understand how the rapid advancement of emerging technologies gives rise to entrepreneurial opportunities (Bailey et al., 2019; Nambisan, 2017; Steininger, 2018) and explore the role of technologies in activating dynamic capabilities (Cetindamar et al., 2009; Conboy et al., 2019; Franco et al., 2009; Parida et al., 2016; Steininger et al., 2022).

Given the lack of systematic evidence on the microfoundations supporting the dynamic capabilities (Chen et al., 2023; Kay et al., 2018), we explore how blockchain can facilitate the microfoundational processes (Helfat & Peteraf, 2003; Teece, 2007) underlying the sensing, seizing, and transforming activities that constitute the temporal process of dynamic capability development in early-stage technology-based firms.

3. Methodology

3.1. Research design

Given the exploratory nature of our work, we adopted a partially-inductive approach based on qualitative data (cf. Graebner et al., 2012). Inductive approaches are appropriate when extant theoretical and empirical knowledge of a phenomenon is limited, and often utilise context-rich data to develop and extend theoretical models and drive a field's progress (Eisenhardt & Graebner, 2007; Siggelkow, 2007). The flexibility, granularity, and richness of qualitative data makes it especially well-suited for teasing apart the complex processes that are involved in dynamic capability development (Graebner et al., 2012; Ozcan & Gurses, 2018). We used the multiple case study method, in which several cases are jointly analysed (Yin, 2014). The case method is appropriate for our research because it allows for the examination of processes "at a fine-grained level" of contextual detail (Ozcan et al., 2017: 93) and focuses on temporal questions "examining how and why things emerge, develop, grow, or terminate over time" (Langley et al., 2013: 1). Recent studies suggest that the case study methodology is particularly suitable for identifying the factors that lead entrepreneurial businesses to embrace blockchain technology, the functions this technology performs, and the processes of capability emergence in new ventures (Kouhizadeh et al., 2019; Treiblmaier, 2019).

In pursuing our research questions, we took the analytical approach of "theory elaboration" which involves researchers using preexisting conceptual ideas and/or a preliminary, a priori, model to inform the study's design (Eisenhardt, 1989; Lee et al.,

1999). Theory elaboration refines theories so that they more accurately explain empirical observations. With theory elaboration, researchers analyse and assess how data collected from an empirical setting fit with an existing theory and evaluate how aspects of the theory can be adapted and advanced.

3.2. Setting

Our context and research setting are early-stage ventures in Hungary. Hungary, along with other Central and Eastern European (CEE) countries, is an under-researched and unexplored context with a burgeoning entrepreneurial ecosystem (Müller, 2022). The blockchain-enabled businesses selected as case studies are a component of Hungary's information and communication technology (ICT) industry. Hungarian entrepreneurs are creating a growing number of ICT businesses, in part, because of the country's investments in STEM education (e.g., Budapest University of Technology and Economics, Eötvös Lóránd University) and its deep technical talent pool. In recent years, there has been substantial growth in Hungarian startups in the blockchain industry. The large number of entrepreneurs and innovative ventures specialising in blockchain technologies is exemplified by Blockchain Landscape Hungary (cf. Kalocsai & Kalocsai, 2019). The health of the blockchain ecosystem in the country makes the Hungarian setting a context well-suited for researching dynamic capability development in blockchain start-ups.

3.3. Case identification, data collection, and analysis

Data collection took place from January 2020 to January 2023. To identify early-stage blockchain ventures, we began by collecting venture information from publicly available sources, such as the Blockchain Hungary Association and the "B-Day" conference. We considered the following criteria in selecting ventures for our case studies. First, the firms had to offer advanced blockchain-based services and products. We also sought ventures from different industries to increase variation within the sample. Finally, in alignment with our focus on early-stage ventures and to track the learning processes and development of their dynamic capabilities from venture inception, we selected businesses that were less than three years of age at the time of the first interview (Kay et al., 2018).

We initially selected seven early-stage ventures as case studies (see Appendix A). However, as we indicated, blockchain-based initiatives have a significant failure rate. Two of the seven initial ventures whose founders were the subjects of our

interviews discontinued their business. In contrast, five ventures demonstrated stable growth and/or generated profits and, thus, were the subjects of our study (see Table 2).

Table 2
Description of the case firms.

Firm / Founding year	Offerings	No. of founders	No. of staff	Initial financing
Firm A 2018	producing microgreens, edible flowers, herbs, and leafy greens for chefs and local specialty stores, R&D in service and on demand	2	7	2 angel investors, 1 venture capital €100,000
Firm B 2019	building and connecting mobile data centres, which provide fixed consumption and extra flexibility, to power plants	2	20	angel investor $500,000
Firm C 2019	web and mobile application development, system integrations, front-end/back-end and blockchain-based services, digital document solution	3	8	angel investor €350,000
Firm D 2018	innovative parametric microinsurance products: ski & flight delay insurance, 2 products are coming: weather insurance and catastrophe insurance	3	7	venture capital $1.31 million
Firm E 2018	healthcare trading platform where tissue banks are linked to healthcare professionals (manufacturers, hospitals, and universities), consultancy services, developing tissue banking related courses and blockchain specialised training programme for the universities	2	4	angel investors HUF 200 million (approx. over $700,000)

The information about the ventures selected as case studies was collected in parallel and by combining three sources: interviews, archival data, and direct observation. First, we conducted semi-structured interviews with the founders/co-founders of blockchain startups operating in the following industries: urban farming, energy, insurance, health, information technology and services, and finance. In addition to these interviews, to further our immersion in the setting and better understand the background of the Hungarian blockchain-related ecosystem, we conducted complementary interviews with a professor teaching a blockchain course at the leading technological university, a technical team from the largest Hungarian bank, and the President and Vice-President of Blockchain Hungary Association. The Association is a particularly important player in the ecosystem because its mission is to contribute to enhancing cooperation and knowledge transfer among established and startup blockchain firms. The interviews lasted between 40 and 108 minutes. All participants confirmed their consent prior to the interviews. The interviews were audio- and video-recorded and transcribed, resulting in approximately 24 hours of audio files that were

integrated with our secondary data, described below (see Appendix A, "The key respondents and organisations included in the sample"). In total, 20 interviews were conducted with 18 respondents: 13 interviews in the first phase (April 2020-June 2021) and 7 interviews in the second phase (July 2022-January 2023). The longitudinal nature of the data strengthens internal validity and allows for tracking changes in responses (and organisational processes) over time (Stremersch et al., 2022).

The questions for interviews were aggregated into three main groups, corresponding to the major sections of the interview protocol, including (1) the background of the interviewee and the creation of the venture, (2) the key activities of the venture, and (3) the implementation and effect of blockchain technology (see Appendix B, "Interview protocol"). In prior research, it has been noted that high-tech entrepreneurs fear expropriation of the firm's knowledge (Deeds et al., 1997). Thus, conducting multiple rounds of interviews was critical for increasing entrepreneurs' willingness to disclose critical information. During the first round of the interviews, the entrepreneurs were more hesitant to disclose details of the firms' technology and operations. However, in the second round, the interviewees were more open and willing to share information.

Interviews were supplemented with archival materials derived from white papers, presentations, firms' websites, YouTube interviews, media articles, and news sources. We also reviewed the blog posts, comments, tweets, likes, endorsements, tags, shares, photographs, and videos generated from entrepreneurs' activities on social media channels, such as LinkedIn, Twitter, Facebook, and Instagram. The observation of entrepreneurs' and their ventures' social media accounts allowed us to track their development, personal networks, and perceptions by other stakeholders (e.g., other startup founders, managers of established companies, customers). These sources helped us capture the dynamics of events occurring with the companies under study. Finally, the interviews and archival materials were supported by direct observations at the offices of one of the cases and by observing founders discussing their entrepreneurial journeys in an educational setting.

We conducted thematic analysis on the collected data (Miles et al., 2014) using ATLAS.ti, a qualitative research software program, to assist in the process. To improve the rigour of our coding process, we employed pre-defined codes based on Table 1. In the first step, we examined patterns and differences in respondents' descriptions of how blockchain enabled startup operations and capability development. We then linked related concepts within each case and connected them to emergent themes. While we

had some guiding theoretical concepts, we allowed other patterns to emerge from the primary data. Finally, we connected emergent themes and concepts with existing literature, using an iterative approach to explore and explain our findings.

4. Empirical evidence

First, we elucidate how the fledgling companies turned to blockchain to facilitate and augment various facets of their operations (see Section 4.1). The impact of blockchain technology on each venture's sensing, seizing, and transforming capabilities is then discussed in Section 4.2.

4.1. Employing blockchain to enhance startup operations

Consistent with our research questions, we analysed the influence of implementing blockchain technology on startup operations across the five case studies. Our findings indicate that integrating blockchain into the operations of startups has allowed the firms to gain a competitive advantage. Specifically, this integration has enhanced efficiency, transparency, and trust in their business processes, while also streamlining operations such as payment, contracting, and claim settlement processes.

The primary reasons for blockchain adoption are its ability to securely verify, monitor, and share transactions using transparent and encrypted records. The interviewed blockchain-driven start-ups employed blockchain infrastructure for the purpose of increasing reliability and ensuring the sustainability of their offerings, as well as improving their positioning in a given market niche. The technology contributes to improving customer trust and experience, which are intrinsically linked to the product as a component of user value. The activities of Firms A, C, and D, whose core operations are facilitated by blockchain, are the most representative of these findings.

Firm A addressed the transparency issue in agricultural firms' information by utilising blockchain's immutability feature. This strategy aimed to promote trust through transparent organisational activities. The founders of Firm A used blockchain for certifying and validating data about the production, harvesting, and delivery of produce. The firm collects environmental data and gives its produce to labs to assess the quality of the food. The company then posts this data on blockchain. Because of the validation and tracing characteristics of blockchain, the company can offer trustworthy and verified data about its growth conditions (or "recipes") to its customers.

The technology of blockchain and its applications are also an inherent part of Firm C's and Firm D's operations as they enable the creation of digital products and help to make those products futureproof. Firm C implemented blockchain in the digitisation of contracts due to the technology's ability to retain data in a permanent and immutable way based on decentralised consensus. The CEO of Firm C stated:

> We created the concept of storing not just document hashes but real documents on the [blockchain] ledger.

Firm C's platform allows its users to create and sign binding contracts and register them on the company's ledger. Firm C manages the complete contracting process, starting with document generation, for micro legal deals involving individuals (e.g., bills of sale, loan agreements, rental agreements, and the like). Following document generation, Firm C's platform handles all digital interactions between the parties, resulting in a legally executed, digitally signed, and compliant business agreement. The company's mobile application allows its users to create and sign binding contracts and register them on its ledger blockchain. The digital signature of the mobile application enables legally compliant paperless contracting, while blockchain allows immutable storage and decentralised verification of contracts. Blockchain technology acts as a medium to record and certify the contract in a trustless manner. It adds another layer of security by cryptographically encrypting the users' data, ensuring the confidentiality of deals, and creating tamper-proof contracts.

Firm D offers parametric insurances, non-traditional insurance products with pre-specified payouts based upon a predefined trigger event. Firm D processes a variety of data streams (weather, flight, ski lift operation, natural disaster, IoT/agro, and medical) from third-party providers; this data is in turn constantly monitored by its systems. The company stores the received insurance parameters in smart contracts saved on its private blockchain network, which ensures that the insurance information is secure and unalterable. The smart contracts can be made publicly available for authorised parties (e.g., Firm D's clients or insurers). This feature of blockchain ensures transparency by enabling those parties to verify the recorded information at any time. Based on the collection of code and data, smart contracts check the state of insurance damage events. In the case of a trigger event, the claim can be settled if the conditions are met, and a notification is automatically sent to the insurer to execute a payout. The assessment of the insured event is executed automatically after the cancellation or delay

of an event (e.g., an airline flight). The compensation process is simplified, both for the insurance company and for customers. The CEO remarked:

> I find this period very exciting for the insurance market. New solutions respond to new customer needs, resulting in a faster, easier claim settlement process and providing wider insurance coverage.

In the case of Firm E, blockchain proved instrumental in identifying a niche solution for the medical tissue market. The goal of the company was to improve cross-border tissue flow within the European Union member states by involving all the interested actors in the tissue market to increase the available supply and quality as well as to make scientific and clinical data accessible. As a result, Firm E built a "one-stop-shop" business model for the tissue industry. To accomplish this, Firm E implemented the distributed ledger to check the authenticity of the IDs and track transactions of tissues. Blockchain addresses the issues of transparency, trust, and immutability in the tissue industry and boosts the credibility of the firm's products and services. The CEO noted:

> The technology we bring to the market is basically blockchain for registering transactions and ensuring the authenticity of identities.

Lastly, Firm B realised the potential of energy-intensive blockchain technology and cryptocurrency mining in optimising power plant production. Firm B built a new business model by selling data centres, which convert the electricity produced by surplus generation into computing capacity, to energy companies and renting out these facilities to crypto miners and other companies that require large amounts of computing power and electricity. The company integrates the data centres with hardware equipment in the power plants to do the bitcoin mining and other complex artificial intelligence tasks. From a value chain perspective, blockchain enables Firm B to add a new value dimension for its customers. The high-tech computing data centres installed directly at power plants consume excess energy, especially solar, hydro, and wind power. In addition, Firm B is working with a wide range of international companies from three continents, and the use of cryptocurrencies is a rapid and effective way to make and receive its payments. The CEO specified:

> We are working in many countries; when we make a deal, we need to close it within a second, and it is fast and cheap to pay with cryptocurrency.

Table 3 presents the types of blockchain technologies deployed by each firm as well as the impact they had on their operations. The discussed companies' fundamental activities for creating value depend on blockchain technologies, with blockchain being

integral to their final products. Grounded on these findings, we posit the following proposition:

Proposition 1. *Integrating blockchain technologies influences the operations of early-stage companies.*

Table 3
Blockchain technologies used and their impact on startup operations.

Firms	Blockchain and its applications	Impact on startup operations
Firm A	Public blockchain	Transparent organisational activities: certification and validation of data about its products' growth conditions.
Firm B	Blockchain servers/hardware Cryptocurrencies	An innovative value offering: optimisation solution for leveraging power plants' unexploited capacity. Execution of global operations: enabling swift payments and streamlining transaction processing.
Firm C	Public blockchain	Simplification and automation of the legal contracting process: the immutable storage and decentralised verification of contracts.
Firm D	Private blockchain Smart contracts	Simplification and automation of the insurance claim and settlement process. Smart contracts ensure transparency and security in recording the details of compensation conditions.
Firm E	Blockchain (type is undisclosed)	Registering and tracing transactions, ensuring the credibility of the firm's products and services.

4.2. Blockchain-driven dynamic capabilities

The discussed early-stage firms leveraged blockchain technology to address customer needs, develop innovative business models, enhance the credibility of their products and services, and solidify their competitive position. The respondents highlighted three primary areas of activities where blockchain-based solutions strengthened their firms, aligning with the fundamental dimensions of dynamic capabilities.

First, the adoption of blockchain allowed the case firms to identify unmet customer needs and emerging market demands. Second, the respondents noted that blockchain enabled more efficient decision-making processes, enhanced customer relationships, and improved collaborative capabilities within their firms. Third, the respondents discussed the potential impact of blockchain on developing new services and solutions, transforming their own and their customers' internal operations, and providing new avenues for revenue generation. These findings suggest the following proposition:

Proposition 2. *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced dynamic capabilities.*

Employing the framework of dynamic capabilities theory, we discerned and juxtaposed key capabilities and their underlying microfoundational elements within each case. This process aimed to deepen our understanding of the firms' dynamic capabilities enhanced by blockchain technology and to gather evidence supporting the respective sub-propositions. Table 4 offers a concise overview of the cross-case analysis for each firm, followed by an exploration of the microfoundations that constitute these dynamic capabilities. We now consider the insights that can be gained by looking across cases for recurring patterns.

Table 4

Observed dynamic capabilities and related microfoundations of the case companies.

CAPABILITIES & MICROFOUNDATIONS EXPLANATION OF BLOCKCHAIN IMPACT	**CASE FIRMS**	**SUPPORTING DETAILS** (REPRESENTATIVE QUOTES FROM INTERVIEWS/ARCHIVAL DATA)
SENSING		
Unveiling inefficiencies in business processes Blockchain provides firms with the capability to recognise the inefficiencies in their current operational processes and reduce information asymmetry by sharing more credible and secure data.	Firm A (x) Firm B (x) Firm C (x) Firm D (x) Firm E (x)	*"Transparency and mission are that none of the agricultural firms are willing to hand out this inner information because it is a huge value for them"* (Interview, Firm A) "*Banking system is so slow and not working enough. We need a different type of payment structure*" (Interview, Firm B) "*I worked as a natural gas wholesale expert, when the idea came that data centres installed next to power plants could provide an alternative coverage option*" (Interview, Firm B) *"Business is growing across borders. I think it is powerful to have a database which is credible anywhere in the world"* (Archival source, Firm C) *"People expect personalised offers with transparent processes, where their interaction with the product is completely digital. The answer to these expectations is the introduction of parametric and micro insurances that are betting on people's fear of missing out on fun and adventure"* (Archival source, Firm D) *"Information asymmetry is huge in the medical field…a lack of transparent tracking system"* (Interview, Firm E)
Identifying customer needs Blockchain provides firms with the capability to identify customers' needs for new products and processes.	Firm A (x) Firm B (x) Firm C (x) Firm D (x) Firm E (x)	*"If greenhouses want to buy the environmental data ('recipes'), it is a really expensive thing to buy because it is the core information that they can use every growth cycle and we need to validate it"* (Interview, Firm A) *"Cryptography could be used for energy regulation"* (Archival source, Firm B) *"I started thinking about the automation and digitisation of mindless logistics wrapped around the process of contracting"* (Interview, Firm C) *"New solutions respond to new customer needs, result in a faster, easier claim settlement process. Smart contracts can help ensure that the fulfilment of insurance conditions can be easily monitored"* (Archival source, Firm D) *"A need to decrease administrative burden of the dental and medical professionals because this is a huge burden for them. And the tissues must be traced"* (Archival source, Firm E)
Understanding latent demand and the structural evolution of industries and markets	Firm A (x) Firm B (x) Firm C (x) Firm D (x)	*"How we are disrupting is that we are willing to be more transparent than anyone else. With transparency, maybe others can use our data to start, and they can build the first product or service much faster"* (Interview, Firm A) *"We realised that the power plants' unexploited capacity has*

Blockchain provides firms with the capability to discover niche solution that exploit the unique characteristics of blockchain.	Firm E (x)	*good potential for Bitcoin mining and blockchain"* (Interview, Firm B) *"Small value everyday contracts, such as sale, rent, loan or dealings with handymen, are rarely and poorly documented. These deals deserve proper attention, and we provide with a tool for easily but properly concluding these agreements"* (Interview, Firm C) *"Turning insurance products into an innovative, appealing customer experience. Customers became more critical and sensitive when it comes to choosing a product"* (Interview, Firm D) *"We realised that what the tissue industry is missing is transparency, trust, and immutability. It was a strategic match"* (Interview, Firm E)
SEIZING		
Designing mechanisms to capture value Blockchain provides an additional level of security for seizing activities and increases the transparency of business models.	Firm A (x) Firm B (x) Firm C (x) Firm D (x) Firm E (x)	*"We use public blockchain because that is the hardest to change. We are choosing our technology based on the promise that it cannot be changed after it is injected. We are using blockchain to validate this type of data that we harvested"* (Interview, Firm A) *"We operate globally, and we need to make payments very quickly and the transaction fees are very high. Cryptocurrencies take a few minutes, and it is completely transparent"* (Interview, Firm B) *"Blockchain serves as a medium to record and certify a contract in a trustless manner. The data is cryptographically encrypted, so your deal remains confidential"* (Interview, Firm C) *"We develop the private Ethereum network. We deploy the information in smart contract which can help us in the automatisation, transparency, and security"* (Interview, Firm D) *"The main function of blockchain, in our cases, is registering transactions and making sure the IDs are not fake"* (Interview, Firm E)
Enhancing customer relationships Blockchain enhances customer engagements by introducing transparency, trust, security, and simplification into various processes such as purchasing, insurance, and contracting.	Firm A (x) Firm B (x) Firm C (x) Firm D (x) Firm E (x)	*"We gather and validate data with our partner (i.e., a software development firm) not only for ourselves but also for our customers, who can check whether the data is real and was not falsified. The customers can be sure that we do not manually insert more yields or reduce costs. They will be able to test the data and be sure that it is based on hard proof"* (Interview, Firm A) *"We are working in many countries and sometimes we make a deal, and you need to close it within a second and when we are pushing assets or server equipment, for example, then it is easy to pay with any crypto"* (Interview, Firm B) *"We enable people to use basic contracting capabilities"* (Interview, Firm C) *"We use blockchain and smart contracts to simplify the compensation process in case of cancellation of travel insurance and airplane flights"* (Interview, Firm D) *"We are linking together European tissue establishments for improving the cross-border tissue flow to increase the available supply and quality"* (Archival source, Firm E)
Developing partnering and collaborative capabilities Blockchain enables firms to access new opportunities for collaboration and harness partners' resources.	Firm A (x) Firm B (x) Firm C (x) Firm D (x) Firm E (x)	*"We provide validated data for others and help them to start their own production, growing, and gardening"* (Interview, Firm A) *"We are currently working in Sweden, New Zealand, Argentina and the United States to launch the first data centres"* (Interview, Firm B) *"Our blockchain infrastructure is easy to integrate into any business or organisation which issues important digital*

		document" (Interview, Firm C) *"Together with our partner, we developed blockchain-based insurance. The partner's goal was not to generate profit but to innovate"* (Interview, Firm D) *"We were able to sign contracts with 5 universities in 6 months. And our focus was to help them with the tissue banks"* (Interview, Firm E)
RECONFIGURING		
Renewing the business model and strategic approach and expanding the customer base Blockchain enables the capability to find new customers and reconfigure internal processes for managing operational knowledge.	Firm A (x) Firm B (x) Firm C (x) Firm D (x) Firm E (x)	*"We changed our focus...we became more like a data and R&D marketplace and R&D network company than like a traditional grower"* (Interview, Firm A) *"We are restructuring actually the whole companies because we are working in more multinational scale"* (Interview, Firm B) *"We make an investment to green the model of power plants"* (Archival source, Firm B) *"We plan to enter into B2B partnerships, whereby companies or organisations will be offered with the possibility of technology implementation for mass registration of certificates"* (Archival source, Firm C) *"To have another insurer that comes from abroad who wants to integrate this solution to their portfolio. We plan to create other parametric-based insurance solutions"* (Interview, Firm D) *"The current situation of the tissue industry is outdated, and the market is huge. Hungarian universities and hospitals, you can imagine, they do not have access to the cutting-edge technologies"* (Interview, Firm E)
Knowledge-sharing and integrating procedures Blockchain improves businesses' capabilities to share knowledge and information through the authentication and verification of data, documents, and digital assets.	Firm A (x) Firm B (-) Firm C (x) Firm D (x) Firm E (x)	*"Other farmers can reproduce our findings themselves if they want to check if the data is real. This is the real value of using blockchain"* (Interview, Firm A) *"Assisting and educating people of properly documenting even their micro legal dealings based on blockchain consensus model"* (Archival source, Firm C) *"Innovative product, it can be easily integrated to the insurance portfolio, and it is fully automated"* (Interview, Firm D) *"Synthesising different data storing and processing solutions in place. They are valid exclusively for tracking the movement of tissues. With DLT technology this can easily be solved without handling or keeping the sensible information"* (Archival source, Firm E)

Note:
(x) - this specific microfoundation is found in the case firm,
(-) - no supporting details are available. However, it is uncertain whether the case firm possesses this microfoundation.

4.2.1. Blockchain-driven sensing capabilities

We found that the sensing capabilities of the observed firms were enhanced through blockchain technology. Blockchain, complemented by its unique technical features and applications, enabled entrepreneurs to detect the inefficiencies in their existing operations, sense areas where technology could be implemented to improve processes and create new products, and capitalise on market opportunities. For instance, using blockchain, Firm E found a solution that created a niche market in the tissue sector. The CEO of Firm E noted:

> Information asymmetry is huge in the medical field. We realised that what the tissue industry is missing is transparency, trust, and immutability. It was a strategic match.

In the case of Firm B, high energy-intensive blockchain mining operations were found to provide a solution for addressing inefficiencies in the allocation of surplus power resources. The company leveraged blockchain technology to offer innovative services to energy companies and promote sustainable business practices. The CEO remarked:

> I recognised that blockchain and innovations in the digital sector would bring important paradigm shifts for the energy sector.

The similarity between the other four firms—Firms A, C, D, and E—is that blockchain provides firms with enhanced capabilities for trust because of verification mechanisms, immutability, and information transparency. This capability was explained by the managing director of Firm A:

> None of the agricultural firms are willing to hand out inner information because it is of huge value to them. [We can] disrupt this by sharing such information that is certified and validated on the blockchain technology and [be] more transparent than anyone else.

Sensing capabilities driven by blockchain enabled the companies to recognise underserved needs and emerging demand areas. The companies were able to stand out and build reliable startup operations across urban farming, energy, insurance, health, information technology and services sectors. We derive the following proposition from these findings:

Proposition 2(a). *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced sensing capabilities.*

In addition, our findings provide reinforcing evidence to support prior studies (Ma et al., 2015) demonstrating that the dynamic capability of sensing opportunities is shaped by entrepreneur's industry experience and interests in blockchain technologies (see Appendix C, "Description of entrepreneurial background"). The business opportunities sensed by entrepreneurs were tied directly to founders' network through the deliberate search for industrial fields where blockchain technologies can be utilised and/or the founders' education and employment in the industry where they discovered the structural problems that can be solved by blockchain implementation (i.e., Firms B, C, D, and E). The founder of Firm B, as an example, had worked as an energy trader for several years. He has been interested in cryptocurrencies and other innovations in the

digital sector and has discovered how to meet the immense energy demand of cryptocurrency miners and data centres. The founder explained:

> I started my career as an energy trader. I was dealing with natural gas. That was the time when I realised how this technology works... I saw the opportunity in how we could implement this type of mining technology into the energy industry.

In other cases, entrepreneurs, along with their colleagues from existing professional networks, originally founded blockchain-related agencies and consultancy firms where they researched blockchain technology and provided consulting and teaching services, and then, in parallel, developed the observed start-ups (i.e., Firms C, D, and E). For example, Firm D was founded in 2018 when a group of financial experts developed the demo version of a blockchain-enabled product for automating insurance. Earlier, the members of this group had started to be actively involved in the activities of nonprofit and for-profit consulting companies, specialised in the blockchain industry and development of blockchain-based projects. Firm E was founded in 2018 as a response to the research and sensing activities of a consultancy agency that identified blockchain potential in the health sector. The CEO of Firm E recalled:

> We started researching blockchain at Mensa International and the Mensa Hungarian Association. We start with everything, from bitcoin mining to the potential of the technology. We started to share knowledge within this small group, teach what we knew, and share our knowledge outside of the association, and that is why we first established the consulting company, where we found a gap in the health industry.

The founders' background and active engagement in researching the blockchain field played a crucial role in shaping how blockchain impacted the microfoundations of sensing capabilities within the discussed firms.

4.2.2. Blockchain-driven seizing capabilities

In the examined companies, seizing capabilities were driven by blockchain technology. Specifically, firms leveraged the technology's strengths in automation, transparency, security, and trust to pursue opportunities based on more informed and efficient decision-making processes. The technology verifies the authenticity of transactions, adding an extra layer of security to seizing actions. Blockchain also helped to strengthen innovative business models by guaranteeing the credibility of the case firms' products and services and by making their business models more transparent. This transparency ensures that data is trustworthy and tamper-resistant, which is critical for making informed decisions. For example, the managing director of Firm A explained:

> We use the public blockchain because it is the hardest to change. We are choosing our technology based on the promise that the data cannot be changed after it is injected.

Blockchain's effect on the seizing capabilities of startups lies in its ability to automate processes through smart contracts. Such contracts automatically trigger actions when predetermined conditions are met without the need for intermediaries. This automation speeds up decision implementation. This can be seen in the case of Firm D, which deploys a smart contract on a blockchain network to create automated claim settlement and payout processes and, as a result, improves customer relationships in the insurance process. As Firm D's CEO described:

> Customers became more critical when it came to choosing a product. They expect personalised offers with transparent processes, where their interaction with the product is completely digital. Insurance administration becomes an automatic, fast, cheap, transparent, and convenient process with the use of blockchain.

Blockchain was found to enhance collaborative capabilities of the observed early-stage firms by enabling them to be seen as an attractive partner for collaboration in strategic relationships. Explaining its partnership with a large public life insurance company, the co-founder of Firm D noted:

> They wanted to appear as an innovative insurance company, and if someone asks why you are making this claim, they can show that they have blockchain-based ski insurance.

In the case of Firm C, the technology facilitates customers' contracting capabilities. As the CEO put it:

> We enable people to use basic contracting capabilities. We store and certify legal contracts on blockchain and assist individuals with their microdeals.

Our findings indicate that blockchain acts as a facilitator, enhancing the reliability of firms' primary value-creation activities and boosting operational efficiency. Blockchain features enable firms to fulfil client expectations and build trust with their customers and partners. The use of technology in the studied firms has helped to increase clients' awareness of their goods and services. The analysis of the data also reveals that blockchain allows the observed businesses to demonstrate their dedication to sustainable practices and provide verifiable evidence. Hence, we propose:

Proposition 2(b). *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced seizing capabilities.*

4.2.3. Blockchain-driven reconfiguring capabilities

We found that reconfiguring capabilities driven by blockchain provide the observed companies with the tools to adapt to changing circumstances, optimise processes, and renew their business models. All of the cases used blockchain to either renew firms' strategies and product portfolios (e.g., Firms B, C, and D) or transform business models and internal processes (Firms A and E). The evidence of blockchain-driven reconfiguration capabilities can be clearly seen in the case of Firm C, which has been developing new strategies for engaging new customer segments. The company is renewing its offerings and targeting new customers by creating software-as-a-service products for institutional clients (e.g., educational institutions). Organisations will be offered the possibility of implementing technology for mass registration of certificates due to blockchain's immediate and tamper-proof validation feature. The CEO explained:

> Educational institutions are a very important target for us. [With the new service] You would be able to immediately prove the authenticity of your college degree in any part of the world.

The effectiveness of blockchain in enabling transformation has been exemplified in the case of Firm A. The company has transformed its business model and become a data research company and R&D marketplace that helps other greenhouses and indoor farms reduce their go-to-market costs. Utilising the blockchain verification feature, Firm A's model has evolved to provide data about the growing conditions and input parameters for plants. The managing director noted:

> We are able to gather our data and validate it with our partner through blockchain. The customers will be able to test the data and be sure that it is based on hard proof and that it is what it says.

Due to blockchain's decentralised and immutable nature, over time, the firms transformed their existing knowledge and information sharing capabilities by providing a single, unalterable source of truth to verify the authenticity of data, documents, and digital assets. These findings lead to the following proposition:

Proposition 2(c). *Integrating blockchain into the operations of early-stage organisations can lead to improvements in their competitive position through enhanced transforming capabilities.*

5. Discussion

The organisational implications of blockchain technology have recently become the subject of a growing stream of research, which has focused on understanding blockchain's impact on business practices (Frizzo-Barker et al., 2020; Tönnissen et al., 2020) and business models (Morkunas et al., 2019; Weking et al., 2020), its effect on entrepreneurship and innovation (Chalmers et al., 2021; Chen, 2018; Larios-Hernández, 2017), and its influence on enterprises' dynamic capabilities (Gupta et al., 2023; Meier et al., 2023; Pattanayak et al., 2023; Quayson et al., 2023). Dynamic capabilities are crucial for the functioning of businesses (Newbert, 2005; Zahra et al., 2006), their entry into new markets, and their survival, particularly in global markets (Buccieri et al., 2021; Rakshit et al., 2022; Sapienza et al., 2006). However, prior research has paid little attention to the processes involved in capability development in the context of young firms (Zahra et al., 2006). In addition, although prior studies have examined the relationship between technology and dynamic capabilities (Conboy et al., 2019; Gupta et al., 2023; Mikalef & Pateli, 2017; Parida et al., 2016; Pattanayak et al., 2023; Quayson et al., 2023), research has not considered the impact of blockchain technologies in the context of early-stage ventures.

To address this critical omission in the understanding of blockchain, early-stage ventures, and dynamic capabilities theory, and to answer our first research question (*how do early-stage firms leverage blockchain technology to support their activities in dynamic and uncertain environments?*), we first identified the function of blockchain at the operational level within early-stage ventures. We show that the utilisation of blockchain technologies can promote capability-development in young firms. The implications of blockchain for the firms we studied add to the body of knowledge on blockchain-related entrepreneurship research (Chalmers et al., 2021; Ilbiz & Durst, 2019; Morkunas et al., 2019; Park et al., 2020; Weking et al., 2020) by disclosing why entrepreneurial firms use blockchain technology and its specific functions in the ventures' value chains.

Providing a response to our second research question (*what effect does blockchain have on early-stage firms' dynamic capabilities in generating business value?*), we advance research on the impact of technologies on processes (or foundations) leading to the development of dynamic capabilities (Cetindamar et al., 2009; Conboy et al., 2019; Franco et al., 2009; Mikalef & Pateli, 2017; Parida et al., 2016). In our study, we identified the underlying micro-level processes through which

blockchain can enable the sensing, seizing, and reconfiguring capacities that comprise the dynamic capabilities of early-stage firms.

Table 4 introduces blockchain-driven dynamic capabilities and the underlying micro-level processes that enabled the blockchain-driven ventures to survive, achieve legitimacy, and benefit from innovation. Three microfoundations that constitute the sensing capability were found among the cases: *blockchain-driven recognition of inefficiencies in the incumbents' business processes, identification of customer needs for sustainable products,* and *discovery of latent demand and niche solutions.* Rather than necessarily threatening existing industry incumbents (Chalmers et al., 2021; Frizzo-Barker et al., 2020), we found that firms used blockchain to create new technological solutions that were complementary to incumbent offerings. For example, blockchain applications enabled companies to offer new revenue opportunities and efficient operating methods to large established players, particularly in the energy and insurance sectors (e.g., Firms B and D). Consistent with the findings of Aspelund et al. (2005) and Koh et al. (2020), our study affirms that blockchain as a strategic tool empowers technology entrepreneurs with limited resources to sense new opportunities, generate income from the narrow resource bases they manage, and open up new markets.

Further, Table 4 summarises that the blockchain-driven seizing capability consists of three microfoundations: *designing mechanisms to capture value*, *enhancing customer relationships*, and *developing partnering and collaborative capabilities*. Transparency, immutability, automation, and security were the key technical characteristics of blockchain that assisted these firms in ensuring the authenticity and safety of their own and their customers' data and executing operations automatically. Morkunas et al.'s (2019) argument is supported by the examples of Firms B, C, and D, which show that the use of smart contracts and cryptocurrencies provides secure, faster, and more cost-effective transactions than those carried out using traditional technologies. Our examples from various industries demonstrate that blockchain fosters innovative business models built around automation, efficiency, and transparency. We found that the use of blockchain in the studied firms helped increase clients' awareness of their goods and services as well as enhance consumer service. These findings enrich the results of prior research on digital transformations (Baiyere et al., 2020; Pérez-Sánchez et al., 2021; Weking et al., 2020). The examined ventures experimented with blockchain and developed innovative products for niche markets that are neglected by large companies. In line with Chen (2018), as well as the opinion of the interviewed topic expert, our findings indicated that blockchain facilitated the innovation process of

the firms we studied, their client companies, and the performance of firms' collaborative innovation (Wan et al., 2022).

High levels of environmental dynamism forced all the analysed ventures to continually improve their offerings and realign internal resources. The observed firms' capacity to quickly adjust to the changing environment was demonstrated by the following common microfoundations, which supported the reconfiguration dynamic capability: *renewing the business model, expanding the customer base,* and *sharing and integrating knowledge.* These microfoundations were facilitated by blockchain technology, which resulted in improved operational efficiency for both the studied firms and their customers. These findings corroborate the conclusions of earlier studies conducted by Hasan et al. (2020) and Quayson et al. (2023) on the link between blockchain and improvements in operational efficiency. Blockchain technology also offers startup companies the chance to develop innovative solutions for established enterprises. These larger companies can then integrate these solutions into their operations, mitigating the risk of becoming obsolete or having less efficient resources and capabilities. Recognising the importance of time and change in organisational contexts, established companies can strategically align themselves by embracing blockchain-based products and services to sustain long-run competitiveness. As an illustration, Firm E identified an opportunity to leverage innovative technological solutions to strengthen the most vulnerable aspects of the tissue sector and support its key stakeholders, including tissue banks, hospitals, and universities. The goal was to enhance transparency, elevate quality, and expedite cross-border tissue flow.

Finally, in this study, we addressed the calls by Helfat and Peteraf (2003) and Corner and Wu (2011) to investigate the evolution of dynamic capabilities during firm formation and growth. We added to the body of knowledge on the dynamic capabilities of young businesses by illuminating the development of start-ups' sensing, seizing, and reconfiguring capabilities, and how they are enhanced through blockchain technology. To summarise our results, we presented a set of propositions that can guide future research and introduce the conceptual framework depicted in Fig. 1. The model demonstrates how blockchain-enhanced dynamic capabilities bolster the operations of nascent companies and sustain their competitiveness.

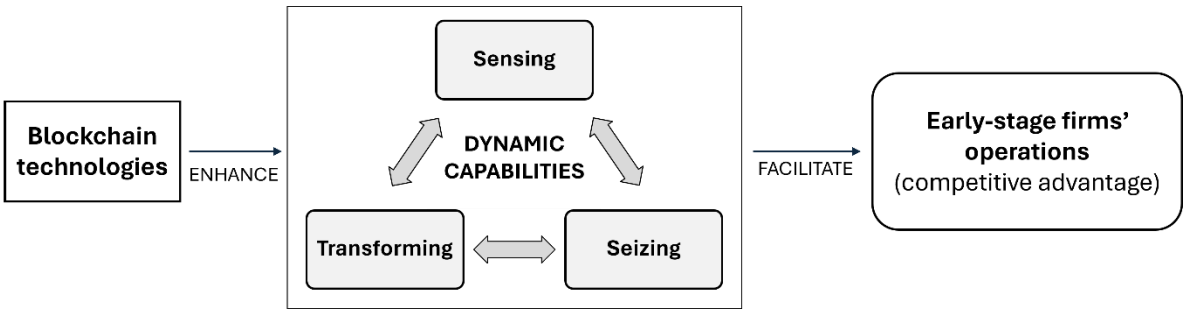

Fig. 1. Conceptual framework.

6. Limitations, directions for future research, and practical implications

The case study methodology is well suited for exploring process- and practice-based issues where the experiences of participants matter; however, the methodology has limitations, which represent opportunities for future research on the blockchain-enabled dynamic capabilities of early-stage firms. First, our case studies are comprised of blockchain-driven start-ups from an understudied context, Hungary. This context is unlikely to represent the full diversity of practices present in other countries, which may limit the generalisability of our results. Second, our study included five in-depth case studies; although we attempted to triangulate findings with archival data and other sources, informant biases cannot be completely excluded. Future research could also conduct "demand side" (Priem et al., 2018) interviews with the customers of blockchain-enabled ventures to gain consumer perspectives and understand how they align with the perspectives of entrepreneurs. Finally, to enhance the generalisability of the findings from our single-country case studies, it is advisable for researchers to undertake comparative cultural research, where they examine cases across multiple countries. This method would allow for a deeper understanding of the unique contextual factors influencing the phenomenon.

Our study can inform policymakers and practitioners about the role of new technologies in the transformation of traditional industries and the creation of new market niches, industries, and customer segments. Specifically, the results of our research have practical implications for both emerging and incumbent organisations. We advise entrepreneurs and managers to pay careful attention to the unique implications of blockchain technologies and their ability to influence the micro-level activities that support sensing, seizing, and reconfiguring capabilities. The dynamic capabilities enhanced by blockchain can be critical for allowing companies to find profitable niches (or reposition themselves) in competitive environments. In this paper, we studied the startup firms that developed blockchain-enabled offerings and, in some

cases, helped their partners and clients innovate outdated business processes and create innovative products. Our findings suggest that practitioners should take a closer look at the technological characteristics underlying their value creation and appropriation processes and consider the opportunities that blockchain may create in these processes.

Based on our findings, we would also recommend that policymakers invest resources to make contexts more favourable for entrepreneurial activities involving the adoption of new technologies (e.g., taking steps to strengthen local entrepreneurial ecosystems; Wurth et al., 2022). These ecosystem-building efforts can enable new businesses to enter the market and facilitate their capability development as well as be integrated into the value chains of incumbent organisations. Indeed, our case studies demonstrated how collaboration between start-ups and mature corporations (e.g., hospitals, power plants, and insurance companies) could boost the innovation activities of incumbents and their reception of new technologies. The benefits of collaborating with entrepreneurial firms in the creation and deployment of blockchain technologies should be recognised by established organisations as a strategy for better competing in the market for knowledge-intensive products and services.

7. Concluding remarks

The objective of this study was to understand the effects of blockchain technology on the emergence and evolution of dynamic capabilities in the context of new ventures. Incorporating the dynamic capability perspective enabled us to identify the capability development that facilitated firms' growth and to study the use of blockchain in start-ups' sensing, seizing, and reconfiguring activities. Synthesising the findings across the cases, we formulated several propositions and developed the conceptual model. In sum, our study addresses the paucity of management and entrepreneurship research on blockchain and its application by early-stage ventures as a newly emerging phenomenon (Chalmers et al., 2021; Kher et al., 2020). We shed light on how entrepreneurs can use blockchain technology as the centrepiece of their business models and as a strategic driver in dynamic environments. We hope that the findings of our study spur future research at the intersection of entrepreneurship, dynamic capabilities, and blockchain innovation and management.

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Appendix A. Key respondents and organisations

Date	Interviewees	Length (min)
08.04.2020	Managing director of Firm A	75
18.04.2020	CEO of Firm E	88
20.04.2020	Professor (topic expert) from the leading Hungarian technical university	108
24.04.2020	CEO of a Europe-based professional blockchain	87
04.05.2020	services network [closed]	55
06.05.2020	Head of the R&D department and 3 developers from one of the biggest Hungarian banks	81
26.05.2020	Co-founder / Consultant (former CEO) of Firm D	81
10.06.2020	CEO of Firm B	80
19.06.2020	Former CEO of a start-up that builds blockchain-based e-warranty solutions [closed] / President of Blockchain Hungary Association	46
05.10.2020	CEO of Firm C	51
13.11.2020	President of Blockchain Hungary Association	56
18.12.2020	Blockchain legal expert / Founder of Blockchain law lab	70
24.06.2021	Co-founder / General Manager of the Netherlands-based company that tracks the global blockchain economy	40
14.07.2022	CEO of Firm B	60
17.07.2022	Managing director of Firm A	70
05.09.2022	President and Vice President of Blockchain Hungary Association	62
19.09.2022	CEO of Firm B	90
17.10.2022	Managing director of Firm A	90
17.01.2023	CEO (former COO) of Firm D	65
23.01.2023	CTO and Business Development Manager of a family- and friend-based IT company	75

Note: We conducted 20 interviews with 18 people totalling approximately 24 hours.

Appendix B. Interview protocol

1. Founders and company background
Could you tell us more about yourself, your educational background and working experiences?
How did the idea for your business come about?
How many employees are in your company?
What product or service do you offer to your customers?
Do you have any other products/services currently under development?
What problems are you trying to solve?
What value do you deliver to the customer?
How did you raise funding for your venture?
What are the main resources and competences of the company?
2. Company's activities and capabilities
Can you name your most important markets and clients?
How did you establish relationships with them?
Has your customer base changed since the beginning of your firm's operations?
Can you detail the revenue mechanisms for your offerings?
How did/do you assess the potential of new markets?
How do you assess your company's performance?
How do you identify your partnership opportunities and establish relations with new partners?
Could you describe your current business model? How did it change from the initial business model?
What is your long-term strategic path?
What does the company do to improve organisational processes?
How do you renew the company from time to time?
3. Blockchain technology
For which purposes do you use blockchain?
Could you describe the planning process for implementing the technology?
What are the key characteristics of blockchain technology that enable your company's operations and creation of products?
What are the sources of value that blockchain can provide?

Does the use of blockchain enable better customer service and higher value propositions? How can blockchain activate new market niches? Can blockchain enhance the firm's competitive advantage?

Appendix C. Description of entrepreneurial background

FOUNDERS / MANAGEMENT	EDUCATION	ENTREPRENEURIAL EXPERIENCE	WORK EXPERIENCE
Firm A			
Founder & Managing Director	Bachelor of Industrial Engineering and Management	Yes	Web development, customer communication and team management
Co-Founder & Head of Biotechnology	Bachelor of Business & Management, PhD in Food-hygiene	No	Experience in agriculture and brand management
Firm B			
Founder & CEO	Bachelor of International Administration	No	6+ years of experience as business analyst and gas wholesale expert (MET Group)
Co-Founder & COO	Bachelor of Transportation Engineering	Yes	10+ years of experience in marketing, namely industrial marketing, management
Firm C			
Founder & CEO	Master of European Law, Doctor of Law	Yes	20+ years of experience as attorney at law and legal adviser
Founder & CTO	Degree in Electrical and Electronics Engineering	Yes Forbes-featured startup founder	15+ years of experience in developing application and the mobile industry
Founder & CLO	Doctor of Law	Yes	15+ years of experience in corporate law, business law, data protection law, real estate law and other areas
Firm D			
CEO	Degree in Business Economics & Management	No	6+ years of experience in the telecommunications industry, fintech, product development, business planning, and go-to-market planning
Co-Founder & Consultant	Bachelor's degree in Law	Yes	15+ years of experience as legal officer, project manager, and ICT expert in Ministry for National Economy of Hungary, Governmental Information-Technology Development Agency, Hungarian Post and RowanHill Global
Co-Founder & Consultant	Doctor of Law	Yes	Experienced in many types of law and innovative projects
Co-Founder & Consultant	Economist in Business Administration and Management (E-business management specialisation)	Yes	13 years of experience in the insurance sector. Skilled in business process and planning, analytical skills, banking, and electronic payments

Firm E			
Founder & CEO	MBA, MSc in Finance, MA in International Relations	Yes	Multi-industrial managerial and consultant experience in developing business strategies for SMEs and corporates. Lecturing at universities, business clubs and special events
Founder & Chief Medical Officer	MSc in International Health Care Management, Economics and Policy	Yes	15+ years of experience in public health and education (e.g., programme director of Health Management MSc at Semmelweis University, deputy director-general at the Hungarian National Blood Transfusion Service). Developing a unique course in the field of tissue therapies

7. CONCLUSION AND FUTURE RESEARCH DIRECTIONS

7.1. Concluding remarks and novelty of the research

This dissertation enriches the conversation surrounding technology management by offering strategic insights tailored to the distinctive opportunities posed by novel technologies. The four papers encompassed in my dissertation collectively provide a multifaceted exploration at the intersection of novel technologies, entrepreneurship, strategic management, and innovation management. By integrating ideas from these diverse perspectives, we offer a comprehensive understanding of how organisations can effectively navigate the challenges and opportunities presented by emerging technologies. This research not only advances scholarly knowledge in these domains but also offers practical implications for decision-makers striving to excel in an increasingly technology-driven world.

In the first paper, through a literature review, I analysed the theoretical underpinnings of blockchain acceptance and its subsequent implications, employing technology adoption theories alongside functionalist and interpretive paradigms. These theoretical lenses provide invaluable insights into how various stakeholders, such as supply chain practitioners, perceive and champion the adoption of blockchain across enterprises. However, the literature review revealed a significant scarcity of empirical research studies, underscoring the necessity for more robust theoretical frameworks to expedite the adoption of emerging technologies within organisational contexts.

In the second paper, we investigated the characteristics of innovative Spanish companies in the high-tech manufacturing sector, focusing on the degree of novelty, using quantitative research and two discrete choice models. We examined the likelihood of product innovation, considering factors such as geographical location, R&D expenditures, firm size, researchers' salaries, and technological development. Through this process, we shed light on the interplay between these variables. The findings underscored the significance of certain firm attributes in driving product innovation, suggesting that policymakers could leverage these insights to tailor industrial policies that foster regional growth.

In our third paper, we delved into the transformative potential of blockchain technology in generating innovative business ideas while also examining the crucial contributions of founders and entrepreneurial teams in sensing and seizing emerging opportunities. By using theoretical frameworks like dynamic capabilities, external enabler theory, and dynamic managerial capabilities, along with a qualitative approach,

we explained the interaction between actor-independent and actor-dependent factors that are fundamental to the process of new firm formation. We developed a conceptual model that illustrates the relationship between external enablers, entrepreneurs' dynamic managerial capabilities, and entrepreneurs' activities in the establishment of new ventures.

In the fourth paper, we investigated how blockchain technology influences the emergence and advancement of dynamic capabilities in early-stage firms. By incorporating the theory of dynamic capabilities and utilising a multi-case study approach, we developed a conceptual framework and formulated a set of propositions to elucidate the influence of blockchain on the micro-level actions involved in dynamic capability development processes. This paper contributes to our understanding of how organisations can strategically leverage technological innovation to gain a competitive advantage.

This dissertation presents several novel contributions to the fields of technology management, entrepreneurship, organisational studies, and strategic management. The following sections outline the unique insights and new scientific findings generated through this research:

- This study provides a comprehensive examination of blockchain technology through the perspectives of organisation theories, including technology adoption theories and sensemaking theory, as well as two categories of Burrell and Morgan's typology of sociological paradigms, the functionalist and interpretive paradigms.
- A new methodological approach is employed to examine the profiles of high-tech manufacturing enterprises within specific regional contexts, focusing on two Spanish regions.
- The application of novel-to-the-topic methodology, specifically two discrete choice models—the multinomial logit and mixed logit models—brings a new perspective to evaluating the likelihood of a firm's innovation decisions on innovation novelty.
- This study explores the implementation of novel blockchain technology within small, early-stage businesses, shedding light on the challenges and opportunities associated with integrating blockchain into organisational processes.
- An actor-dependent view of external enablers has been incorporated into the external enabler theory within the context of blockchain-enabled emerging businesses. This theoretical advancement enriches the current framework by highlighting the influence of actors in shaping the adoption and dissemination of blockchain technology within organisations.

- The research integrates the theory of dynamic capabilities as a theoretical framework, providing a detailed analysis of the nature and function of dynamic capabilities in the establishment of new ventures.
- An in-depth analysis is offered on the advancement of sensing, seizing, and reconfiguring capabilities, supported by their microfoundations, within the context of early-stage companies, with particular attention given to the impact of blockchain technology.
- The conceptual model is constructed to demonstrate how the combination of external enablers, founders' capabilities, and firm capabilities facilitated the formation and growth of new ventures.
- Two main propositions and three supporting sub-propositions are formulated that provide directions for future research.
- The conceptual framework is developed to illustrate how blockchain-enhanced dynamic capabilities reinforce the operations of emerging companies and sustain their competitiveness.
- Through the application of a case study approach, new empirical data on emerging Hungarian firms utilising blockchain was collected, addressing the deficiency in blockchain use cases.

In summary, this dissertation makes significant theoretical and empirical contributions by offering novel perspectives, theoretical advancements, and empirical findings that enhance our understanding of the strategic implications of emerging technologies for organisational development and innovation.

7.2. Limitations and directions for further research

Each paper comprising this dissertation acknowledges its limitations and proposes directions for future research, thus enriching ongoing scholarly discourse and advancing knowledge within their respective domains. The research discussed in the first article is primarily conceptual, highlighting the need for future empirical research. It is advisable for subsequent studies to further explore various organisational and strategic management theories and concepts, deriving classifications to enhance understanding. Considering the nascent stage of blockchain technology, existing studies have predominantly focused on pre-adoption attitudes. Hence, there is a significant opportunity for further investigation into the post-adoption process across diverse

industries. Notably, elements of this research trajectory were explored in the third and fourth papers of this dissertation.

The research presented in the second paper was constrained by the limited number of enterprises and variables within the dataset. While the focus of this study was on Spanish enterprises and regions, we are confident that many of the findings hold explanatory potential and can be generalised to similar socioeconomic contexts. However, we strongly advocate for replicating this study to develop precisely targeted innovation policies for specific regions. Future investigations on this topic should aim to include a broader sample of enterprises representing various industries, such as the food and fashion sectors. Moreover, incorporating additional firm attributes and expanding the analysis to encompass a wider range of regions will enhance the reliability and robustness of the conclusions.

In both the third and fourth articles, empirical studies were conducted using the case study methodology, which is well-suited for exploring process- and practice-based issues where participant experiences are pivotal. However, this methodology has inherent limitations, presenting opportunities for future research on the blockchain-enabled dynamic capabilities of early-stage firms. Firstly, since our empirical study primarily relies on self-reported data from management interviews, future research should seek to incorporate the perspectives of clients and external partners to gain a comprehensive understanding of technology's impact. Secondly, given that the study was conducted in Hungary, the generalisability of the results to companies in other geographical regions may be restricted. Scholars are encouraged to explore the effects of blockchain across a broader spectrum of industries and countries to mitigate this limitation. Thirdly, akin to most qualitative research, the primary constraint of the present study lies in the inability to make statistical generalisations. Given the research centring on startups, which are uniquely positioned to exploit emerging technologies owing to their agile nature and willingness to experiment, future studies could gather more empirical data regarding the survival rates of blockchain startups and conduct survival analyses. Further investigation into the current topic is advised, with a call for research to explore the effects of the business environment and conditions on the dynamic capabilities of new ventures and the adoption of blockchain technology. Alternative theories, such as institutional isomorphism, resource dependence theory, and the resource-based view, could provide valuable insights into explaining the decision-making process surrounding blockchain adoption. Incorporating these theories into future research endeavours may yield significant benefits.

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