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Harnessing Individual Dynamic Capabilities for Blockchain Technology Adoption in Healthcare

Antonio Miguel Barreiras Pesqueira

PhD in Information Science and Technology

Supervisors:

Doctor Maria José Sousa, Associate Professor with Aggregation, ISCTE - Instituto Universitário de Lisboa

Doctor Rúben Filipe de Sousa Pereira, Assistant Professor, INESC-INOV; ISCTE - Instituto Universitário de Lisboa

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TECNOLOGIAS
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Department of Information Science and Technology

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Jury:

Doctor Pedro de Paula Nogueira Ramos, Full Professor at Iscte - Instituto Universitário de Lisboa;

Doctor Francesca Dal Mas, Associate Professor at Ca' Foscari University of Venice;

Doctor Gabriel César Ferreira Pestana, Coordinating Professor at the Instituto Politécnico de Setúbal;

Doctor João Carlos Amaro Ferreira, Assistant Professor with Habilitation at Iscte - Instituto Universitário de Lisboa;

Doctor Rúben Filipe de Sousa Pereira, Assistant Professor at Iscte - Instituto Universitário de Lisboa.

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"As a writer, you should not judge; you should understand."

Ernest Hemingway

Acknowledgments

When I embarked on this PhD, I could not have anticipated the profound sense of enrichment and personal transformation it would bring. It has been a source of individual and intellectual growth for me. Throughout this process, I have had the opportunity to learn a great deal about perseverance, the importance of collaboration, and the power of curiosity.

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Resumo

As organizações de saúde estão a sofrer uma pressão crescente para adotar tecnologias de proteção, como blockchains autorizadas, com o objetivo de garantir a integridade dos dados, facilitar a interoperabilidade contínua e permitir relatórios auditáveis sobre questões ambientais, sociais e de governança. No entanto, a maioria dos projetos-piloto enfrenta dificuldades na implementação dessas mudanças devido à ausência de micro-rotinas na equipa de primeira linha, como os profissionais de saúde. Conforme delineado na teoria da Capacidade Dinâmica, essas micro-rotinas envolvem a deteção de novos casos de uso, a mobilização de recursos interdisciplinares e a refatoração de fluxos de trabalho.

A presente tese abrange um total de oito estudos, dos quais cinco foram publicados em revistas relacionadas à gestão empresarial, informática na saúde, computadores, engenharia industrial e sistemas de medicina inteligente. Estes estudos abrangem uma ampla gama de metodologias de investigação, incluindo revisões sistemáticas, descoberta qualitativa, desenvolvimento de escalas, análise de casos e um inquérito a profissionais de saúde sobre tecnologias digitais avançadas, como a adoção da blockchain na gestão de operações de saúde. O conjunto destes estudos sugere que as Capacidades Dinâmicas Individuais superam o orçamento ou a utilidade percebida como um fator impulsionador da adoção sustentada do livro-razão. Além disso, uma escala de maturidade validada de cinco níveis demonstrou correlacionar maior capacidade com melhores resultados.

A tese contribui para o campo em fornecer um modelo microfundado que integra as capacidades dinâmicas individuais à lógica tecnologia-organização-ambiente. Igualmente, partilha evidências empíricas que comprovam a capacidade de mediação das capacidades dinâmicas.

Palavras Chave: Blockchain; Capacidades dinâmicas; Gestão de operações; Saúde; Tecnologia

Abstract

Healthcare organizations are experiencing increasing pressure to adopt protective technologies like permissioned blockchains to ensure data integrity, facilitate seamless interoperability, and enable auditable environmental, social, and governance reporting. However, the majority of pilots encounter difficulties in implementing these changes due to the absence of micro-routines in frontline staff, like healthcare professionals. As delineated in Dynamic Capability theory, these micro-routines entail the sensing of novel use cases, the mobilization of cross-disciplinary resources, and the refactoring of workflows.

The present thesis encompasses a total of eight studies, of which five have been published in journals related to business management, health informatics, computers, industrial engineering, and intelligent medicine systems. These studies encompass a wide range of research methodologies, including systematic reviews, qualitative discovery, scale development, case analysis, and a survey of healthcare professionals regarding advanced digital technologies like blockchain adoption in healthcare operations management. The aggregate of these studies suggests that Individual Dynamic Capabilities outrank budget or perceived usefulness as a driver of sustained ledger adoption. Also, a validated five-level maturity scale has been demonstrated to correlate higher capability with enhanced outcomes.

The thesis contributes to the field by providing a micro-founded model integrating Individual Dynamic Capabilities into Technology–Organization–Environment logic. Additionally, it provides empirical evidence that substantiates the Dynamic Capabilities' mediating capacity.

Keywords: Blockchain; Dynamic Capabilities; Operations Management; Healthcare; Technology

Contents

List of Figures

List of Acronyms

ADT	Advanced Digital Technologies
AI	Artificial Intelligence
BDA	Big-Data Analytics
BT	Blockchain Technology
dAI	Decentralized AI
DC	Dynamic Capabilities
DICOM	Digital Imaging and Communications in Medicine
EHR	Electronic Health Record
ESG	Environmental, Social, and Governance
FHIR	Fast Healthcare Interoperability Resources
GDPR	General Data Protection Regulation
HCO	Healthcare Organizations
HCPs	Healthcare Professionals
HIPAA	Health Insurance Portability and Accountability Act
HL7	Health Level Seven International (messaging standard)
IDC	Individual Dynamic Capabilities
IoT	Internet of Things
MDS	Maturity Development Scale
RBV	Resources Based-View
RQ	Research Questions
SJR	SCImago Journal Rank
SLR	Systematic Literature Review
SL	Strategic Leadership
TAM	Technology Acceptance Management
USA	United States of America
UTAUT	Unified Theory of Acceptance and Use of Technology
ZKP	Zero-knowledge Proof

CHAPTER 1

Introduction

This thesis builds upon the research initiated during my professional experience as a Scrum Master for a large global pharmaceutical company. My position at the company headquarters in Berlin, Germany, offered a comprehensive perspective on the intricate relationships and supply chain operational business processes with healthcare organizations (HCO) worldwide. The global program involved implementing decentralized data protection models, decentralized autonomous organizational concepts, and data governance processes aligned with the General Data Protection Regulation (GDPR). The facilitation of these processes was primarily accomplished through the implementation of zero-knowledge proof (ZKP) protocols and encrypted data masking procedures, in conjunction with other encryption data governance models.

Furthermore, the program encompassed decentralized identity management and privacy enhancing technologies connected with consent management across multiple HCO [1]. Preliminary observations from this work experience revealed a persistent discrepancy between the technical potential of decentralized solutions and their practical implementation in healthcare settings. The collected experience also highlighted the intricate interrelationship between advanced digital technologies (ADT), such as blockchain technology, artificial intelligence (AI), and big data analytics (BDA), which are undergoing rapid and exponential development. These observations constitute some of the most solid challenges encountered during my tenure as a Scrum Master and within our development team [2]. Moreover, the tensions previously identified between rigid governance protocols, fragmented information architectures, and the human capabilities necessary to utilize advanced tools, continue to reemerge in different organizational scenarios [3, 4].

By integrating contextual reflection and contextual analysis, this thesis establishes the rationale for leveraging Individual Dynamic Capabilities (IDC) as a factor in the sustainable adoption of BT in the healthcare sector [4]. It was my understanding that innovative frameworks could enhance the team's competencies. These frameworks have been systematically selected to ensure their alignment with the overarching program strategy, the strategic plan, and the broader organizational objectives. The primary objective of these efforts has been to integrate the principles of value development and attainment with the organization's overarching goals. The following discussion will focus on the concept of dynamic capabilities (DC) and its significant impact on agile working principles and package delivery [5, 6]. Thus, it is relevant to investigate the reasons why numerous HCO blockchain pilots are unsuccessful in achieving solid results, while a limited number of them progress to demonstrate enterprise value [7]. The solution, is found at the nexus of two complementary lenses: enterprise-blockchain governance, which establishes the structural and procedural rails, and IDC, which serves as the adaptive, human engine. Additionally, the alignment of these domains results in the generation of value in operational efficiency, resource management, Environmental, social, and governance (ESG) reporting, and AI-enabled care. Conversely, misalignment can result in costly complications [8, 9].

1.1. Context and Motivation

Over the past decade, the healthcare sector has been confronted with a dual mandate: to provide clinical services that are both safer and more environmentally sustainable, and to demonstrate the efficacy of these services to regulatory bodies and the general public. Permissioned blockchains were identified as a potentially optimal solution for this task, given their capacity to provide immutable audit trails and multi-party consensus [10, 11]. However, real-world implementations have exposed a paradox: the very controls that ensure the reliability of ledgers, as consensus protocols, smart-contract governance, and data-protection checkpoints, impede the agility necessary for HCO to respond promptly to rapidly evolving clinical and regulatory requirements [2].

Recent research has demonstrated the potential benefits and the associated challenges. A consortium of European HCO has developed a system that can reduce the time required to detect counterfeit drugs from days to minutes. This system involves the integration of Internet of Things (IoT) sensors with a blockchain-based traceability network. However, a parallel effort has encountered significant delays, with each update to the smart contracts requiring sequential approval from data protection officers, clinical safety boards, and legal counsel [4, 12].

Also, it has been determined that technical affordances alone do not constitute the primary impediment to success. Rather, the key factor is an empowered workforce capable of identifying novel ledger opportunities, acquiring resources, and dynamically modifying workflows. This capability is precisely aligned with the micro-routines delineated by the IDC construct [3]. In this context, the human capacity to work at different levels in implementing new technologies that can solve complex operational problems is crucial. However, it is also important to emphasize the significance of fostering a more profound understanding and alignment between managerial and healthcare administration teams. This collaborative effort is instrumental in facilitating a comprehensive comprehension of the technological infrastructures necessary for achieving success. Moreover, it serves to unify operational teams in the execution of technological projects, ensuring their alignment with the overarching strategic direction of HCO [13].

It has been suggested that conventional technology-adoption models, including the Technology Acceptance Model (TAM), prioritize perceived usefulness and organizational readiness, thereby neglecting to adequately delineate capability readiness. HCO that have achieved success with BT have integrated structural governance with IDC development programs that are tracked by maturity. These programs have enabled clinicians to enhance their skills in smart-contract logic, pharmacists to acquire the ability to audit tokenized supply chains, and middle managers to oversee the establishment of cross-department ledger guilds [3, 14].

Concurrently, the integration of decentralized AI (dAI) and BDA with BT is becoming increasingly prevalent. In addition, federated learning models have the potential to significantly impact data privacy, and real-time Environmental, Social, and Governance (ESG) dashboards rely on ledger-notarized events. The implementation of these stacked technologies has been demonstrated to intensify governance demands while concomitantly amplifying the benefits derived from IDC when the necessary conditions are met [15, 16].

In this context, it is pertinent to assess how conceptual frameworks such as IDC function as a conduit between comprehensive governance and agile, value-creating adoption. In evaluating the integration of qualitative discovery, scale development, and case studies, it multifaceted explanation is required regarding how individuals catalyze enterprise BT success in healthcare and what governance levers amplify those capabilities [4, 8].

1.2. Research problem

Despite the growing consensus among practitioners and scholars that permissioned blockchains, often in conjunction with dAI and BT, have the potential to significantly enhance clinical traceability, ESG reporting, and overall operational efficiency, there is a paucity of robust evidence regarding the specific DC routines and governance metrics that are instrumental in successful enterprise-scale implementations [9, 10]. In the field, pilots have reported a variety of outcomes. Some HCO progress from proof-of-concept to multi-site deployment within brief periods, while others abandon ledgers due to budget overruns and change-control management [8].

Recent studies have identified several persistent issues, including the fragmentation of decision-making authority, the absence of mature governance mechanisms, and the variability in staff proficiency in sensing, seizing, and reconfiguring workflows [7, 17]. HCO leaders require practical guidance rooted in quantifiable capability indicators, as opposed to abstract lessons learned, to effectively guide the adoption of technology throughout its lifecycle. The aforementioned guidance must facilitate meticulous self-assessment, continuous monitoring, and targeted upskilling. In the absence of such mechanisms, BT projects are susceptible to stagnation, despite the presence of discernible strategic intent [2, 13]. Consequently, an additional challenge is characterized by the observation that numerous healthcare BT pilots are unsuccessful due to frontline actors', like nurses or physicians, or other healthcare professionals (HCPs), limited ability to recognize opportunities, mobilize resources, and reconfigure workflows around the technology [2, 8].

As illustrated in Figure 1.1, the identified core thesis problem stems from two primary sources. Firstly, the lack of awareness regarding opportunities faced by HCO in complex environments, coupled with challenges related to the reconfiguration of workflows, constitutes a significant impediment to the effective adoption of BT projects [2, 18]. This challenge is further compounded by the absence of IDC within HCPs and management teams, leading to a bottleneck in the implementation process. The presence of these constraints at the structure and processes stage of the innovation process can have deleterious effects, including the failure to generate value-added innovation, inadequate governance, the inefficient use of resources, and the emergence of operational risks. These adverse consequences can manifest in the subsequent implementation of advanced technologies in an irregular manner and the absence of effective solutions for ensuring operational sustainability [10, 11].

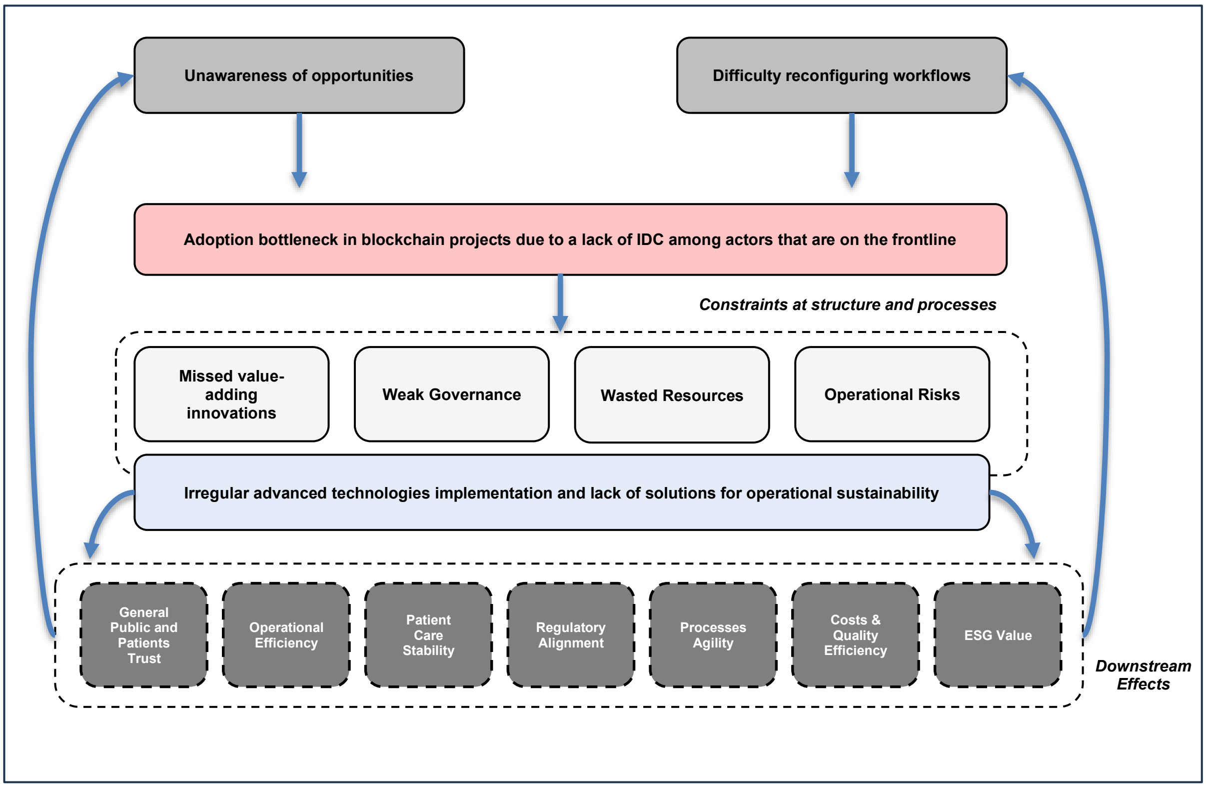

Figure 1.1: Thesis problem map

About the downstream effects, the general public and patient trust are associated with a lack of operational efficiency. This is connected with patient care improvements, regulatory compliance, organizational agility, costs, quality efficiency, and ESG value. These factors are key dimensions. The aforementioned factors have been identified in the literature, which includes research that has indicated these dimensions to be fundamental and associated with the overall effects of HCO's inability to effectively develop advanced digital technology programs [9, 19]. About the thesis inquiries, there exist four fundamental overarching research questions (RQ). These questions are built upon the foundational concepts of DC and their application in modern healthcare contexts [5, 7].

- RQ1: What insights does vast scholarship provide, and what aspects of IDC's role in blockchain-enabled healthcare innovation have been overlooked?
- RQ2: Which specific sensing, seizing, and transforming routines do HCPs regard as most critical, and how can these routines be organized into an actionable capability framework?
- RQ3: How can those routines be operationalized in a reliable scale, and how do differing maturity levels manifest in real-world clinical and supply-chain contexts?
- RQ4: To what extent do higher IDC-maturity scores explain successful BT adoption and

downstream organizational benefits across a multitude of HCO?

Collectively, these inquiries progress methodically from the identification of issues to their practical implementation, thereby addressing the empirical gap that continues to impede numerous BT initiatives within healthcare. The answers to these questions are developed sequentially across the eight publications, moving from literature synthesis and qualitative discovery through scale construction, multi-case validation, and large-sample testing [2, 8, 20].

1.3. Objectives

The research process is structured around four overarching objectives: literature synthesis, qualitative discovery, instrument creation, and broad-scale validation. The RQs are inherently integrated within this framework [8, 21].

According to Figure 1.2, the overarching focus was to elucidate, quantify, and refine the micro-foundations that empower HCPs to translate blockchain's technical potential into secure, value-adding clinical solutions. Consequently, four connected objectives have been delineated to address this central problem [2, 10].

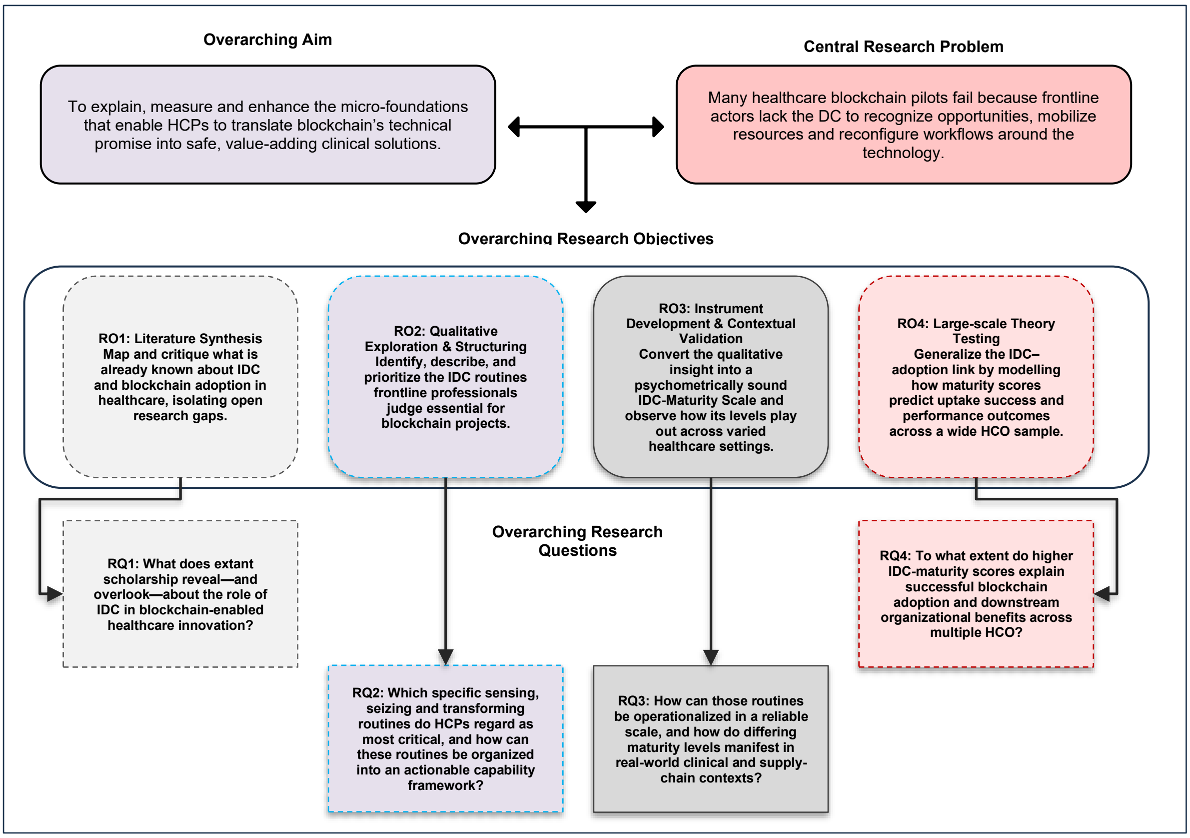

Figure 1.2: Thesis objectives and RQs relationships

The primary objective of this research is to provide a comprehensive literature synthesis that will map and critique the existing knowledge surrounding the adoption of IDC and BT in the healthcare sector. This objective will entail identifying and isolating any research gaps that are currently present. The second research objective is to qualitatively explore and structure the need to identify, describe, and prioritize the IDC routines that frontline professionals judge essential for BT projects. The third is then linked to the necessity of developing an instrument for development and contextual validation. The main logic is to transform the qualitative insight into a psychometrically sound IDC-Maturity Development Scale (IDC-MDS) and to observe how its levels manifest across various healthcare settings. This objective is intrinsically linked to the RQ of how operational and technological implementation routines can be operationalized on a reliable scale, and how differing maturity levels manifest in real-world clinical and supply-chain contexts. The final objective is to conduct a large-scale theory testing to generalize the IDC–adoption link. This will be achieved by modeling how maturity scores predict uptake success and performance outcomes across a wide HCO. The assessment will also determine to what extent higher IDC-maturity scores explain successful BT adoption and downstream organizational benefits across multiple HCO [3, 4, 8].

1.4. Background

A substantial corpus of scholarship in the fields of management and information systems posits that health-technology programs that achieve substantive transformation are contingent upon the concurrent evolution of structural governance, enabling technologies, and human capabilities. When considered as a whole, concepts like IDC and ADT form a unified argument that HCO, such as hospitals, find themselves at a significant juncture as they navigate the imminent convergence of technological advancements [20- 23]. Distributed ledgers, privacy-preserving AI, and event-stream analytics have reached a sufficient level of development, offering the potential to ensure safer medications, streamline logistics processes, and substantiate sustainability claims. Nevertheless, the evidence collected in policy reports, audit dossiers, and two background manuscripts indicates that pilots encounter difficulties when the individuals responsible for operating and governing the stack are unable to align their actions with the technology's capabilities [3, 8].

The possession of DC is a factor in the ability of certain institutions to navigate periods of significant turbulence. These institutions possess ingrained routines that enable them to scan the environment, rapidly mobilize resources, and modify their operational protocols before the re-emergence of legacy practices [5, 6].

These capabilities include the ability to think critically, the capacity for curiosity, the aptitude for translation, and the iterative mindset that enables individuals to transform cryptographic intricacies into practical clinical applications. Additionally, the BT offers a tamper-proof substrate, as dAI and BDA engines draw intelligence from that substrate. However, it is important to note that neither code nor cryptography will change a single patient outcome unless HCPs trust the system, unless governance approves updates at the speed of need, and unless each layer speaks a semantic language that its neighbors understand [4, 15]. Technology-acceptance thinking remains a necessary doorway, revealing whether frontline staff see the point of the change. However, intention crosses the threshold into behavior only when capability is present and risk is governable. The capacity of HCO to obtain licenses to operate and to finance further innovation is contingent upon indisputable evidence that the new stack enhances operational efficiency while aligning with the increasingly stringent ESG expectations [9, 10].

As illustrated in Figure 1.3, the conceptual framework under consideration comprises three primary domains in which DC ascertains the pertinence of IDC to the operational efficiency of BT implementation and corresponding adoption. From a technological perspective, the integration of AI and BT with the HCO processes, technology, and resources is a factor in determining the adoption of BT. Thirdly, the healthcare context is an area of consideration wherein regulatory frameworks, the interoperability of systems, and the concomitant market pressures exert influence on organizational capabilities and management levels. The thesis background then focuses on the triple combination of the relevance of IDC, the BT adoption, and the HCO structures, processes, and systems [3, 4, 8].

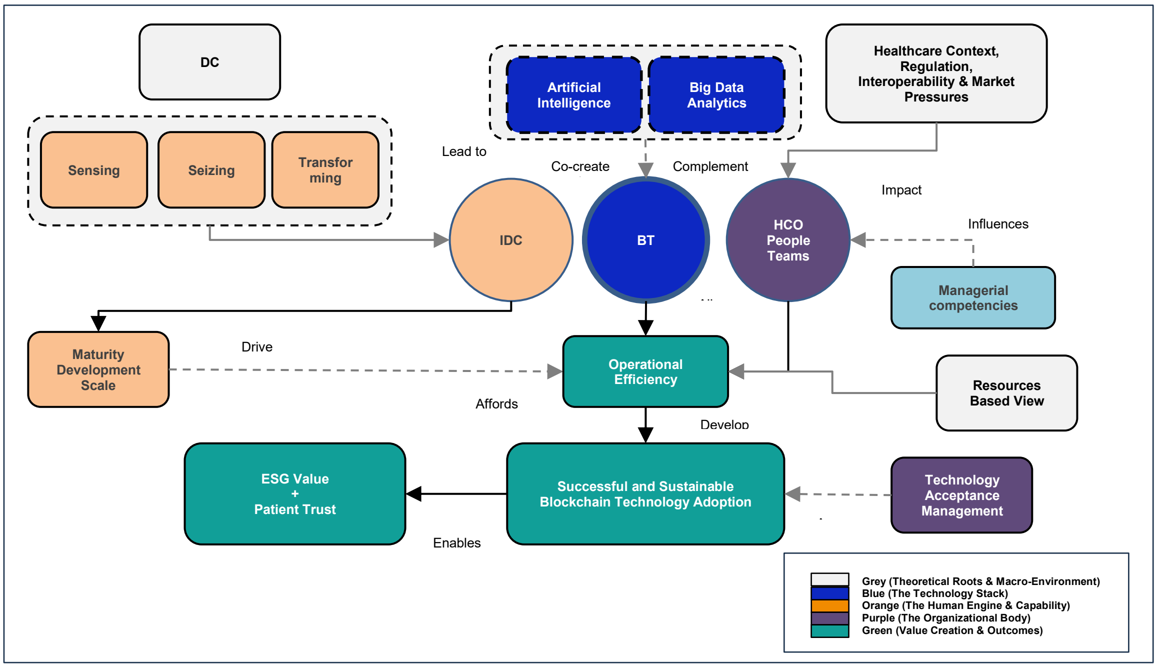

Figure 1.3: Conceptual framework and connection between core research areas

While the DC framework and TAM offer essential theoretical scaffolding, a critical analysis reveals significant explanatory gaps when confronted with the complex realities of implementing socio-technical systems like BT in healthcare. These discrepancies demand a more nuanced, human-centric approach. A Macro-level analysis of the limitations of the DC shifted strategic thinking from static resource ownership to the process of organizational renewal. Nevertheless, the implementation of the framework has been subject to persistent critiques regarding its operationalization. The presence of DC has been identified as a characteristic of successful firms, the precise mechanisms underlying this phenomenon remain opaque [6-8].

The present state of research is characterized by limitations that preclude a comprehensive understanding of the micro-foundations, the individual-level actions, cognitions, and skills that collectively constitute these capabilities. The DC framework is a high-level abstraction that offers limited prescriptive guidance for managers seeking to cultivate these capabilities from the ground up without first understanding the individual actors who perform these routines. Conversely, models such as TAM and its successor, the Unified Theory of Acceptance and Use of Technology (UTAUT), emphasize the individual user but do so through a constrained cognitive lens. While these models are indisputably significant, it is crucial to acknowledge that they were developed during a period characterized by the prevalence of more elementary, standalone software tools [3, 5, 8].

These individuals often lack the expertise necessary to comprehensively articulate the intricacies and ramifications of adopting advanced, systemic technologies such as permissioned BT. These technologies, it should be noted, are not merely instruments in and of themselves; rather, they constitute novel institutional infrastructures that profoundly impact workflows, power dynamics, and the scope and nature of professional accountability [2-5].

This line of research addresses these theoretical gaps by proposing that to comprehend and promote the integration of sophisticated ADT within the healthcare sector, research endeavors must transcend the limitations of firm-level capabilities and the simplifications inherent in acceptance models. It is also suggested that a framework be developed that is centered on the tangible, measurable, and developable IDC. This framework would empower frontline professionals to bridge the chasm between technological potential and operational reality [3-6].

1.4.1 Dynamic Capabilities: an organisational engine for perpetual renewal

Teece et al. (1997) [5] explained that DC are of particular significance in contemporary strategic thinking because they explain not what an organization owns but how it keeps renewing what it owns as markets, regulations, and technologies move. This framework supplanted the conventional, static perspective on strategy with a dynamic, cinematic representation. HCO has inherited this discourse due to the rapid changes in the clinical, regulatory, and technological landscapes in which it operates. These changes would have been unthinkable a generation ago. The rapid redeployment of wards, staff, and supply chains necessitated by the onset of the COVID-19 pandemic served to underscore a phenomenon previously documented in the available literature: HCPs who can institutionalize horizon-scanning, rapid decision forums, and continuous process redesign can pivot more rapidly and effectively. DC demonstrates a high degree of adaptability, readily transitioning from its initial industrial contexts to the healthcare sector. The concept of sensing encompasses the implementation of disciplined technology and policy intelligence. The term "seizing" refers to the execution of cross-functional governance, which can facilitate the release of funds and the authorization of pilot projects under time constraints [5, 7].

The initial phase of "sensing" transcends the realm of mere opportunistic curiosity. The practice is methodical and systematic. It involves the thorough examination of scientific journals, regulatory drafts, start-up ecosystems, and patient feedback channels. The purpose of this examination is to detect faint signals before they become shocks. HCO implement sensing through a variety of mechanisms, including technology assessment boards, epidemiological surveillance units, and data hackathons, which are open to clinicians and data scientists alike. Sensing is defined as the ability to scan, probe, and explore the external environment for emerging opportunities and threats. It is further noted that analytical tools, professional networks, and experiential knowledge strengthen this ability at the individual and team level [7, 21].

Then the concept of "seizing" is applicable in circumstances where opportunities are transformed into strategic investments. In practice, HCO, as hospitals convene mixed panels—comprised of medical leads, informaticians, legal officers, and finance directors—to determine whether a permissioned ledger for oncology drug traceability merits budgetary and policy consideration. The alignment of clinical benefit with considerations of cybersecurity, privacy law, and return on investment serves as a prime example of strategic decision-making [7, 17].

The third key DC process, "transforming", is the least visible but most consequential. This process entails the retraining of staff, the revision of standard operating procedures, the decommissioning of redundant information technology, and the auditing of whether the new configuration continues to meet compliance and quality objectives. Transformation is labor-intensive because it compels individuals to relinquish entrenched practices. Absent this labor, sensing and seizing devolve into costly proof-of-concepts that are incapable of scaling. The logic that defines sensing and seizing also emphasizes that transformation is contingent on collective learning, creativity, and a willingness to experiment. HCO that have institutionalized after-action reviews and published updated smart-contract guidelines following each release have demonstrated this capability; those that have become stagnant when confronted with the initial privacy inquiry have not [7, 8].

DC does not exist in a vacuum; rather, it is enacted by individuals whose skills, mindsets, and behaviors collectively result in organizational routines. IDC are then the micro-foundations of the macro engine. The core components that facilitate this transformation are technological literacy, strategic vision, and adaptive learning. These elements enable clinicians, pharmacists, and middle managers to translate perceived opportunities into pilot initiatives and, ultimately, into a transformed workflow. The relationship is reciprocal: organizations cultivate IDC through training and culture, and, in turn, those individual capabilities strengthen organizational sensing, seizing, and transforming [3, 7].

The concept of path dependency introduces an additional dimension to the existing investment in Lean improvement circles or quality-and-safety collaboratives. These initiatives instruct staff to perceive change as a recurrent process rather than as a series of discrete events. Consequently, this fosters the rapid implementation of DC actions in the future. Conversely, hospitals that outsourced their IT strategy for decades often lack the absorptive capacity to recognize, let alone integrate, disruptive tools such as the BT [22, 23].

DC also aligns with the Resource-Based View (RBV), which posits that capabilities must orchestrate valuable, rare, inimitable, and non-substitutable assets to create sustained advantage. These assets may include clinical data lakes, trusted patient brands, or AI-ready imaging archives. Additionally, it intersects with institutional theory, insofar as coercive forces, such as GDPR fines or public pressure over data breaches, can catalyze or constrain capability activation. Finally, socio-technical perspectives underscore the notion that the advent of every new technology invariably gives rise to a reconfiguration of human relationships. Consequently, DC must encompass not only technical dexterity but also the capacity for negotiation and sense-making [4, 5, 7].

The prevailing criticisms of the theory have been chiefly that it risks circularity or suffers from imprecise measurement. These criticisms have prompted methodological innovations such as longitudinal process tracing, multi-case comparison, and survey-based maturity scales. Researchers acknowledge both the promise and the gaps, noting limited exploration of how the IDC of HCPs influences the adoption and integration of new technologies and calling for more empirical work to trace the mechanisms from micro-skills to macro outcomes [24].

Consequently, DC integrate the human agency examined in IDC, the architectural decisions evaluated in the BT and AI discourse, the attitudinal pathways of Technology Acceptance, and the definitive metrics of sustainability and operational efficiency. It is relevant to comprehend, quantify, and—most importantly—cultivate these competencies if BT is to be utilized for the enhancement of healthcare delivery systems. This process must be approached with utmost seriousness, as it is not a marginal matter but rather a central component of ensuring the safety, sustainability, and resilience of these vital systems [3].

The concept of IDC has emerged as a critical analytical framework, as it elucidates how individual professionals, as opposed to abstract organizations, transform technological possibility into operational reality. The concept underwent a process of maturation as scholars sought to elucidate the fundamental mechanisms underlying the firm-level routines of sensing, seizing, and transforming described by DC theory. Preliminary studies in the field of strategic management indicated that leadership cognition and entrepreneurial alertness were significant factors. However, it was not until the recent decade, when digital tools became pervasive and began to transform task boundaries monthly, that researchers began to formalize individual-level constructs. The field of healthcare has emerged as a particularly fertile context for this inquiry, partly because its knowledge workers already navigate a dense web of regulation, ethical constraints, and interdisciplinary coordination. At a conceptual level, IDC are best conceptualized as a person's capacity to maintain a dynamic equilibrium between learning, unlearning, and relearning by environmental fluctuations

[18-21]. Three intertwined dispositions have emerged as the prevailing factors in recent definitions. The initial facet is technological literacy, which extends beyond the capacity to operate a device and encompasses fluency in professional dialects. The integration of professionals with a comprehensive understanding of regulatory frameworks and compliance codes, nurses with expertise in machine learning algorithms, and radiologists capable of evaluating and critiquing AI models' confusion matrices exemplifies the necessity for a multifaceted approach to the integration of emerging technologies into clinical practice. This collaborative effort is recommended to ensure that these technologies are not perceived as an exotic intrusion but rather as a valuable clinical solution [17, 21].

The second disposition is strategic vision, defined as the ability to situate a local innovation within a broader agenda of patient safety, ESG compliance, or cost containment. This strategic vision compels a ward manager to advocate for a ledger-based discharge tracker, as she recognizes its capacity to contribute data to a forthcoming carbon-accounting dashboard mandated by the board. The third is adaptive learning, which is defined as an iterative process of experimentation, reflection, and the codification of lessons. This process is intended to improve future workflows. Adaptive learners, on the other hand, do not perceive glitches as evidence of failure; rather, they view them as feedback for redesign, thereby ensuring the continuous flow of the transformation loop [23-25].

Empirical studies have demonstrated how these dispositions materialize. Recent research has detailed cases in which frontline clinicians have spearheaded the rapid design of smart-contract templates after identifying loopholes in manual drug-return logs. The success of these clinicians hinged on their ability to swiftly absorb regulatory language, marshal cross-departmental allies, and refine workflows through successive iterations rather than a single grand rollout [3, 9].

The efforts to operationalize IDC for measurement purposes have evolved from rudimentary checklists to sophisticated psychometric instruments. A body of recent research offers substantiation for the proposition that personnel may be acquainted with BT but depend exclusively on information technology intermediaries. Moreover, HCPs do not merely reconfigure their workflows; they also provide mentorship to their peers and exert influence on policy updates. Recent studies have demonstrated correlations between higher IDC scores and process outcomes, including reduced data-integrity incident duration and expedited smart-contract approval times. A salient finding from these studies underscores the uneven distribution of IDC within HCO. The presence of high-maturity areas, encircled by capability vacuums, engenders friction due to the necessity for ledger-centric teams to repeatedly translate for less agile colleagues, thereby impeding the team's momentum [25-27].

Training interventions represent a potential solution to address this discrepancy. A variety of pilot programs have been implemented, including simulation labs, hackathons, rotating innovation fellowships, and tiered certification programs. The success of these pilot programs has varied. Recent studies have indicated that ledger guilds, which are cross-disciplinary teams that convene fortnightly to examine live issues and develop prototypes for solutions, have been particularly effective. Guild members report an accelerated learning curve, attributing this phenomenon to the interaction of regulatory, clinical, and technical perspectives in real time, thereby circumventing the protracted approval loops that often impede siloed projects. These guilds exemplify deliberate learning mechanisms, experience accumulation through doing, articulation through discussion, and codification into updated playbooks [18, 26].

From a theoretical standpoint, the IDC interacts with other lenses. Within the TAM theory, perceived usefulness may trigger initial curiosity; however, intention converts into sustained use only when individuals can reconfigure their tasks. According to scholars in the field of RBV, the accumulation of individual dexterity alone is insufficient to ensure long-term competitive advantage. They contend that the orchestration of valuable, rare, and non-substitutable assets is paramount. In this context, BT's tamper-proof logs emerge as a crucial element, provided that capable professionals leverage these logs to create auditable patient journeys that are difficult for competitors to replicate. Institutional theory posits that IDC equips its personnel to interpret shifting compliance cues—such as the evolving GDPR guidance on immutable records—without compromising the organization's innovative capacity. Proficient individuals interpret regulatory frameworks not as impediments but as design constraints that can be surmounted through creative problem-solving methodologies. For instance, the utilization of off-chain storage in conjunction with ZKP can facilitate the satisfaction of privacy requirements [9, 27].

However, the IDC construct has been the subject of considerable critique. These critiques primarily address issues of measurement reliability, the potential for individualistic bias, and the difficulty of differentiating between stable capability and transient motivation. In response, scholars have proposed the triangulation of behavioral indicators as a means of reducing subjectivity. These indicators include time to resolve governance exceptions, frequency of protocol revisions, and participation in interdisciplinary retrospectives. Longitudinal designs further differentiate between enduring capability and episodic enthusiasm by tracking the persistence of adaptive routines once novelty has been exhausted. The literature, however, advises caution against conflating formal training hours with capability depth. Genuine IDC is evidenced by practical redesign, not certificates [3, 26].

Also, IDC connects to the value management of sustainability and operational efficiency that serves as the foundation for BT's ultimate value proposition. The utilization of ledgers in the automation of carbon tracking is predicated on the premise that clinicians who possess a comprehensive understanding of data provenance are capable of redesigning clinical pathways to eliminate waste. Smart contracts can recall compromised drug batches within minutes; therefore, pharmacists must seize this opportunity by reorganizing manual checkpoints into automated triggers. Adaptive learning, in turn, facilitates transformation by enabling teams to iteratively refine, report, and embed lessons learned into subsequent audit cycles. Consequently, the materialization of environmental and financial gains is contingent upon the sufficient maturation and widespread distribution of IDC [9, 10].

1.4.2 Managerial, Operational, and Executive Senior Management Levels

At the management and operational levels, IDC underscores the significant role that middle managers and operational staff play in identifying and capitalizing on the opportunities that BT presents. These individuals frequently occupy a vanguard position in the identification of practical challenges and opportunities as novel technologies are integrated into existing operations. Their proximity to the daily operations of the HCO enables them to perceive changes in the operational landscape and patient care needs with greater acuity than senior executives. For instance, through their routine interactions with electronic healthcare records and patient data management systems, nurses and medical technicians can identify specific areas where BT could improve data security and patient privacy. These frontline workers can also provide valuable insights into how BT can be used to track medical supplies, reduce medical errors, and improve patient outcomes [10, 21].

Furthermore, they possess the capability to discern potential areas for cost reduction, such as the optimization of billing and payment processes. The capacity of these individuals to mobilize resources, advocate for change, and implement new technologies within their departments will determine their ability to capitalize on these opportunities. This necessitates not only technical and strategic competencies but also social capital networks and relationships that empower them to influence decisions and garner support for innovative projects. The role of management and operations staff in this transformation process is threefold: first, they are responsible for piloting new technologies; second, they must adapt to new procedures; and third, they provide feedback that shapes the organization-wide adoption of innovations like BT. Possessing a profound comprehension of the organization's culture, they can facilitate the establishment of a culture characterized by innovation, support, and collaboration. Furthermore, they can assist in ensuring that the implementation of new technologies is secure and compliant with existing regulations [4, 8].

At the executive level, IDC focuses on the strategic vision and leadership required to navigate the broader implications of BT adoption. Executives must be able to recognize not only the operational opportunities but also the strategic positioning and competitive advantages that BT can offer the HCO. This necessitates a higher level of abstraction and the capacity to integrate insights from various departments within the organization to inform strategic decisions. In addition, executives must possess the ability to anticipate and plan for the potential risks associated with the implementation of BT. They must possess the capacity to navigate the intricate web of regulations and adhere to compliance standards, while concurrently cultivating an acute sense of ethical discernment to foresee potential dilemmas that may emerge [3, 7, 17]. Finally, they must possess the means to assess the efficacy of their BT initiatives. Capitalizing on such prospects necessitates substantial resource allocation, a reconfiguration of organizational units, and potentially a reevaluation of the organization's strategic direction. Consequently, the competencies of leaders must encompass a substantial degree of risk tolerance and the capacity to navigate intricate regulatory, ethical, and technological landscapes [20, 26].

At this level, organizational transformation may entail spearheading industry partnerships, advocating for regulatory changes, or leading cultural shifts within the organization to embrace innovation and technology-driven healthcare delivery. The interaction of IDCs at different organizational levels underscores the systemic nature of innovation and change management. The strategic framework is shaped by top management, which also provides the resources necessary to implement large-scale change. Concurrently, operational and managerial staff provide front-line insights and drive the early stages of technology adoption. This symbiotic relationship facilitates the expeditious identification and response to novel opportunities while concurrently ensuring the effective management of the innovation process. The examination of dynamic competencies at varying levels of the organization, as well as at the micro level of individual competencies, provides a comprehensive framework for understanding how HCOs can effectively adopt and utilize BT [6, 7].

1.4.3 Blockchain in healthcare

BT may appear to be no more than a digital ledger, a sophisticated database with distributed records that are considered to be permanent. However, in the healthcare sector, this seemingly straightforward architecture has the potential to transform long-standing trust relationships that extend from the loading dock to the patient's bedside. A permissioned chain, wherein only accredited nodes are permitted to validate transactions, has the potential to grant hospitals, regulators, suppliers, and even patients simultaneous visibility into a single source of clinical truth [10, 11]. Each medication lot, every implant serial number, and every algorithm update for an AI triage model is meticulously recorded as a cryptographically sealed event, thereby ensuring that no single stakeholder can manipulate it in private. This assurance of tamper-evident provenance addresses critical concerns that have been documented in numerous studies conducted over several decades within the domains of supply-chain management, pharmacovigilance audits, and malpractice litigation reviews. However, the transition from promise to practice is often challenging because ledgers also encompass design choices and governance burdens that are not well understood by many HCO and are often underestimated by even experienced digital teams [2, 4, 20].

Mariettou et al. (2025) [28] defend that intellectually, BT is situated at the intersection of several theoretical traditions. Socio-technical systems thinking underscores the notion that the implementation of an immutable record constitutes a multifaceted endeavor, one that invariably entails a reconfiguration of decision rights, information asymmetries, and accountability networks. A distributed ledger system eliminates the possibility of covert modifications, thereby transforming the traditional paradigm in which a select group of individuals wielded control over data through privileged access. In this new environment, these individuals find themselves engaged in open negotiations with peers who now verify the same events in real time. Institutional theory posits that external pressures, such as regulators, professional bodies, and industry consortia, influence the urgency and boundaries of adoption. For instance, the European Medicines Agency's directive on counterfeit medicines prompted hospitals to enhance their provenance systems, while the GDPR right-to-erasure clause compelled technologists to devise alternative solutions, such as off-chain storage combined with on-chain hashes. Conversely, RBV theorists emphasize that the value of BTs is contingent upon their integration with complementary assets that are difficult for competitors to replicate. The process of duplicating a tamper-proof log-in isolation is relatively uncomplicated; however, the integration of a ledger with hospital-specific smart-contract templates, dAI dashboards, and staff members capable of redesigning workflows is far more arduous to replicate and thus serves as a source of sustained advantage [5-7].

A HCO decision to invest in BT entails a multifaceted decision-making process, characterized by a branching decision tree that is considerably more complex than the binary choice between adopting or rejecting the BT. The initial branch pertains to ledger scope, i.e., whether the institution should adopt a single-use chain, such as an orthopaedic implant registry, or commit to a multi-use backbone capable of notarizing a wide range of transactions, including cold-chain temperature breaches and carbon-tracking smart contracts [9]. A single-use chain is characterized by its ability to deploy rapidly and deliver immediate, well-defined value. However, a backbone offers economies of scope and data-sharing synergies as new use cases emerge. The trade-off is governance overhead: a backbone, by definition, draws more stakeholders into the consensus process, and each additional node brings its own legal team, risk appetite, and change-management protocols. Researchers cataloguing early pilots have noted that HCO rarely underestimate the technical complexity of federating governance across pharmacy, supply management, infection control, and IT security [13].

A secondary architectural fork pertains to consensus design, wherein proof-of-work—the algorithm powering Bitcoin—has been identified as a potential contributor to environmental concerns, particularly in the context of healthcare facilities [12]. It is noteworthy that these facilities already account for approximately eight percent of global carbon dioxide emissions, underscoring the need for consideration of environmental impact in the healthcare sector. Consequently, the sector gravitates toward proof-of-authority or proof-of-stake variants that are energy-efficient yet still provide Byzantine fault tolerance. Each algorithm implies different validator incentives, audit trails, and failure modes, prompting further deliberation about which departments or external bodies should host validator nodes. In practice, a significant number of HCO—primarily hospitals—participate in industry consortia, wherein a neutral third party, frequently a trusted logistics provider or standards agency, functions as the operator of the shared validator set. This mitigates certain political tensions while concurrently introducing risks related to vendor lock-in and the dilution of direct control over protocol upgrades [20, 29].

Integration choices also follow where clinical and supply data arrive in legacy formats such as Health Level Seven (HL7) standards or Digital Imaging and Communications in Medicine (DICOM), whereas modern health Application Programming Interfaces (APIs) rely on Fast Healthcare Interoperability Resources (FHIR). Mapping engines can translate one into the other; however, message transformation must occur either before data is written on-chain or via microservices that are situated between producer systems and the ledger. It should be noted that both of these approaches incur financial costs and result in increased data latency [2]. A maternity ward pilot study revealed a critical failure in real-time blood unit monitoring during a night-shift handover. This failure was precipitated by a system crash of the HL7-to-FHIR mapper, resulting in the queuing of events and the violation of the promised end-to-end traceability window. The incident, made visible by the ledger's audit trail, which is considered to be unforgiving, eventually prompted an internal conversation regarding the allocation of budget to middleware resilience. This incident served as a reminder that the chain exposes latent weaknesses rather than concealing them [2, 4].

Additionally, the governance of smart contracts presents its own set of challenges. A contract can encapsulate various business rules, temperature thresholds, custody transfers, and cryptographic attestations, thereby automating the workflow. In a permissioned network, any modification to the logic must undergo a rigorous review process. This process involves the involvement of data protection officers, clinical safety leads, legal counsel, and occasionally, ethics committees. In instances where the aforementioned approvals are executed sequentially, the cumulative delay can extend over months, thereby impeding the ledger's capacity for expeditious action [4].

The immutable nature of on-chain data conflicts with the GDPR's erasure requirement. The advent of technical patterns in the field, such as hash linking, encryption key destruction, and personal-data off-chaining, is indicative of the evolution of the field. However, it is imperative to note that each of these patterns is accompanied by trade-offs in latency, query flexibility, and legal interpretation. United States of America (USA) providers must comply with the Health Insurance Portability and Accountability Act (HIPAA) while also aligning ledger access controls with the minimum necessary guidance. The complexity of cross-border clinical trials further exacerbates the situation [27, 30].

A review of the relevant literature reveals a multitude of cases involving stalled pilots. In these instances, post-mortems have identified governance misalignment, inadequate interoperability planning, and, most notably, deficiencies in human capabilities as the primary causes of these failures, rather than core ledger faults. Consequently, the prevailing academic discourse on impact has shifted its focus to the concept of complementarity. It is imperative to acknowledge that BT, in isolation, does not inherently generate value; rather, it constitutes a single layer within a converging stack of technologies, encompassing dAI for privacy-preserving analytics and advanced big-data engines that translate immutable events into actionable insights. According to the general-purpose technology theory, the generation of increasing returns is possible for such stacks once complementary assets have matured. However, only organizations with abundant sensing and adaptive learning capabilities are capable of compressing the lag. Case studies have confirmed the following pattern: HCO that combined BT pilots with federated learning training programs and cross-disciplinary change boards moved from proof-of-concept to production in half the time of their peers who treated the ledger as an isolated IT deliverable [8, 16].

While the promise of this technology is relevant, scholars have cautioned that if the development of new competencies is not sustained, BT's risk of becoming as inflexible as legacy systems. The ledger's inherent strength, which lies in its immutability, can transform into rigidity when change-control boards hesitate to modify smart-contract code. The efficacy of the safest chain is negated if no novel functionalities can be sanctioned; the most auditable provenance is rendered moot if personnel circumvent it with off-ledger spreadsheets. Consequently, the adoption of BT in the healthcare sector is not primarily driven by the appeal of its cryptographic sophistication. Instead, it is largely shaped by the human aspect of HCO grappling with the governance, adaptation, and repurposing of an infrastructure that is inherently resistant to modification [2, 4].

The application of BT in the healthcare sector must be conceptualized not as a singular technological entity but rather as a systemic innovation that fundamentally reshapes how data integrity, accountability, and automation coexist. The success of this initiative is contingent upon a series of design choices, including those pertaining to scope, consensus, integration, and smart-contract governance. It is also influenced by external factors, such as privacy laws and market consortia. Most notably, the initiative's success is shaped by the DC repertoire—both organizational and individual—that enables hospitals to navigate these choices while maintaining patient safety and sustainability objectives [5, 7].

1.4.4 Advanced Digital Technologies: blockchain, artificial intelligence, and big-data analytics

The digital future of HCO's operations is no longer conceptualized as a standalone technology implementation or a well-defined two-step integration process. Conversely, researchers and practitioners are increasingly describing a convergent stack in which permissioned blockchains serve to anchor the integrity of data flows, decentralized or federated AI engines draw insight from those flows without violating privacy, and BDA systems translate the resulting, trust-sealed events into actionable dashboards for clinicians, supply-chain managers, and sustainability officers [9, 15]. When viewed through this lens, BT, AI, and high-volume analytics are not distinct waves of innovation but interconnected layers of a composite infrastructure. The collective potential of these layers exceeds the arithmetic sum of their contributions [23, 31].

The phenomenon of synergy, characterized by the confluence of interdependent components that result in a collective effect, is accompanied by the inherent dynamics of friction. In the context of ledger immutability, this interdependence assumes a dual nature, bearing both advantages and disadvantages. On the one hand, it ensures auditability, providing a record that cannot be altered. However, this characteristic also introduces complexity in the context of AI retraining, particularly in scenarios where clinical guidelines undergo modifications, resulting in the previous ground truth becoming a source of error in subsequent iterations. Federated learning is an approach to distributed systems that aims to prevent the centralization of data. However, it introduces statistical heterogeneity, which refers to the variation in data distribution across nodes. This variation can lead to differences in the distributions of patient age, comorbidity, or device brand, resulting in wider confidence intervals for the algorithm's predictions unless sophisticated aggregation methods are employed. BDA engines demonstrate a high level of functionality with high-volume append-only logs; however, their query planners encounter challenges when faced with every provenance event wrapped in cryptographic signatures and reference hashes. This results in an increase in compute costs if schemas are not optimized. The aforementioned tensions illustrate the limitations of technical architecture in ensuring success. It is imperative to recognize that orchestration routines and capability building become relevant factors in achieving success [7, 16].

The subsequent layer of complexity pertains to interoperability, given that the constituent systems do not utilize a uniform native language. Clinical interfaces continue to emit proprietary messages, analytics warehouses exhibit a preference for columnar formats, and AI frameworks anticipate the utilization of tensors. Concurrently, permissioned ledgers are undergoing a transition to incorporate a more diverse array of data types and conditions. Middleware, in essence, functions as a polyglot translator, meticulously mapping, validating, and occasionally anonymizing data before its traversal across the layer boundary, where data protection and privacy assume paramount importance. It has been posited by scholars that the allocation of substantial resources to middleware can be regarded not as a sunk cost, but rather as an investment in future optionality. The existence of translation pipelines facilitates the subsequent integration of new use cases with minimal additional effort, as each layer can rely on the semantics provided by its neighboring layers [2, 4, 18]

In the context of governance, the BT has the potential to play a significant role. In a convergent stack, the complexity of the technology increases significantly, given its integration with multiple systems. The logic of a ledger's smart contract must satisfy data protection officers by ensuring that no personal identifiers leak onto the chain. The AI that reads these events must satisfy an ethics board by demonstrating that the training labels are unbiased. Furthermore, the analytics dashboards must satisfy finance committees by demonstrating the validity of the key performance indicators. Change-control boards, which are accustomed to quarterly releases, are confronted with continuous-deployment cadences from the machine learning and operations domain. In this domain, model weights may be updated daily to mitigate concept drift. In such environments, hospitals often adopt automation in their governance processes, converting standard operating procedures into machine-readable policy checks that are executed before each deployment. In contrast, others have explored the use of explainable pipelines, wherein each layer emits cryptographically signed attestations. These attestations serve as proof that data transformations or model updates adhere to pre-defined constraints. This approach enables auditors to traverse the entire stack without the need for manual reconciliation, thereby enhancing the reliability and transparency of the data transformation process [31-33].

Connected with the concept of talent architecture represents a significant shift in the traditional approach to siloed disciplines such as clinical informatics, data science, and cybersecurity. This paradigm shift involves the transition from a serial model of information exchange and collaboration, characterized by distinct and sequential stages or "hand-offs," to a more integrated and dynamic framework. Convergent teams or digital clinics, on the other hand, bring together experts who collectively address ledger architecture, statistical modeling, data engineering, and regulatory interpretation. The collaborative charter of these entities is not merely to construct the stack, but rather to recalibrate it as regulations, threats, and clinical priorities evolve. In this context, the IDC and the broader organizational DC engine are thoroughly tested. Professionals must be able to sense shifts in the environment, such as the introduction of a new European AI Act clause, to allocate resources for retraining models and updating smart contracts. They must also be able to transform workflows in a way that ensures the sustainability of the change beyond the project team's tenure [5, 7].

A review of the literature reveals a clear correlation between the allocation of protected learning time and the establishment of cross-disciplinary guilds by organizations and the acceleration of convergence benefits. In contrast, an approach that treats BT, AI, and analytics as discrete procurement categories has been shown to result in friction at every interface. Financial models also evolve under convergence, where a ledger's cost justification traditionally rests on savings through reduced fraud or counterfeit risk. AI proponents promise diagnostic accuracy gains, and analytics teams highlight efficiency in reporting. The convergent stack has been demonstrated to unlock compound value, with spoilage detection translating into carbon-footprint transparency. This, in turn, has been shown to enable green-bond financing or favorable insurer reimbursement. These compound benefits necessitate the development of novel valuation frameworks that encompass a range of factors, including avoided regulatory fines, enhancements in ESG scores, and the consideration of reputational capital. Early adopters frequently execute scenario analyses that conceptualize convergence as a portfolio of real options, with each layer reducing the volatility of returns from the subsequent layers [9, 10, 23].

As the ethical scope expands, provenance logs can unequivocally expose clinician error with the same degree of clarity they demonstrate in unveiling counterfeit shipments. The training of AI models on distributed datasets gives rise to concerns regarding group fairness across socioeconomic or ethnic strata. Furthermore, big-data dashboards have the potential to unintentionally re-identify patients if slice-and-dice queries expose small demographic intersections. Convergent governance, as argued by ethicists, must evolve beyond privacy considerations to embrace broader principles of justice, beneficence, and non-maleficence. The emerging consensus posits that transparent, immutable logs are necessary but not sufficient; they must be coupled with oversight forums that include citizens, patients, and frontline staff to interpret the meaning of the data and determine the course of remedial action [28, 34, 35].

1.4.5 Technology-acceptance thinking

According to Ma et al. (2024) [36], technology acceptance thinking in healthcare has long been dominated by the deceptively elegant proposition that two cognitive appraisals—perceived usefulness and perceived ease of use—explain why clinicians embrace or resist a new system. This was the original promise of the TAM, and for decades, the framework has demonstrated valuable explanatory power across a range of electronic health records, computerized physician-order entry, and telemedicine platforms. However, as digital infrastructures have evolved and become intertwined, many scholars now consider TAM to be merely the beginning of the conversation rather than its conclusion. This is particularly true when the technologies in question—namely, permissioned blockchains, federated AI, and high-volume analytics—reorder accountability, professional identity, and organizational risk in ways that extend far beyond the desktop usability issues that TAM once effectively addressed. A substantial body of research on TAM has identified significant coefficients for usefulness and ease. However, these studies have also noted stalled adoption once projects transition from pilot to production phases. This suggests the presence of additional factors that may be acting as off-stage bouncers, silently hindering progress even when frontline staff express satisfaction with the product [8, 14].

A portion of this discrepancy can be attributed to the complexity inherent in BT, AI, and BDA. These systems, as initially conceptualized by TAM, are not straightforward entities. Instead, they are multifaceted socio-technical infrastructures [10]. Immutability, the feature that auditors find most useful, can provoke anxiety in surgeons who fear that a dosing typo will be etched forever. While a distributed-ledger interface may be characterized by its clarity and intuitive nature, with labels provided in straightforward language, the underlying logic of its smart contracts remains opaque to clinicians trained in evidence-based medicine. In this context, ease of use cannot be reduced to click counts or screen time; it now includes conceptual ease. If the conceptual journey feels impossible, then intentions registered can evaporate under the strain of real-world accountability [4].

Consequently, researchers have proposed extensions to address these limitations. The UTAUT incorporates social influence and facilitating conditions; TAM introduces perceived trust and computer anxiety; health-specific variants add constructs such as privacy concern and data ownership [3, 14]. In the absence of personal capacity, even the most meticulously designed system is destined to confront the formidable barriers of operational challenges. In essence, cognition transitions to behavior solely through the conduit of capability. Another set of extensions recognizes that HCO are hierarchical, multi-actor environments. Classical TAM treats the user as a monolith, where multi-actor TAM variants aim to differentiate these roles, occasionally employing multi-level modeling [19, 36]. Individual perceptions elucidate intention at the individual level; aggregated norms influence unit-level readiness; environmental shocks, new regulations, competitor actions, affect organizational appetite. Additionally, trust has been identified as an essential variable. In the original TAM, trust was considered a subordinate construct, assumed to be indirectly influenced by perceived usefulness. In the context of BT networks, however, trust is ontological. If a user were to question the veracity of validators or the fairness of consortium governance, no amount of front-end usability would suffice. Empirical research has demonstrated that perceived usefulness can function in reverse, wherein the denial of utility serves as a polite proxy for more profound misgivings regarding data politics. Consequently, contemporary models incorporate institutional trust, algorithmic transparency, and data-governance fit as direct antecedents [2, 10, 19].

When considered collectively, the evolution of TAM for complex health technologies indicates a conceptual shift. The model's elegant simplicity remains a useful diagnostic tool; however, for sustainable adoption to occur, a richer synthesis is necessary. This richer synthesis must incorporate trust, role-specific perspectives, the regulatory environment, the DC of individuals and organizations that enable them to absorb disruption. It is possible to conceptualize TAM as the cognitive gateway to blockchain uptake [4, 7, 14].

1.4.6 Sustainability and operational efficiency

The discourse surrounding sustainability and operational efficiency in healthcare has evolved beyond its conventional emphasis on reducing length-of-stay or minimizing procurement expenses. In recent years, global policy frameworks have undergone a significant transformation. Prominent examples include the Paris Climate Accord, the EU Green Deal, and the USA Inflation Reduction Act. Additionally, domestic policy developments, such as the revamped accreditation criteria from bodies like the Joint Commission, have also contributed to a shift in the landscape of healthcare administration [9, 37]. This transformation encompasses various HCO, including clinics, hospitals, and recovery centers. In the contemporary healthcare landscape, the conventional standards of excellence, such as clinical proficiency and financial stability, have been deemed inadequate. Prospective providers are now held to a more expansive set of expectations, including the demonstration of responsible environmental stewardship and transparent social governance. These elements have been integrated into the broader framework of performance evaluation and are subject to rigorous auditing processes. In this landscape, which has undergone a recalibration, digital technologies have emerged, promising two things: the ability to perform routine tasks more quickly and the capacity to document them with greater credibility. The integration of permissioned BT, dAI engines, and big-data analytics establishes an infrastructure capable of verifying the origin of assets, optimizing their utilization, and unveiling previously concealed waste streams with a degree of objectivity that was previously unattainable. The core question is why so many initiatives falter before those gains become enterprise norms, despite pilots demonstrating audit-prep time reductions from weeks to hours and stock-out risks decreasing by double digits [8].

The solution to this issue lies in acknowledging that operational efficiency and sustainability are not two distinct entities, but rather, they are interconnected components of a unified systems problem. The automation of cold-chain monitoring through the implementation of IoT sensors, which facilitate the hashing of events onto a ledger, has the potential to yield several benefits. Primarily, it can reduce the labor-intensive task of manual data entry, thereby enhancing efficiency. Additionally, it can contribute to a reduction in medicine spoilage, which leads to cost savings and a reduction in environmental waste. Furthermore, the immutable evidence generated for ESG reporting can enhance the credibility of such reports [12]. The synergistic effect of these outcomes is evident in the reinforcement of each other's positive effects. The cost-saving funds, in turn, catalyze innovation. The ESG transparency not only meets the expectations of investors and regulators but also fosters a sense of confidence among patients regarding the integrity of provenance data. Economists refer to this phenomenon as a positive externality loop, while systems thinkers term it a virtuous cycle dynamic. However, virtuous cycles are initiated with a degree of fragility. The necessity of meticulously capturing, accurately interpreting, and promptly acting on process data is paramount. This is the nexus where the earlier concepts of capability and governance intersect with sustainability ambitions. The absence of responsive decision-making in the context of immutable data is tantamount to the construction of an elegant tombstone for inefficiency. Similarly, the presence of highly motivated staff without trustworthy data can lead to the pursuit of futile endeavors [3, 7].

Conventional ESG reporting methods depend on supplier self-declarations, spreadsheet-based data collection, and sampling audits, resulting in estimates that are often months out of date and susceptible to inaccuracies. A permissioned blockchain can tokenize each purchase order, attach machine-readable ESG attributes, and feed real-time dashboards. This shift in granularity, from quarterly averages to per-lot figures updated daily, is a significant development. Early pilots demonstrate that audit preparation lead times are decreasing from twenty-one days to twenty-four hours, which is an operational gain that allows compliance officers to focus on mitigation rather than data reconciliation. However, these same studies caution that if pharmacy and procurement teams cannot redesign reorder triggers or if change-control boards cannot expeditiously approve smart-contract modifications, cost savings are jeopardized as staff revert to legacy procurement portals until the new system stabilizes [7, 38].

The social dimension of sustainability introduces further complexity, as health systems are among the largest employers in their regions. Critics of BT have highlighted the energy consumption associated with public proof-of-work chains. However, permissioned health networks frequently utilize consensus algorithms that are less energy-intensive. Beyond the mere measurement of kilowatt hours, the crux of the issue lies in the manner in which immutability unveils latent energy dissipation within clinical operations. Immutable logs reveal equipment idling, refrigerated units cycling unnecessarily, and ventilator runtimes exceeding maintenance schedules [37]. Subsequently, BDA translates these events into dashboards, while AI models generate predictive maintenance alerts. However, the chain can also serve to highlight inefficiency without addressing the underlying causes. If capital-budget committees approve replacements only on an annual basis, or if biomedical engineers lack the authority to decommission obsolete units, the data becomes a measure of failure rather than progress. This is an instance of governance misalignment, not a technological shortfall [4, 39].

Furthermore, additional layers of financial efficiency are being incorporated into immutable provenance cuts, duplicate invoicing, third-party payer validation, and fraud investigation effort reduction. An analysis of case studies reveals that reimbursement cycles have been shortened by days, thereby releasing working capital for patient services. However, the efficacy of these benefits is contingent upon the agility of smart-contract governance. The protracted approval processes that characterize many systems serve to nullify the advantage inherent in liquidity. Furthermore, the efficacy of this system hinges on the level of trust clinicians place in the ledger, sufficient to warrant the abandonment of parallel documentation. Empirical evidence suggests that the implementation of staff training to interpret on-chain audit trails, in conjunction with the transparent publication of incident-response metrics, such as the mean time to repair for data-integrity breaches, fosters the growth of trust. These metrics can also serve as sustainability indicators, as faster incident resolution has been shown to reduce resource waste and avoid costly recall cascades [3, 4].

Ultimately, sustainability and efficiency intersect with strategic reputation. Investors are increasingly correlating funding costs with ESG scores, governments are linking reimbursement bonuses to carbon-reduction milestones, and patients are consulting sustainability indices when selecting providers. BT-anchored reporting systems empower hospitals to disseminate verifiable metrics about the reduction of polluting emissions per surgical procedure, the adherence to cold-chain integrity standards, and the proportion of reused devices [9, 38]. These systems provide hospitals with the assurance that auditors will corroborate the accuracy and veracity of the reported data. Pioneering entities have issued green bonds at reduced interest rates, facilitated by substantiated, ledger-based ESG performance. These capital-market gains are subsequently allocated back into operational budgets, thereby facilitating further investments in technology and capabilities. The resultant paradigm elucidates a nexus wherein sustainability and operational efficiency serve as the validation framework for all preceding conceptual strata. Consequently, sustainability and operational efficiency are not mere afterthoughts or public-relations veneers; rather, they serve as the tangible scorecard of an organization's success in integrating technological, human, and governance assets into a coherent, learning health system [3, 9].

1.4.7 The Nexus of Capabilities, Resources, and Performance

The RBV of the firm provides a foundational lens for understanding how HCOs achieve sustained competitive advantage. This strategic framework asserts that an organisation's most critical assets are not solely its tangible resources, such as advanced medical equipment, but rather its unique, valuable, and difficult-to-imitate capabilities. Within the domain of healthcare, these strategic resources encompass proprietary clinical data, a trusted brand among patients, and, most significantly, the collective expertise of its personnel. In the face of mounting market pressures to deliver superior value, the RBV posits that HCOs must introspect to nurture these distinctive capabilities, as opposed to merely competing on cost or acquiring standard technologies [10, 13].

The RBV is predicated on the assumption that managerial competencies represent the capacity of an organisation's leaders to orchestrate assets, navigate complexity, and foster innovation. For a hospital, this extends far beyond traditional business acumen. This process entails the capacity to decipher and adjust to intricate regulatory frameworks, such as the HIPAA and the GDPR, thereby converting compliance obligations into prospects for fostering patient confidence. Competent managers are those who can foster a culture that balances stringent safety protocols with the agility required to adopt new clinical techniques, thereby ensuring that the organisation remains both compliant and competitive [14, 21].

The overarching objective of leveraging these resources and competencies is to enhance operational efficiency. Within the domain of healthcare, this term extends beyond mere cost-cutting measures; it signifies the capacity to deliver high-quality patient care in a safe, dependable, and efficient manner, whilst minimising waste. This operational efficiency is a direct response to market pressure from payers, patients, and competitors who demand better outcomes for lower costs. Such pressure may take the form of streamlining surgical scheduling, optimising supply chains to reduce spoilage, or reducing patient wait times. The attainment of such efficiency serves as a reliable indicator of an organisation's fundamental capabilities [22, 26].

The challenge of interoperability of systems starkly illustrates the interplay between these three concepts. A hospital may possess valuable patient data, yet if this data is contained within siloed, legacy technology-driven systems, it cannot be utilised efficiently. In order to overcome this issue, managers must possess the following competencies: the vision to invest in modern, interoperable platforms like those using FHIR standards, the skill to manage the complex transition, and the foresight to ensure the new system complies with data-sharing regulations. The resulting integrated data flow represents a rare and valuable capability, with the potential to directly boost operational efficiency by enabling seamless care coordination and powerful analytics. Within the contemporary healthcare landscape, an HCO's most potent strategic asset is its DC to adapt. This is not a static resource but a complex interplay where skilled managerial competencies orchestrate other resources to achieve high operational efficiency. This adaptive capacity enables the organisation to respond continuously to shifting regulations, overcome technical challenges such as interoperability, and thrive under intense market pressure. Consequently, it is relevant for any HCO aspiring to establish a resilient and sustainable competitive advantage to conceptualise these elements as interconnected components of a holistic system [14, 22, 26].

1.5. Contributions

The present thesis is of significance in three distinct ways, namely in terms of theoretical contributions, methodological contributions, and practical contributions. Firstly, the primary theoretical advancement is the development of a micro-founded model of technology adoption. The present work identifies and operationalises IDC, thereby bridging the gap between the high-level, firm-centric perspective of DC theory and the individual-user focus of models such as TAM. The study offers empirical evidence to demonstrate that IDC functions as a critical mediating factor, thereby providing a more comprehensive explanation for why organisational potential for innovation is realised in practice. The subsequent methodological contribution is of particular significance, as it pertains to the creation and validation of the IDC-MDS.

This thesis makes a valuable contribution to the academic literature by providing the scholarly community with the first psychometrically robust instrument for measuring the specific routines of sensing, seizing, and transforming at the individual level in a healthcare context. This tool facilitates the transition of IDC research from a purely conceptual domain to one that can be empirically and quantitatively investigated. Additionally, the practical contribution of this research is twofold: firstly, it offers healthcare leaders and managers a set of actionable tools, and secondly, it provides a framework for understanding the relationship between leadership and management in healthcare. The findings suggest that IDC-MDS can serve as a diagnostic instrument with the purpose of assessing organisational readiness for digital transformation and identifying specific capability gaps. Moreover, the findings concerning the interplay between IDC, governance, and leadership provide a practical roadmap for designing effective training interventions and change management strategies, which, in turn, increases the probability of success for high-stakes technology projects such as blockchain implementation. As the methodology was developed, and in particular following the initial empirical validation phases, the principal theoretical contribution became increasingly evident. This was characterised by the integration of DC thinking with TAM and governance scholarship in a domain where these discourses had rarely converged. The objective of this thesis was to explore the potential of permissioned blockchains to transition from experimental pilots to a state-of-the-art, auditable infrastructure within the healthcare sector, with a particular focus on the hospital context. The validation of the micro-routines of sensing, seizing, and transforming, which serve as crucial conduits, is of paramount importance in facilitating the transformation of immutable ledgers into living, operational assets. Subsequently, the development and validation of an IDC-Maturity Scale, integrated within an adoption framework that concurrently assesses governance bottlenecks, served to expand the scope of DC theory to the level of individual nurses, pharmacists, and middle managers. This approach has been shown to provide a novel explanatory framework that has the capacity to reconcile user attitudes with organisational agility [8, 14].

In essence, the thesis delineates a methodical course for integrating BT, federated AI, and BDA into HCO operational procedures, while ensuring patient safety and ESG obligations. It employs the paradigm of operational efficiency, underpinned by the concept of DC, at the individual level. The process entails the delineation of the alignment between systems interoperability standards, governance protocols, governance organizational layers, and change-control policies. This delineation produces a blueprint that boards can adopt to ensure that new BT initiatives complement existing quality, organizational, and individual capabilities and safety management systems. The value of this mapping for procurement and compliance teams is immediately apparent. It translates the abstract principles of data integrity and privacy into concrete release checklists, validator node responsibilities, and audit trail artifacts [2, 9].

Risk management emerges as a complementary contribution. The thesis also documents mitigation strategies that integrate technical safeguards into human oversight loops. By advocating for the implementation of risk dashboards that prioritize capability and that monitor both ledger metrics (e.g., latency, consensus health) and human metrics (e.g., IDC scores, governance-meeting cadence), the research reframes risk as a joint socio-technical construct. Furthermore, it provides HCO leaders with the capacity to act proactively rather than reactively. The combination of technological domains with sensitive areas, such as healthcare, including data governance, provides a solution to a critical managerial question regarding the expansion of BT and its AI analytics partners while addressing professional jurisdiction, privacy law, and the scarcity of digital talent in the contemporary context. The integration of theoretical frameworks with actionable methodologies outlined in this study signifies a substantial advancement in academic discourse concerning digital health transformation. This advancement equips practitioners with the necessary tools to translate immutable code into resilient, sustainable clinical value [21-24].

1.6. Research design

The research design was constructed through a deliberate and sequential mixed-methods approach, wherein each of the eight articles functions as a logical building block in a larger argumentative structure. This methodological decision was made to ensure that the investigative process progressed systematically from an extensive theoretical exploration to specific, validated, and generalizable conclusions. The initial phase is designated as Phase 1, Foundational Scoping (Article #1). The research process was initiated with a thorough systematic literature review (SLR). The objective of this study was twofold: first, to consolidate the scholarship on blockchain in healthcare, and second, to identify the critical research gaps. This review confirmed that while technical and macro-governance issues were extensively discussed, a significant void existed concerning the micro-level capabilities of individual actors. This finding established the parameters of the inquiry and directly informed the formulation of the central RQs. This phase also initiated the exploration of governance layers and the identification of prevailing challenges [40].

The second phase of the research process is Qualitative Discovery and Structuring, which is further delineated in Articles #2 and #3. With the research gap having been clearly delineated, the subsequent logical step was to transition from theoretical discourse to empirical exploration through qualitative inquiry. It was valuable to first comprehend the phenomenon from the perspective of those engaged in the frontline operations. This phase entailed the conduction of multi-case interviews and dedicated focus groups to ascertain the specific "sensing, seizing, and transforming" routines that HCPs themselves identified as being critical for success. These rich, contextual narratives provided the essential empirical grounding. For instance, hearing managers described the challenge of mobilizing cross-disciplinary resources, and clinicians discussed the need to refactor workflows. These authentic, practitioner-centric expressions are crucial for developing a relevant measurement instrument [41, 42].

Phase 3 encompasses the development and validation of instruments (Article #4). The qualitative insights derived from Phase 2 directly informed the development of the IDC-MDS. The themes, challenges, and success factors identified by practitioners were systematically translated into a pool of psychometric items. The present phase was instrumental in operationalizing the abstract concept of IDC into a five-level scale that was both tangible and reliable, thereby fulfilling a key research objective. The validation of this instrument was a significant moment in the research, as it created a novel tool to quantitatively assess capability readiness [43].

Phase 4 encompasses large-scale theory testing and contextual application, as delineated in articles #5, #6, #7, and #8. With a validated scale in hand, the final phase was dedicated to applying it across diverse contexts to test its predictive power at a larger scale. A series of single-case, multi-case, and hybrid survey methodologies were employed to examine the correlation between IDC maturity scores and concrete performance outcomes. These outcomes included ESG program success, operational efficiency, and the successful implementation of AI-driven clinical decision support systems. This final phase enabled the thesis to generalize the IDC–adoption link, demonstrating empirically that higher IDC maturity consistently explains successful technology adoption and the realization of downstream organizational benefits, thereby answering the final and most critical RQ. Figure 1.4 presents the overview of the research design and the corresponding phases [40-47].

Figure 1.4: Thesis research design architecture.

By presenting the publication sequence as an interconnected web rather than a linear list, the figure underscores the study's systematic yet adaptive methodology. Each article was designed to be a self-contained unit that could withstand scrutiny by the journal's peer review process. However, the RQs, variables, and sample frames were selected to ensure that the findings seamlessly integrated into the overarching narrative. The research strategy explicitly invested in feedback loops, but also case insights aiming to refine the maturity scale, and survey anomalies, demonstrating the iterative nature of the research, where every round of peer review and fieldwork sharpened both theory and practice. The thesis's core argument was also related to the adoption of sustainable BT in healthcare is only possible when organizational governance, IDC, and convergent digital stacks are studied not in isolation but as mutually reinforcing strands. This principle is reflected in the manner in which the eight publications are integrated to form a coherent scholarly contribution [40-47].

1.7. Publications

In the course of developing this thesis, the research studies were designed, executed, and written to stand on their own as contributions of publishable quality. Each paper was designed to address a particular aspect of the overarching research problem, yet all share a common methodological foundation and theoretical through-line [5, 7].

The publication's organizational objectives were twofold: first, to generate research publications derived from the overarching doctoral program; and second, to contribute to the scholarly conversation on BT-enabled health innovation with rigorously vetted evidence. The DC at different organizational and individual levels can play a decisive role in effective technology implementation. Consequently, each project was subjected to blind peer review in journals whose editorial mandates align with the work's clinical, technological, and managerial dimensions. A total of five papers have been published, and three are not yet published, where one is an SLR that is currently under review by the journal editor for consolidation of the peer review cycle's first phase decision. In addition, two additional manuscripts are progressing through the review pipeline, and one has been recently accepted for publication at the Journal of Medical Systems, with the request for minor changes [40-47]. The responsibility for these outputs lay with the doctoral researcher, who served as the primary author for all manuscripts, oversaw data collection, conducted the analyses, and drafted each discussion section. Senior supervisors and domain experts were designated as co-authors after the provision of sustained guidance, which included the refinement of RQs, stress-testing instruments, challenging interpretations, and the direction of each paper toward a suitable publication venue. The mentorship provided by these experts was instrumental in ensuring the methodological soundness of the research, while at the same time, it fostered the intellectual autonomy of the candidate [37, 39, 42].

To assess the external recognition and scholarly impact of the work, the SCImago Journal Rank (SJR) indicator was employed to select and benchmark target journals. SJR offered a field-normalized prestige score that weighted citations by the influence of the citing sources, thereby rewarding not only popularity but also citation quality. This nuance is of particular importance given the multidisciplinary nature of BT in healthcare, which encompasses domains such as clinical informatics, operations management, and sustainability sciences. Each of these fields has its own distinct citation culture, underscoring the need for a comprehensive understanding of research methodologies and publication practices across these disciplines. By prioritizing outlets with solid SJR profiles, the team maximized the likelihood that findings would reach audiences capable of citing, debating, and extending them. The resulting publication portfolio, which is outlined in Figure 1.5, encompasses a range of journals classified as either quartile one or quartile two in the domains of information systems, operations research, medical systems, and digital health [37-42].

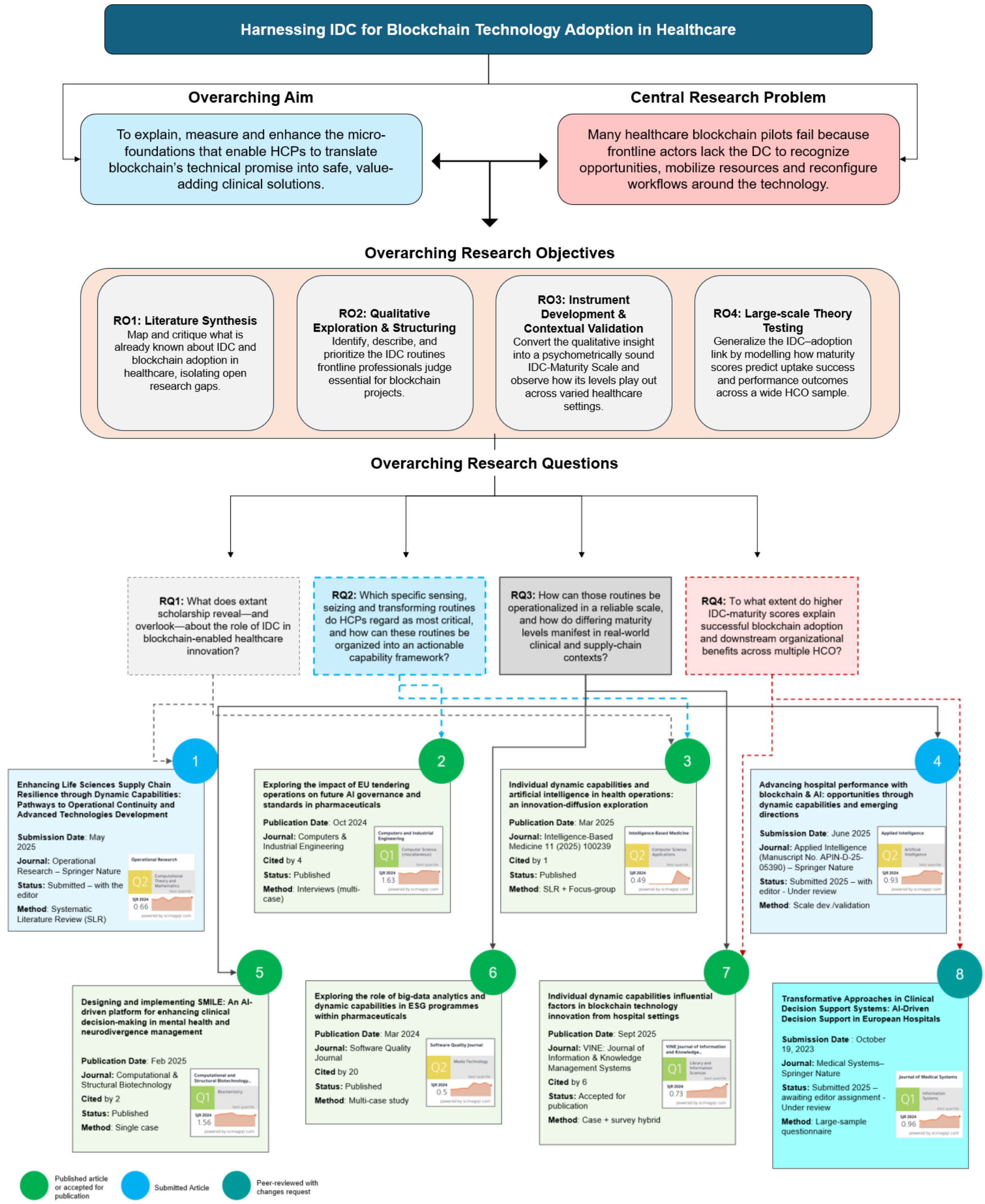

Figure 1.5: Research scheme and publications organization management

The figure presents a visual representation of the relationship between the outlets' SJR values and their thematic foci, which include traceability, capability maturation, and ESG analytics. This approach enables readers to discern the intersection between scientific influence and topic coverage with ease.

1.7.1. Published articles

- **Title: Exploring the impact of EU tendering operations on future AI governance and standards in pharmaceuticals [41]:**
    - Authors: Antonio Pesqueira, Andreia de Bem Machado, Sama Bolog, Rúben Pereira, Maria José Sousa
    - Journal: Computers & Industrial Engineering
    - Impact Score SJR 2024: 1.63
    - Publication Date: October 2024
    - Current Status: Published
    - Dissertation Phase: 2
- **Title: Individual dynamic capabilities and artificial intelligence in health operations: an innovation-diffusion exploration [42]:**
    - Authors: Antonio Pesqueira, Maria José Sousa, Rúben Pereira
    - Journal: Intelligence-Based Medicine
    - Impact Score SJR 2024: 0.49
    - Publication Date: March 2025
    - Current Status: Published
    - Dissertation Phase: 3
- **Title: Designing and implementing SMILE: An AI-driven platform for enhancing clinical decision-making in mental health and neurodivergence management [44]:**
    - Authors: Antonio Pesqueira, Maria Jose Sousa, Ruben Pereira, Mark Schwendinger
    - Journal: Computational & Structural Biotechnology
    - Impact Score SJR 2024: 1.56
    - Publication Date: February 2025
    - Current Status: Published
    - Dissertation Phase: 5
- **Title: Exploring the role of big-data analytics and dynamic capabilities in ESG programmes within pharmaceuticals [45]:**
    - Authors: Antonio Pesqueira, Maria José Sousa
    - Journal: Software Quality Journal
    - Impact Score SJR 2024: 0.5
    - Publication Date: March 2024
    - Current Status: Published
    - Dissertation Phase: 6
- **Title: Individual dynamic capabilities are influential factors in blockchain-technology innovation in hospital settings [46]:**

- Authors: Antonio Pesqueira, Maria José Sousa, Rúben Pereira
- Journal: VINE Journal of Information & Knowledge Management Systems
- Impact Score SJR 2024: 0.73
- Publication Date: September 2025 – Accepted and ready for publication
- Current Status: Pre-final proofreading and publication phase.
- Dissertation Phase: 7

1.7.2. Submitted articles

- **Title: Transformative Approaches in Clinical Decision Support Systems: AI-Driven Decision Support in European Hospitals [47]:**
  - Authors: Antonio Pesqueira, Maria José Sousa, Rúben Pereira
  - Journal: Medical Systems
  - Impact Score SJR 2024: 0.96
  - Submission Date: December 2024
  - Current Status: Accepted, and after the 2nd phase of peer review will be presented the corrected version and final comments to reviewers
  - Dissertation Phase: 8
- **Title: Advancing hospital performance with blockchain & AI: opportunities through dynamic capabilities and emerging directions [43]:**
  - Authors: Antonio Pesqueira, Maria José Sousa, Rúben Pereira
  - Journal: Applied Intelligence (Manuscript No. APIN-D-25-05390) – Springer Nature
  - Impact Score SJR 2024: 0.93
  - Publication Date: Submitted – Peer Review Stage
  - Current Status: Pre-final proofreading and publication phase.
  - Dissertation Phase: 4
- **Title: Enhancing Life Sciences Supply Chain Resilience through Dynamic Capabilities: Pathways to Operational Continuity and Advanced Technologies Development [40]:**
  - Authors: Antonio Pesqueira, Maria José Sousa, Rúben Pereira
  - Journal: Operational Research – Springer Nature
  - Impact Score SJR 2024: 0.66
  - Submission Date: May 2025
  - Current Status: Submitted – with the editor
  - Dissertation Phase: 1

1.8. Thesis organization

The thesis has been structured to act as a thesis-publication document. This deliberate choice enables each component to establish its position within the scholarly discourse while concurrently promoting a unified research agenda. The publications sequence within the thesis is arranged to present the narrative in a logical progression: from initial gap-mapping and qualitative discovery, through measurement development and contextual validation, to large-sample theory testing. This architecture fulfills the dual criteria of rigour and doctoral coherence, thereby ensuring that the cumulative insights of each article converge into a cohesive response to the overarching question of how IDC and governance routines can facilitate sustainable BT adoption.

The peer-reviewed articles that are already part of the archival record are contained in Chapters 2 through 9. The chapters have been arranged sequentially, beginning with the SLR that identified the capability–governance gap and concluding with the construction of the IDC-Maturity Scale and its validation across multiple BT and dAI case studies. This progression is further supported by the integration of interviews and focus groups, which elucidate frontline experiences. The sequence of papers is of consequence: insights obtained in one paper influence the variables measured in the subsequent paper, and methodological lessons—for example, about governance-metric collection—are advanced rather than reiterated [40-47].

Chapter 10 serves as a culminating point, thereby completing the overall narrative arc. It establishes connections that journal page limits could only suggest, drawing meta-inferences about how capability density mediates the relationship between trust perceptions and operational outcomes, how smart-contract approval lead-time functions as an early-warning metric for adoption fatigue, and how the triple-bottom-line gains of BT emerge only when technical, organizational, and human systems co-evolve. The limitations of the study are also presented and acknowledged, and an agenda for future research is offered, calling for longitudinal studies that follow IDC trajectories over multiple technology cycles. In this manner, the conclusion not only synthesizes the knowledge acquired but also entrusts the responsibility to the subsequent generation of scholars and practitioners.

CHAPTER 2

Article nr 1

“Enhancing Life Sciences Supply Chain Resilience through Dynamic Capabilities: Pathways to Operational Continuity and Advanced Technologies Development”

2.1. Introduction

The initial step in the programme was to establish a substantial foundation of preliminary knowledge. This was achieved by conducting a thorough review of the existing literature through the SLR. The primary objective was to investigate the integration of DC and BT within healthcare traceability and coordination, with a view to evaluating their role in fostering resilient supply chains and improving operational performance in healthcare settings. The investigation was conducted with a view to answering the first research question. The applied SLR methodology synthesises the current studies and assesses interventions, processes, and technologies that enhance transparency, logistical efficiency, and service quality in HCOs.

The research scope emphasises the identification and strengthening of organisational and managerial capabilities for the effective adoption and management of BT in healthcare contexts, with a focus on the synergistic interplay between human expertise and technological innovation. Furthermore, the study explores how blockchain-enabled solutions can bolster traceability, mitigate the risks of counterfeit products, and streamline coordination operations within the evolving healthcare landscape. The findings offer meaningful insights for strategic and operational decision-makers who seek to optimise healthcare coordination through the alignment of DC and BT, thereby reinforcing patient safety, service quality, and the overall advancement of healthcare delivery systems [40].

2.2. Research Problem and Objectives

The publication directly addresses the first overarching RQ1 of the thesis: The available scholarship on the subject of the role of IDC in blockchain-enabled healthcare innovation has revealed certain aspects of the topic, as well as certain aspects that have been overlooked.

The primary objective of this SLR was to analyse and synthesise a series of peer-reviewed articles to ascertain how HCOs can leverage DC and BT to manage supply chain disruptions, evolving regulatory demands, and rapid technological change. In addition, the other objectives were to consolidate the existing evidence on how the integration of BT with well-developed DC enhances supply chain transparency, efficiency, and resilience. Furthermore, the objectives included the identification of the key barriers to adoption, such as implementation costs, scalability, and workforce resistance, as documented in the literature. Finally, the objectives encompassed a critical assessment of the state of current research to formally identify the conceptual gaps, particularly concerning the role of individual-level capabilities as a mediating factor between technology and performance.

2.3. Core Contribution

The following URL presents the full manuscript of the article, which has been submitted to the journal Operational Research – Springer Nature. The manuscript meticulously delineates the systematic review methodology, the analysis of 69 peer-reviewed articles, and the comprehensive findings.

Article: https://iscteiul365-my.sharepoint.com/:b:/g/personal/ambpa1_iscte-iul_pt/ERLnSPrQD-RJt0MbQF2gXosBWjmUtZTgCM1S2rm4gXrBmA?e=5KFxHF

2.4. Discussion of Key Findings

The findings provide a foundation for the central argument of this publication and also the thesis. The review empirically confirms several foundational premises, based on the vast body of existing literature on the key concepts like BT and DC. The publication validated the DC-Technology link and indicated that organisational readiness and adaptive capabilities are essential for successful technology adoption; in their absence, it is unlikely that technological investments will yield lasting benefits. This finding serves to substantiate the assertion that the DC framework constitutes a highly pertinent lens through which to examine the adoption of BT, thereby underscoring the notion that the issue at hand transcends the confines of mere technical implementation. The most significant theoretical contribution made is its conceptualisation of DC as a mediator between the technical capabilities of blockchain and the attainment of operational resilience.

Most importantly, while the SLR confirms the link between firm-level DC and BT, it simultaneously highlights a significant void in the literature. The majority of analysed studies focus on DC at the organisational or strategic level, while the micro-foundations – that is to say, the specific skills, mindsets, and routines of individual employees – are largely unexplored. The documented barriers of organizational resistance are frequently presented as a problem to be managed, rather than as a symptom of underdeveloped individual capabilities. This absence in the literature is precisely the research gap that this thesis is designed to address. The SLR has established a clear focus for the subsequent empirical phases by identifying key challenges such as scalability, cost, and resistance. The study emphasised the necessity to transcend theoretical frameworks and to examine the manner in which these barriers are encountered and surmounted by individuals in operational settings.

Additionally, the findings, including the advantages of merging DC with BT initiatives and the centrality of leadership backing, yield tangible suggestions for practitioners in the field. The observations presented herein delineate strategies for nurturing employee competence, fostering strategic thinking, and cultivating an environment of ongoing learning and adaptation. These strategies are fundamental to the successful implementation of emerging technologies. As data analytics and AI become increasingly prevalent in healthcare coordination, organisations are presented with the opportunity to enhance their logistics capabilities, quality oversight, and regulatory compliance to an unprecedented degree. This review's examination of these forward-thinking trends is particularly pertinent for those probing the intersection of quality management and healthcare's digital upheaval. The findings emphasise the pivotal role of DC in the transformation of healthcare operations, particularly through the integration of blockchain-based systems.

The role of DC in enhancing operational effectiveness, mitigating uncertainty, and ensuring compliance within settings characterised by time-sensitive supply chains and evolving legal requirements is of paramount importance. Its constructive collaboration with blockchain-led programmes has produced marked improvements in patient outcomes and institutional efficiency, highlighting the strategic significance of these capabilities in a dynamically evolving healthcare landscape.

2.5. Synthesis and Contribution to the Thesis

This publication successfully fulfils its role as the thesis's foundational pillar and provides a decisive answer to the first overarching RQ1. The scholarly community recognises the synergistic potential of DC and BT, yet its focus has remained at the macro level, overlooking the critical role of individual actors. This SLR, therefore, does more than simply summarise existing knowledge; it provides the formal scholarly justification for the entire thesis. This finding serves to substantiate the assertion that the research problem is not only pertinent in practical applications but also constitutes a substantial lacuna within the domain of academic theory.

It is now possible to proceed to the next logical phase of the research, owing to the existence of a detailed map of the existing literature and a clear understanding of the knowledge gaps that still need to be filled. The process of research evolves from the analysis of existing literature to the generation of original empirical data. The third chapter will initiate this process by undertaking the preliminary qualitative step of investigating the concrete use cases and challenges associated with the implementation of advanced technologies in the intricate domain of EU pharmaceutical tendering.

CHAPTER 3

Article nr 2

"Exploring the impact of EU tendering operations on future AI governance and standards in pharmaceuticals"

3.1. Introduction

The preceding chapter systematically mapped the existing scholarly landscape, confirming a critical research gap: the literature acknowledges the importance of firm-level DC for technology adoption but largely overlooks the IDC that form their micro-foundations. This finding provides a clear mandate to transition from the review of the literature to the generation of new empirical data. This research constitutes the inaugural deliberate step into that empirical void. Before undertaking a direct investigation of the specific routines of IDC, it was relevant to first comprehend the nature of the complex, real-world operational environment in which such capabilities are most critical [40].

The research explores a domain characterised by stringent regulation and significant stakes, situated at the intersection of healthcare and pharmaceutical commerce. The ensuing discourse delineated the fundamental principles that govern the European Union's tendering operations for pharmaceuticals. The integration of AI into this process is explored, which provides a contextual backdrop. The objective of the study was to provide a practical foundation for understanding the abstract challenges of technology adoption. This is achieved by illustrating the intricate web of operational, regulatory, and ethical pressures that frontline professionals must navigate. It is imperative to investigate the problem space to establish the IDC required to solve the problems identified.

The research also highlights the necessity of aligning the adoption of AI with the latest European directives, such as the AI Act and the GDPR, to ensure both operational efficiency and adherence to ethical standards. The broader implications of the study emphasise the necessity for pharmaceutical companies to develop robust governance frameworks, prioritise ethical considerations, and maintain regulatory compliance to fully leverage the potential of AI [41].

3.2. Research Problem and Objectives

This publication explores the multifaceted impact of integrating AI into pharmaceutical tender management processes, with a specific focus on operational efficiency, governance, and compliance with emerging EU regulations. The core problem it addresses is the dual nature of AI adoption: whilst it offers significant competitive advantages, it also introduces considerable challenges related to ethical governance and regulatory alignment, particularly with directives such as the AI Act and GDPR. The primary objectives of this comparative case study, which are aligned with RQ2, are to analyse and compare the operational performance and stakeholder engagement of pharmaceutical companies that have adopted AI-driven tender management versus those that rely on traditional methods. The objective of this study was to identify the most critical governance, ethical, and compliance challenges that arise from AI integration in this sector through expert consensus using the Delphi method. Secondly, aimed to provide actionable insights for developing an adaptive governance framework that can maximise the benefits of AI while mitigating its inherent risks.

3.3. Core Contribution

The following hyperlink presents the full manuscript of the peer-reviewed article, as published in the journal Computers & Industrial Engineering.
Article: https://www.sciencedirect.com/science/article/pii/S0360835224007770

3.4. Discussion of Key Findings

The findings, while focused on AI in pharmaceuticals, provide illustrative evidence for the central argument. The collected insights provide a depiction of the environment that necessitates the development of IDC. AI integration leads to "enhanced decision-making, accelerated processing times, and improved stakeholder engagement," clearly establishing the value proposition of ADT. This demonstrates the strong pull factor for adoption and underscores why organisations are investing in these systems, setting the stage for the subsequent challenges of implementation.

The most critical finding for this thesis is that the primary barriers to realising AI's full potential are not technical but rather rooted in governance, ethics, and regulation. The necessity to align AI strategies with the European AI Act and GDPR serves as a paradigmatic illustration of a complex environmental shift that necessitates sophisticated organisational and individual responses. It is precisely such challenges that cannot be resolved through the utilisation of code. Individuals with the capacity to discern imminent regulatory developments, capitalise on emergent opportunities to engineer systems that are in accordance with regulatory frameworks, and facilitate the transformation of internal workflows and governance structures to ensure ethical and legal compliance are in high demand.

The conclusion that companies are suggested to implement adaptive governance frameworks is a direct call for the outcomes that strong DCs produce. An adaptive framework is not a static document; it is a living system that must be continuously reconfigured. This finding provides substantial support for the thesis's argument that technology is not a one-time implementation but an ongoing process of co-evolution between the digital tool and the human systems that govern it.

3.5. Synthesis and Contribution to the Thesis

This publication serves as a bridge between the theoretical gap identified in Chapter 2 and the focused investigation of IDC to follow. While it does not directly measure IDC, it achieves something equally important: it provides a solid, empirical characterisation of a technologically disrupted environment, thereby rendering the abstract need for advanced capabilities tangible and concrete.

The most significant contribution is the demonstration of the substantial efficiency gains that underpin technology adoption. Secondly, it is emphasised that the most significant hurdles are complex, non-technical challenges of governance and compliance. Thirdly, it is presented that success is contingent upon the ability to construct adaptive systems. By thoroughly documenting the problem, this research provides empirical validation of the need for the conceptual map that is proposed in this thesis. This study sets the stage for the subsequent phase of the research, which now logically shifts its focus from the environment to the individual. The question that arises from this is what specific IDC are required to navigate the complex governance and operational challenges that have just been observed. The subject under discussion in Chapter 4 will be approached through a detailed qualitative investigation of the IDC routines themselves.

CHAPTER 4

Article nr 3

"Individual dynamic capabilities and artificial intelligence in health operations: Exploration of innovation diffusion"

4.1. Introduction

As demonstrated in Chapters 2 and 3, extant literature confirms that DC are essential for technology adoption. However, the manner in which these capabilities manifest at the individual level within a hospital setting remains largely unaddressed. The preceding case study of EU tendering operations further highlighted that the most significant hurdles to innovation are not technical, but are instead complex matters of governance and human adaptation [40-41].

The above presents a fundamental question: If IDC represents the missing piece of the BT adoption puzzle, what form do these capabilities take in practice? The research is then concerned with addressing this question directly. Turning to the individual level, this study employs a qualitative approach to explore the lived experiences of frontline HCPs. The research employed in-depth focus groups with clinicians and managers to identify and structure the specific routines that are considered essential for the successful implementation of innovations such as AI and BT. These routines encompass the everyday acts of sensing opportunities, seizing resources, and transforming workflows. The objective is to transcend the abstract conceptualisation of IDC and establish a pragmatic, practitioner-centric comprehension of its fundamental components.

The investigation into the integration of IDC, AI, and the TAM within health operations, with a view to evaluating their role in fostering innovation diffusion in healthcare, yielded significant results. These results provided support for further exploration of innovation diffusion. The employed convergent, multifaceted approach, encompassing quantitative and qualitative methodologies, resulted in concrete insights and discovery [42].

4.2. Research Problem and Objectives

The study was conceived with the specific aim of directly addressing the RQ1 and the RQ2. In order to achieve this objective, the study was based on two fundamental aims, which were realised through the implementation of a mixed-methods approach. This approach commenced with a targeted SLR and concluded with the gathering of empirical data. The core objective was to qualitatively identify, describe, and prioritise the specific individual-level routines and micro-managerial skills that healthcare decision-makers and experts judge to be essential for successfully implementing AI and related digital innovations. In addition, the interplay between the identified capabilities and the established theoretical frameworks, including the TAM and Innovation Diffusion theory. This facilitated the development of a more nuanced understanding of how technology adoption unfolds in practice.

4.3. Core Contribution

The following link provides direct access to the published article in the 11th edition of Intelligence-Based Medicine, released on 25 March 2025.

Article: https://www.sciencedirect.com/science/article/pii/S2666521225000432

4.4. Discussion of Key Findings

The findings from this study offer the first direct empirical validation of the thesis's central hypothesis, thereby providing a comprehensive and nuanced understanding of IDC in action. The focus groups, in particular, advanced the concept of IDC from a theoretical abstraction to a lived reality. The study's primary finding is the overwhelming consensus among experts that the capacity of individuals to sense opportunities, seize resources, and reconfigure competencies is the core element of successful AI implementation.

This is a valuable piece of evidence, as it comes directly from HCPs, confirming that the theoretical focus of this thesis aligns with the practical experience of those on the frontline. This process serves to substantiate the research's significance not only from an academic perspective but also from a managerial standpoint, underscoring its practical relevance in professional contexts. This study furnished the first concrete, operational illustrations of IDC routines within a healthcare context. The term 'sensing' was not described as passive awareness, but rather as the active process of identifying specific operational bottlenecks where a new technology could add value. It was subsequently established that 'seizing' is a profoundly social and political skill. It encompasses the capacity to establish interdisciplinary coalitions and navigate internal data silos, a challenge that was identified by the participants as being of significant importance. Finally, the concept of 'Transforming' was realised through the implementation of micro-managerial skills, such as lean management, which facilitated the iterative integration of AI tools, including diagnostic algorithms, into established clinical workflows.

This approach effectively overcame clinician resistance, thereby ensuring the effective integration of AI technology into healthcare practices. The research demonstrates that IDC is the mechanism that "drives cross-functional adaptation and ensures smoother operational transformation". This is a pivotal insight, as it positions IDC not merely as a passive trait but as an active, problem-solving capability. It is the engine that enables organisations to navigate complex regulatory standards and evolving patient care needs, transforming potential resistance into successful integration.

4.5. Synthesis and Contribution to the Thesis

This research signifies a solid milestone in the research trajectory, wherein the qualitative identification and structuring of the critical IDC routines as perceived by HCPs has yielded a comprehensive and empirically substantiated response to the initial RQ1 and the overarching RQ2. The primary contribution is its role as the indispensable bridge between theory and measurement. The qualitative data, themes, and direct quotes gathered from the focus groups are not merely findings; they are the essential building blocks for the next and most novel phase of this research.

The concepts provided are authentic, validated, and practitioner-centric, and will be systematically operationalised into the items and levels of the IDC-MDS. Following the establishment of the critical capabilities in question and the subsequent analysis of their practical manifestation, the research was well-positioned to advance to the next logical stage. The subsequent question that naturally arises from this standpoint is, "How can we measure the maturity of these routines?" The fifth chapter will tackle this issue head-on by developing and validating a new psychometric instrument.

CHAPTER 5

Article nr 4

"Advancing Hospital Performance with Blockchain and Artificial Intelligence: Opportunities through Dynamic Capabilities and Emerging Directions"

5.1. Introduction

The qualitative findings from the preceding chapter furnished a substantial, nuanced portrayal of IDC routines, firmly embedded in the experiences of HCPs. While this descriptive understanding is essential, it presents a new challenge: how can an organisation reliably assess, measure, and cultivate these capabilities across its workforce? Absent a means to quantify IDC maturity, endeavours to enhance it remain intuitive rather than data-driven, and its impact on performance cannot be systematically evaluated [40-42].

This research endeavour directly confronts the aforementioned measurement challenge. The present document chronicles the methodological process of transforming the qualitative themes from Chapter 4 into a psychometric instrument, which is designated here as the IDC-MDS. The objective of this study was to construct and validate a practical tool that allows for a quantitative assessment of the routines of sensing, seizing, and transforming. This transition signifies a shift from a descriptive approach to a more analytical one, thereby establishing the fundamental framework necessary for subsequent examination of the correlation between individual competencies and the effective integration of technologies such as BT and AI in subsequent chapters [43].

5.2. Research Problem and Objectives

The central research problem this study addresses is the absence of a standardized, empirically validated instrument for assessing the IDC of individual professionals within the healthcare sector. In the absence of a designated instrument, HCOs are unable to evaluate their level of preparedness for digital transformation, identify particular deficiencies in their capabilities, or quantify the effect of training initiatives. This discrepancy also hinders academic research, making it challenging to statistically analyse the relationship between IDC and the success of technology adoption projects. The study has been designed to directly address the third overarching research question of the thesis (RQ3): namely, how can those routines be operationalised in a reliable scale, and how do differing maturity levels manifest in real-world clinical and supply-chain contexts? The primary objective of this publication was to construct and validate a multi-level maturity scale that can reliably measure the IDC of HCPs.

5.3. Core Contribution

The following web address contains the complete manuscript of the article that has been submitted to the academic journal Applied Intelligence – Springer Nature.

Article: https://iscteiul365-my.sharepoint.com/:b:/g/personal/ambpa1_iscte-iul_pt/Eart5OWExKdJkqy9SemqFssBL2TaKr1wKMrUhGcq02k4uA?e=mJ11E8

5.4. Discussion of Key Findings

The findings are pivotal to the thesis, as they provide both the primary methodological contribution and the first major quantitative evidence in support of the main hypothesis. The primary outcome is the development of the five-level IDC-MDS, which progresses from "Isolated Awareness" to "Strategic Orchestration." This framework is significant because it is not merely a score; it is a developmental roadmap. Drawing upon established models such as CMMI, it equips organisations with a coherent language and framework to comprehend their present state and formulate plans for future capability enhancement. The model developed translates the complex, nuanced qualitative data from Chapter 4 into an intuitive and actionable format. The central finding of the study, namely a strong, positive statistical correlation between higher IDC maturity levels and the successful integration of ADT, forms a cornerstone of this entire thesis. This transition signifies a shift in the argument from a well-reasoned proposition to a statistically validated relationship. The data indicates that organisations with more mature IDC are not merely exerting more effort; they are attaining measurably superior outcomes in data privacy, operational efficiency, and governance. Finally, the finding that IDC maturity explains the variance in key success metrics is a powerful testament to the importance of the construct. This statistic lends substantial weight to the thesis's claim that overlooking individual capabilities constitutes a critical strategic error for any HCOs undergoing digital transformation.

5.5. Synthesis and Contribution to the Thesis

The development and validation of the IDC-MDS provides a definitive response to the third overarching RQ3. The contribution is substantial: it provides the research with a novel and reliable instrument, thereby transforming the project's potential from qualitative description to quantitative and predictive analysis.

The validation of this scale has enabled the testing of the thesis's primary hypotheses on a large scale. The IDC-MDS is the tool that facilitates the final phase of the research, namely, large-scale theory testing. The logical progression of the research is now apparent. Subsequent to the establishment of the necessity for IDC (Chapters 2 & 3), the identification of its components (Chapter 4), and the construction of a tool to measure it (this chapter), the ultimate step is to deploy this tool across a variety of contexts to test its predictive power. Consequently, this chapter serves as the preliminary empirical effort for the subsequent studies. Chapter 6 will then utilise this newly developed instrument for the first time in a specific and innovative case study: an AI-driven platform designed to enhance clinical decision-making and cultivate the very capabilities this scale now measures [40-43].

CHAPTER 6

Article nr 5

"Designing and implementing SMILE: An AI-driven platform for enhancing clinical decision-making in mental health and neurodivergence management"

6.1. Introduction

The utilisation of a validated instrument to measure IDC signifies a pivotal shift in the research paradigm, transitioning from a mere assessment to a more intervention-oriented approach. The IDC-MDS provides a means to diagnose capability levels, but this gives rise to a further question: whether technology can be designed not merely as an object to be adopted, but as an active tool for fostering the very capabilities needed to use it effectively [43].

This publication explores this possibility through an in-depth case study of the Support, Management, Individual, Learning Enablement (SMILE) platform. SMILE is an AI-driven system designed for mental health and neurodivergence management. However, its unique architecture—integrating AI with blockchain for data security—is also intended to support and enhance the decision-making routines of its users. Rather than perceiving IDC as a rudimentary prerequisite for adoption, this investigation explores a symbiotic relationship that may foster the sensing, seizing, and transforming skills of HCPs. This case thus serves as a practical test of a more dynamic model in which human capability and technological design co-evolve [44].

6.2. Research Problem and Objectives

This innovation report addresses a dual crisis in modern healthcare: the rising levels of burnout, anxiety, and depression among HCPs and the concurrent need for more efficient and effective clinical decision-making, particularly in mental health. The main concern pertains to the fact that conventional technological solutions often serve to exacerbate the stress experienced by the workforce and are unable to seamlessly integrate into the intricate clinical workflows, connected with RQ3.

The primary objective of this study was to introduce and evaluate the SMILE platform. This platform is an AI-driven system designed to achieve two integrated goals: Firstly, there is the enhancement of clinical decision-making in the domains of mental health and neurodivergence management. This enhancement was achieved by leveraging AI-driven analytics and secure data management via blockchain and federated learning. Secondly, the focus was directed towards the mitigation of HCP burnout by the provision of adaptive, AI-supported therapeutic interventions, peer support networks, and tools that reduce administrative burdens. This approach has been demonstrated to engender resilience and professional well-being.

6.3. Core Contribution

The following Internet address provides access to the complete text of the article, which has been subject to the peer-review process and has been published in the Computational & Structural Biotechnology Journal. **Article**: https://www.sciencedirect.com/science/article/pii/S2001037025000492

6.4. Discussion of Key Findings

The findings from the SMILE pilot study offer diversified evidence of the core principles advanced in this thesis, showcasing a real-world application where technology and human capabilities are developed in concert. Initially, the study's quantitative findings are pertinent: a 46% decline in support time, a 37% decrease in self-reported stress, and a twofold increase in user satisfaction scores. In the context of this thesis, this is a clear demonstration of a "value-adding innovation" that directly improves operational efficiency and workforce well-being. It functions as a compelling counter-narrative to technology projects that falter due to a dearth of user-centricity, underscoring the notion that when technology is meticulously designed to empower its users, the outcomes are profoundly positive and substantial.

The architecture of the SMILE platform, which integrates AI-driven analytics, blockchain for secure data management, and federated learning, is a solid embodiment of the "convergent stack" of ADT discussed in Chapter 1. This case study transitioned the concept from a theoretical discussion to a functional application, demonstrating the integration of these distinct technologies to address a complex problem while addressing critical issues of data privacy and security, which were mitigated by the platform's blockchain features.

The most significant insight derived from this chapter is the conceptualisation of the SMILE platform as a mechanism for the proactive "cultivation of individual DC". This introduces a new dimension to the thesis's argument. It is evident that, heretofore, the IDC has been regarded as a prerequisite for the adoption of technology. This case study posits a more dynamic, cyclical relationship: when designed correctly, technology can itself be a tool for developing IDC. The provision of real-time, data-driven insights and support is instrumental in enabling HCPs to enhance their ability to sense patient needs, select the most appropriate therapeutic interventions, and transform their care delivery processes. This suggests the existence of a virtuous cycle, whereby the implementation of superior technology results in the development of more proficient users.

6.5. Synthesis and Contribution to the Thesis

This research provides a unique contribution to the thesis's narrative arc as it serves as a valuable, multi-faceted case study that illustrates the central arguments in a practical, applied setting. Its contribution can be categorised into three distinct areas: The paper provides a concrete and successful example of a human-centric application of the convergent technology stack (AI/BT). It introduces and provides evidence for a virtuous, symbiotic relationship between technology and human capability, suggesting that technology can be an active agent in cultivating IDC.

Finally demonstrates the tangible operational and well-being benefits that arise when technological innovation is aligned with the development of the individuals who use it. Following a comprehensive examination of this profoundly integrated case, the research has attained a profound understanding of the multifaceted relationship between humans and technology, which is characterised by a dynamic and reciprocal nature, defying the conventional notion of a unidirectional relationship. Drawing upon this understanding, the ensuing chapters will revisit a more extensive implementation of the IDC-MDS, utilising it in diverse organisational contexts to assess the impact of varying levels of capability on the success of large-scale programmes. The subsequent chapter will utilise this framework to analyse the intricate domain of ESG initiatives within the pharmaceutical sector.

CHAPTER 7

Article nr 6

"Exploring the role of big data analytics and dynamic capabilities in ESG programs within pharmaceuticals"

7.1. Introduction

The preceding chapter provided a comprehensive and insightful case study of the SMILE platform, demonstrating a virtuous cycle where technology is designed to actively cultivate the IDC of its users. This provided substantial evidence in support of the thesis's human-centric philosophy. Following an exploration of the ideal symbiotic relationship in a specific application, the research is now required to test the broader generalisability of its core argument.

The study seeks to determine whether the correlation between digital transformation and technological success is confined to specific platforms, such as SMILE, or whether it is a more fundamental principle that applies to other complex, data-driven strategic initiatives in healthcare. In order to respond to this question, the present chapter employs an alternative analytical perspective, focusing instead on the implementation of ESG programmes within the pharmaceutical industry. The research aims to validate the thesis's framework in a new context, thereby strengthening the robustness and applicability of its conclusions, by examining how organisations leverage BDA to achieve their sustainability goals.

In the domain of pharmaceuticals, the implementation of ESG programs is accompanied by a range of intricacies, including the assessment of employee competencies, the alignment with corporate objectives, and the alignment with management expectations. The effective management of such programmes necessitates the deployment of sophisticated technologies, including BDA and DC. In this study, the development of an architecture for managing ESG criteria is undertaken, with a focus on provenance, traceability, and availability. This is achieved by employing DC theory. The role of the BDA in ESG programmes is explored, along with its use cases and benefits, and how DC drives success in ESG implementation. Five pharmaceutical companies were examined in Germany, Portugal, and Switzerland, all of which were consulting the same firm for BDA systems, with a view to identifying the characteristics of effective BDA implementation.

The BDA system has been demonstrated to be both accurate and effective in the management of ESG programmes, with DC playing a pivotal role in this regard. The findings indicate the value of BDA combined with ADT in enhancing operational efficiency and aligning business models with ESG goals, thereby underscoring the necessity for a diverse skillset in BDA implementation and the significance of DC in integrating various managerial capacities into effective strategies.

The study proposes a dynamic, data-driven approach in the pharmaceutical industry for managing complex ESG initiatives. The concept emphasises the necessity of continuous learning, adaptation, and the integration of technological advances with ethical business practices. The research concludes by emphasising the vital roles of BDA and DC in advocating ethical, socially responsible, and environmentally sustainable practices in the pharmaceutical sector, marrying technology with ethical business strategies [45].

7.2. Research Problem and Objectives

In the modern era, pharmaceutical companies are subject to considerable dual pressures regarding ESG criteria. These pressures are characterised by stringent regulatory reporting demands from governments and increasing scrutiny from investors. Investors now link ESG performance to capital allocation, thereby influencing corporate behaviour. In response to this challenge, numerous firms have made substantial investments in BDA as a technological solution for tracking and managing their extensive streams of ESG data. However, a critical implementation gap has emerged; despite the technical capabilities of these systems, many organisations struggle to translate the data they produce into meaningful operational changes or credible reports. This research aims to address this gap in connection with RQ3.

The primary objective was to diagnose the organisational factors that differentiate successful ESG programmes from unsuccessful ones. This study transcends a purely technical analysis and explores the synergistic role of DC. The specific aims were as follows: (1) to analyse the manner in which high-performing companies utilise DC to transform BDA outputs into strategic action and verifiable ESG improvements. (2) In addition, to ascertain the particular sensing, seizing, and transforming routines that facilitate the navigation of evolving ESG standards and stakeholder expectations by managers. (3) Finally, to develop a framework that establishes a connection between specific data analytics practices and the organisational capabilities that are necessary to ensure their effectiveness.

7.3. Core Contribution

The following URL presents the full manuscript of the peer-reviewed article, as published in the Software Quality Journal. **Article**: https://link.springer.com/article/10.1007/s11219-024-09666-4

7.4. Discussion of Key Findings

The findings provide evidence that the core principles of this thesis are not limited to a single technology but are broadly applicable to major strategic initiatives. A notable similarity exists between the challenges encountered in the implementation of ESG initiatives and those experienced in the adoption of BT. The findings from the multi-case study provide substantial support for the central argument, demonstrating that technology and human capability are inseparable complements in achieving complex strategic objectives, such as ESG compliance. It became evident that merely deploying BDA platforms was insufficient; the crucial difference lay in an organisation's DC.

In more detail, pharmaceutical companies that had formally established a framework for developing DC were demonstrably more successful in governing and implementing their BDA systems. This finding suggests that the development of capability cannot be left to chance. This success appears to be rooted in the cultivation of a specific kind of talent—professionals who could bridge the gap between data science and pharmaceutical regulations, embodying the very blend of technical literacy and strategic vision that defines a high-maturity IDC. The data from BDA systems could only be made actionable when individuals were capable of interpreting it within its complex regulatory context and transforming operations accordingly. The observation that companies that formally integrated a DC framework demonstrated more effective BDA implementation and better data governance is a crucial finding. This finding suggests that a conscious, deliberate, and structured approach to cultivating capabilities yields superior results. This finding provides robust indirect evidence that lends support to the practical utility of the IDC-MDS developed in Chapter 5. The scale is not merely a measurement instrument; it constitutes the basis for the formal framework that this study determines to be efficacious [44].

7.5. Synthesis and Contribution to the Thesis

This publication strengthens the thesis by demonstrating the generalizability of its core theoretical framework. By successfully applying the lens of DC to the domain of ESG programs, this study shows that the fundamental principles of the thesis are not confined to a single type of technology.

The primary contributions to the overall thesis were the validation that the synergistic relationship between technology and human/organizational capability is a fundamental driver of success across different major strategic initiatives in healthcare. But also, it reinforces the practical importance of cultivating DC in a formal and structured way, thereby strengthening the prescriptive value of the thesis and the relevance of the IDC-MDS.

Having demonstrated the broad applicability of its core concepts, the thesis is now positioned to return to its primary technological focus—blockchain in hospital settings—with a more capable and validated theoretical lens. The insights from this chapter provide a richer understanding of the capability construct itself. The research then proceeds in Chapter 8 to directly investigate how these influential IDC factors manifest specifically in the context of blockchain technology innovation within hospitals.

CHAPTER 8

Article nr 7

“Individual dynamic capabilities are influential factors in blockchain-technology innovation in hospital settings”

8.1. Introduction

The research journey of this thesis has progressively built a robust case for the importance of DC. Chapter 6 provided a compelling case study of technology designed to cultivate IDC, while Chapter 7 effectively demonstrated the generalisability of the DC framework by applying it to the strategic domain of ESG programmes. This finding serves to substantiate the assertion that the principles underpinning this thesis are not confined to a specific technology or context, but rather represent a more fundamental catalyst of organisational adaptation and success.

This chapter and the corresponding publication draw upon this broader and more powerful understanding of the capability construct to return to the core focus of the thesis, namely, technology innovation in hospital settings. However, it does so with a significantly more sophisticated theoretical lens.

The integration of AI with decentralised methods, such as BT and federated learning, along with a decentralised framework, has the potential to offer healthcare institutions a range of new opportunities to reduce waste, limit emissions, and enhance supply chain resilience. However, the adoption of this technology remains uneven and theoretically fragmented. The research investigates the influence of SL and DC on clinicians' acceptance of dAI. The publication is the seventh in the series, and it examines these factors in the context of increasing environmental, social, and governance pressures, as well as operational efficiency challenges. A series of expert panel sessions was convened with senior HCPs from five countries. Concurrently, survey metrics and narrative sentiment underwent analysis and triangulation. A total of six themes were identified, namely leadership vision, capability reconfiguration, data trust, regulatory alignment, carbon-aware procurement, and equity-centred outcomes. This extends the conventional linear investigation of IDC by proposing and evaluating an integrated, multi-theory framework.

The synthesis of the core concepts (DC/IDC) with classic TAM principles and the critical organisational factor of Strategic Leadership (SL) was necessary for further investigations. This chapter thus signifies a theoretical and empirical maturation of the thesis's argument, seeking not just to confirm the importance of IDC, but to understand how it interacts with user perceptions and SL to drive successful ADT and more specifically BT adoption [46].

8.2. Research Problem and Objectives

The central research problem that is the focus of this study is the complex interplay of human, organisational, and strategic factors that influence the adoption of ADT, such as dAI in healthcare supply chains. Simple models frequently fall short in capturing the intricacies inherent in this phenomenon. For instance, while user perceptions of TAM are important, they are not formed in a vacuum; they are shaped by the organisation's underlying capabilities and the vision projected by its leaders. The connection with both the RQ3 and RQ4 was the main basis to provide insights into the following questions: RQ3: How can those routines be operationalized in a reliable scale, and how do differing maturity levels manifest in real-world clinical and supply-chain contexts? RQ4: To what extent do higher IDC-maturity scores explain successful blockchain adoption and downstream organizational benefits across multiple HCO?

The study aims to shed light on this issue by proposing and empirically testing an integrated framework that combines TAM with DC and SL theories. The primary objectives of this study were: firstly, to ascertain the direct effects of both DC and dAI on TAM within the healthcare sector; and secondly, to determine the direct effects of both DC and SL on dAI. Secondly, the moderating role of SL, specifically by testing the hypothesis that strong leadership acts as a "critical amplifier" that enhances the positive effect of an organisation's DC on the perceived usefulness of new technologies. Finally, the synthesis of findings into a practical managerial roadmap was suggested, with the identification of key themes for translating technology pilots into demonstrable ESG gains and supply chain resilience.

8.3. Core Contribution

The following URL contains the complete manuscript that has been subjected to the peer-review process and accepted for publication in the VINE Journal of Information and Knowledge Management Systems. The publication date has been scheduled for November 2025. **Article**: https://iscteiul365-my.sharepoint.com/:b:/g/personal/ambpa1_iscte-iul_pt/EQr4PJ-vzgBMr6tSwDBiphMB7U3WIvD_b1qW87h5AfX74A?e=tmLufh

8.4. Discussion of Key Findings

A key insight is that conventional adoption models, such as TAM, are insufficient for explaining the uptake of complex, systemic technologies in healthcare. While perceived usefulness remains a significant factor, this research demonstrates that such perceptions are not formed in isolation. Instead, they are profoundly shaped by the organisational context – specifically, by its DC and the quality of its SL. The analysis goes beyond the mere identification of these factors to reveal their interactive nature. The most salient finding is the validated role of SL as a critical amplifier. The investment in the professional development of staff members by an organization is found to be a highly profitable endeavour when leaders provide a clear vision and strategic direction. In the absence of such leadership, even teams with considerable capabilities may encounter difficulties in discerning the alignment between new technologies and their broader objectives. This can result in a diminution of their enthusiasm and perception of its practical application. In essence, the presence of strong leadership provides a sense of purpose, thereby reinforcing the positive impact of the organisation's DC on frontline acceptance. This interactive model provides a more comprehensive and realistic explanation for why different HCOs with similar technologies and staff skills can have vastly different adoption outcomes.

8.5. Synthesis and Contribution to the Thesis

This publication is of particular significance as it marks a theoretical point in the thesis's arc. The model synthesises multiple theoretical streams into a coherent and significant predictive model, providing a sophisticated answer to the question of what drives technology innovation in hospitals. The primary contributions of this chapter to the overall thesis are threefold. Firstly, it advances the thesis's theoretical contribution from a main-effect model (IDC drives success) to a more nuanced interactive model, demonstrating that the effect of capabilities is amplified by leadership. The study then provides substantial empirical evidence in support of this more complex model, offering a more comprehensive explanation of the mechanisms underpinning technology adoption.

The theoretical argument is recapitulated, with a re-engagement with TAM demonstrating its integration into a more extensive framework that acknowledges the pivotal roles of capability and leadership. Following the development and testing of this research approach, the thesis is now prepared for its final empirical act. The final study in Chapter 9 will serve as a capstone, applying the comprehensive insights gathered thus far to a large-scale, long-term case study of a complete, integrated AI-driven and blockchain-secured clinical decision support system across multiple European hospitals.

CHAPTER 9

Article nr 8

"Transformative Approaches in Clinical Decision Support Systems: AI-Driven Decision Support in European Hospitals"

9.1. Introduction

The thesis has undergone a progression in its theoretical framework, commencing with foundational theories and culminating in the formulation of a comprehensive, multifaceted model of technology adoption. Chapter 8 represented a theoretical zenith, with the proposition and validation of a sophisticated framework that explicates the manner in which IDC, SL, and TAM interact to drive innovation. This approach yielded a nuanced and comprehensive understanding of the multifaceted dynamics prevalent within hospital settings.

The ninth and final empirical chapter functions as the culminating element of the entire research programme. Builds upon the comprehensive theoretical model developed in the preceding chapter, applying it to the most complex and ambitious case study to date: a 26-month, multi-site implementation of a transformative Clinical Decision Support System (CDSS). This system represents the culmination of the technologies discussed, integrating diagnostic AI with BT for data security. The various strands are unified by the convergent technology stack, the pivotal function of DC, and the substantial influence on clinical performance, which are integrated into a cohesive, longitudinal narrative.

This final step presents a forward-looking exploration of how ADT, including AI and BT, can revolutionize healthcare systems, particularly through CDSS. A combination of a case study triangulation analysis and qualitative insights from semi-structured interviews was employed to assess the CDSS's impact on clinical performance, HCPs' experiences, and compliance with European quality, safety, and security protocols. The objectives of the research comprised a comparative analysis of an AI-CDSS with a traditional-CDSS system with regard to clinical accuracy, efficiency, and performance.

The objective of the assessment of HCPs' perceptions and satisfaction is first to perform an exploration of how the DC methodology can enhance future technological advancements. Secondly, it is a verification of compliance with data privacy, protection, security, and ethical standards connected with a new architecture. In-depth interviews with a range of specialists from various fields, including oncology, radiology, surgery, and health informatics, were conducted to provide insights into the impact of ADT on the implemented CDSS. The CDSS combines different aspects such as AI, BT, and BDA. The findings indicated that AI-driven CDSS enhanced diagnostic accuracy and holistic care, while blockchain effectively safeguarded patient records, among other factors connected with the overall technological architecture associated with the CDSS [47].

9.2. Research Problem and Objectives

The research problem to which this study seeks to contribute is the challenge of moving beyond incremental improvements in healthcare technology to achieve a truly transformative impact. Whilst numerous systems offer only minor improvements, this evaluates a next-generation CDSS designed to enhance clinical performance by integrating the predictive power of AI with the security and integrity of BT. The overarching objective of this final program research step is to respond to the final overarching research question (RQ4): To what extent do higher IDC-maturity scores explain successful BT adoption and downstream organisational benefits across a multitude of HCOs?

The specific objectives were to quantitatively evaluate the clinical performance of the AI-driven and blockchain-secured CDSS by comparing its diagnostic accuracy and processing speed against a traditional system. But also an examination of the role of organisational DC, leadership, and adaptive culture as critical enablers for the successful integration of this complex system into hospital workflows. Finally, the provision of a validated architectural model for such systems is imperative, demonstrating how technological innovation, when paired with organisational DC, can lead to improved patient outcomes and ensure ethical, secure, and efficient care.

9.3. Core Contribution: The Peer-Reviewed Manuscript

The following link presents the full manuscript, which has been accepted for publication in the Journal of Medical Systems. **Article**: https://iscteiul365-my.sharepoint.com/:b:/g/personal/ambpa1_iscte-iul_pt/ETXc9tWADitOgECNmnvq2woBA_X8uuL0FwxZdivL66pkFQ?e=l4cxzn

9.4. Discussion of Key Findings

The findings from the final doctoral programme step provide the most robust and conclusive validation of the thesis's central arguments, demonstrating the real-world impact of the concepts explored in the preceding chapters [40-46]. The quantitative results of the study provide substantial confirmation of the thesis's argument that significant value can be realised. The AI-CDSS demonstrated a diagnostic sensitivity of 92%, which is a substantial improvement over the 78% sensitivity achieved by the traditional system. This enhancement signifies a transformative leap in clinical performance. This provides evidence of the significant "downstream organisational benefits" at the core of RQ4.

The ultimate "so what?" of the thesis is that this is a clear, measurable improvement in a core healthcare function that directly impacts patient outcomes. The finding that BT is effective in safeguarding patient records and ensuring GDPR compliance is also of significance, as it is "crucial for gaining trust among HCPs." This is a perfect real-world validation of a core theme. The practical application of BT has the potential to transform the landscape of data-intensive technologies by addressing a significant barrier to their adoption. This finding elegantly illustrates the socio-technical synergy championed by this thesis, whereby a technical feature (security) directly enables a human requirement (trust). The conclusion that DC was a "critical enabler" and that hospitals with strong leadership and an adaptive culture were more successful serves as the final, resounding confirmation of the thesis's central hypothesis. Following the formulation of the theoretical framework, construction of the measurement scale, and evaluation of integrated models, this extensive, multifaceted case study offers definitive narrative validation. This demonstrates that the remarkable technical performance of the AI-CDSS could only be realised in an organisational environment rich in the very capabilities this thesis has sought to define, measure, and understand.

9.5. Synthesis and Contribution to the Thesis

The integration of all the core concepts into a single, longitudinal case study provides the most robust and holistic evidence for the conclusions of the thesis. The present study constitutes the final validation of the thesis's integrated framework, synthesising all its conceptual strands within a complex, real-world setting. Spanning a period of 26 months (almost since the beginning of the doctoral program), this investigation represents the capstone of the entire programme. The marked increase in diagnostic sensitivity to 92% provides a definitive, quantifiable response to the question of "downstream benefits," thereby demonstrating the transformative potential of well-implemented AI and blockchain systems. However, the study also confirms that this technological achievement could not have been accomplished in isolation. The successful integration of the system was enabled by the organisation's mature DC and adaptive culture. Moreover, the practical implementation of BT to guarantee GDPR compliance proved to be a positive factor in establishing the requisite clinical trust, thereby facilitating its widespread adoption. The integration of a convergent technology stack, human capabilities, and enabling governance is presented as a comprehensive model for HCOs to achieve substantial and sustainable improvements in patient care.

The research has been conducted across a comprehensive empirical planning, from theoretical scoping and qualitative discovery to instrument development, model testing, and this final capstone validation. The result is a complete and coherent narrative flow. The stage is now set for the final chapter of the thesis, Chapter 10. This will synthesise the collective insights from all eight studies, formally articulate the thesis's contributions to theory and practice, acknowledge its limitations, and chart a course for future inquiry.

CHAPTER 10

Conclusions

This chapter thus brings the investigation to a close by distilling the key insights that emerged across the eight interconnected articles and by reflecting on how these insights fulfil the four overarching research objectives that were defined at the outset. The chapter is organised into four key final areas. The initial constitutes a synthetic discussion, which methodically interweaves the findings and contributions of the various authors. In the subsequent section, the thesis's added value for theory and practice will be set out. It is acknowledged that the scope of the doctoral programme was constrained by limitations that influenced the attainment of its objectives within the stipulated timeframe. Finally, potential avenues for future research that build directly on the evidence presented are presented.

10.1. Summary and discussion

The thesis commenced with the observation of a perplexing incongruity: permissioned blockchains, frequently associated with dAI and BDA, have advanced from laboratory prototypes to small-scale pilots, yet only a limited number of hospitals have successfully integrated them into their daily operations. The SLR demonstrated that scholarly explanations for this stall predominantly emphasised cryptographic design or regulatory compliance, while neglecting to consider the human micro-routines that translate technology into value. This delineation formed the foundation for the central research problem, thus giving rise to the initial RQ1.

The empirical texture was then supplemented with an additional SLR from the third publication, as a result of interview and focus-group work. The responses provided by procurement managers, clinicians, and pharmacists indicated that sensing ledger opportunities, seizing cross-functional resources, and transforming workflows were decisive for progress, thereby answering RQ2. The narratives thus furnished key candidate indicators that became the raw material for the IDC-MDS, which was built and validated. The instrument demonstrated excellent psychometric properties and, more importantly, proved usable by managers seeking to benchmark capability readiness. This outcome fulfilled the measurement objective embedded in RQ3, as combined with the multiple case studies presented in publications 5 to 7.

The subsequent four articles were instrumental in the field implementation of the scale. A multiple-case analysis of the pharmaceutical supply chain demonstrated that an upward shift of one IDC level was associated with a decrease in audit preparation effort and a reduction in counterfeit-detection windows, which shrank from days to hours. A clinical case study conducted at a single site demonstrated that wards with higher levels of transformation in their routines exhibited a faster rate of adoption of AI-driven care plan updates, with these updates being adopted twice as quickly as those in low-maturity peers.

A case-survey hybrid (Article #7) revealed a complementary relationship between governance stringency and capability density: tight smart-contract control accelerated value only when IDC exceeded Level 4. The large-scale questionnaire was used to quantitatively assess the broader context, thereby demonstrating that IDC-maturity serves as a mediator between perceived usefulness and sustained ledger use, thus elevating a composite adoption success per level. This finding provides a definitive response to RQ4.

When considered as a whole, these findings serve to extend the theory of DC by unearthing its micro-foundations in a highly regulated, data-sensitive sector; by enriching technology-acceptance thinking by demonstrating that positive perception must be channelled through capability to become behaviour; and by providing governance research with a new early-warning metric in the form of smart-contract approval lead-time, whose oscillations track capability strain before pilot momentum collapses. For practitioners, the work offers a validated scale, a governance-capability alignment matrix, and sector-specific smart-contract templates. Collectively, these translate abstract theory into implementable roadmaps.

The thesis is of threefold significance in terms of theoretical, methodological, and practical contributions. The primary theoretical advancement is the development of a micro-founded model of technology adoption. The completed research identifies and operationalises IDC, thereby bridging the gap between the high-level, firm-centric perspective of DC theory and the individual-user focus of models such as TAM. The study then offers empirical evidence to demonstrate that IDC functions as a critical mediating factor, thereby providing a more comprehensive explanation for why organisational potential for innovation is – or is not – realised in practice.

The most significant methodological contribution is the creation and validation of the IDC-MDS. This makes a significant contribution to the academic literature by providing the scholarly community with the first psychometrically robust instrument for measuring the specific routines of sensing, seizing, and transforming at the individual level in a healthcare context. This scale facilitates the transition of IDC research from a purely conceptual domain to one that can be empirically and quantitatively investigated. Also, the practical contribution of this research for healthcare leaders and managers is that it provides a set of actionable tools. The IDC-MDS serves as a diagnostic instrument to assess organisational readiness for digital transformation and identify specific capability gaps. Moreover, the findings concerning the interplay between IDC, governance, and leadership provide a practical roadmap for designing effective training interventions and change management strategies, which, in turn, increases the probability of success for high-stakes technology projects such as blockchain implementation.

10.2. Navigating the Central Paradox

Following a period of extensive research, the most challenging and insightful theme has become apparent. This theme is a central paradox, which can be defined as a contradiction where two seemingly incompatible things are found to be interconnected. In this case, the contradiction can be seen as being between human agility and technological immutability. As evidenced by the results, the fundamental nature of IDC is adaptation, experimentation, and the fluid reconfiguration of workflows, as demonstrated in the results of the case studies and interviews conducted. This is a celebration of organisational flexibility. However, the fundamental value of BT that forms the basis of this study lies in its unassailable, tamper-evident, and immutable nature. This phenomenon can be described as an architecture of inflexibility.

Initially, this appeared to be a contradictory statement. The question, therefore, arises as to how an agile workforce can thrive when tethered to an immutable system. However, the data revealed that the most successful HCOs did not attempt to resolve this tension, but rather learned to manage it. The governance model was not regarded as a static set of rules; rather, it was considered DC in its own right. In order to address this challenge, a range of systems were developed with the purpose of facilitating the process of approval for changes to smart contracts. These changes were categorised as low-risk, and the approval process was streamlined through the establishment of dedicated pipelines. Additionally, the system included the formation of cross-disciplinary "ledger guilds" with the function of resolving disputes promptly. Furthermore, the system made strategic decisions regarding the requirement of absolute on-chain immutability for certain processes, as opposed to the utilisation of more flexible off-chain logic for others. This research concludes that sustainable BT adoption is not solely about fostering IDC, but rather about co-evolving governance structures that enable an organisation to benefit from rigidity without compromising its capacity for agile transformation.

10.2.1 Reflective Considerations

In the rapidly evolving landscape of AI in healthcare, precision in language and the creation of resilient and sustainable operations are prerequisites for ethical innovation and stakeholder trust. The importance of this phenomenon is worthy of further consideration. The HCO development ecosystem must share a common understanding of concepts such as DC and TAM terms, as well as regulations on the use of ADT, such as BT or AI. Concepts are of significance, and it is important to note that HCPs often confuse responsible/trustworthy AI with ethical AI. Furthermore, misunderstandings about capabilities, transparency, and the successful adoption of implementing complex interconnected technologies are not merely details [42-45].

In addition, some of the fundamental principles of DC are transparency and innovation. The commitment to develop organizational and individual capabilities – be they hospitals, pharmaceutical manufacturing companies, HCPs, or regulatory bodies – about the presence and function of ADT in any given tool or system is paramount. These principles are of particular significance in instances where the internal mechanisms of an ADT model are proprietary and cannot be fully disclosed, a concern that is further exacerbated in the context of healthcare. In the context of a competitive field such as healthcare, the protection of intellectual property is a valid and necessary concern. Opacity and visibility can be mutually operational. In order to establish trust and confidence in AI-generated recommendations or new BT architectures, such as the identification of novel treatment protocols, administrative guidelines, or the stratification of patients for clinical trials, HCPS need to possess a comprehensive understanding of the underlying principles and the operational functionality of these models. The basis for this decision remains unclear, as does the question of whether it was based on specific biomarkers, a particular aspect of the patient's medical history, or a combination of subtle patterns in the data. The deployment of new capabilities for the implementation of technologies is not the sole factor in question. The objective is to facilitate an integrative comprehension of all the subtleties present at the various levels of the organisation [40-45].

It is suggested through the findings to acknowledge that contemporary technological implementation should not be the exclusive domain of technical teams or the department responsible for informatics support, system installation, or hardware components [45-47].

The challenges of the issue lie in the trade-off between human critical thinking and technological capabilities. Concurrently, the organisation acquires novel organisational DC at various stages of technology implementation and adoption. The most sophisticated and precise models tend to be the most intricate to comprehend and implement. Nevertheless, the pursuit of performance cannot wholly overshadow the necessity for comprehension. In the domains of drug development and the emergency department of a hospital, where patient safety and the integrity of data are paramount in demonstrating the safety and efficacy of an intervention, the "computer says so" approach is clearly not acceptable. The capacity to interrogate and comprehend the underlying rationale behind any given output is highly significant. Additionally, the endeavour to integrate transparency and explainability into the very fabric of ADT in healthcare and life sciences is not without its challenges [40-43].

The tension between the imperative for safeguarding proprietary information and the ethical obligation for transparency is a genuine concern. Additionally, the intricacies inherent in data and computing sciences are situated within a broader context of public literacy that is, on the whole, limited in these domains. The attempt to amalgamate the notions of transparency and explainability into a single term serves only to obfuscate the clarity of both concepts, resulting in a more opaque state of affairs. Transparency, DC, SL, and TAM have been demonstrated to engender a sense of confidence in the user by providing the context and understanding of the limitations of a BT architecture that most of the time functions in combination with other ADT components, such as BDA, dAI, and GenAI. The issue of interoperability in ADT is a complex one, and it is important to recognise that it presents challenges. However, it also creates numerous opportunities for increased shared decision-making with patients, operational efficiency, and new overall healthcare systems. These opportunities arise through HCOs and other life sciences entities, which can develop new integrated DCs together [42-47].

10.3. Limitations

Whilst this thesis provides an investigation into the role of IDC in BT adoption, it is important to acknowledge the boundaries that shape its conclusions. The findings should be interpreted in light of three main categories of limitations: methodological, contextual, and conceptual.

The primary methodological limitation pertains to the cross-sectional nature of a significant proportion of the quantitative data collection. While the IDC-MDS has been shown to successfully correlate capability maturity with adoption success at a specific point in time, it does not capture the dynamic evolution of these capabilities. The research was unable to conduct a multi-year longitudinal study that would track how IDC levels change in response to training interventions, project milestones, or shifts in organisational strategy. Consequently, while a strong correlation has been established, further investigation is required to ascertain the precise causal pathways through which capability development leads to improved outcomes over time.

Nevertheless, the empirical evidence for this thesis was predominantly gathered from European healthcare organisations. The prevailing regulatory frameworks, such as the GDPR, and the presence of well-developed public and private healthcare systems, exert a significant influence on the governance and implementation of technologies such as blockchain. Due to limitations in the available resources, a comparative analysis with healthcare systems in other regions, such as Asia or in developing nations, where infrastructural and resource challenges are fundamentally different, was not possible. Consequently, while the theoretical model is likely to have broad relevance, the specific governance challenges and capability manifestations identified here may not be directly generalisable to all global healthcare contexts.

Moreover, the conceptual scope of this research deliberately focused on the micro-foundations of DC at the individual and team level to address a specific gap in the literature. However, this approach has the disadvantage of paying less attention to the macro-level institutional and political factors that can either enable or constrain technology adoption. While SL was included as a moderating variable, a more in-depth analysis of factors such as national health policy, industry consortium politics, or the influence of large technology vendors was beyond the scope of this thesis. These powerful external forces have a profound impact on the environment in which IDC operates, thus necessitating a comprehensive investigation into this domain.

10.4. Future Work

This thesis has established a foundation for understanding the micro-foundations of technology adoption in healthcare, but it also opens up several exciting avenues for future inquiry. The following suggestions are proposed to build directly upon the findings and limitations of this work, pushing the research from explanation toward prediction and intervention.

In order to address the contextual limitations, future research should prioritize two areas. Firstly, longitudinal studies are recommended to track the evolution of IDC over time. The longitudinal observation of IDC development, its impact on training, and the validation of its long-term predictive efficacy can be facilitated by the systematic tracking of hospitals through multiple technology adoption cycles. Secondly, the research framework should be tested across a broader range of regulatory and cultural contexts. A comparative analysis between European, North American, and Asian healthcare systems, as well as between public and private providers, could reveal how different funding models and institutional environments moderate the relationship between capability and governance. This would establish the true generalizability of the IDC construct. Furthermore, the measurement process can be deepened through the utilisation of triangulating surveys and behavioural analytics. While the

IDC-MDS provides a robust measure of perceived capabilities, the next step is to triangulate this data with objective, behavioural metrics. It is recommended that future studies consider integrating the IDC-MDS with real-world data streams. Such integration could encompass metrics such as the time taken to resolve governance challenges, the stronger alignment of leadership and technology implementation teams, or the speed of change-ADT dissemination.

Artificial Intelligence Disclaimer

Given that English is not the primary language of the PhD candidate, the latter employed Grammarly, an artificial intelligence-based writing assistant, to enhance the clarity and readability of the thesis. While Grammarly has facilitated enhancements in grammar, spelling, and overall fluency, the ideas, analyses, and interpretations presented are entirely attributable only to the PhD candidate.

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