Valorising Academic Knowledge: A Framework for Research-to-Market Pathways

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Abstract: The present study investigates how entrepreneurial universities can systematically exploit diverse knowledge assets for societal and economic impact. Despite growing emphasis on research valorisation, literature lacks clarity on managing varied research types, such as fundamental or domain-specific, and aligning them with exploitation goals. Universities often struggle to deliver their wealth of research assets to the market. Through an ethnographic case study of a technical university, this research examines three exploitation pathways. By analysing research assets through a framework that classifies knowledge based on its Research Focus and Exploitation Scope, the study unveils the internal and external conditions that enable research exploitation. These results advance knowledge management theory by integrating creation-to-application dynamics and refine the well-known Triple Helix model with operational insights. From a practice perspective, the framework provides a strategic tool for university researchers and administrators to map assets, assess exploitation states, and guide transitions, enhancing governance and partnerships.

Keywords: Knowledge management, Research valorisation, Ethnographic case study.

1. Introduction

Universities are increasingly recognised not only as institutions of higher learning and fundamental research but also as pivotal engines for innovation, economic growth, and societal problem-solving. This evolving role has given rise to the concept of the 'entrepreneurial university', an institution actively engaged in translating its intellectual assets into tangible societal and economic impact (Etzkowitz, 2003; Guerrero & Urbano, 2012). A central challenge within this paradigm lies in the effective management and valorisation of the diverse knowledge generated within academic settings. Bridging the gap between theoretical academic discovery and practical market application requires a deeper understanding of research knowledge types, dedicated strategies, and increasingly, specialised organisational structures.

Despite clear expectations for universities to demonstrate impact, the literature reveals uncertainty about the mechanisms and processes for achieving this across different types of research knowledge and exploitation goals. Studies on knowledge management (KM) highlight the tension between tacit and explicit knowledge (Nonaka, 1994), while the Triple Helix model underscores university-industry-government interactions (Etzkowitz & Leydesdorff, 2000). Research also explores technology transfer offices, spin-offs, and valorisation pathways (Siegel et al., 2003; Molas-Gallart & Castro-Martínez, 2007). However, existing work often lacks clarity on how the nature of knowledge, whether fundamental and broadly applicable or specialised and domain-specific, shapes exploitation strategies. Similarly, the processes for transitioning research to targeted solutions for the market or scalable ventures remain poorly understood, leaving a gap in systematic approaches to valorisation. To address these uncertainties, this study asks: *How can universities effectively map their knowledge assets to understand and facilitate appropriate exploitation strategies?*

This paper tackles this research gap through an in-depth case study of a technical university pursuing an entrepreneurial research-to-market approach. In this context, 'market' encompasses both private and public organisations seeking research-based solutions and funding bodies supporting impactful research projects. Using an ethnographic methodology with participant observation, the study examines multiple cases of research exploitation, offering insights into strategies, challenges, and enabling conditions in valorising diverse knowledge assets.

The study introduces a novel knowledge management framework to classify knowledge and valorisation initiatives. This framework integrates two critical dimensions. The first dimension, Research Focus, distinguishes between basic research, broadly applicable, and vertical research, focused on specialised

knowledge within specific business domains. The second dimension, Exploitation Scope, differentiates problem-solving activities such as consultancy and targeted solutions from scaling efforts including intellectual property exploitation and spin-offs. By applying this framework to fieldwork observations, the paper shows the operational dynamics of knowledge valorisation in an entrepreneurial university context and provides a practical tool for mapping knowledge assets to appropriate exploitation pathways. The study results contribute to knowledge management research by providing an empirically grounded analysis of knowledge valorisation structures and processes. The findings offer valuable implications for university administrators, policymakers, researchers, and practitioners designing organisational structures to maximise the societal and economic returns of academic research.

2. Literature review

2.1 Evolution of Knowledge Management Theories

Knowledge management has evolved from a focus on information systems to a broader understanding of knowledge as a dynamic process involving tacit and explicit forms (Nonaka, 1994). In academic settings, this distinction is critical. While explicit knowledge, codified in experimental data, publications, and patents, is easily stored and shared, tacit knowledge, such as researchers' uncodified expertise, is harder to formalise and often transferred through personal interactions (Nonaka, 1994; Tian et al., 2009). Universities, as knowledge-intensive organizations, excel at producing explicit knowledge but struggle to capture tacit knowledge, a challenge central to research valorisation (Tian et al., 2009).

Universities engage in three KM processes: creation through research, transfer via teaching and outreach, and application to societal problems (Rowley, 2000). However, these processes are often disjointed. Research thrives in creation, yet transfer and application lag, particularly in translating findings into practical outcomes (Ramachandran et al., 2009). The rise of the "third mission" amplifies this, pushing universities to exploit knowledge economically and socially, beyond traditional teaching and research roles (Etzkowitz & Leydesdorff, 2000).

Academic KM faces unique challenges. Disciplinary silos hinder knowledge sharing, reward systems prioritise individual publication over collaboration, and tensions between academic freedom and strategic management resist formalised KM efforts (Fullwood et al., 2013; Bhusry et al., 2011). Open science, which promotes transparent sharing of research outputs to advance collective knowledge, often conflicts with intellectual property protection, complicating valorisation as universities balance societal contributions with revenue generation (Siegel et al., 2003).

2.2 The Entrepreneurial University and Knowledge Valorisation

The concept of the entrepreneurial university arose as universities responded to decreasing public funding and increasing economic demands. This shift marked a departure from the traditional focus on teaching and research, leading to what is termed a "second academic revolution" that incorporates a third mission centred on societal impact (Etzkowitz, 2003; Clark, 1998). This historical change highlights the evolving roles of universities in knowledge-based economies, with a focus on diversifying resources and exploiting knowledge (Slaughter & Leslie, 1997).

The Triple Helix model and the third mission frame universities as entrepreneurial nodes driving innovation through university-industry-government interactions and diverse valorisation activities (Etzkowitz & Leydesdorff, 2000; Molas-Gallart & Castro-Martínez, 2007). Value creation from academic knowledge occurs through mechanisms like direct commercialisation (e.g., spin-offs), collaborative consultancy, policy advice, and public engagement. These pathways transform both explicit and tacit knowledge into economic and social benefits, extending beyond traditional technology transfer to include non-commercial impacts (European Commission, 2020). From an organizational perspective, universities support knowledge exploitation through structures such as technology transfer offices (TTOs) and incubators (Siegel et al., 2003). TTOs manage intellectual property and commercialisation, while incubators foster spin-offs, though informal networks (Tuunainen, 2005). Clark (1998) emphasises that integrating these structures into a cohesive culture aligned with academic strengths can strenghten research valorization, yet effectiveness varies by context (Sánchez-

Barriolluengo, 2014). This diversity in research exploitation mechanisms and structures demands tools and frameworks that capture varied valorisation strategies, aligning with universities' multifaceted roles.

2.3 Challenges in Valorising Academic Research

Despite advances in KM and entrepreneurial models, valorising academic research faces persistent gaps. Literature identifies a disconnect between knowledge creation and application, with universities excelling at the former but lagging in systematic transfer and exploitation (Ramachandran et al., 2009). Disciplinary silos and decentralised governance hinder cross-unit collaboration, while reward systems favoring publication over practical impact discourage valorisation efforts (Fullwood et al., 2013).

The tension between open knowledge sharing and intellectual property protection complicates exploitation, as does the "valley of death" between research and market-ready solutions, requiring resources often beyond academic capacity (Siegel & Wright, 2015). Tacit knowledge uncodified nature further hinders formal exploitation, as existing tools like Nonaka's SECI model (Nonaka, 1994) focus on creation, not application (Nonaka, 1994). The Triple Helix model, while insightful, lacks practical guidance for operationalising interactions (Tuunainen, 2005).

These gaps—fragmented processes, misaligned incentives, and limited methodologies—highlight the need for systematic approaches to exploit diverse research assets. The methodological approaches to studying knowledge valorisation in universities have primarily relied on quantitative metrics (such as patent counts, licensing revenues, and spin-off numbers) or survey-based assessments of technology transfer activities (Perkmann et al., 2013; D'Este & Patel, 2007). While these approaches provide valuable macro-level insights, they often fail to capture the nuanced dynamics and contextual factors influencing knowledge exploitation pathways. This methodological gap limits our understanding of how universities operationalise valorisation strategies across different knowledge types and exploitation goals, further supporting the need for in-depth qualitative approaches as employed in this study.

3. Methodology

3.1 Introduction to the Methodology

This study employs a qualitative ethnographic case study approach to investigate how a technical university exploits its research assets for societal and economic impact. The primary aim is to understand the dynamic processes and conditions shaping knowledge valorisation, a phenomenon best explored through immersive observation of daily practices and stakeholder interactions. Ethnography is well-suited to this research question, as it captures the contextual richness of knowledge management and project-based exploitation strategies within a real-world setting (Myers, 1999). By focusing on a single case, the study achieves depth over breadth, offering revelatory insights into a complex, understudied process (Yin, 2014).

The case study centres on a technical university offering training on disciplines such as engineering, architecture, and design, recognised for its robust research output, support for startup creation, and connections with market actors. Observed phenomena include the generation of research findings across disciplines (e.g., physics, IT, design, business and management), their application through collaborative projects, applied research, and transformation of research results into entrepreneurial ventures. Fieldwork spanned 42 months between July 2021 and December 2024, conducted within the university's ecosystem, including research laboratories, administrative units, and external partner interactions. Research methods comprised semi-structured interviews, field observations, and document analysis, providing a multi-faceted view of knowledge exploitation. This approach enables the study to map research assets to their research focus and to exploitation strategy, while identifying internal and external conditions driving knowledge valorisation. By integrating ethnographic insights with project management perspectives, the methodology unveils strategic pathways for maximising research impact in entrepreneurial universities.

3.2 Interviews to Stakeholders

Semi-structured interviews with key stakeholders provided critical insights into the strategies and conditions underpinning knowledge exploitation in the case university. Two primary groups were interviewed: university

researchers involved in exploitation projects and representatives from collaborating stakeholders. 12 interviews were conducted, with participants purposively selected based on their direct involvement in research valorisation efforts, such as project leaders and industry and health organizations partners engaged in technology development or consultancy. Interviews, lasting 45-60 minutes each, were conducted in person or virtually, ensuring a longitudinal perspective on evolving practices.

The interview protocol explored topics such as research output, project goals, collaboration dynamics, exploitation challenges, and perceived outcomes. Questions were tailored to each group: researchers were asked about internal capabilities (e.g., expertise development), while stakeholders' representatives provided external perspectives (e.g., market needs, partnership structures). This dual approach aligns with the objective of capturing the conditions enabling knowledge valorisation, as well as collecting the university stakeholders' network and environmental influences. Interviews were recorded where possible, transcribed verbatim, and supplemented with researcher notes to contextualise responses. This method enriched the study by revealing stakeholder motivations and tensions, such as aligning academic goals with industry timelines.

3.3 Field Observation

Field observations over three years provided a rich, contextual understanding of knowledge exploitation processes at the case university. Data was collected from multiple settings, including formal events like project meetings, industry collaboration workshops, and startup pitch sessions, as well as informal discussions among researchers, administrators, and external partners. Additional sources included presentations delivered at university events and participation in conferences where exploitation outcomes were showcased. Approximately 50 observation instances were documented, ranging from brief interactions to multi-hour sessions.

Field notes, recorded contemporaneously and later expanded, captured detailed accounts of activities, dialogues, and organizational dynamics. These observations highlighted how research assets, such as novel technologies or methodologies, were applied in projects linked to market needs or transitioned to startups. For example, meetings revealed decision-making on project funding, while events highlighted shifts from a problem-solving approach (e.g., addressing specific industry challenges) to scaling (e.g., commercial prototypes). This method complemented interviews by grounding stakeholder narratives in observable practices, aligning with the ethnographic principle of immersion (Myers, 1999). The longitudinal scope ensured a comprehensive view of trajectory shifts, such as from fundamental research to vertical applications, providing empirical depth to the study.

3.4 Data Analysis

Data analysis followed ethnographic guidelines, emphasising iterative, thematic exploration to derive a knowledge exploitation framework. The initial step involved data organization, or indexing: interview transcripts, field notes, and supplementary documents (e.g., project reports, presentation slides) were catalogued, transcribed where applicable, and sorted chronologically. This corpus was reviewed multiple times to identify recurring patterns and variations. The data was then coded using an in vivo and emergent approach, generating initial themes such as "specialised expertise," "market demand," and "collaborative structures" (Braun & Clarke, 2006).

Themes were organised into abstract domains aligning with the research objectives and exploitation strategies, and categorised by internal (e.g., team capabilities) and external (e.g., funding support) conditions. Focused coding refined data to identify specific exploitation objectives (e.g., problem-solving to scaling), mapping how research assets evolved. This process balanced inductive insights from the data with deductive links to KM literature, ensuring theoretical grounding (O'Reilly, 2008). The goal was not statistical representativeness but meaningful interpretation of exploitation dynamics (Emerson et al., 1995). Descriptions of project contexts and stakeholder interactions enriched the study. This analysis informed a framework for classifying exploitation strategies, detailed in the findings.

4. Findings

4.1 A Framework for Analysing Research Asset Exploitation

Based on a critical review of knowledge management literature, combined with an empirical investigation of three cases of research asset exploitation within a university context, we propose a novel framework to understand how academic research can be valorised (Figure 1). The framework is structured along two key dimensions: Research Focus and Exploitation Scope. The Research Focus dimension distinguishes between basic/horizontal research, which encompasses fundamental, principle-driven knowledge applicable across multiple domains - aligning with what Gibbons et al. (1994) term "Mode 1" knowledge production - and vertical research, which is specialised and tailored to a specific industry or application area and recalls "Mode 2" knowledge production (Gibbons et al., 1994). The Exploitation Scope dimension differentiates between problem-solving, where research is applied to address a specific, often stakeholder-defined challenge, and scaling, where research is transformed into a broader, typically commercial, venture with growth potential. Together, these dimensions form a 2x2 matrix yielding four quadrants: Basic + Problem-Solving, Basic + Scaling, Vertical + Problem-Solving, and Vertical + Scaling. This structure emerged from observing how research assets in the four cases varied in their disciplinary scope and exploitation intent, revealing distinct patterns of valorisation.

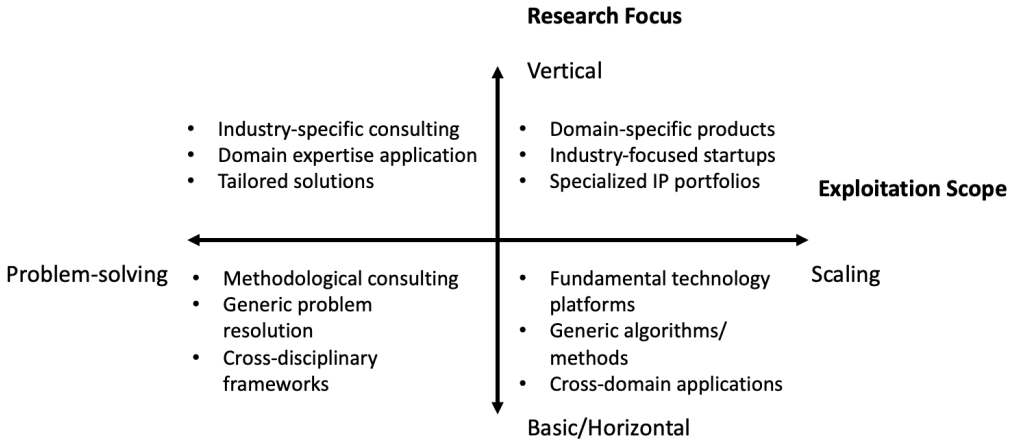

Figure 1: Framework of the study.

4.2 Conditions Influencing Exploitability Across Dimensions

Analysis of the three cases revealed that the exploitability of research assets, classified according to their research focus and exploitation scope, depends on specific conditions, categorised as internal (controlled by the research team) and external (driven by the environment). For the Research Focus dimension, internal conditions for basic/horizontal research include a broad theoretical base and flexibility for adaptation, enabling wide applicability, while external conditions involve an exploratory academic culture and institutional support for fundamental inquiry. For vertical research, internal conditions encompass specialised expertise and targeted development within a domain, whereas external conditions include domain-driven demand and industry/end-user collaboration. For the Exploitation Scope dimension, problem-solving is facilitated by internal conditions such as general applicability and the ability to produce practical deliverables, alongside external conditions like identified stakeholder needs and collaborative bridges to external partners. Conversely, scaling relies on internal conditions like market readiness and commercial viability, paired with external conditions such as platform potential and collaborative networks of stakeholders (e.g., investors, industry partners). These conditions, derived from the interplay of theoretical insights and empirical observations, highlight how exploitability emerges from a synergy of the research team-driven capabilities and environmental opportunities, providing a structured approach to assess and guide research valorisation strategies.

The following sections present three case studies of research asset exploitation, each positioned within the framework to illustrate its analytical potential. Table 1 provides an overview of these cases, summarising their research assets, focus, scope, and exploitation strategies.

Table 1: Overview of three research asset cases, positioning and exploitation strategies.

Description of the Research Asset	Positioning in Research Focus	Positioning in Exploitation Scope	Exploitation Strategy
Competence in advanced optical microscopy using coherent Raman scattering, enabling label-free, high-resolution imaging of biological samples, initially developed in a physics laboratory.	Basic/Horizontal: Broad, principle-driven knowledge applicable across domains, later specialised for healthcare.	Problem-solving: Addressed specific imaging challenges, with prototypes and a startup for spectroscopy/ photonics solutions funded by local authorities.	Applied in a health-focused research project to develop a bio-photonics device, followed by commercialisation through a startup offering high-tech imaging solutions.
Expertise in IT technologies, business requirements analysis, and business-IT alignment frameworks, developed through application design and market trend monitoring, applicable across industries.	Basic/Horizontal: Cross-disciplinary, industry-agnostic skills not tied to a specific sector, later focused on digital innovation.	Problem-solving: Delivered consultancy projects (e.g., process mapping, system assessments).	Provided consultancy for diverse sectors (retail, manufacturing, public bodies), then scaled via standardised IT assessment services and a spin-off offering data-driven digital solutions.
Knowledge in digital technologies for healthcare, developed through hospital applications, IoT solutions, and electronic medical record systems, tailored to healthcare unique data and regulatory needs.	Vertical: Specialised expertise at the intersection of digital innovation and healthcare, focused on medical settings.	Vertical: Supported healthcare institutions via different digital-enabled projects (e.g., big data platforms, traceability systems).	Implemented project-based solutions for hospitals and health authorities, followed by a scalable service model for big data and patient care support across healthcare organizations.

4.3 Case 1: Optical Microscopy Competence in a Health Research Project

The first case pertains to a research asset focused on advanced optical microscopy, developed by a physics research group. This capability utilises Coherent Raman Scattering (CRS), a technique that enhances conventional microscopy by facilitating label-free, non-invasive imaging of biological samples with high resolution. In contrast to fluorescence microscopy, which requires staining that may alter biological functionality, CRS employs intrinsic vibrational frequencies for contrast, offering considerable potential for the investigation of cellular structures. Initially developed within an academic laboratory, this asset represented a broad, principle-driven capability in physics, with applications not yet linked to a specific domain.

In its initial state, the research asset aligned with the *Basic/Horizontal* + *Problem-Solving* quadrant of the framework. Internal conditions supporting this classification included its general applicability, as the CRS technique can address a wide range of imaging challenges, and the research team's ability to produce practical deliverables for academic experimentation. Externally, short-term funding from national basic research grants facilitated problem-solving applications within the physics domain, while the academic orientation of the laboratory environment reinforced its exploratory emphasis. The asset exploitation was limited by the absence of identified stakeholder needs beyond the research domain and a lack of collaborative connections to external partners which limited a broader impact.

The trajectory of the asset exploitation shifted when the research team engaged specialised expertise by collaborating with medical doctors and biologists focused on the study of cells and tissues, transitioning it to the Vertical + Problem-Solving quadrant. This transition was facilitated by internal conditions, such as the targeted development of CRS for health-related applications, and external conditions, including domain-driven demand from cancer research and collaboration with hospitals treating cancer patients. A key external factor

was the applied funding from the European Commission through a project aimed at developing a next-generation bio-photonics imaging device for cellular disease analysis. This funding, linked to a specific healthcare challenge, reinforced the asset vertical focus and problem-solving scope, leading to the creation of a functional prototype for tissue imaging.

Following the European Commission funding, the subsequent exploitation trajectory indicates a movement towards the *Vertical* + *Scaling* quadrant. The team's development of laser microscope prototypes for tissue analysis, combined with internal market readiness stemming from a proven application, creates the conditions for commercialisation. Externally, the launch of a startup focused on high-tech solutions in spectroscopy and photonics reflects the emergence of collaborative networks with industry partners and potential investment support. This transition hinges on achieving commercial viability (internal) and leveraging platform potential (external) to expand the technology's market reach.

4.4 Case 2: Aligning Business and IT in Organizations

The second case involves a research asset comprising expertise in digital technologies, business requirements analysis, and frameworks for business-IT alignment, developed by a multidisciplinary research group. Knowledge of IT stemmed from designing and developing applications, such as enterprise applications integration, public service systems, and supply chain solutions. Competence in business requirements was developed through participation in market analysis projects, including a university-led initiative to monitor digital technology trends across industries, equipping researchers with insights into business needs. Theoretical and practical frameworks, such as enterprise architecture, business requirements modelling, and alignment methodologies, enabled the connection of IT capabilities with market demands. This broad, cross-disciplinary skill set was not confined to a specific industry, reflecting a versatile foundation for addressing diverse challenges.

Initially, this asset was positioned in the *Basic/Horizontal* + *Problem-Solving* quadrant. Internal conditions supporting this placement included general applicability, as the expertise could be adapted to various organizational contexts, and the ability to produce practical deliverables, such as process maps or system assessments. Externally, identified stakeholder needs from organizations seeking digital solutions and short-term funding through applied research grants or consultancy contracts facilitated problem-solving exploitation. The team engaged in projects like business process mapping for retailers, application portfolio assessments for manufacturers, and information system redesigns across sectors, including services and public bodies. However, exploitation was limited by missing conditions: a lack of market readiness and collaborative networks limited the potential for broader, scalable impact beyond individual projects.

The asset exploitation evolved toward the *Basic/Horizontal* + *Scaling* quadrant when the team identified a high-value, industry-agnostic service: IT assessment and software selection. This shift was driven by internal conditions, including targeted development to formalise frameworks and methodological tools for standardised assessments, and commercial viability, as the service was refined to meet diverse client needs efficiently. Externally, platform potential emerged as the service's broad applicability attracted interest across sectors, while collaborative bridges with companies seeking digital transformation supported its adoption.

The asset trajectory moved toward the *Vertical* + *Scaling* quadrant, driven by the creation of a spin-off company focused on digital consultancy, particularly data-driven solutions. Internal conditions enabling this shift include specialised expertise in data governance, cloud transformation, and AI technologies, developed through ongoing research, and market readiness from validated methodologies. Externally, collaboration with industry partners and investment support from a university incubator and external funding bodies supported this move. The spin-off offers services like IT strategy formulation, cloud transformation, and data governance, targeting specific digital innovation needs. This trajectory was underpinned by entrepreneurial commitment (internal) and domain-driven demand (external).

4.5 Case 3: Digital Innovation Competence in Healthcare

The third case centres on a research asset comprising deep knowledge at the intersection of digital technologies and healthcare, developed through collaboration between heterogenous university research groups and various healthcare institutions. This competence emerged from projects including hospital

application development, IoT solutions for tracing surgical devices and blood bags, electronic medical record (EMR) systems, and support for regional authorities in shaping EMR policies. These initiatives equipped the team with expertise in addressing the unique needs of healthcare organizations, such as complex data requirements, stringent regulatory compliance, and public procurement processes, while leveraging technologies like RFID and big data analytics. This specialised skill set was inherently tied to the healthcare domain, reflecting a focused capability to enhance organizational and digital evolution in medical settings.

The asset was initially positioned in the *Vertical* + *Problem-Solving* quadrant. Internal conditions included expertise in healthcare-specific digital solutions and practical deliverables, such as tailored applications and traceability systems for hospitals. Externally, domain-driven demand from healthcare institutions and applied funding from local authorities supported problem-solving exploitation. The asset was utilised in projects such as transfusion process tracking and the design of a big data platform for integrating health data from different domains (e.g., cardiology, oncology, neurology) to advance clinical research and patient care. However, exploitation was limited by a lack of market readiness and collaborative networks for broader dissemination.

The asset's exploitation evolved toward the *Vertical* + *Scaling* quadrant as the team identified a standardised, high-value service offering: support for healthcare organizations in data integration, big data exploitation for patient care, and EMR development. This shift was enabled by internal conditions, including targeted development of formalised methodologies to address common healthcare needs and commercial viability, ensuring services were efficient and replicable. Externally, platform potential arose from the widespread demand for digital transformation across healthcare systems, while industry/end-user collaboration with multiple hospitals validated and expanded the service model.

At the time of the analysis, the evolution trajectory was withing the *Vertical* + *Scaling* quadrant, with potential for further expansion. The team's ongoing work to replicate and refine these services, integrating data, enhancing patient care, and supporting EMR systems deployment, relies on internal conditions like specialised expertise in navigating healthcare's complexities and market readiness from proven methodologies. Externally, collaborative networks with regional health authorities and institutions, coupled with investment support from public funding tied to national health priorities, drive this scaling effort. The asset's ability to address universal healthcare challenges, such as data governance and regulatory compliance, positions it for broader adoption.

5. Discussion

This study aimed to investigate how a technical university exploits its research assets to generate societal and economic value, addressing a gap in systematic approaches to knowledge valorisation. Through an ethnographic case study, we explored the processes, conditions, and strategies shaping research exploitation within the three cases in a technical university. The findings informed a novel framework classifying research assets by Research Focus (basic/horizontal vs. vertical) and Exploitation Scope (problem-solving vs. scaling), supported by internal and external conditions. This framework maps exploitation dynamics and trajectories, offering a structured lens to understand and enhance valorisation strategies in entrepreneurial universities.

5.1 Contributions to Theory

This study advances theoretical understanding of knowledge management and valorisation in academic contexts through three key contributions. First, it enriches knowledge management literature by integrating Nonaka's (1994) tacit-explicit dichotomy with exploitation dynamics. While prior work focuses on knowledge creation and transfer (Rowley, 2000), our framework extends this to application and scaling, addressing Ramachandran et al.'s (2009) noted disconnect between creation and practical use. By classifying research assets into basic/horizontal and vertical focuses, it reveals how knowledge type influences exploitation potential, adding granularity to KM theory.

Second, our study refines the Triple Helix model (Etzkowitz & Leydesdorff, 2000) by operationalising university-industry-government interactions into actionable categories. Unlike the model broad emphasis on institutional roles, our study specifies conditions (e.g., collaborative networks, market readiness) and trajectories (e.g., problem-solving to scaling), offering a practical bridge between theoretical interactions and empirical outcomes. This addresses Tuunainen's (2005) critique of the model's lack of operational detail, enhancing its utility for analysing entrepreneurial universities' innovation roles.

Third, results contribute to entrepreneurial university scholarship by systematising valorisation processes beyond commercialisation (Siegel & Wright, 2015). The framework dual dimensions and conditions highlight diverse pathways—consultancy, standardised services, startups—expanding Clark's (1998) entrepreneurial pathways with a structured approach. This broadens the universities' third mission discourse (Molas-Gallart & Castro-Martínez, 2007), showing how they can strategically align research with societal and economic goals, adding a dynamic, process-oriented perspective to the literature.

5.2 Contributions to Practice

The study offers two practical contributions for university researchers, administrators, and industry partners engaged in knowledge valorisation. First, the framework provides a diagnostic and planning tool for managing research exploitation projects. By mapping assets to quadrants and identifying enabling conditions (e.g., internal expertise, external funding), universities can assess current exploitation states and strategise transitions, such as shifting from problem-solving consultancy to scalable ventures. This also enhances universities governance by clarifying resource needs and stakeholder roles.

Second, our results offer actionable guidance for enhancing university-industry collaboration. The identified conditions (e.g., collaborative bridges for problem-solving, investment support for scaling) enable university administrators to prioritise partnerships and infrastructure, such as technology transfer offices or incubators, to maximise impact. For instance, researchers can leverage external demand to secure funding, while administrators can foster entrepreneurial ecosystems to scale innovations, as seen in the study's startup cases. This practical insight bridges academic knowledge to market outcomes, empowering universities to fulfil their third mission effectively and respond to societal needs, such as healthcare innovation or digital transformation.

5.3 Limitations and Directions for future research

While this study provides valuable insights into knowledge exploitation within a university context, it is subject to limitations that limit the generalisability of its findings. First, the reliance on a single case study, a technical university with strong market connections, and the analysis of three exploitation pathways restricts the framework applicability across diverse contexts. Although the selected cases offer a rich interpretation of how research assets can be modelled and exploited, their specificity to a technically oriented institution with established industry ties may not fully reflect the dynamics of universities with different disciplinary focuses (e.g., humanities) or weaker market linkages. To validate and refine the framework, future research could apply it to a broader range of universities, including non-technical institutions and those in varying innovation ecosystems, testing its robustness across multiple exploitation pathways and organizational settings.

A second limitation lies in the ethnographic approach's emphasis on depth over breadth, which, while yielding detailed qualitative insights, limits the study's ability to quantify exploitation conditions and success or compare them statistically across cases. This qualitative focus may overlook broader patterns or measurable factors (e.g., funding scale, collaboration frequency) that influence valorisation success. Future studies could complement this work with mixed-methods approaches, integrating quantitative metrics such as project budgets, patent outputs, or startup survival rates to assess the framework's efficacy more systematically. Additionally, longitudinal studies tracking exploitation trajectories over extended periods could reveal how conditions evolve, enhancing the framework's predictive power. Finally, an investigation over a prolonged period could also explore the sustainability of the exploitation trajectories described in the present study.

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AI declaration: AI was not used for the creation of the present paper, EditGPT was used for text proofreading.

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