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If we never do it, we will never know

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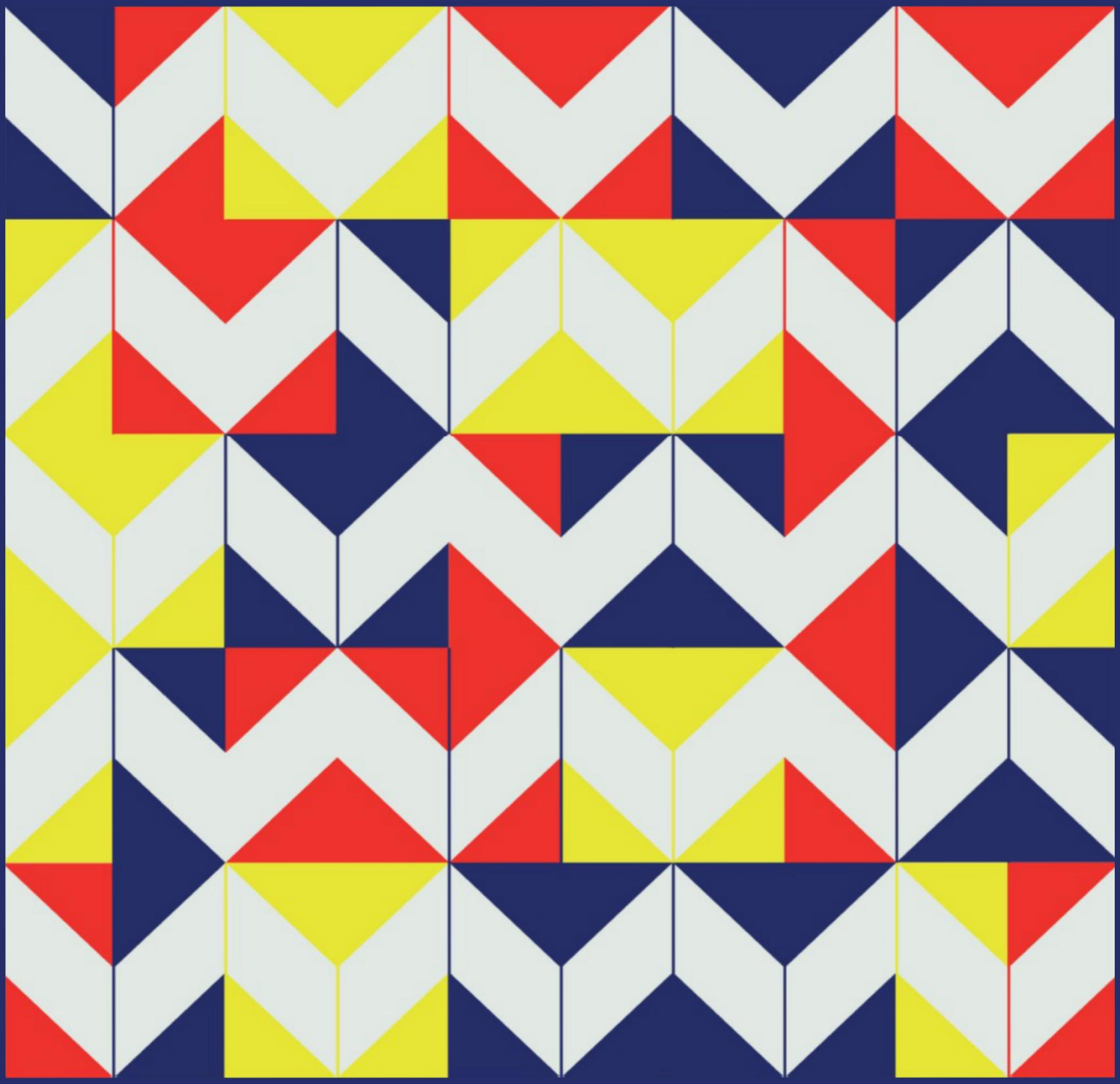

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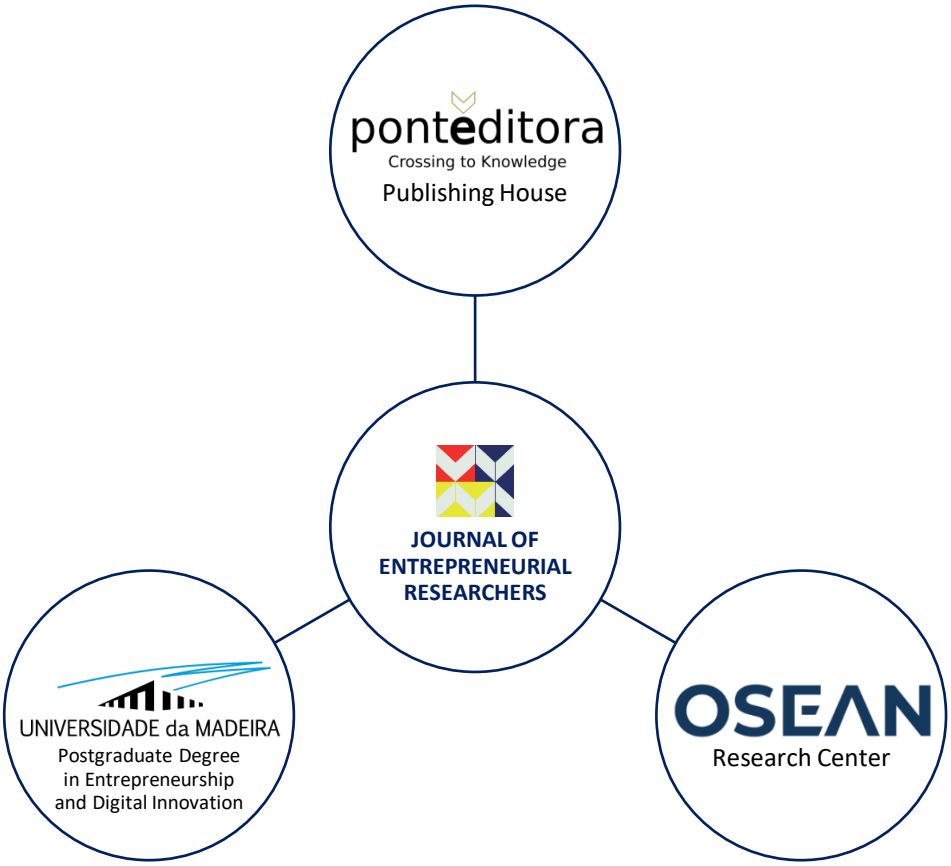

Editorial Team

Editorial Charter

The *Journal of Entrepreneurial Researchers (JER)* is a peer-reviewed, semiannual scientific journal published in digital open-access format by Ponteditora, Sociedade Unipessoal, Lda. JER is committed to advancing research in entrepreneurship and related fields by providing an international platform for the publication and dissemination of high-quality, original scientific contributions.

Mission and Scope

JER aims to foster academic inquiry and global dialogue on topics central to the entrepreneurial research domain. The journal welcomes interdisciplinary, multidisciplinary, transdisciplinary, and pluridisciplinary approaches in areas such as the green and blue economy, eco-entrepreneurship, green accounting, sustainable finance, digital innovation, sustainability, and social inclusion.

Our mission is to promote excellence in entrepreneurial research, stimulate original thinking, and facilitate the exchange of ideas, experiences, and collaborative projects among scholars, professionals, and institutions worldwide.

Language and Publication Format

JER publishes all content in English, accepting both American and British variants, as long as usage is consistent throughout the manuscript. Each article must include a title, abstract, and keywords. The journal publishes two issues per year, with each issue comprising approximately 80 to 180 A4 pages.

Editorial Structure and Peer Review

The Editorial Team is composed of an international group of academics and professionals committed to scientific rigor and editorial independence. In addition to regular issues, JER also publishes special issues coordinated by guest editors with recognized expertise. All submissions undergo a two-stage evaluation:

1. **Desk Review** — Conducted by the Editor-in-Chief and Assistant Editors to assess alignment with the journal's scope and editorial standards.
2. **Peer Review** — Authors may choose between single-blind (anonymous reviewer), double-blind (default), or open peer review. In cases of conflicting evaluations, a third reviewer may be consulted.

All articles are selected based on relevance, scientific quality, and respect for diversity of perspectives.

Ethical Standards

JER adheres to the highest standards of publishing ethics, drawing guidance from internationally recognized frameworks, including:

- Committee on Publication Ethics (COPE)
- World Medical Association's Declaration of Helsinki (WMA)
- International Committee of Medical Journal Editors (ICMJE)
- Animal Research: Reporting of In Vivo Experiments (ARRIVE)

The journal promotes integrity, transparency, and ethical responsibility throughout the publication process. Guidelines for Authors and Peer Reviewers are publicly available and regularly updated.

Editorial Independence and Integrity

JER maintains full editorial independence and is free from political, ideological, or economic influence. The approval of manuscripts is guided strictly by academic merit, originality, and relevance to the field.

The Editorial Team also upholds the ethical principles enshrined in Article 17 of the Portuguese Press Law, ensuring journalistic good faith and responsibility toward readers.

Access and Inclusion

JER is fully open access, offering free and unrestricted access to all its content. The journal actively promotes inclusivity and welcomes submissions from diverse geographic, institutional, and disciplinary backgrounds.

Final Note

JER is a growing international platform committed to contributing meaningfully to the global conversation on entrepreneurship. Through rigorous peer review, ethical integrity, and a collaborative editorial culture, we aim to support the ongoing advancement of research and innovation.

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Editorial—Understanding before celebrating: Entrepreneurship beyond imitation, certainty, and comfort

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Eduardo Leite, University of Madeira, OSEAN—Outermost Regions Sustainable Ecosystem for Entrepreneurship and Innovation, Portugal, eduardo.leite@staff.uma.pt.

In an era marked by permanent disruption, accelerated technological change, and growing uncertainty, entrepreneurship research faces a decisive challenge: whether to merely replicate dominant narratives or to interrogate them critically, exposing their limits, paradoxes, and unintended consequences.

This issue of the *Journal of Entrepreneurial Researchers* deliberately chooses the second path.

The contributions in this issue move beyond celebratory or deficit-based narratives, offering critical and empirically grounded analyses of entrepreneurship as a complex, context-dependent, and systemically embedded phenomenon.

Entrepreneurship in Low-Density Territories: From "Exceptions" to Theory

A further reason this stance matters is that much of entrepreneurship and innovation scholarship has been forged in high-density environments, with abundant venture capital, large proximate markets, and thick institutional networks. Yet an increasing share of entrepreneurial reality unfolds elsewhere: in small economies, remote islands, peripheral regions, and low-density ecosystems where constraints are structural rather than temporary.

These territories are too often treated as marginal cases, where the task is merely to "adapt" models imported from hegemonic centres. The journal's mission is different: to treat low-density contexts not as a deficit, but as an analytical frontier, one that can generate concepts, evidence, and policy insights with broader relevance. In such settings, isolation, resource constraints, brain drain pressures, and market thinness do not simply reduce opportunity; they reshape the very mechanisms through which entrepreneurial resilience, innovation pathways, and sustainable value creation emerge (Collins & Murtagh, 2025).

From Myth to Evidence: Questioning Entrepreneurial Orthodoxies

We open this issue with *Beyond Silicon Valley: Lessons from accelerator programs in small innovation ecosystems*, a study that directly challenges one of the most entrenched assumptions in contemporary entrepreneurship policy: that accelerators are universally beneficial engines of venture success.

Drawing on administrative data from 2019–2023, combined with propensity-score matching and qualitative interviews, the authors reveal a nuanced and uncomfortable reality. While accelerator participation may increase employment growth, it simultaneously correlates with higher failure risk. These counterintuitive findings resist simplistic celebration and instead invite a more mature policy debate, one that recognises that support mechanisms may amplify both opportunity and vulnerability. Methodologically, the use of propensity-score methods aligns with established practice for reducing confounding in observational studies (Austin, 2011).

This contribution exemplifies what this journal seeks to promote: empirically grounded research that does not shy away from ambiguity, and that treats entrepreneurship not as a moral good per se, but as a phenomenon to be carefully examined.

Reframing Creation, Innovation, and Destruction

If the first article destabilises dominant policy narratives, the second, *The dialectics of creative destruction and uncreative construction*, challenges theoretical complacency.

Through the articulation of the concept of uncreative construction, the authors question the romanticisation of innovation through perpetual disruption. Inspired by biomimicry, the article advances a conceptual framework in which sustainability, regeneration, and restraint are not obstacles to innovation, but essential conditions for its long-term viability.

In doing so, the paper aligns with a broader intellectual concern that runs through this issue: the need to move beyond binary thinking, success versus failure, innovation versus stagnation, and to explore the dialectical processes through which entrepreneurial systems evolve.

Responsible Innovation as Practice, Not Rhetoric

This concern is further developed in *Integrating social and responsible innovation for sustainable entrepreneurship*, a meta-synthesis of contemporary case studies. Through a transparent and systematic review process, the authors distil actionable insights that bridge theory and practice.

Rather than treating responsibility as a symbolic add-on, the article demonstrates how social and responsible innovation can be operationalised across contexts. Its contribution lies not only in synthesis, but in offering guiding propositions capable of informing both scholarship and policy design.

Together with *Operationalising the quintuple helix in S3*, which translates complex innovation frameworks into practical instruments for regional development and tourism policy, these articles reinforce a core position of the journal: entrepreneurship research must speak simultaneously to scholars, policymakers, and practitioners. Conceptually, the quintuple helix positions innovation as a socio-ecological system in which the natural environment is not external to innovation, but a driver and constraint within it (Carayannis et al., 2012).

Context, Crisis, and Constrained Choices

The remaining contributions ground these broader reflections in concrete contexts.

The study on circular economy and sustainable entrepreneurship in healthcare illustrates how entrepreneurial action unfolds under material constraints, regulatory pressures, and ethical imperatives, reminding us that innovation is often less about heroic breakthroughs than about careful optimisation, recombination, and systemic awareness.

In addition, the article on crowdfunding for women entrepreneurship highlights persistent structural asymmetries, showing that access to finance remains deeply entangled with social signals, gender norms, and evaluative biases.

The issue also includes an exploratory empirical study on the adoption of emerging information technologies in the financial sector, examining how artificial intelligence and blockchain are reshaping organisational practices and workforce perceptions within highly regulated environments.

The case study of marketing strategies in the restaurant sector during a global crisis further reinforces a key lesson: in moments of extreme uncertainty, entrepreneurial survival depends less on imitation of best practices and more on adaptive judgment, contextual sensitivity, and the capacity to avoid avoidable failure.

A Journal-Positioning Statement

Taken together, the articles in this issue articulate a coherent editorial stance.

The *Journal of Entrepreneurial Researchers* is not interested in entrepreneurship as spectacle, nor in innovation as slogan. Instead, it seeks contributions that:

- confront dominant assumptions with evidence,
- embrace uncertainty rather than obscure it,
- recognise failure as an analytical category, not a stigma,
- and situate entrepreneurial action within broader social, institutional, and ecological dynamics.

In a world increasingly tempted by simplification, speed, and superficial metrics, this issue argues, implicitly but firmly, that depth, rigor, and critical reflection remain indispensable.

Understanding must come before celebration. Only then can entrepreneurship genuinely contribute to sustainable and meaningful futures.

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Ethical Statement

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Beyond Silicon Valley: Lessons from accelerator programs in small innovation ecosystems

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Abstract

Accelerator programmes have become a prominent policy tool for stimulating entrepreneurship, yet rigorous evidence on their firm-level impact remains limited, especially in smaller economies. This article examines whether participation in Norwegian accelerators can be associated with performance gains for early-stage ventures. Using registry data from 2019 to 2023, we combine participation records from eight SIVA-affiliated accelerators (supported by the Norwegian government) with full-population accounting data and apply propensity-score matching to create a cross-sectional control group comparable on founding year, industry, region and total assets. Five outcomes are analysed one year after programme completion: employment growth, revenue growth, labour productivity, return on total capital and survival. Qualitative semi-structured interviews with former participants provide additional context for interpreting the quantitative results.

Key findings: Accelerator graduates expand employment about 31 percent faster than matched non-participants, a statistically and economically significant effect that interviewees attribute to heightened ambitions and improved recruiting networks. However, no reliable differences emerge in revenue, productivity or capital efficiency, and participants face roughly 2.2 times higher odds of bankruptcy, translating to an eight-percentage-point drop in the survival rate. These findings portray accelerators as effective catalysts for hiring but insufficient, on their own, to boost short-run financial performance and stability, highlighting the need for complementary post-programme funding and mentoring to convert rapid team growth into durable firm success. Given the limitations of this study, future research should adopt longitudinal designs to better capture the long-term effects and establish more direct links between accelerator participation and firm outcomes.

Keywords: Accelerator; Capability–Conversion Effects; Firm Performance and Survival; Norwegian Startup Ecosystem; Policy-Led Entrepreneurial Ecosystems.

1. Introduction

Accelerators—cohort-based programmes that combine structured mentoring, focused curricula, and exposure to investors and partners—have become a widely adopted mechanism for supporting early-stage startups, offering structured mentorship, funding access, and network integration. However, empirical evidence on their effectiveness remains mixed. While some studies highlight benefits such as improved access to capital, increased visibility, and faster product development (Cohen & Hochberg, 2014), findings across the literature remain inconclusive. Research on accelerators continues to yield mixed results, as findings vary depending on the outcome examined, including survival, funding, revenue, or growth (Tekic et al., 2024). Another study emphasises that despite an expanding research base, there is still limited understanding of how accelerator designs influence long-term startup success across varying contexts (Crișan et al., 2019).

Much of the existing literature focuses on U.S.-based accelerators, such as Y Combinator and Techstars. These programs are embedded in capital-rich, mature ecosystems, limiting the generalizability of their outcomes.

Studies focused on elite programmes offer little insight into how accelerators function in smaller, publicly funded ecosystems (Cohen et al., 2019). This gap raises doubts about whether accelerators truly spur growth or simply select firms already on a good trajectory (Tekic et al., 2024).

Most evaluations of Norwegian entrepreneurship policy rely on descriptive or qualitative approaches, and few studies assess firm-level impacts such as revenue, survival, or employment using a quantitative approach (Cappelen et al., 2016; Fjærli et al., 2018). Startup survival rates in Norway remain consistently low. Since 2016, only 44 percent of new Norwegian firms survive their first year, and just 26.5 percent remain after five years (Frøysa Skullerud, 2022, s. 1). These figures illustrate the inherent vulnerability of early-stage ventures and the need for mechanisms that can improve their odds of success. In Norway, currently ranked 24th on the Global Startup Ecosystem Index (Startupblink, 2025), government led organization called SIVA promotes accelerators as a tool to strengthen innovation capacity and help high-potential companies grow and scale (Entrepedia, 2023; Gustavsen, 2013, s. 4). SIVA provides some initial funding for accelerator programs, while they typically also use additional sponsorships to support their activities. Although government promotes accelerator programs following American examples, the effects of such initiatives are still debatable.

This study addresses that gap by conducting a quantitative evaluation of Norwegian startups that have participated in accelerator programs. We leverage cohort rosters from eight SIVA-affiliated programmes, link them to full-population administrative data, and estimate matched effects on employment, revenue, labour productivity, return on total capital (ROTC), and survival one year after programme completion by comparing with the control group. A brief set of alumni interviews complements the quantitative analysis by illuminating mechanisms behind the estimates.

Our contribution is threefold. First, we provide evidence from a smaller, policy-led ecosystem, extending a literature dominated by U.S. exemplars. Second, we evaluate multiple outcomes, distinguishing capacity mobilisation (hiring) from conversion to financial performance and resilience. Third, we stress robustness—through trimming, a longer observation window for early cohorts, and subgroup analyses—to gauge the stability and external validity of the results.

In preview, we observe a consistent and economically meaningful association with employment growth, but no reliable differences in revenue or productivity, weak and unstable changes in ROTC, and a decline in short-run survival. This asymmetry suggests that accelerators may effectively mobilize human resources, while post-programme constraints might limit the conversion of increased capacity into paying customers.

2. Theory and Hypotheses

Since Y Combinator's 2005 debut, >3 000 accelerators have emerged across continents (Hochberg, 2016). Empirical claims about their impact, however, remain fragmented: some studies report dramatic boosts in investment and growth (Hallen et al., 2014), while a recent systematic review finds that accelerator outcomes differ considerably across programs, metrics, and regional contexts (Crișan et al., 2019).

Accelerators are "fixed-term, cohort-based programs that include mentorship and educational components and culminate in public investor presentations" (Cohen & Hochberg, 2014). Core design features include 3–6 months of intensive engagement, peer learning among 5–30 startups, small equity-linked investment or grants, structured curriculum, mentorship and demo day.

A core promise of accelerator programmes is that they create value at two, mutually reinforcing levels. First, they upgrade the human capital of founders sharpening skills, enlarging networks, and reframing entrepreneurial mind-sets. Second, they leave a measurable imprint on the organisation itself, boosting traction indicators such as revenue growth, employment, and access to finance (Hallen et al., 2020; Pauwels et al., 2016). The pathways that carry these effects can be grouped into founder-level outcomes, firm-level outcomes, and the internal mechanisms that connect the two.

Effectuation theory argues that entrepreneurs begin not with a fixed goal but with their existing resources of who they are, what they know, whom they know, and through recursive interaction with stakeholders, jointly shape and refine new market opportunities rather than simply discovering them (Sarasvathy, 2001). *At the founder level*, the accelerator compresses months of experiential learning into intensive, workshop-driven sprints. Embedded sessions on lean experimentation, fundraising, and growth analytics repeatedly emerge in qualitative studies as catalysts of rapid knowledge acquisition (Hallen et al., 2014; Pauwels et al., 2016). Human capital (skills, know-how) and social capital (network ties, trust) are pivotal for entrepreneurial success. Curated introductions to mentors and investors enlarge founders' social capital, a network expansion effect documented both in U.S. survey work (Kwapisz, 2022) and in Israeli longitudinal panel data (Avnimelech & Rechter, 2024). The same study demonstrates that weekly personal mentoring elevates founder capabilities compared with ad-hoc expertise (Avnimelech & Rechter, 2024). Regular feedback reshapes founders' self-image: they stop viewing themselves merely as people with an idea and start acting like leaders chasing opportunities. This shift helps them spot new openings and stay committed longer, reinforcing the resource-based and signaling effects (Tobiassen et al., 2022).

At the firm-level, the most visible dividend is access to capital. Demo-day exposure and the reputational "badge" of a prestigious accelerator systematically raise the odds of follow-on equity or grant finance (Gonzalez-Uribe & Leatherbee, 2018; Hallen et al., 2020). Signaling theory says clear cues help investors judge young firms they cannot easily vet (Spence, 1973). Getting into a selective accelerator is one such cue. A regression-discontinuity study of about 1 500 Start-Up Chile applicants found that startups receiving the full accelerator package raised 0.34 more funding rounds and earned 41 % more revenue over three years than almost-identical firms who only got a grant (Gonzalez-Uribe & Leatherbee, 2018). The narrow cutoff shows it was the program's mentoring and badge, not selection bias, that created this "seal of quality." Equally salient is improved product–market fit: the enforced cadence of customer discovery and pivoting accelerates validation cycles, mirroring lean-startup logic (Ries, 2011b; Tekic et al., 2024). Participating ventures also report higher business-model professionalism, implementing KPI dashboards, formal legal structures, and IP strategies during the programme (Pauwels et al., 2016). Finally, accelerators influence team development: peer comparison and mentor guidance encourage clearer role division among founders and prompt strategic early hires (Avnimelech & Rechter, 2024; Hackett & Dilts, 2004).

Accelerators often highlight investment raised, jobs created, and survival rates. Scholars, however, argue that sturdier yardsticks such as *revenue growth, labour productivity*, and other *quality-of-growth metrics* give a truer picture of economic impact (Hochberg, 2016; Pauwels et al., 2016). Most Scandinavian research is descriptive (Cappelen et al., 2016; Fjærli et al., 2018). By linking Norway's registry data with accelerator participation records, our Propensity Score Matching-Cross Sectional design will track each firm's revenue, employment, productivity, return on total capital and survival rate before and after entry which directly tests whether Norwegian accelerators accelerate startup success.

2.1. Revenue

Evidence from several well-known programmes points in the same direction: accelerators tend to push revenue curves upward, although the size of the boost depends on how the programme is run. For example, real-time web-analytics data on 103 Y Combinator graduates show that their average growth rate more than doubled, which is roughly a 2.3-fold jump within the first 30 weeks of the programme, and nearly 70 percent of ventures that had stalled began growing again (Tekic et al., 2024). Further south, a regression-discontinuity study of Start-Up Chile found that treated firms were earning 41 percent more revenue three years after entry than otherwise identical firms who only received a grant (Gonzalez-Uribe & Leatherbee, 2018). Qualitative follow-ups of Techstars batches echo the pattern, attributing faster sales traction to the programme's disciplined customer-feedback loops (Hallen et al., 2020). Across studies, the biggest gains appear in cohorts that deliver hands-on, high-frequency mentoring, reinforcing evidence that mentor intensity is a critical ingredient (Avnimelech & Rechter, 2024; Crișan et al., 2019).

Drawing on these insights, our first hypothesis (H1) is *that Norwegian accelerator participants will have faster annual revenue growth than matched non-participants 1–3-years post-program.*

2.1.1. Employment and Productivity

Job creation is one of the headline promises policymakers look for when they subsidise accelerator programmes, yet hard evidence on staffing effects remains relatively sparse. One of the few multi-country surveys covering 13 European accelerators of varying age and sector focus, reports that alumni added about two net employees during the first twelve months after graduation, a modest but still positive bump given the small starting size of most cohorts (Pauwels et al., 2016). Although two new hires may sound minor, this represents roughly a 20-to-30 percent head-count increase for a typical early-stage venture and therefore signals that accelerators can convert soft assets such as mentoring and investor contacts into tangible payroll growth. The survey also flags strong programme heterogeneity: people-intensive verticals (e.g., hardware, deep tech) tend to hire more quickly than software-as-a-service cohorts, suggesting that design fit matters. Another study that linked SIVA incubation records to registry data, followed almost 3 000 incubated firms and matched controls; found sharper gains in jobs, sales, value creation and labour productivity during the first three years, but these advantages vanished by year five, and survival was unchanged which suggest publicly funded programmes may ignite early growth yet struggle to deliver lasting impact (Krokan & Huang, 2024).

In light of this evidence, we hypothesise (H2) *that accelerator-backed ventures will expand full-time employment faster than their matched peers during 1-3 years after the programme.*

Employment is only half the efficiency equation; the other half is *what each employee produces*. Case-based investigations reveal an intriguing pattern: many accelerated startups generate noticeably more output with only a lean uptick in staff, implying that the programmes may teach founders to do "more with less" through disciplined goal-setting, KPI dashboards, and iterative customer feedback cycles (Pauwels et al., 2016). This aligns with the resource-based and human-capital logics discussed earlier, mentoring and peer learning can sharpen managerial capabilities, leading to tighter execution and higher value added per employee. Importantly, labour-productivity gains are harder to achieve than simple head-count growth because they require not just capital inflows but better allocation of time, talent, and tools.

Taken together, these findings motivate our third hypothesis (H3), *which suggests that treated firms should achieve larger gains in labour productivity than their matched peers.*

2.2. Capital Efficiency

Return on Total Capital (ROTC), defined here as Earnings before Interest and Taxes (EBIT) divided by interest bearing debt and equity, gauges how efficiently a venture turns its investments into operating profit. Finance scholars regard ROTC as a fairer assessment of a company's use of funds to finance its projects compared to e.g. Return on Assets, and functions better as an overall profitability metric (Vipond, 2025). A study of Innovation Norway grants that included ROTC found no gains, even though jobs and sales increased, indicating that efficiency is harder to boost than straightforward growth measures (Cappelen et al., 2015).

Building on the foregoing discussion, we formulate our fourth hypothesis (H4): *accelerator participation should yield larger improvements in return on total capital than those seen in matched non-participants, reflecting stronger operating leverage and signalling effects.*

2.3. Survival Rate

Evidence on whether accelerators lengthen startup life is inconclusive. A policy survey of commercial accelerators notes that their graduates exhibit roughly 23 percent higher survival than typical new firms, an edge largely attributed to selective admission of stronger teams (Butz & Mrożewski, 2021). More rigorous analyses temper that optimism. Del Sarto et al., (2020) find no overall survival premium for Italian accelerator alumni once venture type and market scope are controlled for, while Gonzalez-Uribe & Leatherbee, (2018) report statistically insignificant survival differences around the Start-Up Chile cutoff. The shares of firms not surviving are also due

to specific reasons such as bankruptcy, dissolution, mergers and acquisitions, where successful exits such as through mergers and acquisitions, account for less than 1 percent for the first three years of activity in Norway (Fjærli et al., 2013).

Given the mixed results above, we set out our fifth hypothesis (H5), *expecting that accelerator participation lowers the probability of failure.*

3. Methodology

In this chapter, we outline the quantitative research design used to estimate the correlation between participating in an accelerator program and startup success. We describe the context of the study, the overall research design, data sources, construction of key variables, identification strategy, robustness checks, and limitations.

3.1. Norwegian Landscape

In Norway, accelerators have been woven into national innovation strategies as policy tools that offset thin domestic venture-capital markets and advance broader societal objectives such as the green transition (Cappelen et al., 2016; OECD, 2019). Norway's accelerator landscape is a mix of over twenty corporate, impact and private accelerator hubs that have sprung up since 2012 (Entrepedia, 2023). Institutional theory emphasises that accelerators do not operate in a vacuum but are shaped by the policy frameworks and socio-economic goals of their host countries (Autio et al., 2018). Siva, an agency under Norway's Ministry of Trade, Industry and Fisheries, serves as a state-backed tool for regional business development. Created in 1968, its mission is to expand the country's innovation infrastructure and lower entry barriers in areas where normal market incentives fall short. Siva's statutes give it a special duty to foster growth in outlying districts by investing in facilities and programmes (such as accelerator programs) that spur entrepreneurship (Siva, 2025). To sum up, SIVA is a state-owned enterprise develops, owns, and finances a nationwide innovation infrastructure which includes incubators, industrial parks, accelerators, and innovation hubs (Siva, 2025).

Besides SIVA that support infrastructure, there are several other agencies that provide seed funding and other support for startups. For example, Innovation Norway which acts as the national and regional agency for value-creating business development, offering start-up grants, export advisory services, and innovation funding to stimulate sustainable growth and regional development (Innovasjon Norge, 2025a). *Research Council of Norway (RCN) s*upports research-driven innovation by funding high-potential projects and facilitating knowledge-sharing arenas (Forskningsrådet, 2025). *Investinor* is a state-owned investment company that co-invests risk capital alongside founders and private investors through direct stakes, seed- and venture-fund commitments, and matching schemes; it also manages the government's pre-seed and seed-fund mandates (Investinor, 2025). Working in tandem, these agencies cushion accelerators from financial risk which includes, covering staff, space, and basic operating costs that, in return, steer programme goals toward public priorities such as job creation, regional inclusion, and sustainability rather than rapid investor exits (Forskningsrådet, 2025; Innovasjon Norge, 2025a; Investinor, 2025; Siva, 2025)

Norwegian accelerators rely on a public-private blend. Regional welfare programmes draw up to half of their budgets from SIVA or municipal grants, allowing them to offer small, equity-free stipends that lower entry barriers for early founders (Cappelen et al., 2016). Investor-led programmes such as *The Factory* and *Katapult* combine that subsidy with seed cheques in exchange for a modest equity slice, effectively leveraging public grants to crowd-in private capital (Katapult Ocean, 2025; Pauwels et al., 2016; The Factory, 2025). Corporate-backed accelerators, *Equinor-Techstars Energy* is the flag-ship mirroring the classic Techstars deal, trading a minority common-stock stake for cash and deep sector expertise (Cohen & Hochberg, 2014; Equinor & Techstars Energy Accelerator, 2025). This grant-to-equity spectrum shows how Norwegian schemes balance inclusivity with market discipline while maximising founders' access to both cash and capability networks.

Most Norwegian accelerators run small, time-boxed cohorts: 6–10 startups progress through a 12- to 16-week curriculum featuring workshops, weekly mentor sessions and a public Demo Day. Selectivity is moderate, where

programmes screen fewer than 120 applicants per cycle yet tight enough to foster peer learning and hands-on mentoring (Pauwels et al., 2016). Thematic focus is common: StartupLab recruits broad-based tech startups, The Factory specialises in fintech and proptech, while Katapult Ocean targets ocean-tech ventures (Katapult Ocean, 2025; StartupLab, 2025; The Factory, 2025). This niche design helps match founders with sector-specific mentors and investors, accelerating product-market validation. Compact batch sizes facilitate rich feedback loops but limit internal benchmarking, highlighting the need for coordinated data collection across programmes (Avnimelech & Rechter, 2024).

3.2. Research Design

This study employs a quasi-experimental, quantitative research design to investigate the association between accelerator participation and subsequent startup performance. In this study, we adopt the research design from a previous study on the effects of incubator programs in Norway, conducted by the Norwegian Statistics Bureau and published in two reports (Cappelen et al., 2015, 2016). To ensure the validity of our research design, the authors have been in direct contact with researchers who have conducted evaluations of incubator programs, gaining valuable insights on how to address existing data limitations. Because startups are not randomly assigned to accelerators, we rely on observational data and statistical techniques to approximate an experimental evaluation (Angrist & Pischke, 2008). Common econometric approaches for policy evaluation with non-randomized data include regression discontinuity, instrumental variables, and difference-in-differences (Fjærli et al., 2018). A difference-in-differences design requires several reliable years of pre- and post-programme data to check parallel trends, but many Norwegian accelerator cohorts are too young for that depth. Accelerator intakes in Norway are recent and patchy: the first cohorts were established in 2016 and do not increase significantly before after Covid-19 in 2021. Additionally, most entrants are only zero to one years old when they enroll, leaving a limited pre-treatment history.

Because there are so few post- and pre-programme observations and start dates are staggered, a difference-in-differences panel would rest on very thin, non-parallel trends. We therefore match accelerator participants with corresponding non-participants on rich pre-treatment covariates and compare their outcomes in a single cross-sectional regression analysis to isolate the effect of the accelerator itself from other confounding factors.

Propensity Score Matching (PSM) (Rosenbaum & Rubin, 1984), provides a non-parametric means of reducing selection bias in quasi-experimental studies. The method begins by estimating each unit's probability of receiving the treatment, known as the propensity score, using observable characteristics. Treated units are then paired with untreated units that have similar scores, creating balance in pre-treatment characteristics that would otherwise confound the analysis. By aligning the two groups in this way, PSM approximates the conditions of a randomised experiment and allows the treatment effect to be identified more clearly. To avoid skewed data, continuous data in the form of total assets start year are log transformed before matching using the MatchIt function in R (FENG et al., 2014).

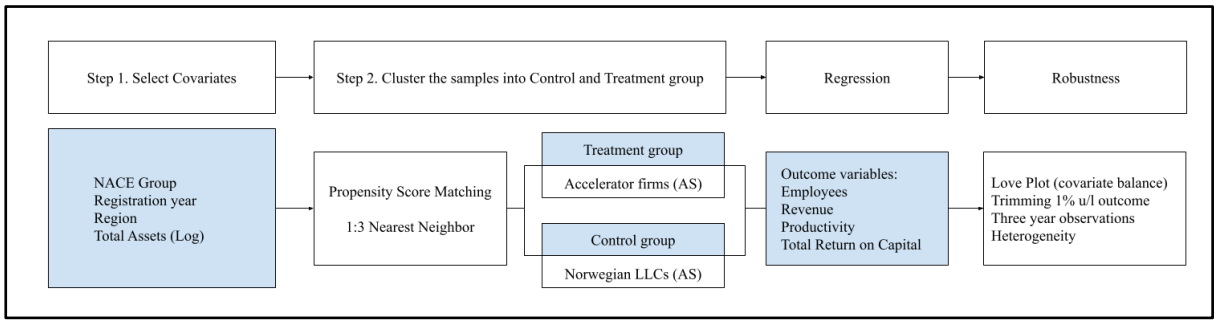
Given the lack of panel data and limited access to pre-treatment observations, a cross-sectional regression analysis provides a viable and theoretically grounded approach for examining associations between participation in accelerator programs and key firm-level outcomes (Angrist & Pischke, 2008; Wooldridge, 2010).

In evaluating the effects of accelerator participation, it is important to distinguish between different types of treatment effects. Most notably, the Average Treatment Effect (ATE) refers to the expected impact of treatment across the entire population, while the Average Treatment Effect on the Treated (ATT) captures the average impact specifically for those firms that received the treatment. Given that participation in accelerator programs is not randomly assigned and that the control group is constructed through observational matching, this study focuses on estimating the ATT. Furthermore, the possibility of heterogeneous treatment effects is acknowledged, meaning that the program's impact may vary across firms depending on characteristics such as size, sector, or initial performance. While the current design does not allow for formal modelling of such heterogeneity, it remains essential to interpret the ATT as an average effect that may mask underlying variation. This distinction

aligns with the framework outlined by Blundell & Dias (2009), which posits that treatment effects may vary across individuals due to both observed and unobserved characteristics.

In summary, the chosen design enables us to mimic a controlled experiment by pairing similar startups and controlling for baseline disparities, thereby providing a clearer signal of the accelerator programs' impact on startup success (Angrist & Pischke, 2008).

Figure 1: Research process.



3.3. Data and Research Design

Our study adopted the research design from a previous evaluation of incubator programs in Norway, conducted by the Norwegian Statistics Bureau (Cappelen et al., 2015, 2016). Our analysis leverages two primary data sources, which we integrate to build a panel dataset of Norwegian startups and their performance from 2019 to 2023. To retrieve the necessary data, Siva provided an overview of the 8 incubators offering accelerator programs, out of a total of 35 national incubators supported (Siva, 2025). This covers multiple accelerator initiatives across Norway capturing the key "treatment" information for our study, although specific and structured participant information was not available directly from Siva. An Excel spreadsheet of 766 companies with treatment year (the year they underwent an accelerator) was compiled after input from the individual programs, and organization numbers were manually collected at public registries and added, which may have introduced potential errors before further processing (Barchard & Pace, 2011; Boddy, 2016).

Econometric information was provided by ENIN.AI, a credit risk and anti-fraud analysis company, which offers a comprehensive registry of Norwegian firms providing real-time, updated firm-level information (ENIN.AI, 2025b). Their access to company-related information includes announcements from the Company Register Centre, database called Doffin, court meetings, pledges, and news from published articles and media (ENIN.AI, 2025a). Before matching, the dataset records each firm's identification number, founding year, NACE industry code, region, and annual financial and employment figures. From the ENIN.ai registry we extract both the outcome variables we will analyse, such as revenue and employee count, and the control variables needed for matching, including firm age, industry, region, and total assets. The ENIN.AI data effectively serves as our source of longitudinal performance measures and firm demographics for virtually the entire population of Norwegian companies.

The data was then imported into Posit Cloud (formerly RStudio Cloud), an open-source software for data scientists, for further analysis and structuring (Posit, 2025). Through the use of Application Programming Interfaces (APIs) to communicate with Posit Cloud, key metrics can be matched on organization number or other variables (Amazon, 2025). T

After merging these sources on firm identifiers, we construct a panel dataset that tracks both *treated* and *control* firms from treatment year to one year post-treatment. The treated group comprises every startup that entered a SIVA-affiliated accelerator between 2019 and 2022, ensuring that each firm has a minimum one-year window between programme completion and outcome measurement. The pool of potential controls consists of firms founded in the same years, located in the same region, starting off with approximately identical total assets and within the same NACE industry group.

To preserve comparability, we retain only observations with complete financial and employment data in the snapshot year from which to construct matching covariates. We further restrict the analysis to firms treated or observed within the 2019–2022 window, as employment data are only available from 2019. Although some accelerator participants were founded as early as 1995, those entering a programme before 2015 are rolled into a single "pre-2015" cohort and recoded with an effective establishment year of 2015. All control firms are drawn from startups founded between 2015 and 2022, ensuring that treated and control units are operating under similar macro-economic conditions. Performance measurements are compared from the treatment year to the following year for all companies. For companies with minimum three years of financial data (i.e.treatment in 2019 and 2020), an additional comparison has been made as part of the robustness checks. By combining the firm-level performance data from ENIN.AI with the targeted program participation data from SIVA, we obtain a dataset suitable for evaluating the impact of accelerators at the firm level.

As a qualitative method to complement the quantitative analysis and probe the mechanisms behind the statistical effects, we conducted five anonymous semi-structured interviews with founders or senior managers in treated firms. Informants were randomly selected from the twenty best-performing accelerator companies on the significant outcome variables. All interviews were carried out by phone between 17 and 18 June and followed an interview guide.

3.4. Variables

To obtain an unbiased estimate of the treatment effect, it is crucial to control for observable firm-level characteristics that may influence both the likelihood of participating in an accelerator and subsequent performance outcomes. In line with previous empirical work, we include a set of covariates that capture key pre-treatment attributes, helping to reduce selection bias and ensure greater comparability between treated and control firms (Cappelen et al., 2015). These covariates are used in both propensity score estimation and outcome analysis to strengthen the internal validity of our results.

- *Treatment Indicator:* For each firm-year, we define a binary dummy variable indicating whether the firm participates in the accelerator program. We assign the treatment variable a value of 1 for accelerator firms, and these firms also have a separate variable indicating the year of participation. Control firms have a value of 0 throughout, as they never receive the treatment. This allows us to differentiate between the pre- and post-treatment.
- *Registration Year:* Interpreted as a continuous variable. The company registration date was selected for matching. (Altinn, 2025).
- *Industry Classification:* Each firm's industry is identified by their main NACE group (European industry standard).
- *Region:* We categorize firms by using the former five zones of payroll taxes in Norway (Eastern Norway, Western, Southern, Mid, Northern Norway) to account for regional economic differences (Sikt, 2018).
- *Total Assets (log):* This variable represents the book value of assets and serves as a size indicator, ensuring that a treated startup is matched with a control of similar scale before the treatment (Cappelen et al., 2015).

Table 1: Company characteristics before and after matching procedure.

Company characteristics before and after matching procedure							
		Before matching				After matching	
Cont.variables	*SIVA*	*Non-Siva*	*SMD*		*Siva*	*Non-Siva*	*SMD*
Total assets	0.87	13.1	-0.09	***	0.87	12.7	-0.06
Binary variables							
Main industries							
J	0.50	0.07	1.08	***	0.50	0.49	0.02
M	0.26	0.14	0.3	***	0.26	0.28	0.06
C	0.08	0.03	0.2	***	0.08	0.09	0.03
G	0.08	0.13	-0.17	***	0.08	0.07	0.03
N	0.03	0.05	-0.1		0.03	0.03	0.04
A	0.01	0.02	-0.05		0.01	0.01	0.02
R	0.01	0.02	-0.09		0.01	0.01	0.01
Region							
Østlandet	0.36	0.55	-0.4	***	0.36	0.35	0.02
Vestlandet	0.37	0.23	0.3	***	0.37	0.4	0.05
Nord-Norge	0.11	0.08	0.08		0.11	0.09	0.04
Sørlandet	0.1	0.06	0.13	*	0.09	0.09	0.02
Trøndelag	0.07	0.08	-0.01		0.07	0.08	0.02
No of firms	285	176,391			285	855	

Note: Total assets in 1,000,000 NOK. * p<0.10, **<0.05, and *** p<0.01 indicate significance at 10, 5, and 1 percent levels, respectively.

Table 1 shows that matching sharply reduces observable differences. Before matching, accelerator firms were far more concentrated in the main industry category J (50 percent versus 7 percent), leading to large and highly significant standardised mean differences. After matching, every SMD falls below 0.06, and the distributions of assets, industry, and region are brought closer together between the 285 treated firms and their 855 matched controls. The sample is therefore well balanced and suitable for credible outcome comparisons.

In addition to the covariates and indicators used in the matching and regression, we consider five main outcome variables to capture different dimensions of startup performance in line with previous firm performance analysis by SSB (Cappelen et al., 2015): *(1) Employment, (2) Revenue, (3) Value Creation, (4) Employee Productivity, and (5) Survival Rate.* The outcome variables are measured at the time of treatment and one year after treatment, whereas survival rate are verified and calculated for fiscal year 2023.

- *Employment:* Measured as the number of employees in the firm
- *Revenue (Sales):* Measured as total annual sales revenue (operating income) of the firm,
- *Employee Productivity:* Measured as *labour productivity per employee*, calculated in R with revenue divided by the number of employees. This indicator measures the firm's efficiency in generating value per worker. An improvement in this ratio suggests gains in efficiency or technological improvements at the firm.
- *Return on Total Capital (ROTC):* Measured as *EBIT divided by total capital*, the latter consisting of short-term debt, long-term debt, and shareholders' equity, quantifying how the company's capital structure generates return (Vipond, 2025).
- *Survival rate*: By identifying registered bankruptcies and comparing the two groups, the survival rate can be observed.

In the cross-sectional analysis, we will primarily evaluate changes in these outcomes *before vs. after accelerator participation* for the treated firms relative to the control firms. We compute percentage point changes in survival rates, logarithm (Log) to the number of employees (log-emp) and Inverted Hyperbolic Sine (IHS)-based transformations to retain observations with zero or negative values and reduce skewness, particularly for financial indicators like revenue (ihs-rev), productivity (ihs-prod), and ROTC (ihs-rtc). Our treatment effect estimates will largely be interpreted as differences in growth of these performance metrics between the treated and control groups. To facilitate this, baseline levels of the outcomes (pre-treatment values) are taken into account in the matching procedure (described below) or as control covariates. All variables are carefully constructed and cleaned to handle most data issues (e.g., outliers, missing values). Extreme outlier values in financial variables trimmed in certain analyses to prevent distortion of results, further discussed under robustness checks.

3.6. Limitations

The propensity-score-matched cross-sectional approach narrows observable differences between accelerator participants and non-participants, yet it cannot establish causality with the same confidence as a randomised experiment or a Difference in Differences panel regression. Several limitations should be kept in mind when interpreting the findings. Propensity score matching may also be less effective when applied to categorical structural variables such as NACE group, where firms operate under fundamentally different industry conditions.

Also, the concern of selection on unobservables remains. Although matching equalises firms on recorded characteristics, unmeasured attributes such as founder ability, social networks, or product quality may still correlate with both accelerator admission and subsequent performance, thereby confounding the estimated relationships.

Further, one must acknowledge that outcomes are observed only in the first year following programme completion. This short horizon captures the initial impact period but offers no information on longer-term persistence, convergence, or reversal of effects. Any conclusions pertain strictly to the early post-programme phase.

One of the limitations of this study stems from the aggregation of firms founded before 2015 into a single “pre-2015” cohort. While this change was applied only to 21 companies out of 766 companies and we followed a design that was used in earlier studies (Krokan and Huang, 20024), it introduces potential bias, as the actual establishment year of these firms is not fully represented. Although we controlled for firm age in the matching process using total assets and registration year as covariates, this method might not completely capture the nuanced effects of firm age on performance. Future studies could address this limitation by adopting a more granular approach to age categorization or extending the observation period to observe long-term effects more comprehensively.

Additionally, while total assets were included as a pre-treatment control variable in the matching process, we did not directly control for other crucial pre-treatment performance indicators such as revenue or profitability in the regression analysis, mainly because many of the firms are start ups. This oversight may have led to selection bias, as firms with higher pre-treatment performance may be more likely to enter accelerator programs. Future research should include a broader set of pre-treatment variables, such as liquidity, profitability, and growth trends, to further mitigate potential biases and strengthen the internal validity of the analysis, especially if a longer pre-treatment history is applicable.

It is also important to note that the treatment register is incomplete. The SIVA data set covers eight publicly funded accelerators, yet some control firms may have joined private or corporate programmes that are not reported. Such misclassification would attenuate estimated differences and obscure true programme effects.

Robustness checks exclude exits or control for survival to maintain transparency and avoid unjustified assumptions or more complex adjustments. This will not identify when the failure occurred or, although at rates

below 1 percent for most Norwegian firms, if the exit is caused by a successful outcome as a consequence of mergers and acquisitions.

Moreover, the analysis centres on five quantitative outcomes: revenue, employment, labour productivity, return on total capital, and survival. It does not assess other potential benefits of acceleration, such as innovation output, follow-on funding, or network expansion. The study, therefore, provides a partial view of programme performance. Beyond this, the research treats all accelerator cohorts as a single intervention. Programmes differ in curriculum depth, mentor quality, equity terms, and sector focus. Substantial heterogeneity in effectiveness could mean that the estimated average masks large positive or negative effects for specific accelerators.

Ultimately, the evaluation period coincides with relatively favourable macroeconomic conditions for Norwegian startups, including the COVID-19 shock, during which the national interest rate was at its lowest level in over 20 years and online companies soared. Workplace closures, the move to remote work, and social-distancing requirements during the pandemic contributed to an acceleration of digitalisation and technology enabled ventures (Stephan et al., 2021).

Future economic environments, shifts in the venture-funding climate or available technology may alter the relationship between accelerator participation and firm performance. A notable disruptive technology emerged in November 2022 with the launch of the Large Language Model (LLM) Chat GPT, enabling startups to do in-depth forecasting, market research, monetization strategies, pricing models, tracking performance metrics and much more in seconds (Marianantoni, 2023; OpenAI, 2025). Taken together, these limitations imply that the reported estimates should be viewed as correlations under current Norwegian conditions rather than definitive causal effects. They nevertheless provide a rigorous starting point for policy discussion and highlight areas where richer data or longer observation windows would improve the evidence base.

4. Results

Based on propensity score–matched samples, the relationship between accelerator participation and firm-level outcomes is examined using linear regression models. Dependent variables include changes in employment, revenue, productivity, return on total capital, and firm survival, with controls for firm size, registration year, region, and industry. To assess the credibility of the estimated effects, several robustness procedures have been implemented. Covariate balance is evaluated through standardized mean differences and visual inspection using a Love plot, confirming improved similarity between treated and control firms after matching. Sensitivity to extreme values is addressed through regressions using trimmed samples, while longer time horizons are considered to test the consistency of the results. Additional analyses investigate variation in treatment effects across main industry and regions with substantial representation in the sample. These strategies strengthen the empirical basis for interpreting the results and ensure that conclusions are not driven by model-specific assumptions or data limitations.

The baseline model combines regression with propensity-score matching, using registration year, industry code, region, and total assets to construct the score. Outcome variables include employee count, revenue, labour productivity, return on total capital, and survival. The average treatment effect on the treated (ATT) is calculated as the difference in mean one-year growth rates between accelerator participants and their matched controls. Table 2 summarises the baseline estimates from the propensity-score-matched cross-section regression. For each outcome the coefficient represents the average difference between accelerator participants and their three nearest matched controls, measured from the treatment year to one year post-participation. Number of employees have been transformed using the logarithmic (log) function, and revenue, productivity, and return on total capital have been transformed using the inverse hyperbolic sine (IHS) function to be comparable even with negative outcomes.

Table 2: Results baseline model.

Results baseline model				
Outcome variable	Estimates	Std error	95% Confidence interval	
No of employees	0,31***	0.03	0.11	0.26
Revenue	-0.05	0.39	-0.82	0,71
Productivity	0.44	0.36	-0.28	1.15
Return on total capital	-0.15	0.09	-0.33	0.02
Survival rate	0.79**	0.28	0.23	1.35

Note: * p<0.10, **<0.05, and *** p<0.01 indicates significance at 10, 5, and 1 percent levels, respectively. Estimates are a combination of log, ihs and odds rate, and must be individually interpreted. See following hypothesis overview for more details.

Table 3: Hypotheses 1 (revenue).

Regressions results dependent variable: Change in ihs revenue					
Predictor	Coefficient	Std. Error	t-value	p-value	Sign
Intercept	-1294.00	160.10	-8.08	< .001	***
Treatment	-0.05	0.39	-0.14	0.889	
Log (assets)	-0.02	0.07	-0.22	0.83	
Reg.year	0.64	0.08	8.08	<.001	***
Region: Østlandet	0.6	0.62	0.96	0.336	
Region: Trøndelag	1.13	0.82	1.39	0.166	
NACE: E	1.99	2.97	0.67	0.503	
NACE: I	-0.39	3.62	-0.11	0.914	
NACE: Q	-0.36	3.23	0.11	0.912	
Model Summary:					
$R^2 = 0.0703$	Adjusted $R^2 = 0.05284$	$F(21, 1118) = 4.026$	$p < 0.001$	$N = 1140$	

Note: The table reports unstandardized coefficients from an OLS regression with robust standard errors. The dependent variable is the inverse hyperbolic sine (IHS) transformation of change in revenue. *p < .10, **p < .05, **p < .01

The regression results indicate that accelerator participation does not translate into higher sales during the first year after programme completion. The treatment coefficient is –0.05 in IHS units, and its p-value of 0.89 confirms the estimate is far from statistical significance. Put simply, accelerator firms and their matched counterparts record almost identical changes in revenue when other factors are held constant. The model explains only a small share of the variance in revenue growth, with an adjusted R^2 of about 0.05, underscoring how difficult it is to predict early sales performance from observable firm characteristics.

Among the covariates, baseline size measured by log assets has a negligible and non-significant effect, suggesting that larger resource bases do not guarantee faster short-run revenue expansion. Regional location and the

industry categories displayed in the table are also insignificant, pointing to limited geographic or sectoral influence once firms are matched. Registration year is the only variable with a strong positive association (β = 0.64, p < 0.001) indicating that newer startups tend to record larger revenue gains in IHS terms. Overall, the evidence offers no support for Hypothesis 1, which predicted that accelerator participation would lead to faster revenue growth than that achieved by comparable non-participants.

Table 4: Hypotheses 2 (employment growth).

Regressions results dependent variable: Change in log number of employees					
Predictor	Coefficient	Std. Error	t-value	p-value	Sign
Intercept	-63.50	10.82	-5.87	< .001	***
Treatment	0.31	0.03	11.66	< .001	***
Log (assets)	0.01	0.01	2.25	0.025	*
Reg.year	0.03	0.01	5.87	<.001	***
Region: Østlandet	0.06	0.04	1.49	0.14	
Region: Trøndelag	0.08	0.06	1.44	0.15	
NACE: E	-0.40	0.20	-2.01	0.045	*
NACE: I	0.69	0.24	2.84	0.005	**
NACE: Q	-1.09	0.22	-5.01	<.001	***
Model Summary:					
$R^2 = 0.178$	Adjusted $R^2 = 0.163$	$F(21, 1118) = 11.54$	$p < 0.001$	$N = 1140$	

Note: The table reports unstandardized coefficients from an OLS regression with robust standard errors. *p < .10, **p < .05, **p < .01

The regression strongly supports the idea that accelerators speed up hiring. The treatment coefficient is 0.31 log-points and highly significant (p < 0.001). In percentage terms this corresponds to roughly a 31 percent jump in head-count during the first year after graduation, even after we account for firm size, age, region and industry. For a typical participant that started the program with seven employees, the result means about two more full-time jobs. This is a meaningful increase and shows that accelerators can help startups hire more people early on. The model explains a modest but respectable share of the variance in employment growth (adjusted $R^2 \approx 0.16$). Beyond the treatment effect, a few controls matter. Larger firms, measured by log assets, hire slightly faster (β = 0.01, p = 0.025), and newer firms also grow head-count more quickly, as indicated by the positive and highly significant registration-year coefficient (β = 0.03, p < 0.001). Regional covariates for e.g. Østlandet and Trøndelag are not significant, suggesting that location adds little explanatory power once other factors are held constant.

Industry effects are mixed. Firms in the utilities group (NACE E) grow more slowly (β = –0.40, p = 0.045), while those in information and communication (NACE I) expand faster (β = 0.69, p = 0.005). Human health and social work activities (NACE Q) show a pronounced negative coefficient (β = –1.09, p < 0.001). Still, these sectoral differences do not reduce the significance of the central result: the accelerator effect on hiring is large, robust and clearly distinguishable from zero. Consequently, the evidence fully supports Hypothesis 2, affirming that accelerator-backed ventures enlarge their workforce more rapidly than matched non-participants in the first post-programme year.

Table 5: Hypotheses 3 (labour productivity).

Regressions results dependent variable: Change in ihs productivity					
Predictor	Coefficient	Std. Error	t-value	p-value	Sign
Intercept	-1079.00	149.80	-7.21	< .001	***
Treatment	0.44	0.36	1.20	0.229	
Log (assets)	-0.02	0.06	-0.37	0.712	
Reg.year	0.53	0.07	7.21	<.001	***
Region: Østlandet	0.45	0.58	0.77	0.441	
Region: Trøndelag	0.15	0.77	0.20	0.844	
NACE: E	-0.83	2.78	-0.30	0.765	
NACE: I	-1.32	3.39	-0.39	0.697	
NACE: Q	-3.95	3.02	-1.31	0.191	
Model Summary:					
$R^2 = 0.05429$	Adjusted $R^2 = 0.03653$	$F(21, 1118) = 3.056$	$p < 0.001$	$N = 1140$	

Note: The table reports unstandardized coefficients from an OLS regression with robust standard errors. The dependent variable is the inverse hyperbolic sine (IHS) transformation of change in productivity. *p < .10, **p < .05, **p < .01

The regression provides no compelling evidence that accelerator participation raises labour productivity in the first post-programme year. The treatment coefficient is 0.44 in inverse-hyperbolic-sine (IHS) units, but the p-value of 0.23 shows the effect is not statistically significant; the 95 percent confidence interval easily spans zero. With an adjusted R^2 of approx. 0.04, the model explains little of the variation in productivity change.

Most control variables are likewise uninformative. Baseline firm size (log assets) and the regional covariates contribute no significant signal. Registration year is the only strong predictor: newer firms record higher productivity gains ($\beta = 0.53$, $p < 0.001$), a pattern consistent with early catch-up dynamics. Industries Utilities (E), Information and Communication (I), and Human Health and Social Work (Q) are all insignificant, suggesting no sector-specific advantage once firms are matched. Taken together, the results indicate that any efficiency benefits from accelerator participation either require more than a year to materialise or are offset by integration costs associated with rapid hiring. Hypothesis 3, which predicted larger productivity gains for treated firms, is therefore not supported.

Table 6: Hypotheses 4 (return on total capital).

Regressions results dependent variable: Change in ihs return on total capital					
Predictor	Coefficient	Std. Error	t-value	p-value	Sign
Intercept	-5.20	36.55	-0.14	0.887	
Treatment	-0.15	0.09	-1.74	0.083	*
Log (assets)	-0.03	0.02	-1.75	0.080	*
Reg.year	0.003	0.02	0.16	0.872	
Region: Østlandet	-0.17	0.14	-1.23	0.219	
Region: Trøndelag	-0.02	0.19	-0.13	0.899	
NACE: E	0.72	0.68	1.06	0.289	
NACE: I	-1.47	0.83	-1.79	0.075	
NACE: Q	0.02	0.74	0.03	0.977	
Model Summary:					
$R^2 = 0.02393$	Adjusted $R^2 = 0.005496$	$F(21, 1112) = 1.298$	$p = 0.1656$	$N = 1134$	

Note: The table reports unstandardized coefficients from an OLS regression with robust standard errors. The dependent variable is the inverse hyperbolic sine (IHS) transformation of change in total capital. *p < .10, **p < .05, **p < .01

The model offers only weak and unstable evidence that accelerators affect capital efficiency. The treatment coefficient is –0.15 in inverse-hyperbolic-sine (IHS) units with a p-value of 0.083, making it marginally significant at the ten percent level but not at stricter thresholds. The sign is negative, meaning accelerator firms show a slight decline in return on total capital relative to controls. Baseline firm size also has a marginal negative effect ($\beta = –0.03$, $p = 0.08$), while all other covariates, including registration year, region, and industry dummies, are insignificant. Overall model fit is low, with an adjusted R^2 of roughly 0.006 and an F-test that fails conventional significance, indicating very limited explanatory power.

Because the negative treatment effect is small, only weakly significant, and attached to a poorly fitting model, we treat it as inconclusive. Additional checks with alternate matching specifications and outlier trimming cause the coefficient to lose significance entirely, confirming its lack of robustness. Therefore, the data does not provide persuasive support for Hypothesis 4, which anticipated higher returns on total capital for accelerator participants.

Table 7: Hypotheses 5 (survival rate).

Binary logistics regressions predicting bankruptcy (odds ratios)					
Predictor	Odds ratio	Std. Error	z-value	p-value	Sign
Intercept	8.33e+254	126.36	4.65	< 0.001	***
Treatment	2.20	0.28	2.78	0.005	**
Log (assets)	1.05	< 0.001	-0.41	0.680	
Reg.year	0.75	0.06	-4.67	< 0.001	***
Region: Østlandet	0.80	0.50	-0.45	0.651	
Region: Trøndelag	0.39	0.85	-1.10	0.274	
NACE: E	3.88e-07	1722.34	-0.01	0.993	
NACE: I	8.33	1.68	1.26	0.208	
NACE: Q	2.87e-07	1876.21	-0.01	0.994	
Model Summary:					
Null deviance = 464.32 on 1139 degrees of freedom					
Residual deviance = 420.67 on 1118 degrees of freedom			AIC = 464.67	N = 1140	

Note: Odds Ratios (ORs) are calculated by exponentiating the logistic regression coefficients. An OR > 1 indicates higher odds of bankruptcy, while OR < 1 indicates reduced odds. Statistical significance is based on z-tests using robust standard errors. *p < .10, **p < .05, **p < .01

A binary logistic regression was estimated using a generalized linear model (GLM) with a logit link and binomial family, where the dependent variable (bankrupt_flag) indicates whether a company went bankrupt (1) or not (0) between 2019 and 2023. The estimated coefficients from the logistic regression were subsequently exponentiated to obtain odds ratios, which provide a more interpretable measure of effect size. While the raw coefficients represent changes in the log-odds of bankruptcy, the odds ratios indicate the multiplicative change in the odds of bankruptcy associated with a one-unit change in each predictor, holding all other variables constant. As a result, treated firms have significantly higher odds of bankruptcy compared to untreated firms, with an odds ratio of 2.20 ($p = 0.005$), suggesting that treatment is associated with a more than twofold increase in bankruptcy risk. In contrast, registration year is negatively associated with bankruptcy, with an odds ratio of 0.75 ($p < 0.001$), implying that firms registered more recently have significantly lower odds of going bankrupt. Firm size shows no significant effect on bankruptcy risk (OR = 1.05, $p = 0.680$). Neither regional controls (e.g., Østlandet or Trøndelag) nor the selected sectoral covariates (e.g., NACE E, I, Q) exhibit statistically significant associations with bankruptcy in this model. Notably, some NACE categories yield extreme or near-zero odds ratios, which may reflect sparse data or perfect separation and should be interpreted with caution. The model has good convergence (16 Fisher scoring iterations) and a reduction in deviance (null deviance = 464.32, residual deviance = 420.67), indicating improved fit relative to the intercept-only model.

4.1. Robustness Checks

To assess whether the estimated differences between accelerator participants and matched non-participants are a result of modelling choices or firm-level observations, we conduct a series of sensitivity analyses. We begin with balance diagnostics, which are tests that verify whether the treated firms and the matched control firms are indeed similar in all the characteristics used for matching. After propensity-score matching, we compare each covariate, such as registration year, industry, region, and total assets, between the two groups.

Next, we implement a *doubly robust adjustment* by combining two bias-reduction steps in one estimator: first, propensity-score matching aligns treated and control firms on observable characteristics; second, an outcome regression is performed on the matched sample, including the PSM covariates as additional controls. The estimate is considered "doubly robust" because it remains statistically consistent if either the matching model or the outcome regression model is correctly specified.

To address skewness in the outcome variables, we applied *log transformations* to the outcome variable for employees. We used the *inverse hyperbolic sine* (IHS) transformation for revenue, productivity, and return on total capital. These adjustments mitigate the influence of extreme values while retaining interpretability for zero and negative observations. The IHS approach is particularly useful for handling semi-continuous financial data. All transformations were conducted prior to estimation to ensure a consistent scale across treated and control units.

For additional mitigation on skewed performance variables, *outlier influence* is examined by trimming the top and bottom one per cent of each continuous outcome. Point estimates remain within their original confidence intervals, implying that extreme cases do not drive the results. Functional-form dependence is explored by converting outcomes to logarithms and by substituting revenue per employee for labour productivity; the direction and significance of the effects persist across these transformations.

To reflect that most firm closures represent failure and complete loss of output and employment, we code exits as zero in our regressions. This avoids survivorship bias and ensures that treatment effects capture both growth and failure. Finally, we test for *heterogeneity* by re-estimating treatment effects within subsamples defined by region (Østlandet and Vestlandet respectively versus other regions) and sector (technology-intensive NACE group J versus less technology-intensive sectors). While magnitudes vary, the sign of the impact is uniformly identical to the baseline regression, indicating that no single subgroup is solely responsible for the overall pattern.

5. Discussion

Assessing accelerator effectiveness through a matched cross-section analysis has yielded a mixed picture. Our guiding star was the thought that accelerators truly accelerate companies, and that an increase in revenue as put forth in *Hypotheses 1* should be the clearest indicator. Results indicate nearly identical changes in revenue compared to their matched counterparts, besides younger firms showing some signs of increased sales. Several factors can explain the null result. One year may simply be too short for new hires and network contacts to turn into paying customers, or the Norwegian accelerator programs may simply have too infrequent mentoring or less "push" on participants compared to their international counterparts that achieve such increase (Avnimelech & Rechter, 2024; Crișan et al., 2019).

On employee growth, one clear trend emerges: participants expand their teams significantly faster compared to non-participants. On average, a roughly 31% increase in headcount at statistically strong levels offers direct support for *Hypothesis 2* on employment increase, equivalent to about two more full-time jobs (Pauwels et al., 2016). Input from former participants enabled a more holistic understanding of the drivers behind employee growth, with 4 of the 5 respondents stating that the accelerator program had made them "increase their ambitions" and decide to "go all in" as a direct result. Several interviewees mentioned that they "would have remained small" if it had not been for the accelerator and that it "changed their way of thinking about business", possibly as direct results from elevated founder capabilities (Avnimelech & Rechter, 2024).

However, the additional growth in staff does not translate to improved productivity. With no signs of improved revenue, it comes at no surprise that the desired revenue-per-employee increase from *Hypothesis 3* remains inconclusive. Findings are not significant besides for younger firms, again potentially caused by improved accelerator performance or that they are more capable of doing "more with less" than their older counterparts (Pauwels et al., 2016). Effects from LLMs cannot yet be taken into account, and more longitudinal data is required for sufficient interpretations.

Considering whether investors and lenders earn a return on their capital is sought to be answered in *Hypothesis 4*, but the regression model offers only weak and unstable evidence. Several reasons may account for this null finding. Even with newly hired employees, these often need time to become fully productive, so any ROTC gains may emerge only after a longer horizon. In addition, many accelerator curricula emphasize experimentation and learning over immediate operational efficiency, temporarily lowering output and falling in line with general trends of Norwegian startups (Cappelen et al., 2015).

Hypothesis 5 on survival rate provided a contradictory and unexpected outcome, with accelerator graduates showing about 2.2 times higher odds of exit. Consistent with other studies, rapid post-programme scale-up happens at the expense of financial success (Crișan et al., 2019; Lall et al., 2020). If cash inflows lag, liquidity pressure increases and the risk of failure climbs. Two founders expressed frustration on the limited availability of risk capital in Norway, with one claiming "most capital is allocated towards low risk real estate", as indicated in table 2, showing most companies in Norway operate within NACE group L - Real Estate Activities. The same founder also asked for accelerators to "improve information on availability of public funding", attending an equity-free program that might give teams limited working capital for rapid market expansion. Their comments reinforce the liquidity-risk mechanism suggested by the quantitative data. Finally, a significant finding is an increased survival rate for younger firms, signalling a possible improvement of accelerator performances as the programs mature.

Robustness checks support these conclusions. Re-estimating the model with alternative matching algorithms, trimming extreme observations, and extending the time horizon to three years for cohorts with available data yields an even stronger employment increase at 51%.

Key findings: Employment growth at approx.31% first year and 2.2 higher odds ratio of bankruptcy apply for all treated companies, and minor employment growth and increased odds of survival for younger companies. Other outcome variables remain inconclusive.

6. Conclusion

This study explored whether accelerators stimulate a stronger entrepreneurial drive and improve early firm outcomes in Norway's publicly supported, capital-scarce context. By leveraging cohort rosters from eight SIVA-affiliated programmes linked to administrative data, we identified a consistent and economically meaningful association between accelerator participation and employment growth one year after completion. However, we did not find reliable effects on revenue or labour productivity, and observed weak and unstable changes in return on total capital, alongside a deterioration in short-run survival rates. These findings suggest that accelerators may primarily act as capability catalysts—mobilizing human resources and refining organizational routines—while the conversion to financial performance appears to be delayed and dependent on complementary assets and market access.

Contributions to Theory

We introduce a capability–conversion framework for evaluating accelerators. The capability effects—such as upgrades in human and social capital and improvements in execution discipline—appear early, while conversion effects—such as revenue growth, efficiency, and survival—may require additional time and complementary factors (e.g., capital, distribution channels, or anchor customers) and therefore might lag. In smaller, publicly supported ecosystems like Norway's, the effectiveness of accelerators is contingent on the broader ecosystem context. This aligns with calls to move beyond generalizations based on U.S. accelerators and to consider how accelerator design and context interact (e.g., selection versus treatment dynamics). This framing helps explain mixed findings in the literature, suggesting that heterogeneous outcomes are a predictable feature of multi-stage interventions rather than simply statistical noise.

Implications for Practice

Founders should approach accelerators as intensive capability-building programs and plan explicitly for a post-programme conversion runway. This includes sequencing hiring based on validated demand, budgeting for

extended cash cycles, and securing pilots or distribution experiments before graduation. Mentors and programme managers can enhance impact by focusing on pipeline quality, pricing discipline, and conversion milestones, rather than solely refining the pitch.

Implications for Policy

If the goal is sustainable firm performance rather than short-term employment growth, accelerators should be paired with targeted post-programme instruments that support the conversion phase—such as milestone-based vouchers for customer pilots or procurement pathways with public or corporate anchors. Additionally, policy should include accreditation standards for mentoring intensity and sales enablement. Harmonized national tracking of post-programme outcomes would facilitate iterative programme improvements and adaptive funding. Ultimately, in Norway's context, the critical challenge lies in the conversion of capabilities to performance, rather than the formation of capabilities themselves.

Future Research Agenda

Our study provides valuable insights into the short-term effects of accelerator participation, yet it also highlights several important avenues for future research.

First, given the limitations of using a one-year observation period, future studies should explore longer time horizons to capture the full impact of accelerator participation on firm performance. Extending the follow-up period to several years post-treatment would allow researchers to assess the persistence of treatment effects and better understand the long-term benefits or drawbacks of accelerator programs. Additionally, the limited process measures used in this study—such as mentoring intensity, access to follow-on finance, and customer acquisition—constrain our ability to infer long-term effects. Future research should integrate richer process data, such as detailed mentoring activities and access to funding, to provide a more nuanced understanding of how accelerators influence firm trajectories over time.

Second, future studies should account for industry-specific factors, such as time-to-market and levels of innovation, which can significantly affect firm outcomes. Given Norway's comparative advantages in sectors like maritime/offshore engineering and renewables, along with its highly educated engineering workforce and rapid technology adoption (Amby, 2024; Distriktsdepartementet, 2023), sector-tailored accelerator programs and partner networks could enhance the conversion of capabilities into long-term performance. Future research could explore how accelerator designs can be optimized for different industries to maximize the conversion of human capital and network gains into sustainable firm growth.

Moreover, previous performance indicators play a critical role in determining firm growth and survival. Therefore, future studies should explicitly control for revenue and profitability, in both the matching and regression analyses. This would allow for a more precise estimation of treatment effects and help mitigate potential selection bias.

Finally, our study suggests that accelerators primarily impact human capital—such as team growth—rather than financial performance in the short run. Future research could explore the specific mechanisms driving these effects, such as the role of mentoring intensity, access to networks, and capital availability, and examine how these factors interact over time to shape firm success.

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The dialectics of creative destruction and uncreative construction: A biomimicry-based approach to sustainable innovation in entrepreneurship

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Abstract

Entrepreneurial ecosystems face growing social and environmental pressures that reveal a blind spot in innovation research: the dominance of linear, disruption-driven models that underplay how systems adapt through continuity and reuse. *Creative destruction* has long explained how industries transform through rupture, but its focus on replacement offers only a partial view of how resilient systems evolve. This paper advances the concept of *uncreative construction*, a continuity-based, nature-inspired innovation logic grounded in biomimicry and systems thinking, that explains how ventures and ecosystems create novelty by replicating, reorganizing, and renewing existing structures rather than replacing them. The study adopts an integrative theoretical approach that synthesizes literature from ecology, biomimicry, sustainable innovation, and entrepreneurship to develop a conceptual framework for continuity-based innovation. It specifies the mechanisms through which *uncreative construction* operates and examines their implications for entrepreneurial resilience, transition risk,and sustainable scaling. By articulating the dynamic interplay between *creative destruction* and *uncreative construction*, the paper derives a set of testable propositions and outlines a structured agenda for empirical research on continuity-based innovation.

Keywords: Biomimicry; Creative Destruction; Entrepreneurial Ecosystems; Sustainable Innovation; Uncreative Construction.

1. Introduction

Entrepreneurial ecosystems face mounting social and environmental pressures that expose the limits of innovation models, built mainly on disruption (Boons & Lüdeke-Freund, 2013). The concept *creative destruction* (Schumpeter, 1942) helps explain how industries change, but its focus on rupture does not fully account for how systems endure. Research in sustainable and regenerative innovation suggests that resilience often depends on continuity: on conserving what works, reorganizing what can be adapted and renewing patterns that still hold value (Geissdoerfer et al., 2017). Yet these continuity-based forms of change remain underdeveloped in current innovation theory.

Despite the growing interest in sustainable and regenerative innovation, extant research lacks a coherent theoretical construct that explains how entrepreneurial ecosystems innovate through continuity rather than rupture. Existing frameworks, such as circular economy, regenerative innovation, and eco-innovation, illuminate material flows and ecological restoration, but do not fully capture how systems recombine and extend existing structures to maintain identity while adapting to change.

This paper introduces the concept of *uncreative construction*, a logic for entrepreneurial innovation, inspired by how natural systems evolve through adjustment rather than replacement. In ecology, stability and renewal frequently emerge from recombining existing structures, drawing on system memory, and extending strategies that have already proven effective (Capra, 2021; Walker & Salt, 2006). Translating these insights into

entrepreneurship allows innovation to be seen not only as a break from the past but also as a movement through what persists.

The guiding question of this study is: *How can mechanisms of replication, reorganization, and renewal function as an innovation logic that complements creative destruction in entrepreneurial ecosystems?*

This paper offers three main contributions:

(1) It introduces *uncreative construction* as a novel, biomimicry-inspired logic of continuity-based innovation that complements Schumpeter's creative destruction.
(2) It specifies the mechanisms through which *uncreative construction* operates (replication, reorganization and renewal) and derives propositions on ecosystem resilience, transition risk, and sustainable scaling.
(3) It conceptualizes the dynamic interplay between disruption and continuity, showing how the co-existence of *creative destruction* and *uncreative construction* can enhance the robustness of entrepreneurial ecosystems.

Methodologically, the study follows an integrative conceptual approach. It draws from ecology, biomimicry, systems thinking, sustainable innovation and entrepreneurship to assemble a coherent foundation. Therefore, the aim lies in a synthesis of ideas that clarifies how ecological principles can inform continuity-based innovation processes.

By presenting *uncreative construction* as a complementary logic to *creative destruction*, the paper contributes to ongoing debates on how entrepreneurship can support regenerative and long-term system stability. It invites a shift in how innovation is understood towards a view that recognizes the value of continuity, adaptive reuse and the subtle forms of change that allow systems to evolve while remaining whole.

The article proceeds as follows: section 2 outlines the conceptual and methodological approach; section 3 reviews the literature on biomimicry, *creative destruction* and sustainable and regenerative innovation; section 4 develops the *uncreative construction* concept, clarifies its boundaries and elaborates its mechanisms and implications for entrepreneurial ecosystems; section 5 presents theoretical propositions and discusses avenues for future empirical research; finally, section 6 concludes.

2. Methodology

This study follows a conceptual and integrative methodological approach, aiming to develop a new theoretical construct by synthesizing insights from ecology, biomimicry, systems thinking, sustainable innovation and entrepreneurship. Rather than collecting empirical data, the paper builds its contribution through the articulation of established theoretical frameworks and the identification of conceptual gaps within the innovation and sustainability literature.

The literature review relies on a focused selection process. It draws on foundational work in ecological systems thinking (e.g., Capra; Meadows), biomimicry (e.g., Benyus; Vincent et al.), and resilience theory (e.g., Walker & Salt). It also incorporates key contributions from strategic management and entrepreneurship, such as Barney's resource-based view and Schumpeter's theory of *creative destruction*, together with contemporary research on sustainable and regenerative innovation.

The integrative review followed a theoretically driven, rather than exhaustive, sampling logic. The analysis focuses on canonical contributions in ecology, biomimicry, resilience and entrepreneurial ecosystems, complemented by seminal works on sustainable and regenerative innovation published mainly from the early 1990s onwards, when systemic perspectives on sustainability gained prominence. Only peer-reviewed journal articles and widely cited scholarly books were included; purely technical biomimicry applications lacking a systemic lens, as well as practitioner-oriented material and grey literature, were excluded. This strategy aligns with the objective of conceptual refinement rather than bibliometric coverage.

The selection criteria prioritized:

(i) conceptual relevance to system-level innovation,
(ii) contribution to understanding adaptive and regenerative mechanisms, and
(iii) alignment with the aim of bridging ecological principles with entrepreneurial dynamics.

The methodological process unfolded in three stages. First, the study identified convergences between ecological resilience mechanisms and entrepreneurial innovation logics, highlighting the limits of disruption-oriented models. Second, the literature was synthesized comparatively, examining distinctions and complementarities among circular innovation, regenerative design, eco-innovation, and biomimetic strategies. Finally, these insights were integrated into a theoretical framework for developing the logic of a new concept, the *uncreative construction*, from which theoretical propositions were developed to guide future empirical work.

This approach allows the study to bring together ideas that rarely intersect and to examine how ecological principles can support new ways of understanding innovation in entrepreneurial systems. By making explicit the theoretical sampling strategy, inclusion and exclusion criteria, and stages of synthesis, the methodology reinforces the transparency and rigor of the conceptual contribution. Table 1 summarizes the main theoretical streams mobilized and clarifies how each contributes to the development of the uncreative construction concept.

Table 1: Theoretical streams informing the concept of *uncreative construction*

Theoretical stream	*Main focus*	*Relevance for uncreative construction*
Ecological systems thinking	Interdependence, feedback loops, system memory	Provides a systemic lens on continuity, adaptation and renewal.
Resilience theory	Persistence, transformation, adaptive cycles	Illuminates how systems absorb shocks without collapsing.
Biomimicry (systems-oriented)	Learning from nature's design and processes	Offers nature-inspired patterns of continuity-based innovation.
Circular and regenerative innovation	Resource loops, regeneration of socio-ecological systems	Clarifies how material and systemic continuity support sustainability.
Strategic management & entrepreneurship	Firm resources, creative destruction, opportunity processes	Anchors the new concept within established innovation logics.

Source: Developed by the authors.

3. Theoretical Background

3.1. Biomimicry and Systems Thinking

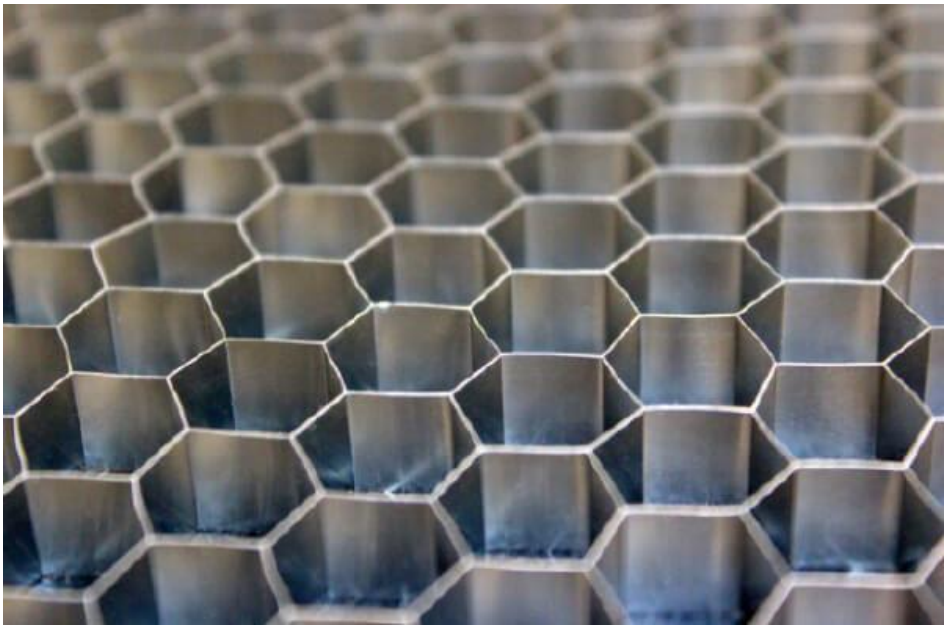
Ecology offers a systemic foundation for understanding how life evolved and persists through relationships. Instead of isolating elements, it examines how interactions among organisms create patterns, functions, and forms that cannot be reduced to individual parts. Capra (2021) describes this as the shift from a mechanistic worldview to a relational one, where the coherence of a system emerges from the quality of its connections. This perspective moves beyond the reductionist tendency that has shaped much of industrial thinking, in which problems are treated as isolated events rather than expressions of a larger system.

Nature's long evolutionary history reinforces this systemic lens. Over 3.8 billion years, organisms and ecosystems have refined strategies that enable adaptation and continuity. As Benyus (1997) notes, the natural world maintains what works and discards what does not, leaving failures as fossils and preserving solutions that support long-term survival. These solutions reflect principles such as feedback regulation, decentralized organization, redundancy and cooperation, which are properties that sustain resilience without relying on central control.

Biomimicry builds on these foundations by seeking to understand how nature solves recurrent challenges and by translating these strategies into human contexts. Its scope extends across three levels: forms, processes, and systems (Benyus, 1997; Vincent et al., 2006). Examples such as Velcro, inspired by burdock seeds; aerodynamic

improvements modeled on humpback whale flippers; and honeycomb structures applied to lightweight engineering illustrate how biological strategies can inform innovation without copying nature literally (Fish et al., 2011; Vincent, 1990). In this regard, Figure 1 illustrates biomimetic honeycomb structures applied to engineering and architecture, exemplifying how natural patterns can be translated into efficient human-made designs. Beyond form, biomimicry emphasizes circular metabolic flows, adaptive feedback loops and distributed networks, which are, in essence, systemic patterns that are highly relevant for innovation under conditions of uncertainty.

Figure 1: Biomimetic metal honeycomb structures for engineering and architecture.



Source: https://corex-honeycomb.com/products-and-services/, 2025.

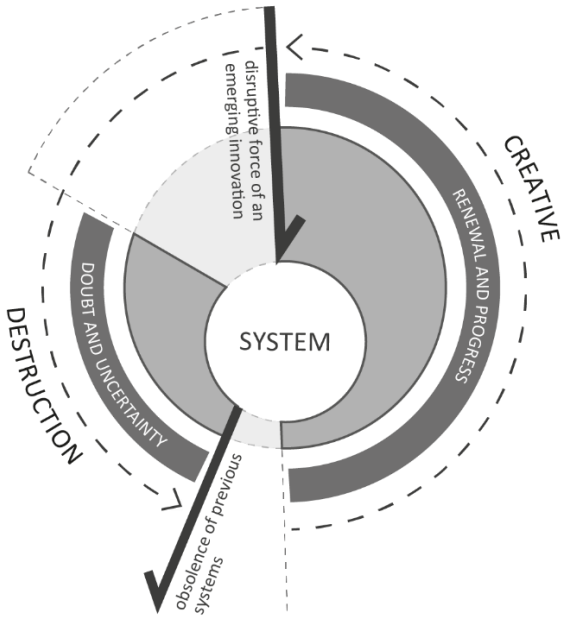
Diversity is central to this ecological paradigm. Ecosystems remain functional because multiple species can fulfill similar or overlapping roles, creating buffers against disturbance. Chapin et al. (2000) show that this functional diversity stabilizes systems by providing alternative pathways when one component fails. In human organizations and entrepreneurial ecosystems, diversity of approaches, capabilities, and relationships plays a similar role. Walker and Salt (2006) frame resilience as the capacity of a system to absorb change while retaining its identity. This perspective highlights why complexity and diversity are not obstacles, but structural conditions for adaptability.

In this sense, biomimicry is not merely the mimicry of nature's shapes or materials. It is the adoption of a systemic worldview that considers relationships, flows, and adaptive cycles as the core ingredients of innovation. This orientation provides an alternative to linear, reductionist, or purely disruptive models. It reveals how principles observed in natural ecosystems, such as interdependence, distributed decision-making, and diversity, can inform more resilient approaches to entrepreneurial innovation. These insights establish the theoretical basis for exploring alternative logics of innovation, developed in the following chapter.

3.2 Creative Destruction

Schumpeter describes innovation as a force that changes economic life by removing structures that no longer serve the system (Schumpeter, 1942). In this view, industries move forward when older arrangements give way to new ones. This concept, labeled as *creative destruction,* works by breaking continuity, disrupting what exists so that something different can take its place. When this happens, the system does not adapt around what it has; it starts again from a new foundation. In this sense, what is dismantled cannot be carried forward, and the system must reorganize itself around the new logic that enters. Figure 2 synthesizes this mechanism, representing creative destruction as a process of rupture and replacement at the system level.

Figure 2: Representative diagram of the *creative destruction* concept.



Source: Developed by the authors.

Seen through a systems lens, this mechanism operates by shifting the rules and goals that organize economic activity. Meadows (1999) calls these shifts *leverage points*, which means the changes in the underlying logic of a system. When disruption alters these deep structures, the system behaves differently, often abruptly.

However, disruption is only one way that systems change. In ecological systems, renewal does not depend solely on elimination. It also occurs through adjustment, recombination, and the reuse of structures that remain functional. Systems evolve by carrying forward what continues to work. This reveals a conceptual blind spot in creative destruction: it captures the dynamics of rupture but fails to account for the dynamics of continuity.

Creative destruction explains how new industries emerge, but not how systems maintain coherence, identity and resilience through change. It assumes that progress requires replacement. Yet ecological systems demonstrate that adaptation can arise through preservation and modification, not only through rupture. This distinction is crucial in innovation contexts where both stability and resilience are required. Entrepreneurs operating in complex social and environmental conditions often work with existing structures rather than discarding them (Barney, 1991). Similarly, sustainable business models frequently evolve by redirecting existing capabilities instead of replacing them (Boons & Lüdeke-Freund, 2013). Innovation, therefore, can also emerge by reorganizing what is already present.

To clarify how rupture-based innovation differs from continuity-based adaptation, Table 2 contrasts the core assumptions and implications of disruption-oriented models with those of continuity-oriented approaches. This contrast is presented here only to highlight the need for complementary perspectives in innovation theory; the alternative logic grounded in continuity is developed in detail in the following chapter.

Table 2: *Creative destruction* vs. Continuity-based innovation: A Comparative Conceptual Summary

Dimension	*Creative Destruction (Schumpeter, 1942)*	*Continuity-based innovation*
Type of change	Rupture; replacement of existing structures with new forms; innovation as discontinuity.	Continuity; transformation through replication, reorganization, and renewal of existing elements.
Attitude toward existing structures	Existing structures are obstacles to innovation and must be discarded.	Existing structures contain functional value and adaptive memory; they should be retained and repurposed when effective.
Role of system memory	Largely disregarded; the past is what must be overcome.	Central; systems innovate by preserving and recombining patterns that continue to work.
Speed of change	High; abrupt shifts driven by disruption and replacement.	Moderate or cumulative; preserves coherence.
Transition risk	High; disruptions may generate instability and loss of adaptive capacity.	Lower; continuity safeguards capabilities and reduces systemic fragility.
Relationship with resilience	Resilience is secondary; instability is the price of radical innovation.	Resilience is central to innovation.
Primary unit of analysis	Individual firms or industries replacing the old	Ecosystem-level patterns that extend what works.
Logic of value creation	Value stems from radical novelty and the ability to surpass existing structures.	Value emerges from intelligent continuity and adaptive reuse.
Guiding metaphor	"Storm of creative destruction."	"Ecological renewal and functional recombination."

Source: Developed by the authors.

While Table 2 highlights the contrast between rupture-based and continuity-based patterns of change, continuity-oriented adaptation is not unique to entrepreneurship. It appears consistently across natural systems. Table 3 illustrates how replication, reorganization and renewal operate at different ecological and physical scales, offering insight into how systems evolve by extending and reshaping what already exists.

Table 3: Innovation Through Adaptation in Nature (across scales).

Scales	Adaptation / Strategy
- Spiral Mollusks **- Galaxies**	Fibonacci spiral, optimizing space and energy distribution
- Tree Branching **- Rivers**	Fractal branching patterns for efficient resource flow
- Veins in Leaves **- Blood Vessels**	Redundant network design for efficient transport
- Beehive Hexagonal Structures **- Basalt Column Formations**	Hexagonal efficiency for packing and strength

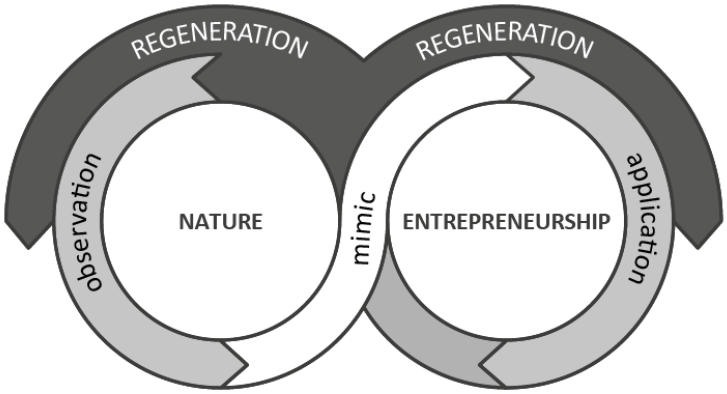
Source: Developed by the authors.

These natural examples illustrate how continuity-based adaptation appears across ecological systems. This insight reveals a conceptual boundary within the *creative destruction* framework: it cannot account for forms of change grounded in continuity. This opens space for a complementary innovation logic. The next section develops such a logic, from an ecological perspective.

3.3. Sustainable and Regenerative Innovation

The study on sustainable innovation has moved beyond efficiency and optimization. It now calls for approaches that renew systems rather than merely reduce their impact. Geissdoerfer et al. (2017) distinguish between circular and regenerative innovation. Circular models close resource loops. Regenerative models restore and strengthen socio-ecological systems. This distinction matters as it clarifies that sustainability is not only about cycling materials but about sustaining the conditions that allow systems to endure. Figure 3 illustrates how regenerative processes can restore and strengthen both natural and entrepreneurial systems, showing the biomimetic link between them through observation, mimicry, and application.

Figure 3: Biomimetic-informed regeneration supporting natural and entrepreneurial systems.



Source: Developed by the authors.

In entrepreneurship, this shift appears in efforts to design business models that embed ecological principles. Boons and Lüdeke-Freund (2013) argue that sustainable value creation depends on aligning how value is created, delivered and maintained with environmental integrity. Their work highlights that innovation can emerge by reconfiguring existing structures instead of replacing them. Adaptation rather than destruction becomes a viable path for change.

Bocken et al. (2014) extend this reasoning through regenerative and sufficiency-driven archetypes. These models slow resource flows, restore ecological functions and create room for resilience. They show that innovation often advances by amplifying strategies that already work in nature. Replication and adjustment, rather than novelty alone, can support systemic renewal.

Regenerative design theory reinforces this orientation. McDonough and Braungart (2002) argue that design should contribute to ecosystems instead of merely limiting harm. Their cradle-to-cradle framework treats biological and technical systems as cycles that can be strengthened through thoughtful design. This view connects ecological renewal with entrepreneurial action and demonstrates that new solutions can grow from existing structures.

Elkington's (1997) *triple bottom line* expands this understanding. It positions sustainability as the integration of economic, environmental, and social value. This integration reflects biomimetic principles: systems remain resilient when their elements are balanced and interconnected. Stability, not disruption, becomes a condition for innovation.

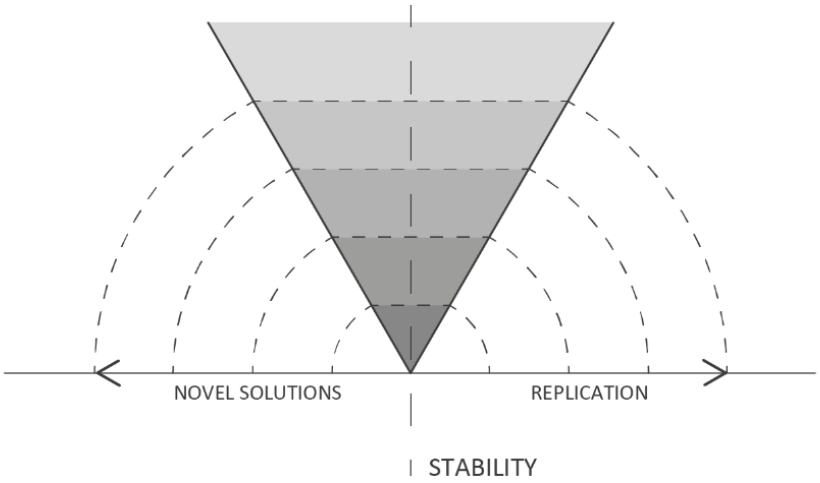
Together, these contributions form a coherent foundation for approaches that renew rather than replace. They show that innovation can emerge through restoration, continuity and systemic alignment, which opens conceptual space for alternative logics of change that move beyond disruption-centric models. The next chapter builds on this foundation to develop a novel concept that will complement Schumpeter's *creative destruction.*

4. Conceptual Development: Uncreative Construction

4.1. Definition of Uncreative Construction

As analyzed previously, systems do not evolve only through rupture. Much of what endures in nature persists not because it resists change, but because it adapts without discarding what already works (Benyus, 1997). Ecological systems show that renewal often begins with what is already present. They recombine, reorganize, and extend existing structures rather than replacing them outright. This pattern, recurrent across scales, suggests that innovation can arise from continuity as much as from disruption (Capra, 2021). Figure 4 summarizes this role of diversity in supporting systemic stability.

Figure 4: The Role of Diversity in Systemic Stability.



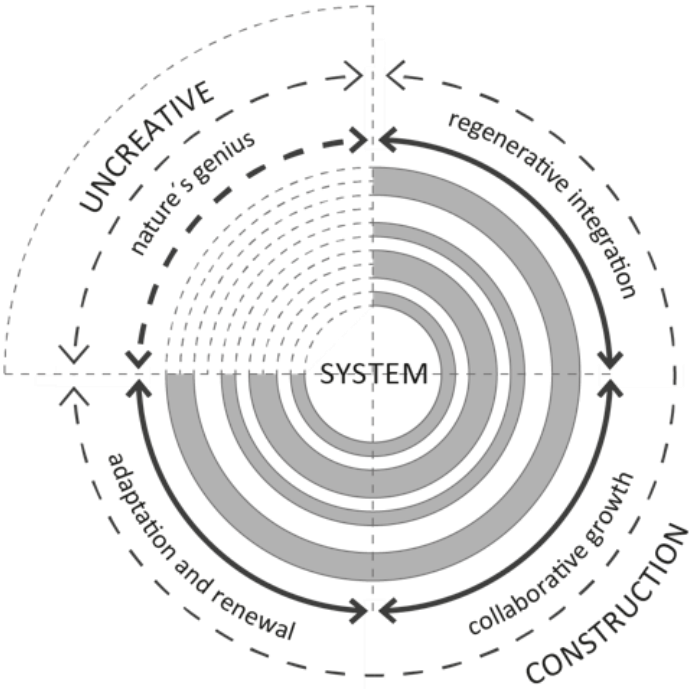
Source: Developed by the authors.

It is in this context that we propose a new concept developed in response to a gap within *creative destruction*: the concept of *uncreative construction*. *Creative destruction* explains how industries advance when the old gives way to the new (Schumpeter, 1942). However, it does not explain how systems maintain coherence while they change, nor how they adapt when replacement is neither possible nor desirable. It assumes that progress depends on elimination. *Uncreative construction* emerges as its complementary opposite: instead of advancing through rupture, it advances through continuity. It highlights the forms of change that grow from what persists, drawing stability forward rather than clearing it away.

The term "uncreative" signals that novelty does not always require invention from scratch. Nature rarely starts over. It works with what has survived, shifting, adjusting, and redirecting what is already present. In this sense, "uncreative" does not diminish creativity; it reframes it. Creativity can also manifest through continuity rather than rupture (Benyus, 1997). The term "construction" reinforces this orientation. It points to the act of shaping, reorganizing, and assembling existing elements into new configurations. In contrast to "destruction," construction suggests a process that builds with what remains rather than clearing what existed.

Taken together, *uncreative construction* describes a way of creating by conserving, of transforming by reorganizing and of responding to change through structures that already hold ecological intelligence (Capra, 2021). It does not reject disruption; it acknowledges its place. But it argues that resilient systems often evolve by carrying forward what works and reorganizing it to meet new conditions. Figure 5 synthesizes this logic, representing uncreative construction as a continuity-based pathway of innovation grounded in ecological patterns.

Figure 5: Representative diagram of the *uncreative construction* concept.



Source: Developed by the authors.

This view is consistent with broader work in sustainability and strategic management. Hart and Dowell (2011) argue that sustainability is a foundation for long-term resilience, reinforcing the idea that innovation grounded in renewal and conservation can strengthen system adaptability. Barney's (1991) resource-based view also supports this orientation by showing that competitive advantage often emerges from leveraging and recombining existing resources rather than replacing them. Almeida Leite et al. (2024) further argue that innovation gains robustness when creative processes build on, rather than discard, existing foundations. Together, these perspectives position *uncreative construction* as a logic that expands how innovation can be understood beyond rupture alone, and as a complementary counterpart to Schumpeter's theory.

4.2. Boundaries with Existing Concepts

Uncreative construction intersects with several established approaches to sustainable and entrepreneurial innovation, but it does so from a distinct position. Rather than replacing existing frameworks, it complements them by emphasizing how continuity, adaptation and the reuse of functional structures contribute to system-level resilience.

Biomimicry at the level of form or process replicates shapes, materials, or mechanisms found in living systems (Benyus, 1997; Vincent et al., 2006). *Uncreative construction* aligns with biomimicry's systemic dimension: the study of ecosystems principles, more specifically on how they maintain coherence through adaptation and interconnectedness. In this sense, *uncreative construction* draws from nature's logic of continuity, focusing its implementation for the context of entrepreneurship.

Circular innovation focuses on resource flows and the closing of loops through reuse and recycling (Geissdoerfer et al., 2017). Its strength lies in material efficiency. *Uncreative construction* aligns with this logic at a structural level, in the sense that both recognize that what already exists can be extended rather than discarded. However, circularity concentrates on the movement of materials while *uncreative construction* concentrates on the reorganization of relationships, functions and patterns within a system.

Regenerative innovation seeks to restore and enhance ecological capacity (McDonough & Braungart, 2002). Its emphasis is ecological renewal. *Uncreative construction* shares the same principle that systems improve by

building on what retains vitality. However, the difference lies in scope: regenerative innovation rebuilds ecological foundations, while *uncreative construction* repurposes social, organizational, or cognitive structures that remain functional. Both approaches recognize that resilience depends on what persists.

Eco-innovation often advances through technological efficiency and reduced environmental impact (Boons & Lüdeke-Freund, 2013). Its logic is instrumental. *Uncreative construction* operates differently, as it addresses how systems adapt when they reorganize existing capabilities, rather than substituting them. Yet there is a parallel: both recognize that innovation can emerge without rupture, often through the deepening or redirection of structures already in place.

These examples show some parallels that position *uncreative construction* as part of a broader ecosystem of ideas, seeking alternatives to linear, disruption-driven models of innovation. They also reveal their unique contribution: circular innovation addresses flows; regenerative innovation addresses restoration; eco-innovation addresses efficiency; and *uncreative construction* addresses the stability of the patterns that hold systems together and the adaptive potential within them.

This conceptual positioning creates the conditions for a deeper dialogue with Schumpeter's *creative destruction*. Each concept offers a different pathway through which innovation unfolds: one through rupture, the other through continuity. Both can coexist within the same system. The next section develops this interplay, showing how the two logics can operate in symbiosis rather than opposition.

4.3. Mechanisms of Uncreative Construction

Uncreative construction operates through mechanisms that reflect how living systems adapt without resorting to rupture. These mechanisms show that continuity is not the absence of change but a mode of transformation grounded in what remains viable. They translate ecological patterns, that were refined through evolution, into processes that can inform entrepreneurial innovation. Three mechanisms structure this logic: the replication of functional patterns, the reorganization of existing structures and renewal through adaptive continuity.

Replication of Functional Patterns

Natural systems often respond to emerging conditions by drawing on strategies that have already proven effective. Evolution retains patterns that work and reuses them across contexts, a process visible in convergent evolution and the persistence of forms or functions across species (Benyus, 1997; Vincent et al., 2006). Replication in this sense is not imitation but a way of reinforcing stability while enabling adaptation. In entrepreneurial settings, similar dynamics appear when ventures extend or transfer existing models into new applications. Business model research shows that replication of effective patterns can generate competitive advantage by leveraging known structures rather than inventing from scratch (Baden-Fuller & Morgan, 2010; Barney, 1991). Replication becomes a pathway through which novelty emerges from continuity.

Reorganization of Existing Structures

Ecosystems endure disruptions by reorganizing internal relationships rather than collapsing them. Redundancy, overlapping functions and distributed organization allow systems to shift roles and reconfigure interactions while maintaining coherence (Chapin et al., 2000). The capacity to reorganize without dismantling the whole is central to resilience (Walker & Salt, 2006). In entrepreneurship, reorganization appears in the recombination of resources, capabilities, and partnerships. Sustainable business models often evolve not through replacement but also through reconfiguration, redirecting existing elements toward new purposes (Boons & Lüdeke-Freund, 2013; de Almeida Leite et al., 2024). This mechanism shows that systems can adapt meaningfully through internal rearrangement.

Renewal Through Adaptive Continuity

Ecological renewal frequently occurs within structures that persist over time. Successional cycles, adaptive feedback loops, and cross-scale interactions allow ecosystems to evolve while retaining identity (Capra, 2021). Renewal is not a return to the past, but rather a forward movement grounded in memory, pattern, and

accumulated ecological intelligence. In entrepreneurial contexts, renewal emerges when ventures update practices, reorient strategies, or expand value propositions without discarding their foundational structures. Research in sustainability and strategic management shows that organizations can strengthen resilience by building on their existing resource base while aligning with changing environmental and social conditions (Hart & Dowell, 2011). Renewal in this sense embodies continuity as a source of transformation.

Taken together, these mechanisms illustrate how *uncreative construction* functions as an innovation logic rooted in stability, adaptation and systemic coherence. Change unfolds not by erasing what exists but by extending, reorganizing and renewing it. This internal logic prepares the ground for understanding how *uncreative construction* operates in entrepreneurial ecosystems, where resilience depends on a balance between continuity and disruption. The next section examines these implications in practice.

4.4. Implications for Entrepreneurial Ecosystems

The mechanisms that structure *uncreative construction* have direct implications for how entrepreneurial ecosystems evolve and sustain themselves. They reveal that innovation does not depend exclusively on disruption but also on the capacity of a system to reorganize and extend what already functions. When seen through this lens, entrepreneurial ecosystems emerge not only as spaces of experimentation but as living systems in which continuity and adaptation operate side by side to support resilience. The following implications illustrate how this logic appears in practice:

Innovation Through the Replication of Functional Patterns

Ecosystems gain resilience when they can replicate patterns that already demonstrate effectiveness. *Biohm* offers a clear example. Rather than inventing a new material logic, the company works with the structural intelligence of mycelium, through an adaptive pattern already explored in biomaterial research and construction science (Sayed & Jones, 2018). By scaling this biological architecture into construction materials, innovation can emerge through continuity. The ecosystem benefits by integrating a solution that is familiar at the structural level, reducing uncertainty and lowering the cost of transition. In this sense, replication becomes an entrepreneurial strategy that preserves coherence while opening new avenues for change.

Adaptation Through Reorganization of Existing Structures

Entrepreneurial ecosystems evolve by reorganizing relationships, not only by replacing them. Structural reconfiguration can redirect existing capabilities toward new purposes while preserving the stability of the system. *Yuca Bio-Plastics* demonstrates this mechanism: Its cassava-based material integrates into the same processing infrastructure used for traditional plastics, building on a body of research that establishes cassava's potential as a biodegradable polymer (Garrido & Oliveira, 2019). With this strategy, no new industrial environment is required, as the ecosystem adapts by reorganizing its flows rather than dismantling its foundations. This reveals an important implication: ecosystems can move toward sustainable innovation through redirection rather than collapse. It aligns with resource-based perspectives in entrepreneurship that see competitive advantage emerging from the reconfiguration of what already exists.

Renewal Through Adaptive Continuity

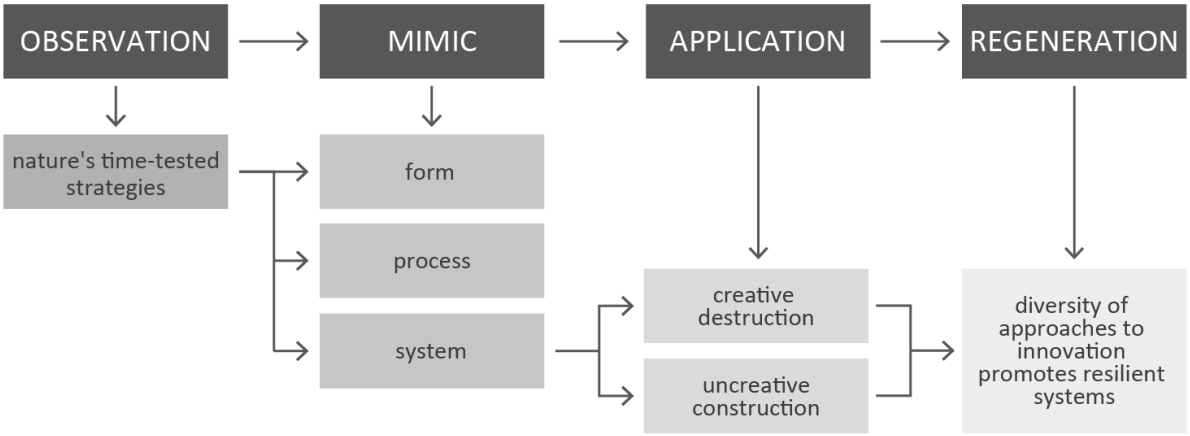
Renewal in ecosystems doesn't mean abandoning their identity. It can also occur when systems carry forward structures that hold value, but reorganize them to meet new conditions. *Navdanya's seed networks* illustrate this dynamic. The preservation of diverse and ancestral seeds forms the foundation for agricultural systems, that can respond to ecological and social change. This is made without splitting ties to their origins, which is a principle well documented in regenerative agriculture and biodiversity knowledge (Shiva, 1993; 2005). This approach does not reject modern innovation, as it roots renewal in the continuity of ecological and cultural memory. For entrepreneurial ecosystems, this highlights a different pathway to adaptation. Stability becomes an asset, not an obstacle, and renewal arises by reinforcing the elements that allow the system to maintain its function, while evolving.

Taken together, these implications show that entrepreneurial ecosystems benefit not only from disruptive forces but from the steady work of continuity. In this sense, replication, reorganization and renewal provide pathways for innovation that reduce systemic fragility, support long-term adaptability, and allow transitions to occur without eroding the foundations that hold systems together. These insights create the conditions for a more integrated understanding of innovation, one that recognizes the complementary roles of rupture and continuity. The next section explores this interplay in greater depth.

4.5. The Dynamic Interplay Between Creative Destruction and Uncreative Construction

Innovation within entrepreneurial ecosystems does not follow a single trajectory (Stam, 2015). Systems evolve through phases of disruption and phases of reorganization, and their stability depends on the diversity of pathways available. In ecological terms, diversity is the foundation of resilience. It allows systems to absorb disturbance because multiple structures, functions and relationships can carry the system forward when conditions shift (Elmqvist et al., 2003; Folke et al., 2004; Walker & Salt, 2006). This ecological principle provides the lens through which the interplay between *creative destruction* and *uncreative construction* can be understood. While one relies purely on novelty, the other maintains consistency and both rely on diversity to sustain the capacity of the system to adapt. Figure 6 synthesizes these nature-inspired strategies, framing resilience as the outcome of diversified pathways of change.

Figure 6: Nature-inspired strategies for resilient systems.



Source: Developed by the authors.

As already stated, *creative destruction* generates the disturbances that open space for new configurations to emerge. It exposes limitations in established structures and initiates transitions by altering the rules or feedbacks that shape economic activity (Schumpeter, 1942). However, disruption alone cannot ensure stability. For new patterns to take hold, ecosystems must reorganize around what remains functional. *Uncreative construction* provides a complementary perspective to this logic. It enables systems to absorb the shock of disruption by recombining existing capabilities, strengthening relationships that retain value and redirecting structures that continue to serve a purpose. Together, these dynamics reflect the adaptive cycles observed in ecology, where periods of release are followed by phases of reorganization and renewal (Gunderson & Holling, 2002).

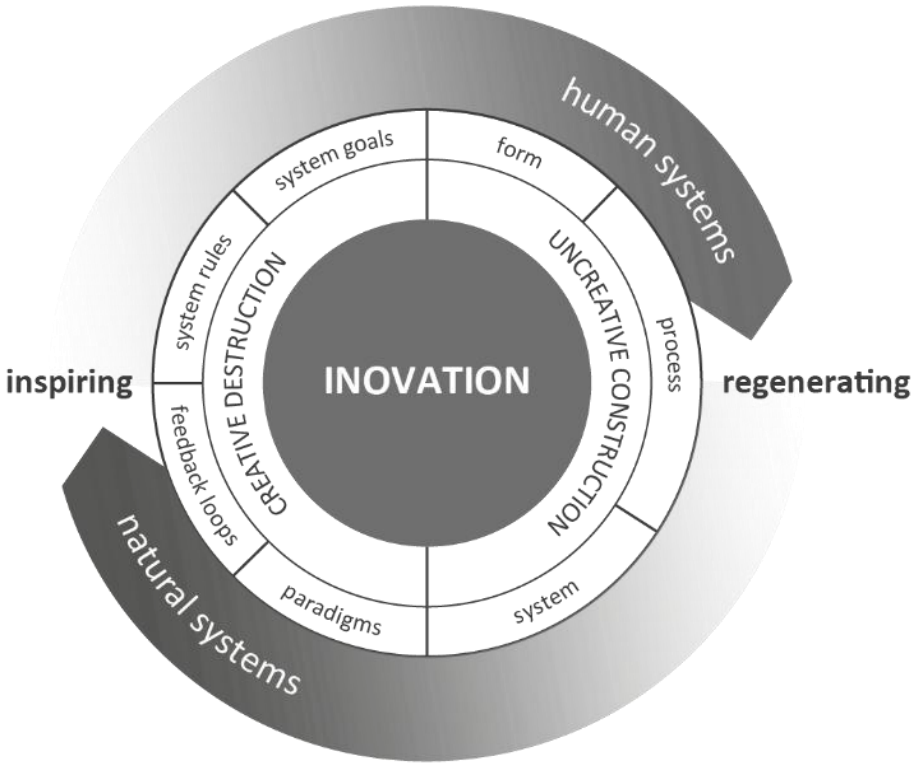
Real-world cases of transitions demonstrate how these logics interact. In the biomaterials sector, the emergence of alternatives to petrochemical plastics introduced a disruptive force. Yet, the viability of these transitions depended on the ecosystem's ability to reorganize without collapse. *Yuca Bio-Plastics* illustrates this interplay: while its cassava-based material challenged the logic of plastic production, its compatibility with existing industrial infrastructure enabled continuity in processing and distribution (Garrido & Oliveira, 2019). In other words, in this case, disruption initiated the shift and continuity allowed it to stabilize.

A similar dynamic appeared in the built environment, when *Biohm's* mycelium-based materials questioned extractive construction models, but integrated new models into architectural practices that already exist. Their innovation is disruptive in intent yet continuous in implementation (Sayed & Jones, 2018). The ecosystem transitions because it can carry forward familiar forms of design, production, and collaboration while adopting new material intelligence. Here, novelty enters the system without eroding its underlying structure.

In agriculture, the long-standing effects of industrialization reflect decades of *creative destruction*, which replaced local seed diversity with standardized, high-input systems. *Navdanya's seed networks* respond through *uncreative construction*: they renew agricultural capacity by preserving and reorganizing existing ecological and cultural resources rather than discarding them (Shiva, 1993; 2005). At this point, the interplay between disruption and continuity becomes explicit. Although industrial agriculture created the conditions for change, adaptive continuity provided a path toward resilience.

Across these contexts, the interplay between *creative destruction* and *uncreative construction* becomes a source of systemic strength. Diversity enables ecosystems to navigate transitions through multiple pathways: disruption for transformation and continuity for coherence. Neither logic is absolutely sufficient on its own. *Creative destruction* catalyzes shifts, but, without continuity, transitions may fragment. *Uncreative construction* stabilizes change, but, without disruption, systems stagnate. Resilience arises from the dialogue between these forces, echoing the complementary roles of disturbance and renewal in ecological systems. Figure 7 captures this dual dynamic, representing creative destruction and uncreative construction as interdependent drivers of sustainable progress.

Figure 7: Dynamic interplay of concepts for sustainable progress.



Source: Developed by the authors.

Understanding this interplay allows entrepreneurial ecosystems to steer transitions more intentionally. It highlights that innovation strategies should not rely exclusively on rupture nor solely on conservation. Instead, ecosystems benefit when both dynamics are present and in balance. Disruption generates new possibilities; continuity reorganizes them into viable forms. This integration creates pathways through which ecosystems can

evolve while maintaining the foundations that support long-term functioning. Such dual logic offers a more complete view of how innovation unfolds within complex environments and sets the stage for broader reflections in the conclusion that follows.

5. Theoretical Propositions

The mechanisms underlying *uncreative construction* provide the basis for theoretical propositions that clarify how continuity-based innovation shapes entrepreneurial ecosystems. These propositions extend existing work on sustainable innovation by demonstrating how adaptation, reorganization, and renewal draw from patterns already present in natural and social systems. As seen, they reflect the logic that systems evolve not only through disruption, but also through the amplification, recombination, and repurposing of structures that have proven effective across time and context.

Proposition 1 — Replicating Functional Patterns Enhances Ecosystem Resilience

Natural systems often rely on pattern recurrence to maintain functionality under changing conditions. Phenomena such as the lotus effect (Barthlott & Neinhuis, 1997), the hydrodynamics of humpback whale flippers (Fish et al., 2011), or the structural efficiency of honeycomb geometries (Vincent, 1990) illustrate how recurrent forms persist because they are effective. *Uncreative construction* extends this principle to entrepreneurship: ecosystems that support the replication of functional patterns, whether in business models, organizational structures, or resource configurations (Baden-Fuller & Morgan, 2010), develop greater resilience. Replication stabilizes systems by building on known solutions, while allowing room for contextual adaptation.

Proposition 2 — Reorganizing Existing Structures Strengthens Adaptive Capacity

Ecological resilience emerges from the redundancy and distributed structure of ecosystems (Chapin et al., 2000; Walker & Salt, 2006). Fungal networks, as described by Sheldrake (2020), reorganize internally without losing coherence, redirecting flows while preserving the system. In entrepreneurship, a similar dynamic occurs when ventures reorganize existing capabilities rather than replacing them. The reconfiguration of resources, which is a core principle in the resource-based view (Barney, 1991), enables systems to adapt while conserving functional parts. Sustainable business model research reinforces this view, showing that reorganization can generate innovation without destabilizing the system (Boons & Lüdeke-Freund, 2013; de Almeida Leite et al., 2024). Thus, *uncreative construction* predicts that ecosystems with strong reorganization capacity exhibit higher adaptability.

Proposition 3 — Renewal Through Continuity Supports Long-Term Innovation Stability

Ecological renewal frequently arises through continuity rather than rupture. Successional processes, feedback loops, and the redistribution of functions enable systems to evolve while retaining identity (Capra, 2021). Architectural and design practices inspired by ecological principles likewise show that continuity can be a generative force. The approaches documented by Pawlyn (2019) reveal how regenerative cycles maintain structural integrity while supporting new forms. In entrepreneurial contexts, renewal emerges when ventures retain core structures while updating practices to meet new conditions. This view aligns with sustainability research that treats stability as a prerequisite for resilience (Hart & Dowell, 2011) and with economic models that emphasize regenerative flows (Raworth, 2018). *Uncreative construction,* therefore, predicts that continuity-driven renewal enhances long-term innovation stability.

Proposition 4 — Balancing Disruption and Continuity Enhances Ecosystem Robustness

Creative destruction introduces variation and opens pathways for change (Schumpeter, 1942). Yet, ecosystems do not depend on disruption alone. Their robustness comes from diversity, redundancy, and the coexistence of multiple adaptive strategies (Folke et al., 2004; Elmqvist et al., 2003). *Uncreative construction* complements *creative destruction* by stabilizing transitions, reorganizing what remains functional, and preserving system memory. In combination, these forces mirror the adaptive cycles described by Gunderson & Holling (2002), where periods of release are followed by phases of reorganization and renewal. The proposition that entrepreneurial ecosystems are most robust when disruption and continuity operate together reflects their ecological counterparts.

Proposition 5 — Continuity-Based Innovation Reduces Transition Risk and Supports Sustainable Scaling

Efficiency and sufficiency-oriented innovation models emphasize the value of reducing unnecessary resource use, stabilizing flows, and aligning products with ecological limits (Niessen & Bocken, 2021). *Uncreative construction* advances this orientation by leveraging existing infrastructures, relationships, and cognitive frameworks. By reducing the need for systemic replacement, continuity-based innovation lowers transition risks and supports the gradual scaling of sustainable solutions. This aligns with findings that resource recombination can be a strategic advantage (Barney, 1991) and that regenerative innovation often emerges from building upon existing system intelligence (McDonough & Braungart, 2002).

These propositions show that *uncreative construction* offers an innovative logic focused on continuity, adaptation, and coherence. They offer a structured foundation for future research exploring how entrepreneurial ecosystems evolve when innovation arises not from rupture alone, but from the intelligent reuse, redirection, and renewal of what already works.

6. Conclusion

This study introduced a novel concept, *uncreative construction,* as a continuity-based logic of innovation grounded in ecological systems thinking. It responds to a gap in prevailing innovation theory, which tends to privilege disruption while overlooking how systems adapt through the preservation and reorganization of what remains functional. By drawing from ecological principles, *uncreative construction* demonstrates that continuity can be a generative force, enabling systems to evolve without destabilizing their foundations.

Through a precise conceptual definition, clear boundaries with related frameworks and the identification of three core mechanisms - replication, reorganization, and renewal - the study reframes innovation as a structural, rather than purely disruptive, process. These mechanisms translate ecological intelligence into entrepreneurial dynamics and offer a vocabulary for understanding how systems change through adaptive reuse rather than collapse.

The implications for entrepreneurial ecosystems highlight how continuity-oriented strategies can support resilience, reduce transition risk and facilitate smoother adaptation. The examples of *Biohm, Yuca Bio-Plastics and Navdanya* illustrate how novelty can emerge by extending existing patterns, redirecting infrastructures and renewing system memory. These cases show that ecosystems can innovate effectively when transformation builds on what already holds value.

The interplay between *creative destruction* and *uncreative construction* reinforces the need for diversity in how ecosystems evolve. Disruption creates openings where continuity stabilizes them. Their co-existence reflects ecological adaptive cycles, where renewal depends on both disturbance and the capacity to reorganize. Understanding this duality provides a more complete account of innovation and clarifies why entrepreneurial ecosystems require both modes of change to remain robust over time.

The theoretical propositions derived from this framework establish pathways for future empirical research. They articulate how continuity-based mechanisms shape resilience, adaptation and systemic coherence. In doing so, they position *uncreative construction* not as an alternative to disruption, but as its necessary counterpart, a logic that enables innovation to unfold without eroding the structures that support long-term functioning.

This article is conceptual in nature and, as such, is constrained by the scope of the literature selected and the absence of empirical validation. Future research could operationalize uncreative construction at multiple levels of analysis—venture, ecosystem, and policy—and test the proposed mechanisms and propositions using longitudinal designs, comparative case studies, and network-based methods. Empirical work is particularly needed to explore how continuity-based innovation unfolds in different sectors and institutional contexts, and how it interacts with disruptive forces over time.

Ultimately, *uncreative construction* expands the conceptual landscape of innovation by revealing how systems can change through what they conserve as much as through what they abandon. By integrating ecological principles with entrepreneurship knowledge, this work offers a foundation for understanding how resilient systems grow, adapt and endure, in a world increasingly defined by uncertainty, which highlights the need for sustainable transitions.

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Integrating social and responsible innovation for sustainable entrepreneurship: A metasynthesis of contemporary case studies

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Abstract

This article analyzes the possibilities for integrating Social Innovation (SI) and Responsible Innovation (RI) to guide the development of models of innovation and sustainable entrepreneurship. To this end, a metasynthesis was carried out, analyzing qualitative case studies published between 2021 and 2025, totaling 51 articles. The analysis resulted in four analytical propositions that distinguish the two fields in terms of focus (resolution of social demands versus ethical reflection), impact (systemic transformation versus normative alignment), forms of engagement (organic versus institutionalized collaboration) and locus of origin (bottom-up versus top-down). Based on these propositions, the study proposes a set of integrative guidelines for hybrid initiatives — reflective co-creation, ethical scalability, polycentric governance, and multidimensional evaluation — applicable to social enterprises, impact startups, sustainability-oriented organizations, and community initiatives. These guidelines articulate the normative foundations of IR with the participatory and contextual processes of SI, contributing to the theoretical advancement of the field of innovation and entrepreneurship guided by social, environmental and ethical values. The main contribution lies in the construction of an analytical model capable of guiding practices, public policies and organizational strategies committed to the transition to more responsible and transformative forms of innovation.

Keywords: Metasynthesis; Responsible Innovation; Social Innovation; Sustainability; Sustainable Entrepreneurship.

1. Introduction

As a society, we evolve in different ways. If we consider the industrial revolutions, for example, we started with steam engines and mechanical looms, and we reached the era of information technology, bringing man and machine closer together. Each phase brought with it innovations and transformations that altered the standards of institutions as a whole. New products, new forms of consumption, new experiences, and new social and environmental challenges typical of the evolutionary trajectory are placed in our daily lives.

Reflecting on the implications of these transformations also becomes part of the agenda in this evolutionary scenario. Increasingly complex challenges arise as technological and social evolution advance. Responding to them through new forms of innovation, aimed not only at the market but also at solving social and environmental problems, can contribute to a journey of growth and development across the economic, social, and environmental spheres, responsibly and inclusively.

In this scenario, the combination of social innovation and responsible innovation becomes essential for strengthening sustainable entrepreneurship practices and models, aligning innovative processes with long-term social, environmental, and economic impacts.

In this context, the assumptions of Social Innovation and Responsible Innovation emerge, seeking to address and fill gaps in neglected or absent social demands in the service of market dynamics. Social innovation comprises solutions to social problems (Taylor, 1970) that positively impact a community or social collective. In turn, Responsible Innovation is defined as the way innovations are produced, which must be technically viable, profitable, socially desirable, and ethically acceptable (Von Schomberg, 2013; Owen, Stilgoe & Macnaghten, 2012).

From this perspective, the research question is to identify the convergences and divergences between the principles and practices of social innovation and responsible innovation, and how they can be integrated into initiatives seeking sustainable impacts. In light of the assumptions presented, the research is justified because both social innovation and responsible innovation emerge as responses to ethical, social, and environmental crises and share values such as stakeholder inclusion, sustainability, and social justice. However, few studies analyze, in a comparative or integrated way, how these two fields dialogue with or complement each other in theory and practice.

To deepen these aspects, the objectives of this study are: to identify the main concepts, principles, and dimensions of social innovation and responsible innovation; to analyze the points of convergence and divergence between the two fields; and to propose integrated guidelines for hybrid initiatives. Considering the objective of integrating two partially overlapping conceptual fields — social innovation and responsible innovation — we chose to use the metasynthesis approach proposed by Hoon (2013), which allows us to critically reinterpret the findings of primary studies to build a new theoretical understanding.

To meet the research proposal, the study presents the theoretical foundation in the next section, followed by the methodology section. Section four discusses the analysis of results, and section five concludes.

2. Theoretical Foundations

2.1. Social Innovation: Foundations, Specificities and Challenges

Innovation, as it is widely understood, refers to the creation or improvement of new ideas with the intention of economic gain (Pol & Ville, 2009). This paradigm was popularized by one of the great scholars of innovation, the economist and political scientist Schumpeter (1982), who argued that innovation is the engine of economic development in a capitalist economy. The OECD (2018, p.20) defines innovation as "a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or put into use by the unit (process)". For example, an innovation can take four different forms: i) product (inclusion of a new good or service or relevant improvement to existing ones); ii) organizational (introduction of new organizational methods or business practices); (iii) process (a new or significantly improved method of production) and; v) marketing (new techniques that result in significant changes in the design of the product and/or service) (OECD, 2018).

Given this context, social innovation (SI) can be considered a subtype of innovation, distinct from technological innovation, in that it prioritizes the social dimension as its main objective. In his seminal study, Taylor (1970) approaches SI as a means of addressing social needs through the introduction of a social invention, that is, a "new way of doing things". It is a "new solution" or a "new response", which is deliberately undertaken to offer a solution to an identified social problem that can affect all sectors of society and also suggests that this change must be sustainable (Cloutier, 2003). According to Cajaiba-Santana (2014), the ultimate goal of social innovation is to propose solutions that result in changes in the social sphere, which are triggered by collective action.

In this sense, social innovation is a process often initiated by communities and individuals proposing new ideas; when these ideas are disseminated beyond the context in which they are initially implemented and have a lasting

impact, we can call them social innovations (Westley & Antadze, 2010). Consequently, solutions do not necessarily arise from companies, large institutions, or research institutes, but can come from modest initiatives, such as groups, communities, and users, which further distinguishes it from technological innovation (Benneworth & Cunha, 2015; Howaldt et al., 2016). Table 1 illustrates the main elements that differentiate, conceptually and empirically, technological innovation from social innovation.

Table 1: The main elements that differentiate technological innovation from social innovation are.

Prospect	Technological innovation	Social innovation
Application	Improvement of a product, process, or service.	Social issues, well-being of individuals and the collectivity.
Purpose	Focus on technological advancement and competitive advantage for increase in profits.	Social and sustainable, which may or may not occur from technological advancement.
Benefit	Specific or private group.	Society as a whole or communities in need Specific.
Social impact	It is not required.	It is necessarily required.
Impact on sustainable development	It addresses only the economic pillar.	It addresses the three pillars of sustainability: social, economic and environmental.
Value creation	Appropriation of economic value, may or may not add value social.	Creation of social value, from the addition of the social and environmental.
Process by which it occurs	Closed. Protected through intellectual and technological mechanisms and protection, in order to prevent replication.	Diffuse, favouring the transposition of knowledge between organizations and communities, stimulating the replication.

Source: By the authors, based on Schumpeter (1912); Pol & Ville (2009); Cajaíba-Santana (2014); Howaldt et al. (2016); Bilali (2018); Bataglin et al., 2021.

Two aspects are highlighted in the perspectives summarized in Table 1: first, differences in application, purpose, and beneficiaries; and second, the process of social innovation. Unlike technological innovation, social innovation has as its main characteristic the collaborative process, since, as highlighted by Bittencourt and Bignetti (2012, p.16), "by definition, it implies the participation of all the actors involved, in a process of social construction, and the use of networks and mechanisms for coordinating activities facilitate linkage, communication and joint action."

Therefore, it requires interaction between the social sectors of government, business, and civil society (Howaldt et al., 2016), and can be developed, exclusively or collaboratively, in the nonprofit sectors, public, private, or even informally, by individuals, families, communities, and social movements (Caulier-Grice et al., 2012). Given this and other aspects, the process of social innovation becomes complex, requiring the adoption of several mechanisms to acquire the necessary resources for its implementation, especially financial, infrastructure, and institutional and political support (Bufali et al., 2023).

To achieve a systemic and lasting impact, which is its main objective (Cajaiba-Santana, 2014), social innovation needs to be validated by its users, incorporated into its environment, become a common practice, and change existing structures and systems. However, for this to occur, solutions need to be scaled up and sustained to generate large-scale impact, which represents one of the main challenges of social innovation (Moore et al.,

2015). The lack of long-term funding, organizational and leadership tensions, and the need for continuous adaptation to dynamic environments are among the factors to consider when discussing scalability in social innovation (Moore et al., 2015).

Thus, social innovation is a multifaceted process that can involve multiple actors and present complex implementation challenges. While expanding its transformative potential, its characteristics also impose significant challenges along the way. By comparing these aspects with other value-driven innovation approaches, such as responsible innovation, we can highlight and analyze potential convergences and differences.

2.2. Responsible Innovation: Foundations, Specificities and Challenges

Responsible Research and Innovation (RRI) emerge as a critical approach to the traditional way of producing science and innovation, proposing a new logic of governance guided by social, ethical and sustainable values. RRI seeks to align research and development processes with the expectations and needs of society, promoting innovation that is not only technically feasible or economically profitable, but also socially desirable and ethically acceptable (Von Schomberg, 2013; Owen, Stilgoe & Macnaghten, 2012).

According to Stilgoe et al. (2013), RRI is supported by four interrelated dimensions: i) anticipation — identification and analysis of the possible impacts and risks of innovation; ii) reflexivity — questioning of the assumptions, values and purposes that guide the research; iii) inclusion — engagement of multiple stakeholders in the decision-making process; and iv) responsiveness — ability to adapt innovation paths to new knowledge and social demands. These dimensions operate as guiding principles for scientific institutions, companies, policymakers, and other actors involved in innovation.

While traditional innovation is often guided by goals of competitiveness, economic growth, and technological advancement, responsible innovation introduces a more normative perspective by emphasizing the “why” and "for whom" of innovation (Owen et al., 2012). Thus, it shifts the focus from innovation as an end in itself to innovation as a means of addressing major societal challenges — such as climate change, digital inclusion, health equity, or social justice — and is particularly relevant in contexts of uncertainty and vulnerability (van Oudheusden, 2014; Stilgoe, 2020).

RRI is therefore an interdisciplinary and cross-sectoral field that requires practices of open dialogue between science and society, participatory methodologies, and mechanisms for continuous evaluation of the socioeconomic and environmental impacts of innovation. Among its main challenges, the difficulty of institutionalizing its principles in traditional research and innovation structures stands out, especially in environments guided by productivist metrics and market logics (Burget, Bardone & Pedaste, 2017). In addition, there are tensions inherent in combining accountability with adaptive flexibility, as well as ethical dilemmas about who defines what is "socially desirable" (Owen et al., 2013).

Table 2 summarises the main elements that characterise responsible innovation compared to traditional innovation.

Table 2: Key elements that differentiate traditional innovation from responsible innovation.

Prospect	Traditional Innovation	Responsible Innovation
Purpose	Competitiveness, efficiency, profit	Social value, equity, sustainability
Social participation	Limited or advisory	Inclusive, participatory and deliberative
Anticipation of impacts	Focus on technical risks	Proactive ethical, environmental and social analysis
Decision-making processes	Linear, top-down	Reflective, adaptive and responsive
Evaluation of results	Based on technical and economic performance	Based on social and environmental impacts
Application examples	Pharmaceutical industries, information technology	Public health, biotechnology, energy, and smart cities

Source: By the authors, based Owen et al. (2012); Stilgoe et al. (2013); Von Schomberg (2013); Burget et al. (2017); Stilgoe (2020).

The integration of IRR principles into scientific practice and innovation management also requires structural changes in how projects are conceived, funded, and evaluated. It includes strengthening organizational capacities for dialogue with external stakeholders, creating qualitative indicators of social impact, and developing governance structures sensitive to cultural, territorial, and institutional diversity (Mejlgaard et al., 2018).

Despite its theoretical and normative relevance, the RRI approach is the target of significant criticism. De Saille (2015) argues that the concept of RRI has a strong Eurocentric bias, having emerged in the context of the European Union's innovation policies, which may limit its applicability in other cultural and institutional realities. Blok and Lemmens (2015) denounce the ambiguity of the concept, highlighting its dependence on a narrow technological and economic vision, which weakens its practical application in the face of the complexity of real innovation processes. In addition, the instrumentalization of social participation is questioned when stakeholder engagement is reduced to a formal requirement without ensuring effective influence over decision-making, thereby compromising the credibility of the participatory process.

Like social innovation, responsible innovation broadens the scope of the actors involved and the significance of the value generated by innovation. However, while the former tends to emerge from local contexts and social practices, RRI often starts from public policies on science and technology, which are institutionalized in development programs and regulatory frameworks, especially in the global north. Despite their distinct trajectories, both share the ambition to align innovation more closely with contemporary social challenges and, therefore, present areas of convergence and complementarity that deserve exploration.

3. Methodology

Since the objective of the study is to understand the convergences and divergences between the principles and practices of social innovation and responsible innovation, and how they can be integrated into initiatives seeking sustainable impacts, the authors chose to conduct a meta-synthesis of qualitative case studies. According to Hoon (2013), the methodology is suitable for integrating fragmented literature to develop a deeper, more integrative theoretical understanding. This approach is especially useful when seeking to connect emerging domains of research, such as social innovation and responsible innovation, and to generate conceptual contributions from multiple qualitative sources.

Over the past few years, there has been a growth in studies that adopt this methodology, including those connected to social innovation, such as Rocha et al. (2023), who analyzed the generation of social impact, or with responsible innovation, such as Silva et al. (2019), who addressed the role of external stakeholders.

The metasynthesis of qualitative case studies, proposed by Hoon (2013), presupposes a specific research design comprising eight stages. The first step is formulating the research question. In this study, the authors chose to jointly analyze the fields of social innovation and responsible innovation, noting that both address contemporary ethical, social, and environmental challenges. Although with different origins, both share normative fundamentals, such as valuing the inclusion of multiple stakeholders, commitment to sustainability, and orientation towards transformative social impacts. From this understanding, the research question emerges: What are the convergences and divergences between the principles and practices of social innovation and responsible innovation, and how can they be integrated into initiatives seeking sustainable impact?

The second step is to locate relevant searches. To this end, extractions were carried out in June 2025 in the selected databases, Scopus and Web of Science, defining only articles (already excluding book chapters, editorials, etc.), from the last 5 years (2021-2025), in the 10 scientific journals with the highest number of publications, in open access, in the area of "business" and "economics". The search terms used were (1) "social innovation" and (2) "responsible research and innovation" OR "responsible innovation". In all, 402 articles were extracted, as shown in Table 3.

Table 3: Articles extracted from databases.

Database	Social Innovation	Responsible research and innovation OR Responsible innovation	Total
Scopus	61	105	**166**
Web of Science	83	153	**236**
Total	**144**	**258**	**402**

Source: By the authors.

The authors used the Rayyan platform (https://www.rayyan.ai/) to analyze the articles. Of the 402 studies, 109 were duplicates, leaving 293 articles.

The third stage concerns the inclusion and exclusion criteria. Since the selected methodology was to analyze qualitative case studies, the articles were evaluated, and those that did not meet the criteria were excluded. At least two authors evaluated each article to ensure the reliability of the choice. In the end, 51 articles were considered.

The fourth step concerns the extraction and coding of data. To this end, a shared spreadsheet was created for each author to include information about the articles that performed the analysis. To enhance analytical rigor, multiple authors independently coded the studies, followed by iterative discussions to resolve discrepancies and reach consensus on interpretations. Information such as title, author, journal, year of publication, authors, location (geographical), study objective, concept used, context, area of application, main results, and other relevant information was extracted.

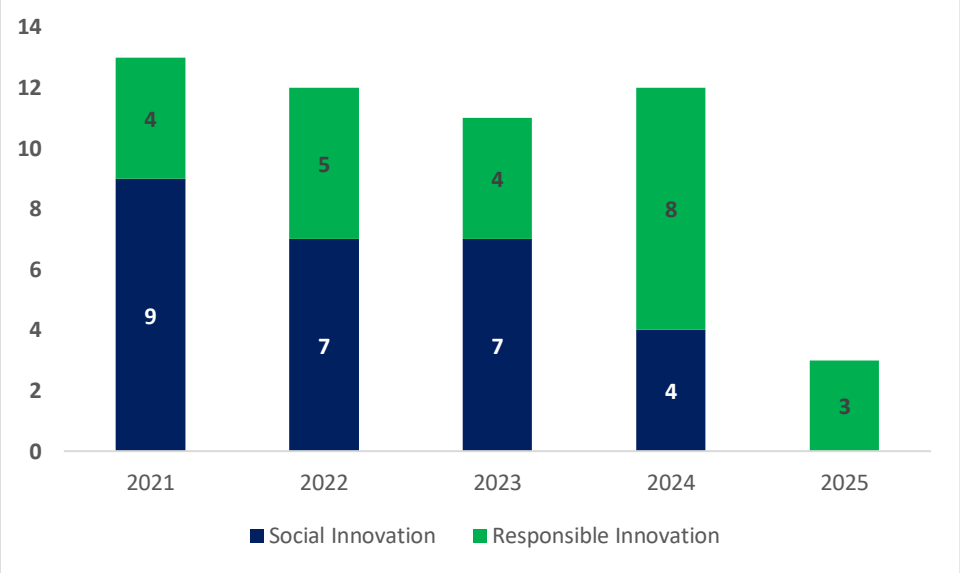
The remaining steps, (5) analyzing at a specific case level, (6) synthesizing at a cross-study level, (7) constructing theory from metasynthesis, and (8) discussion, are summarized in the following sections.

4. Analysis of the Results

4.1. Descriptive Analysis of the Included Studies

This subsection presents a descriptive overview of the studies selected for this meta-synthesis. The analysis includes quantitative and qualitative aspects that allow us to understand the profile and context of the studies that addressed the themes of social innovation and responsible innovation during 2021-2025. Of the 51 selected studies, 27 address the theme of social innovation and 24 of responsible innovation. The evolution of studies over the years is shown in Figure 1.

Figure 1: Publications per year.



Source: By the authors.

Between 2021 and 2014, the total volume of studies published on the themes remained practically the same. Between 2021 and 2024, the theme of social innovation surpassed that of responsible innovation, with 9, 7, and 7 studies published, respectively. However, in 2024, the trend reversed, with 8 studies on responsible innovation and 4 on social innovation. The low number of studies in 2025 is likely due to the incompleteness of that year. However, the 3 selected studies focus on responsible innovation.

Given that social innovation and responsible innovation are generally strongly related to the cultural and socioeconomic contexts in which they are developed, it was decided to analyze the countries where the data were collected for the elaboration of the studies. In a general context, and considering separately the countries that appear together, the most recurrent are Spain, Italy, Austria, the United States, and the United Kingdom, with 4 studies each. Next, with three studies each, Brazil, China and Scotland stand out. South Africa, Canada, the Netherlands, and France follow with two studies each. When analyzing the ten most recurrent countries by theme (Table 4), we noticed that the United Kingdom, the United States, Austria, Brazil and China stand out in the theme of responsible innovation, while Spain, Italy and Scotland stand out in the theme of social innovation. This distinction may indicate both the degree of institutionalization of these concepts in the countries and the development and implementation of public policies that promote such innovations.

Table 4: Most recurrent countries by theme.

Country	Responsible Innovation	Social Innovation	Total
United Kingdom	4	0	4
United States	3	1	4
Spain	1	3	4
Italy	1	3	4
Austria	3	1	4
Brazil	3	0	3
China	3	0	3
Scotland	0	3	3
Canada	2	0	2
Netherlands	2	0	2

Source: By the authors.

To determine the predominant level of analysis for each theme, a categorization was performed based on the origin of the data collection. Studies whose data source was national projects and sectors of the economy were categorized as macro. Studies focusing on organizations such as social enterprises, universities, and nonprofit entities were categorized at the meso level of analysis, and studies aimed at community groups, local centers, and specific populations were categorized as micro. Table 5 presents the data sources for the studies on social and responsible innovation.

Table 5: Origin of data from social innovation studies.

Level of Analysis	Social Innovation	Responsible Innovation
Meso	19	17
Micro	4	6
Macro	4	1

Source: By the authors.

There is a predominance of studies that address cases in organizations. The studies collected data on social enterprises (5), university ecosystems (3), nonprofit entities (2), startups (2), local production systems (2), private enterprise (1), voluntary sector (1), microenterprises (1), cooperative (1), and social entrepreneurship ecosystem (1). The studies that used independent groups/community centers (2) and specific groups of people (2) as the unit of analysis approached social innovation from immediate social contexts, focusing on experiences and perceptions. At the macro level, we have studies that addressed specific national projects (3) and one study that addressed the public sector as a whole.

Responsible innovation studies also prioritize meso-level analyses, as shown in Table xx. Such studies are developed in academic projects, research networks and centers (5), private companies (2), industries (2), health sector (2), startup (1), cooperative (1), university (1), collaboration network (1), energy sector (1) and science and high technology sector (1). Macro-level studies focus on large-scale national projects (6), which address social issues such as mobility, nanotechnology, and urban development. The only micro-level study was conducted with institutional entrepreneurs funded by the European Union's Horizon 2020 Research and Innovation program.

In summary, both themes prioritize analysis in organizational contexts. Social innovation has a more balanced distribution across levels of analysis, which aligns with its ability to engage with more diverse and decentralized social problems. Responsible innovation is clearly more closely associated with the macro level, with strong development in projects led by the public sector, reinforcing their alignment with structured policy agendas.

4.2. Social Innovation and Responsible Innovation: Conceptual Distinctions, Purposes, and Impacts

Although Social Innovation (SI) and Responsible Innovation (RI) can be observed in the same context or object of analysis, they have distinct definitions, characteristics, and purposes, even though they converge in some respects. Both sciences devote attention to long-term social, environmental, and economic issues.

Regarding SI, efforts are made to address specific social needs through new ideas (Lauren et al., 2022). These, in turn, should be characterized by generating significant and lasting changes in systems that benefit the authors' network (Chen *et al*., 2024). SI-driven solutions often involve institutional voids or unresolved societal challenges (Sacchetti, 2022).

RI, on the other hand, is characterized by its reflexivity in research and innovation, especially regarding its implications for society. For example, authors Dabars and Dwyer (2022) emphasize the importance of approaching transformative technologies with care and foresight. The alignment between market (financial) outcomes of innovations with relevant societal objectives should be considered before these technologies are offered to institutions.

In the cases analyzed, we observed a contrast between social innovation initiatives and those of responsible innovation. For example, cases focused on social innovation generally originate from localized social demands—such as community initiatives aimed at inclusion or local development—while cases of responsible innovation more frequently emerge from institutional or research-oriented contexts, where ethical reflection precedes or accompanies technological development. Although both aim to contribute to societal benefits, the empirical cases reveal different logics regarding the framing of the problem, the origin of the initiatives, and the paths to impact. To contribute to a definition of the two concepts, the proposition is presented:

Proposition 1: Social Innovation aims to meet latent social demands, while Responsible Innovation aims to reflect on innovations available in the market or in the development phase.

Generating positive and socially accepted impact is central to both SI and IR principles. Social Innovation is intrinsically driven by the need to address social challenges and create collective value, actively seeking social change and enhancing people's well-being, quality of life, and social relationships (Gustafssona *et al.*, 2023). It manifests itself through "new ideas (products, services, and models) that simultaneously meet social needs and create new social relationships or collaborations" (Sheik *et al*., 2023; Tuckerman, 2022), resulting in profound social changes by altering perceptions, behaviors, and structures. SI-related impacts include:

- Achieving Social Change: Social innovation is a means to achieve social change, with different approaches to "openness" (such as open social innovation) leading to different ways to generate this change (Tuckerman, 2022). There is a tension in social enterprises between maximizing social impact and ensuring financial sustainability. Voluntary organizations and co-creation in urban planning show how social innovation can overcome structural barriers and scale solutions (Khan *et al*., 2023).

- Development and Well-being: Strengthens microenterprises, improves quality of life, and promotes behavioral and social structural changes (Chen *et al*., 2024; Gustafssona *et al*., 2023; Kassim *et al*., 2022).
- Empowerment and Inclusion: Digital technologies expand access, citizen participation, and inclusion of marginalized populations, strengthening fairer urban ecosystems (Petersen & Kruss, 2022; Paredes & Vigiola, 2024). The combination of people-centered design and technology powers sustainable, high-impact solutions (Christopoulos *et al*., 2023).
- Governance and Social Relations: Proposes new models of self-management and collaboration, as alternative forms of urban governance with lower hierarchy (Sheik et al., 2023; Morandeira-Arca *et al*., 2021; Petersen & Kruss, 2022). Voluntary organizations and co-creation in urban planning show how social innovation can overcome structural barriers and scale solutions.

In turn, Responsible Innovation (RI), especially in the field of research and innovation (RRI), acts as a normative framework that seeks to proactively direct research and innovation towards desired outcomes, aligned with social, ethical, and environmental values (Lehoux *et al*., 2021; Heltzel *et al.*, 2022). The impacts related to IR include:

- Addressing major societal challenges: RRI seeks to align the research and innovation process with societal needs and expectations, and to address challenges such as the Sustainable Development Goals (SDGs), climate change, and inclusive growth. It is critical to address these challenges and promote a sustainable future (Lehoux *et al*., 2021; Degbey *et al*., 2024).
- Ethical, Social, and Environmental Value Creation: RI is a normative concept driven by values and purposes, requiring the alignment of economic, social, and environmental objectives for responsible value creation **(**Lehoux *et al*., 2021). Organizations that produce responsible innovations in health, for example, strive to meet ethical, economic, social, and environmental principles **(**Lehoux *et al*., 2021).
- More Acceptable Scientific Outcomes: RRI seeks to ensure that scientific outcomes and outputs are more ethically acceptable, sustainable, and socially desirable (Heltzel *et al*., 2022).

Both social innovation and responsible innovation are focused on generating positive, lasting change, whether through the satisfaction of social needs, the transformation of systems, the empowerment of communities, the creation of shared value, or the direction of science and technology toward a more equitable and sustainable future. A comparative reading of the cases also reveals distinct interpretations of impact between the two approaches. On the one hand, social innovation cases predominantly describe impact in terms of observable and lasting changes in social relations, community practices, or local systems, often emphasizing empowerment, inclusion, and collective well-being. On the other hand, responsible innovation cases frame impact primarily as the alignment of research and innovation processes with ethical standards, social expectations, and long-term sustainability goals, even when a broader systemic change is not immediately observable. These empirical differences underpin a differentiated understanding of impact in social innovation and responsible innovation. Thus, proposition 2 proposes:

Proposition 2: In Social Innovation (SI), impact refers to lasting social change. In Responsible Innovation (RI), the impact lies in the ethical and social alignment of research and innovation processes with society's real needs.

Both approaches also value multistakeholder collaboration as a key element for the development and implementation of innovations with social and ethical impact. However, the analysis of the articles reveals important nuances.

Several studies of social innovation demonstrate that collaboration occurs in a more organic, horizontal manner, often involving local communities, marginalized groups, and grassroots organizations. This participation is central to the conception and execution of the solutions (Bufali et al., 2023; Tuckerman, 2022). In responsible innovation, stakeholder inclusion is often articulated through institutional structures or public policies, assuming a more normative or formalized role, as observed in European projects linked to Horizon 2020. This difference in the

mode of engagement suggests that collaboration in SI is more distributed and bottom-up. In IR, it is articulated from regulatory or scientific contexts.

While social innovation case studies consistently describe stakeholder engagement as emergent, informal, and embedded in local social relations, responsible innovation case studies tend to institutionalize participation through formal procedures, policy frameworks, or research protocols. This contrast suggests different governance foundations underpinning collaboration in each approach. This leads to proposition 3:

Proposition 3: Stakeholder collaboration is central to both approaches, but occurs in a more distributed, spontaneous manner in Social Innovation and in a more institutionalized, standardized manner in Responsible Innovation.

The analysis of data origin levels also confirms a significant structural divergence. RI studies are mostly developed from projects at the macro level, led by public policies, research centers and universities (17 meso, 6 macro, 1 micro). SI studies, on the other hand, show a more balanced distribution between meso, micro and macro levels (19 meso, 4 micro, 4 macro), reflecting its more decentralized and emerging nature. This evidence reinforces the argument that RI has a stronger top-down bias, while SI operates mostly with a bottom-up logic, though it is also tied to established institutions.

Proposition 4: Responsible Innovation tends to emerge in formal institutional contexts with top-down approaches, while bottom-up dynamics, connected to communities, social organizations, and collaborative networks, more often enable Social Innovation.

4.3. Integrative Guidelines between Social and Responsible Approaches

Based on the analysis of the 51 qualitative studies and the previous propositions, this study proposes a set of guidelines that guide the convergence between Social Innovation (SI) and Responsible Innovation (RI), resulting in a hybrid model focused on sustainability. This proposal responds to the call in the literature for more intersectional approaches, capable of articulating social, ethical, and environmental values in contexts of high complexity (Stilgoe et al., 2013; Cajaiba-Santana, 2014; Lehoux et al., 2021).

Social innovation, with its emphasis on citizen participation, local impact, and systemic change (Moulaert et al., 2007; Westley & Antadze, 2010), makes important contributions to the social rooting of innovations. Responsible innovation, on the other hand, adds to the equation the principles of anticipation, reflexivity, inclusion, and responsiveness (Owen et al., 2012; Von Schomberg, 2013), which are fundamental to aligning innovation with collective values and future needs. Integrating these approaches requires rethinking traditional models of innovation and proposing organizational and institutional practices that are both socially relevant and ethically oriented.

Based on this, we propose four integrative guidelines that articulate the strengths of the two approaches:

Guideline 1 — Reflective Co-creation: integrating social deliberation and ethical anticipation

Inspired by the participatory practices of SI and the anticipation and reflexivity dimensions of IR (Stilgoe et al., 2013), this guideline proposes that problem identification and solution design occur in continuous cycles of listening, learning, and critical reflection. Innovation must not only emerge from the community but also consider future scenarios, ethical dilemmas, and potential externalities. Methods such as participatory foresight and social labs can operationalize this integration.

Guideline 2 — Ethical and Responsive Scalability: Expand with contextual responsibility

Although social innovation faces scalability difficulties (Moore et al., 2015), IR contributes mechanisms for responsible adaptation and continuous evaluation. The guideline proposes expanding solutions that meet clear ethical criteria, respect local values, and promote distributive justice. It involves creating adaptive feedback

mechanisms and evaluating impacts not only quantitatively, but also according to qualitative criteria, such as equity, legitimacy, and social acceptability (Lehoux et al., 2021; Degbey et al., 2024).

Guideline 3 — Polycentric and Multistakeholder Governance: aligning social networks and institutional structures

Based on Ostrom (2010) and Howaldt et al. (2016), we propose a governance that combines the spontaneity and horizontality of SI with the institutional capacity of RI. Instead of centralization or excessive informality, it is suggested that polycentric arrangements be formed, in which universities, governments, companies, NGOs, and communities share authority and co-responsibility for innovation. It requires organizational capacities for cross-sectoral collaboration, institutional learning, and policy articulation.

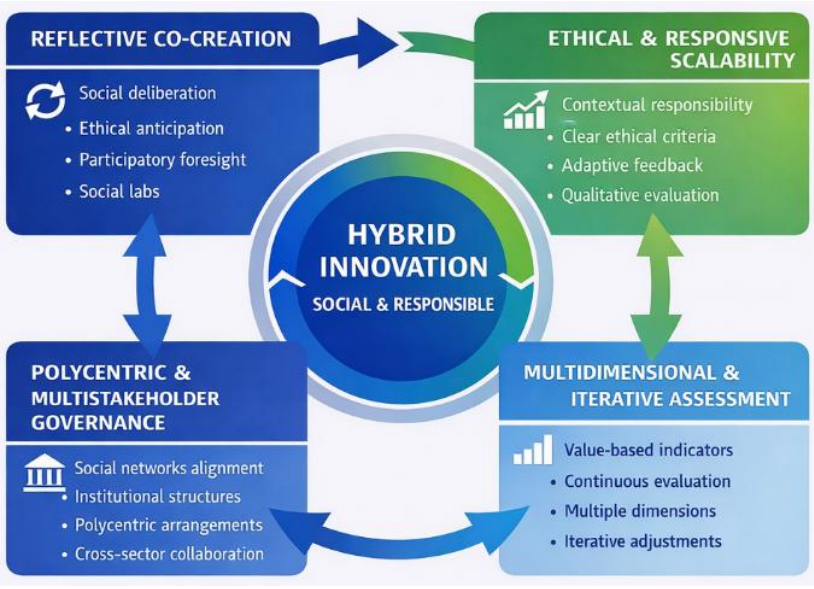
Guideline 4 — Multidimensional and Iterative Assessment: Incorporating Values into the Measurement Process

Evaluating hybrid initiatives should go beyond technical performance metrics or social outreach. Combining the RI accountability criteria (Burget et al., 2017) and the SI systemic transformation indicators (Cajaiba-Santana, 2014), this guideline proposes continuous, iterative, and multidimensional evaluation systems. The indicators should cover social impact, ethical value, institutional transformation, and perceived legitimacy, allowing for adjustments throughout the innovation cycle.

These guidelines do not form a prescriptive model, but rather a flexible analytical framework that can guide managers, policymakers, and researchers in the design and evaluation of sustainability-oriented innovations. Together, they point to the construction of a hybrid innovation field, where ethics, impact and inclusion go hand in hand.

In addition to guiding organizational practices and social strategies, these guidelines offer relevant subsidies for the design of public innovation policies. By articulating ethical foundations and citizen participation, the hybrid model can inspire more responsive, collaborative, and context-sensitive state initiatives, especially in areas such as health, education, the environment, and sustainable urban development. Figure 2 synthesizes these four integrative guidelines, visually illustrating how principles of Social Innovation and Responsible Innovation converge into a hybrid innovation logic.

Figure 2: Integrative Guidelines for Hybrid Innovation Models.



Source: By the authors.

Taken together, the four integrative guidelines synthesized in Figure X do not constitute a prescriptive model, but rather an analytical framework that highlights how social and responsible innovation logics can be articulated in practice. By combining bottom-up social dynamics with top-down ethical and governance-oriented mechanisms, the framework underscores the importance of reflexivity, scalability, governance, and evaluation as interdependent dimensions of hybrid innovation. This integrative perspective advances current debates on sustainable entrepreneurship by moving beyond isolated approaches and offering a coherent lens for understanding how value-driven innovations can be designed, governed, and assessed in complex societal contexts.

5. Conclusion

This article contributed to the theoretical deepening of the fields of Social Innovation (SI) and Responsible Innovation (RI) by proposing a systematized comparative analysis based on a metasynthesis of qualitative case studies published between 2021 and 2025. From the identification of convergences and divergences between these approaches, the study showed that both share normative foundations oriented to social transformation and sustainability, even though they operate with different logics, structures and purposes.

The main theoretical contribution lies in the formulation of four analytical propositions that differentiate SI and IR in terms of focus (social demand versus ethical reflection), impact (systemic transformation versus normative alignment), stakeholder engagement (organic versus institutionalized) and origin of initiatives (bottom-up versus top-down). Based on these propositions, the study proposes a set of integrative guidelines that guide the constitution of hybrid models of innovation, anchored in reflexive co-creation, ethical scalability, polycentric governance and multidimensional evaluation.

This hybrid model represents a relevant conceptual advance by proposing an overcoming of the limits of one-dimensional approaches, reinforcing the importance of integrating social, ethical, and environmental values into innovation processes. By systematizing the elements that favor the articulation between emerging practices and institutional structures, the proposal contributes not only to the construction of more robust analytical frameworks but also to the improvement of public policies aimed at sustainable innovation. Governments and policymakers can benefit from the guidelines presented here to develop more inclusive, responsive, and ethically driven instruments and programs — particularly in sectors such as education, health, smart cities, and socio-environmental transitions.

Among the limitations of this study, the scope of the metasynthesis stands out: it is restricted to qualitative case studies in open access and in the domain of applied social sciences, which may limit the analysis's interdisciplinary breadth. In addition, metasynthesis does not allow empirical generalizations, being more suitable for theoretical construction and refinement.

As a future research agenda, the empirical deepening of the proposed model is suggested through multi-case studies in different sectors and territorial contexts, especially in the Global South. Longitudinal investigations into the transformative effects of hybrid initiatives, as well as the development of evaluative instruments to capture their ethical and social impacts, represent promising avenues to consolidate the field of value-driven innovation.

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Operationalising the quintuple helix in S3: Towards sustainable innovation in tourism

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Abstract

This paper analyses how the Quintuple Helix (QUH) may be designed as a tool for a more efficient operation of the Smart Specialisation Strategy (S3) and its current evolution towards the Smart Specialisation Strategies for sustainable and inclusive growth (S4+), considering tourism as a priority domain and how both can enhance each other. By combining the natural environment and societal actors into policy design, the study argues that adding the QUH model into S3 improves innovation governance. The proposed QUH–S4+ framework links five helices: academia, industry, government, civil society, and the natural environment, forming a collaborative system for sustainable and innovation-driven regional development. This approach assigns a pivotal role to the natural environment as a catalyst for knowledge production and innovation. The QUH emphasises cohesive interaction and knowledge sharing across cultural, political, and economic systems, where cross-regional cooperation can particularly benefit less developed regions that embrace green technologies aligned with the European Green Deal. Innovative technology solutions can completely transform tourism, making the vision of smart tourism a reality. The natural environment is a crucial element of the knowledge-building process, and innovation is particularly crucial since it helps to thrive, better serve humankind, and commit to green technology more successfully. Methodologically, the paper conducts a conceptual, theory-building review, deriving operational propositions and a policy checklist that translates the QUH framework into S3/S4+ implementation in tourism.

Keywords: Quadruple Helix; Quintuple Helix; RIS3; Smart Specialization Strategy; Tourism.

1. Introduction

The study of public policy in the European Union (EU) has grown in recent years mainly due to the economic crisis that has emerged in recent years, combined with the need to sharpen strategic public initiatives to improve regional economic performance necessity. As a result, the Smart Specialisation Strategy (S3) concept has gained traction. It features an innovative, place-based policy framework for regional economic growth, which is a fundamental concept and component of the EU's 2020 innovation program and the new cohesion policy reform. (Foray D., 2014; McCann & Ortega-Argilés, 2015).

S3 in the context of Research and Innovation for Smart Specialisation Strategy (RIS3) is a strategic approach to economic development through research and innovation-focused support. This notion is based on the idea that by concentrating knowledge resources and linking them to a limited number of core economic activities, countries and regions will compete in the global economy and stay competitive (Foray, 2014; Foray et al., 2009, 2012a).

Regional research and innovation policies are used to put the concepts described in S3 into action. The RIS3 promotes entrepreneurship and the building of territorial partnerships between diverse public and private players, as well as the establishment of the necessary conditions for long-term economic development. Local policymakers, universities, and private enterprises are major players in boosting knowledge and innovation (Camagni & Capello, 2013). In this sense, the evolution of innovative models from the Triple Helix (TH) and Quadruple Helix (QH) to the Quintuple Helix (QUH) is especially appealing to European regions. Furthermore,

concerning innovative models, the QUH model reinforces the interaction between public institutions, private organizations, research institutes, local agencies, and the general public within a single environmental system (Carayannis et al., 2012).

The fundamental question that arises is to what degree can S3 be employed with and within a natural environment towards sustainability (QUH model) when considering a specific domain such as tourism as a strategy to boost regional development. This essay aims to establish a meaningful relationship between the concepts to provide valuable insights into this discussion.

Results indicate that S3 is beginning to play an increasingly important role in how regions create their policy frameworks, particularly in less developed areas (Bailey & De Propris, 2019). However, establishing S3 goals considering tourism as a thematic priority for regions is only the beginning, as RIS3 is a continuous process of policy learning, experimentation, and implementation. In addition, extra-regional cooperation towards the QUH practice can benefit all but especially less developed regions, mainly if they result in quicker acceptance of new technologies in this specific case, green technologies, information exchange, diversification, related variety, and better capacities for a green and inclusive economy in line with the UN 2030 Agenda for Sustainable Development and Green Deal (McCann & Soete, 2020). Overall, RIS3 can improve regional resilience and its ability to capitalize on newly emerging market opportunities (Barzotto et al., 2019).

Recent EU guidance reframes S3 as S4+ (Smart Specialisation Strategies for Sustainable and Inclusive Growth) a mission-oriented, place-based logic that couples innovation with sustainability and inclusion through multi-level governance and stronger directionality. For tourism, this transition is anchored in the Transition Pathway for Tourism and the emerging European Tourism Data Space, which together provide the mission logic and the knowledge infrastructure to operationalise QUH in practice.

A quick rundown of the S3 in the sections below is presented. The models of knowledge creation and their major components are then introduced, followed by an in-depth discussion on the QUH on S3. Afterwards, we consider the key ideas and components and the connection between tourism, S3, and the QUH. Finally, the paper ends with some final remarks.

1.1. Methods (Conceptual Review)

We adopt a conceptual, theory-building review to synthesise QUH and S3; S4+ literatures with tourism policy and green/digital transition documents. We searched Scopus and Google Scholar (2014-2025) using combinations of “smart specialization/RIS3/RIS4/S4+”, “quintuple helix/quadruple helix”, “tourism transition pathway/data space/living labs”, and “related variety/creative and cultural industries”. Inclusion emphasised peer-reviewed articles, EU policy reports, and JRC guidance. We used an abductive approach: (i) map constructs; (ii) identify operational mechanisms per helix; (iii) derive propositions and a policy checklist. Limitations: we prioritise breadth over exhaustiveness and focus on EU-centric sources.

2. Smart Specialization Strategy

The EU's current economic development strategy is based on territorial-based policies aimed at promoting competitiveness by increasing socio-economic innovation capacity. The structuring axis of this strategy is S3, in which the current programs of Horizon Europe are based, and which had an influence already in the previous framework program.

The S3 that regions are challenged to achieve assumes that innovation and the competitiveness of regions should be based on their characteristics and assets existing in their territory, concentrating resources on the areas and economic activities in which there is or can be pooled with relevant critical mass, with the aim of creating value and employment. This approach to S3 reinforces the need for regions to reassess their competitive positioning according to the global market and their capacity for international affirmation (Asheim et al., 2017; Foray et al., 2012a; McCann & Ortega-Argilés, 2015).

S3, in the context of RIS3, is a strategic approach to economic development through research and innovation-focused support. RIS3 is a proposed "ex-ante conditionality" for a local approach to regional growth. Meaning that before they can obtain financial support from the EU through the Structural Funds for their planned innovation measures, all Member States and Regions must have a well-developed strategy (EC, 2014; Foray et al., 2012a). The concept is based on the idea that by concentrating knowledge resources and linking them to a small number of core economic activities, countries and regions will be able to compete in the global economy and stay competitive. (EC, 2014; Foray et al., 2012a). Hence regions cannot be competitive in all areas of knowledge, innovation, and technology. Therefore, it is necessary to prioritize to concentrate resources in certain areas, considering the existing capacities of the region. The purpose is to reinvent regional trajectories and create new ones, fixed in existing assets in the region, with the aim of diversifying the regional economic structure and increasing its innovative delivery, concentrating resources and skills in a set of areas where the region shows greater aptitude and installed resources (Foray, 2014).

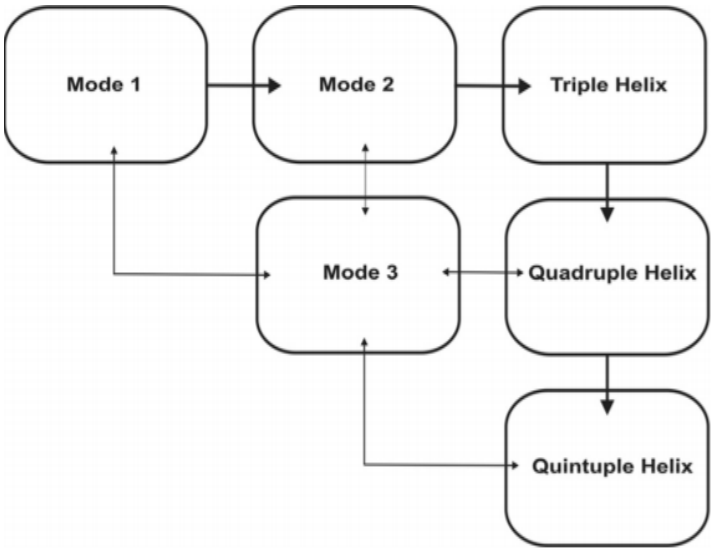
For the regional dynamics of innovation and the very system governance, the vision of a QH is commonly assumed as structuring of RIS3. However, the relevance of academia, government agencies, the business fabric, and users and other beneficiaries do play a key role in the implementation phase of this typology of strategy that must be endorsed with an entrepreneurial discovery process (EDP), where the foremost players try to find areas of knowledge and economic activities capable of becoming engines of economic change (EC, 2014; Foray, 2014; Foray et al., 2009, 2012a).

3. Models of Knowledge Creation

Knowledge has the potential to be a crucial factor in achieving long-term development success. Essentially, it should be known today that nation-states focused on societal growth, economic competitiveness, or a better and more sustainable quality of life must use information as a resource. In the transition to a knowledge-based society, knowledge-based economy, or knowledge-based democracy, there are several factors to consider (Carayannis & Campbell, 2009, p. 224), namely, the possibility to generate new and usable knowledge in conjunction with sustainable development under the guise of S3. As a result, knowledge becomes a highly vital resource (Lundvall, 1992).

Knowledge is developed as a resource through creative processes, combinations, and creations in so-called 'Knowledge models' or 'Innovation models,' and is thus made available to society: The authors also call this the 'creativity of knowledge creation' (Carayannis & Campbell, 2010a, p. 48). There are six current models of knowledge creation and innovation creativity as follows (Carayannis et al., 2012, p. 3):

Figure 1: Evolution of the models of knowledge creation.



Source: Carayannis et al. (2012, p. 3).

Associated with the Linear Innovation Model, Mode 1 (Gibbons et al., 1994), 'focuses on the traditional role of university research understanding' were a success. This production occurs mainly through fundamental research practised in universities or other higher education institutions, in a logic of separation of scientific fields, organized in a disciplinary structure. (Carayannis and Campbell 2011).

Mode 2 is typified by: (1) "knowledge produced in the context of application," (2) "transdisciplinary," (3) "heterogeneity and organizational variety," (4) "social accountability and reflexivity," and (5) "quality control" (Gibbons et al., 1994, p. 3). The transition that has occurred at the social system level, according to Mode-2, has transformed the way knowledge is produced. They propose that scientific knowledge has become redundant and should be replaced with technical-scientific knowledge developed through transdisciplinary projects. It focuses on problem-solving through the application of knowledge.

The Mode 3 knowledge production system advocates that innovation networks and knowledge clusters are significant components for understanding the dynamics of stocks and knowledge flows. Through networks of variable configurations and platforms, universities and other higher education institutions and companies connect by creating innovation networks and knowledge clusters, emphasizing the coexistence and co-evolution of diverse modes of knowledge and innovation. Mode 3 supports interdisciplinary thinking and transdisciplinary application of multidisciplinary knowledge and the coexistence and co-evolution of diverse knowledge and innovation paradigms (Carayannis & Campbell, 2010a).

The TH model is an analytical tool for the study of the complex dynamics underlying the evolution of knowledge-based economies and innovation systems (Etzkowitz & Leydesdorff, 2000). The constant need to innovate increasingly reinforces the importance of knowledge for economic or innovation systems, intensifying the strengthening of networks of relations between 3 main axes - university, industry, and government institutions (Carayannis & Campbell, 2010a).

The QH Model adds the university, industry and government institutions, civil society, and the public, shaped by culture and the media. It attaches importance to the culture of knowledge and knowledge of culture, to values and lifestyles, to the heterogeneity and diversity of the modes of knowledge production and innovation. It puts the sciences and the arts in the same way and involves the concept of democracy of knowledge. In the design of knowledge and innovation strategies and policies, in the authors' opinion, the contribution of the public and media dynamics to the successful pursuit of goals and objectives should be recognized (Carayannis & Campbell, 2009, 2010a).

The QUH purpose and interest are to include the natural environment as a new subsystem for knowledge and innovation models, establishing "nature" as a major and analogous component of and for knowledge creation and innovation. The natural environment is essential for the process of knowledge production, and the creation of innovation is especially important because it aids in the preservation, survival, and vitalization of humanity, as well as the potential development of new green technologies. 'Sustainable development' and 'social ecology' become ingredients for social (societal) innovation and knowledge production with the helix of natural environment. As a result, the exchange of knowledge in a state (nation-state) is dealt with in a QUH by and via the five helices to foster knowledge-production-based sustainable development.

The Quintuple Helix Model is interdisciplinary and transdisciplinary at the same time: the complexity of the five-helix structure implies that a full analytical understanding of all helices requires the continuous involvement of the whole disciplinary spectrum, ranging from the natural sciences (because of the natural environment) to the social sciences and humanities (because of society, democracy, and the economy) (Carayannis & Campbell, 2010a, p. 62).

Overall, the QUH Model emphasizes the role of the environment of societies and economies as a driver for further advances in knowledge production processes and in innovation systems. It builds on the TH and QH models by adding a fifth helix to represent the natural environment, in which the environment or natural

environments are represented by the fifth helix (Carayannis & Campbell, 2010a). The Mode-3 innovation ecosystem frames the QH and QUH models and balances the non-linear models in the context of innovation systems, mirroring the coexistence and co-evolution of different paradigms of knowledge and innovation. Within the scope of the QH and QUH Models, the concept of Open Innovation Diplomacy (OID) emerges as a new strategy, an approach of making policy in terms of governance, essentially consisting in shortening distances and promoting initiatives to connect agents, ideas, markets, and solutions. *OID qualifies as a new and novel strategy, policymaking, and governance approach in the context of the QH and QUH innovation helices* (Carayannis & Campbell, 2011, p. 328).

To move beyond descriptive helices, we specify operational mechanisms, per helix, that convert QUH into governance routines (EDP cadence, data sharing, demand-side instruments) aligned with S4+ missions in tourism.

4. Towards a Quintuple Helix in Smart Specialization Strategy?

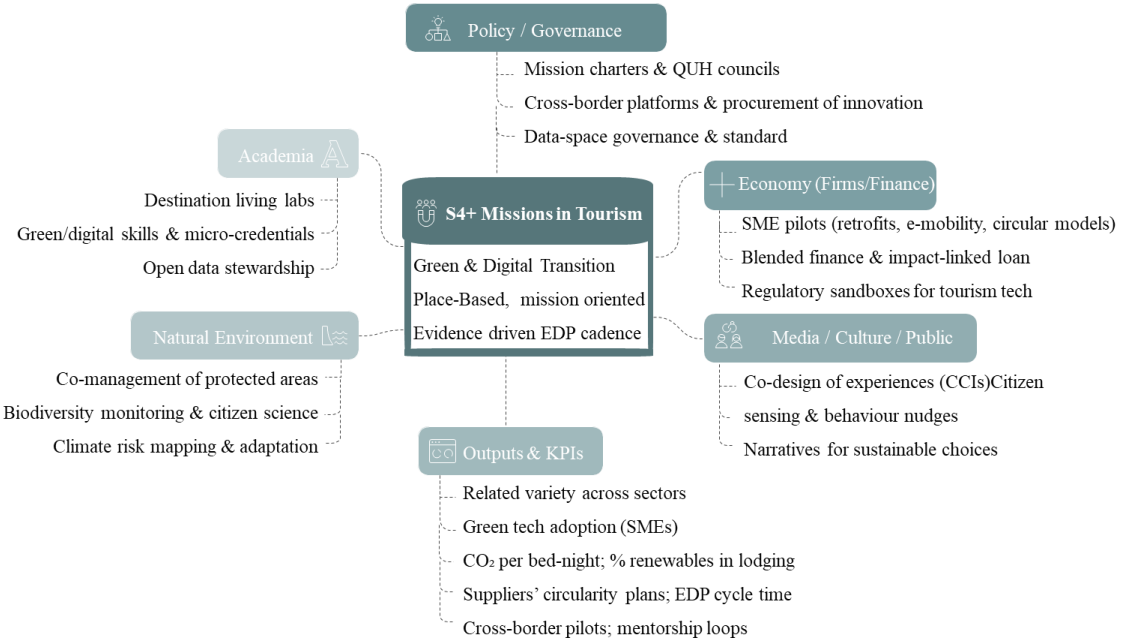
S3 enables regional and national policymakers to concentrate on several key processes in the knowledge economy and society, providing evidence that further facilitates innovation in a range of trans-disciplinary areas. The RIS3 focuses on the need to reinvigorate regional policies, hence stimulating the development of regional innovation systems, which must be conceptualized and executed with a top-down view, i.e., across government, university, and industry sectors and localities (Leydesdorff, 2012) complemented and enhanced by a bottom-up set of insights coming from the civil society. This is the operationalization of the QH innovation helix concept in the context of RIS3 (Carayannis & Rakhmatullin, 2014). (see Figure 2).

Figure 2: RIS3 Quadruple Helix.

Source: Authors' elaboration based on RIS3 Guide (Foray et al., 2012a).

Figure 2 recaps the canonical Quadruple Helix used in RIS3 governance. Building on this architecture, our contribution is to move from descriptive helices to operational mechanisms. Figure 3 therefore specifies, for each helix, concrete governance routines—EDP cadence, data sharing and demand-side instruments—and the outcome KPIs aligned with S4+ missions in tourism.

Figure 3: Operationalising the Quintuple Helix (QUH) for S4+ in Tourism - mechanisms by helix and outcome KPIs.



Source: Authors' elaboration based on Carayannis & Campbell (2010) and EC materials on S4+/Tourism.

Figure 3 summarises the operational mechanisms per helix that translate QUH into S4+ governance routines in tourism (EDP cadence, data sharing, and demand-side instruments). Building on this logic, KPIs for tourism S4+ missions can be operationalised with standardised indicator sets tested in outermost regions, covering energy, emissions, mobility and circularity at destination and firm levels. Recent work validates a portable grid of sustainable tourism indicators for RUP contexts, offering a ready baseline for CO_2 per bed-night, renewable energy uptake in lodging, and supplier circularity plans (Leite et al., 2022). This operational turn is coherent with recent theory linking creativity and entrepreneurship in policy design (the W.O.M.B. model) (de Almeida Leite, Audretsch & Leite, 2025).

While one identifies key operational mechanisms and outcome indicators for S4+ missions in tourism in Figure 3, a significant challenge lies in monitoring and measuring the long-term impact of these governance processes. The QUH-S4+ framework proposed in this paper embeds measurement as an integral part of its adaptive governance logic. The model views evaluation as a feedback mechanism that supports continuous learning and policy adjustment rather than as an external activity (Schot & Steinmueller, 2018).

Multidimensional assessment in three interconnected domains is necessary for long-term monitoring: (i) the intensity and diversity of multi-helix collaboration; (ii) the integration of sustainability and digital objectives within innovation projects; (iii) the evolution of tourism sustainability performance over time.

These dimensions can be operationalised using established European instruments such as the European Tourism Indicator System for Sustainable Destinations (EC, 2013), the ISO 37101 standard for sustainable development in communities (ISO, 2016), and the Regional Innovation Scoreboard in accordance with RIS3 monitoring practices (EC, 2025). This strategy aligns with the innovation policy principles of transformative learning and adaptive governance (Schot & Steinmueller, 2018). It is consistent with earlier studies on using indicator-based systems to measure sustainability in tourism (Torres-Delgado & Palomeque, 2014).

This approach depends on ensuring data interoperability between tourism observatories, statistical agencies, and regional innovation systems. To establish periodic monitoring cycles, for example, every three years, would track cumulative impacts and capture learning effects at all governance scales. In this way, the QUH-S4+

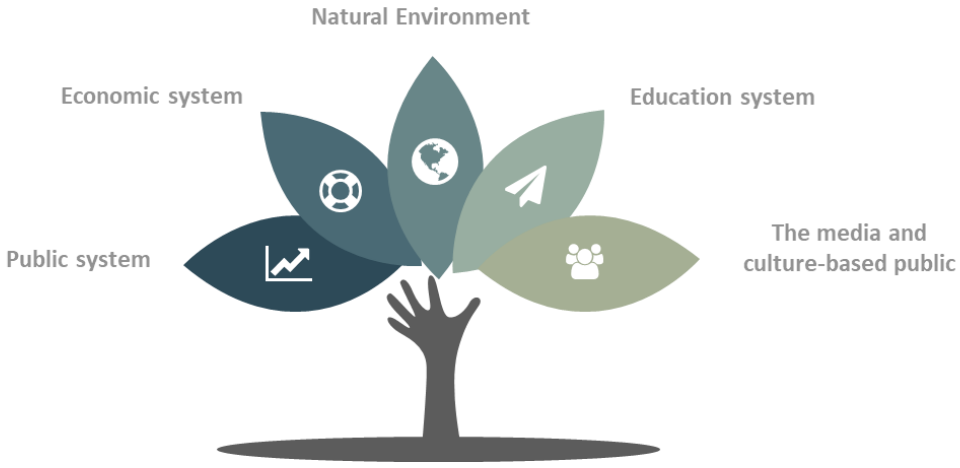
framework functions as a learning system, translating data into adaptive governance and supporting evidence-based transitions to sustainable and smart tourism ecosystems.

Although previous studies have proposed indicator sets for the Quintuple Helix model (e.g. Barcellos-Paula et al., 2021; Sudiana et al., 2020), there remains no standardised matrix covering all five helices within a tourism-specific S4+ context. Further empirical research will therefore be needed to validate and refine the indicator grid proposed conceptually in this framework.

The European Commission (EC) has set the goal of moving from a knowledge economy to a knowledge society, explicitly referencing the QH model of innovation (Carayannis & Campbell, 2009). More specifically, the QH model is based on the openness of innovation processes to civil society for the application of the S3, surpassing the third helix model developed by Etzkowitz and Leydesdorff (1997), which was based on the relationships between the public system, universities, and business. Pursuing the QH model, the users' orientation is expected to develop and produce, as well as to access new products, processes, and industrial services. At the same time, we need an additional step to identify a new layer of regional innovation processes. Moreover, the QUH stresses the importance of the natural environment as an asset to produce knowledge and innovation. The QUH model comprises five helices: the education system, the economic system, the natural environment, the media- and culture-based public, and the political system (Carayannis & Campbell, 2010a).

For completeness, Figure 4 restates the generic QUH architecture that underpins these mechanisms, highlighting the natural environment as the fifth helix.

Figure 4: Quintuple Helix.



Source: Authors' elaboration based on Carayannis and Campbell (2010).

The natural environment is considered a central element to produce knowledge and innovation, being a unique source for the very survival of humankind. The creation of new green technology and innovative processes geared towards sustainable development become fundamental for fostering innovative long-term strategies. Protection of the Environment and biodiversity propels knowledge and innovation in the direction of a sustainable and social economy where all the actors are involved and responsible for the formulation of strategies for local development. The model is a framework for transdisciplinary analysis of sustainable development and social ecology that is capable of rendering less developed regions more competitive (Carayannis & Campbell, 2010a).

Within S3, the innovation is increasingly seen as an open system where multiple actors collaborate to foster inclusive governance that encourages both conventional and new innovators (Provenzano et al., 2018). New political aspirations are needed so that innovative practices and green technology solutions drive sustainable development; the environmentally conscious use of resources becomes a key factor for long-term strategies that will lead to interconnections or cross-border linkage between dominant and bordering regions (Carayannis et al.,

2012; Provenzano et al., 2018). As a side effect, the evolution of innovative models such as the QUH, which aims to strengthen the interaction between public institutions, private organizations, research institutes, local agencies, and the public within a single environmental system, is particularly appealing to lagging regions (Provenzano et al., 2018).

5. In the Field of Tourism, How Would a Smart Specialization Strategy Incorporate the Quintuple Helix Model?

It is critical to ensure that all S3 adopted by EU regions and Member States are anchored on a solid foundation in terms of priorities, governance, cooperation, monitoring, and evaluation over the current programming period 2021-2027. Deepening S3 also entails including the sustainability dimension, which is critical for meeting the EC's objective for achieving competitive sustainability. In addition to its economic and social foundations, SS's green dimension must be reinforced, in line with the European Green Deal.

Concretely, the Transition Pathway for Tourism specifies priority actions for green and digital upgrades, while the Tourism Data Space underpins interoperable, privacy-preserving data sharing across destinations and firms. Together, they shorten EDP cycles, inform evidence-based prioritisation, and enable cross-regional learning consistent with QUH.

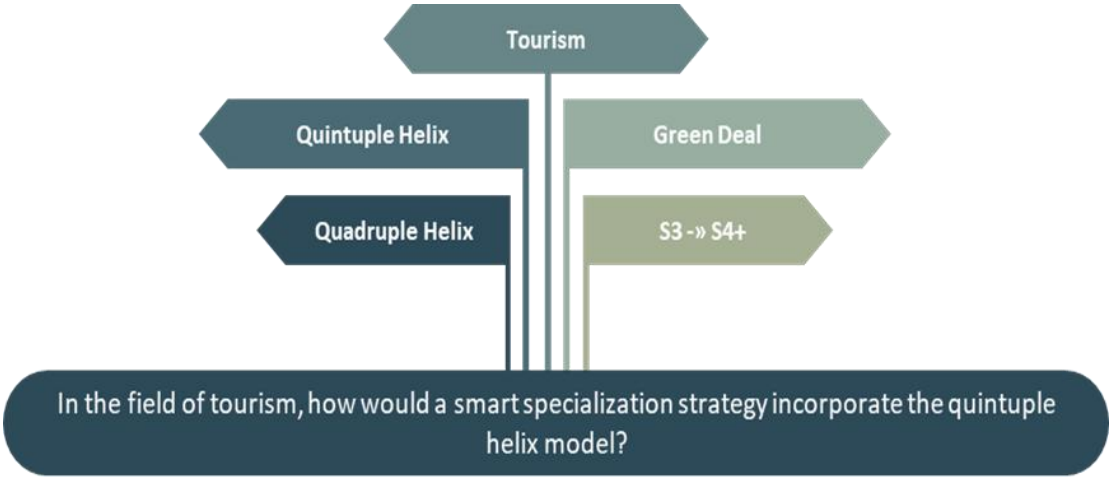
The EC prioritized sustainability and European values in its long-term policy agenda, the European Green Deal lays out a roadmap for the EU to achieve carbon neutrality by 2050. The UN Sustainable Development Goals (SDGs) will guide policy efforts and changes in Europe and beyond. This is a policy agenda based on innovation for new systemic solutions and job development as a result of the ecological and digital transformations (McCann & Soete, 2020).

As McCann and Soete (2020) eloquently phrase it: *the European Green Deal is at the same time the EU's Moonshot mission and its global S3*. They do emphasize, however, that this journey will not be without its challenges. A sustainable place-based innovation policy will necessitate multi-level solid governance and policy flexibility to address potential adjustments soon. On the other hand, bottom-up leadership must be combined with a new directionality of sustainability and inclusion. The authors refer to this as the transition from S3 to S4+ (smart specialization strategies for sustainable and inclusive growth).

McCann and Soete (2020) propose a shift in policy logic from S3 to (S4+), using a non-neutrality, direction, and system approach to involve regions in European initiatives to reinforce the S3 mission-oriented policy approach. S4+ denotes a policy shift in how regions think about defining policy priorities to encourage technological innovation and regional solutions to societal concerns.

According to the information presented in this essay, the QUH is an adequate model in principles and application for society to perceive the link between knowledge and innovation, to promote ongoing development. This contribution, under the theme of S3, focuses on the following crucial question: how can sustainable development regarding S3 be practised with and within a QUH model, considering a specific domain such as tourism?

Figure 5: S3, QUH and tourism.



Source: Authors' creation.

Because tourism is a critical industry for several places and boosting it suits well within a cross-sectoral logic, S3 is a viable policy framework for tourism (Benner, 2017; Del Vecchio & Passiante, 2017; Weidenfeld, 2018). A new policy mix centred on interconnecting determined priority thematic areas with other cross-cutting concerns like tourism and ICT to displace fragmented government policies (Bečić & Švarc, 2015).

A concrete illustration of related variety within tourism ecosystems is the rise of digital nomads in island regions. Evidence from Madeira documents how new workleisure mobilities trigger cross-sector linkages (accommodation, co-working, CCIs, mobility services), consistent with QUH dynamics and with our Proposition P2 (Sardinha et al., 2023).

To incorporate the sustainability dimension, tourism appears as an asset in pursuing SS. Due to the diversified range of services that make up a destination's production chain, tourism has much potential to become a central feature of S3. (EC, 2016; Weidenfeld, 2018). Also, a wide variety of economic activities is required to supply products and services in a tourism destination, establishing a decentralized value chain that facilitates the formation of different ties and exchanges within local and regional economic systems. (Erkuş-Öztürk, 2016; Romão, 2020a, 2020b). As a result, tourism emerges as a viable economic activity capable of forging intra-sectoral solid interconnections promoting innovation and long-term sustainability (Benner, 2020; Lazzeretti et al., 2016). Furthermore, knowledge externalities and spillover effects emerging from the development of a creative regional economy, where various industries contribute to diversifying regional economic structures, might promote tourism development and innovation (Aarstad et al., 2016; Bečić & Švarc, 2015; EC, 2016; Romão, 2020b; Romão & Nijkamp, 2018).

According to Benner (2020), SS presents an opportunity for economies to revitalize their tourism development strategies by connecting tourism to other sectors and priorities in order to promote tourism environmental sustainability, keeping in mind that the green deal is seen as a path to the green transformation of the tourism ecosystem.

Benchmarks help regions position their strategies. Eye@RIS3 reveals how many regions prioritise tourism and adjacent domains (e.g., CCIs, health, blue economy), supporting related variety plays. Cross-regional alliances (e.g., RIS4-oriented networks) operationalise extra-regional cooperation, a key QUH lever for lagging regions.

In outermost regions, intermediation capacity has been mobilised via the OSEAN initiative, which orchestrates QUH actors around mission-oriented pilots (skills, digitalisation, sustainability) and cross-border exchanges, an example aligned with P1 and P4 regarding living labs and policy brokering (Leite & Leite, 2024). Complementarily, network studies of resilient innovation ecosystems in EU Outermost Regions highlight the role of critical assets

and value networks for implementation effectiveness—again consistent with our moderation claim in P4 (Schwabe et al., 2025).

According to Turismo de Portugal[1], within the framework of the green deal strategy, there are several initiatives proposed by the Commission that may have, in the short/medium term, a direct or indirect impact on tourism:

- "Proposal for the Climate Law, which establishes the objective of carbon neutrality in the EU by 2050
- Review of existing environmental legislation: CELE (Trading in CO2 Emissions), Use of Land and Forests; Energy Efficiency Directive; Energy Taxation Directive (Electricity VAT)
- New EU Climate Change Mitigation Strategy, especially for coastal regions (relevance for coastal tourism activities, especially given the potential reduction in the attractiveness of these regions)
- New smart planning strategy, including land planning
- Public building recovery initiative (hotel schools, airports, tourism support infrastructures) and private (tourist developments and related infrastructure)
- New Action Plan for the Circular Economy
- EU strategy "from meadow to plate" to be complemented with national strategies in this field
- 2030 Biodiversity Strategy, where the Sustainable Tourism aspect may have a strategic contribution
- New EU Zero Pollution Strategy, which will include the proposed action plan "zero pollution for water, air and soils"
- Improvement in the statistical production and auditing processes of companies, avoiding "greenwashing" (unjustified appropriation of environmental virtues by organizations – companies, governments – or individuals, using marketing techniques)".

Delivering these ambitions requires digital maturity and future-skills across the ecosystem. Editorial guidance in JER frames “digital creativity” as a lever for capability-building in SMEs and public administrators—precisely the skills dimension embedded in S4+ and in our helix-specific mechanisms (Figure 3) (Vezzani et al., 2024).

Innovative technology solutions have the potential to completely transform this industry, making the vision of smart tourism a reality. Moreover, by investing in the environmental sustainability of the tourism sector, sustainable, smart, and green tourism are becoming valuable and tangible. Reductions in energy use and harmful pollution will result in a more economical, socially, and environmentally sustainable tourism industry.

Climate-transition pressures in hospitality are now systematically mapped: a recent systematic literature review identifies adaptation and mitigation fronts in lodging (energy retrofits, water, waste, mobility), reinforcing the priority of green-tech adoption and measurement in our S4+ KPI set (Mota, Leite & Ghasemi, 2024).

Nevertheless, governments have a critical role in setting the necessary conditions to pursue the digital transformation for the tourism ecosystem. Therefore, to maximize the value of digitalization is necessary an integrated and cohesive policy measure.

5.1 Propositions and testable implications

Building on the QUH–S4+ rationale and the tourism policy pathway discussed above, we advance four testable propositions to guide empirical work and policy evaluation in tourism ecosystems:
The QUH–S4+ framework integrates the ecological and social dimensions of innovation into regional policy design. It assumes that innovation for sustainability depends on collaborative governance, evidence-based decision-making, and systemic learning mechanisms. Based on research on the QUH model (Carayannis & Campbell, 2010b) and S3 (Foray et al., 2012b; McCann & Ortega-Argilés, 2016) the following propositions explain how this integration could improve the shift to S4+.

[1] https://business.turismodeportugal.pt/en/Conhecer/Oportunidades_UE/programas-iniciativas/Pages/european-green-deal-pacto-ecologico-europeu.aspx

P1. Regions with QUH operational living labs exhibit higher green-tech adoption in lodging and mobility than comparable regions without labs.

P2. A formal S4+ mission is positively associated with related variety between tourism and CCIs/health/blue economy.

P3. Participation in a Tourism Data Space accelerates EDP cycles and reduces information asymmetries, increasing SME innovation outcomes.

P4. Intermediation capacity (policy brokers/authorities) moderates the relationship between S4+ design and implementation effectiveness.

Note: These propositions are designed to be operationalised with standard indicators (e.g., CO_2/bed-night, % renewable energy in lodging, number of cross-sector linkages, EDP cycle time, SME innovation outputs), enabling comparative analysis across regions.

Together, these four propositions outline a conceptual architecture for embedding the Quintuple Helix within Smart Specialisation to advance S4+. Although they were conceived theoretically, they are already observable in practice in the growing policy and innovation ecosystems of European tourism, particularly those organised as Living Labs that test sustainable integration and multi-actor collaboration. The following section presents such illustrative cases, highlighting how the principles of the QUH–S4+ framework are being interpreted and tested within ongoing European initiatives.

6. Living Labs as Emerging QUH-S4+ Ecosystems

This section builds on the theoretical propositions mentioned above by giving examples of how the principles of the QUH-S4+ framework are being used and understood in current tourism innovation projects. These cases are not empirical tests of the model but examples of alignment between S3 and the multi-helix logic of collaborative, sustainability-oriented governance. Each case reflects one or more of the Propositions 1 to 4, showing how the framework's underlying mechanisms can manifest across distinct governance levels and territorial contexts.

The Spain Living Lab (SLL)[2] is a nationwide open innovation ecosystem designed to revolutionise the tourism sector by transforming its economic model into one based on Artificial Intelligence (AI). Led by the Canary Islands and funded by European RETECH funds, the project involves seven autonomous communities: the Canary Islands, Navarre, Andalusia, Aragon, Asturias, Castilla-La Mancha, and the Balearic Islands.

The main goal is to create a positive feedback loop of innovation by using Living Labs (businesses that test disruptive technologies) to generate data, sharing that data in Data Spaces, and using that data to develop AI. This organization seeks to increase the sector's competitiveness and promote an innovative culture. More than 300 hotels and 450 travel agencies in Spain will be converted into data labs, generating information for the predictive improvement of demand, pricing, products, and experiences. SLL utilises technologies such as AI, Virtual and Augmented Reality (VR/AR) to create hyper-personalised systems and achieve maximum efficiency.

The project explicitly describes itself as structured within a quintuple-helix framework, linking academia, government, business, civil society and environmental actors. This configuration reflects Proposition 2 (multi-helix knowledge co-creation) and Proposition 4 (multi-scalar coordination) of the QUH–S4+ model:

- Proposition 2 is visible in the co-development of shared data and sustainability solutions among research, business, and policy actors.
- Proposition 4 is observable in the project's vertical coordination, where national governance interacts with regional adaptation and experimentation.

[2] Spain Living Lab

The **Alimara Living Lab (ALL)**[3] is an open innovation ecosystem and a real-world experimentation environment based at the Alimara University Hotel in Barcelona. Driven by the CETT Barcelona School of Tourism, Hospitality, and Gastronomy, ALL aims to drive change and innovation in the hospitality and restaurant sectors. It serves as a platform for collaboration, bringing together businesses, organisations, researchers, and experts to develop and test ideas jointly. Process optimisation, risk mitigation, and enhancing customer satisfaction and operational effectiveness are the main goals of ALL's services.

The lab operates in three main areas: the hotel/gastronomy industry, the technology sector (tech), and the equipment/design sector (contract). ALL uses participatory methods (design thinking) and promotes sustainable transformation, encompassing areas such as Circular Economy and Emerging Technologies. Its activities covering circular hospitality, responsible urban tourism and digital transformation mirror Proposition 1 (sustainability-oriented collaboration) and Proposition 2 (multi-helix co-creation):

- Through sustainability-focused projects, the Lab integrates environmental and social dimensions into innovation, as envisaged in Proposition 1.
- Its collaborative platform, involving university, business and policy actors, embodies Proposition 2, reinforcing the knowledge-exchange logic of the Quintuple Helix.

The ALL thus operationalises the role of universities as policy intermediaries, mediating between scientific knowledge and policy implementation, an aspect central to the QUH-S4+ framework.

The Urban Leisure and Tourism Living Lab (ULTL)[4], rooted at Inholland University of Applied Sciences, operates in Amsterdam North and Rotterdam South, off the beaten tourist track. The Lab redefines tourism, using it as a lens to improve the quality of urban life, rather than viewing it as an end in itself. Its focus is on making tourism act as a catalyst for social cohesion, healthy urban development, and regenerative placemaking.

ULTL focuses on hyperlocal engagement, ensuring that tourism serves communities rather than burdening them. The QH (residents, businesses, municipalities, and students) and the QUH (including nature itself, such as programs on urban animals and rooftop biodiversity) require collaboration. The Lab integrates students from diverse disciplines in real and deeply rooted intervention projects to create sustainable, safe, and fun places (placemaking), such as the creation of the "Story Bench" in Amsterdam.

The ULTLab unites municipalities, tourism organisations, creative industries and residents to co-design sustainable and inclusive tourism experiences. Its iterative experimentation and feedback mechanisms closely align with Proposition 3 (data-driven and adaptive governance) and Proposition 4 (multi-scalar policy coordination):

- Proposition 3 is reflected in the Lab's emphasis on continuous monitoring, feedback and learning loops across participating cities.
- Proposition 4 is evident in its multi-level cooperation structure, which enables knowledge transfer between local initiatives and broader European innovation agendas.

It demonstrates how S4+ principles of openness, evidence-based learning and sustainability integration can be implemented in a cross-regional tourism innovation context.

The three Living Labs collectively illustrate that the core mechanisms hypothesised in the QUH–S4+ model (propositions 1 through 4) are observable, albeit in exploratory form, across distinct governance scales:

- Proposition 1: Environmental and sustainability concerns are integrated into innovation design (ALL, ULTL).
- Proposition 2: Cross-sectoral collaboration is central to knowledge co-creation (SLL, ALL).
- Proposition 3: Data-based and learning-oriented governance emerges through iterative experimentation (ULTL, SLL).

[3] Alimara Living Lab
[4] Urban leisure and Tourism Living Lab

- Proposition 4: Multi-scalar coordination connects local experimentation to national and European policy frameworks (SLL, ALL, ULTL).

Therefore, even though the QUH-S4+ framework has not been institutionalised as such, these efforts offer illustrative proof of its applicability and indicate that its theoretical principles are observable within current innovation activities. They also highlight the potential of Living Labs to act as translational infrastructures between S3 and the broader sustainability missions of European tourism policy.

7. Conclusion

At this point, we are most likely trying to describe a modus operandi rather than a model of analysis. However, some observations may help advance the debate about the challenges of moving towards a QUH structure within S3, and even more challenging is the inclusion of tourism in this transformation.

The essay underlines how the logical structure of the QUH model can enhance the S3 framework by introducing an explicit ecological and societal dimension. It is reasonable to infer that a healthy natural environment combined with participatory governance may balance top-down planning with bottom-up experimentation, especially in the context of the green and digital transitions in tourism, even though no empirical confirmation was undertaken.

Territories fixing their efforts in cooperation, involving various stakeholders and groups of interest in policymaking processes, may create durability for the decisions made. Furthermore, the availability of technology, more specifically concentrating efforts on the green side of tech, helps provide a new approach to studying the tourism domain within S3 towards a QUH framework. Long-term collaboration between researchers, businesses, and users abolishes traditional approaches, and the QUH can value assets that are not assured in a conventional economic paradigm.

The QUH innovation model shows how this societal and environmental change can be successfully handled in tandem with knowledge production and innovation policy by providing a solution-oriented approach to problem-solving and long-term development. In a QUH system, knowledge is not only a factor of production but the driving force of transformation, linking research, governance, and community learning to build cooperation mechanisms for sustainable development (Carayannis & Campbell, 2010a; Provenzano et al., 2018).

The four propositions advanced in this paper articulate how the QUH-S4+ framework may transform S3 into a more inclusive and sustainability-oriented system. The Living Lab examples discussed do not constitute empirical tests of these propositions but illustrate their observability in current innovation practices. They demonstrate that regions and institutions are already experimenting with collaborative governance, sustainability metrics, and cross-regional learning, all of which are essential to the transition from S3 to S4+. Such initiatives provide the proof of concept that the principles of the QUH-S4+ are transferable, measurable, and policy-relevant. They suggest that the path forward lies not in creating new frameworks but in translating existing S3 instruments into a QUH logic that privileges cooperation, ecological intelligence, and adaptive policymaking.

Towards a QUH may enhance the effectiveness of S3 by reducing economic and territorial inequality while capitalising on the spillover potential of tourism. Innovation is no longer limited to technology; it now encompasses sustainability goals and community resilience, as demonstrated by the European Green Deal and the Transition Pathway for Tourism.

The digital-green transition might be accelerated, and tourism's role in regional diversification strengthened by incorporating the QUH rationale into these missions.

Future research should therefore examine the feasibility and performance of QUH-oriented Living Labs, testing whether collaborative ecosystems can deliver measurable impacts on sustainability indicators and SME productivity.

Beyond Europe, comparative studies could explore how similar frameworks emerge under different institutional conditions, thus extending the conceptual reach of the QUH–S4+ beyond EU Cohesion Policy.

Limitations and avenues. Our synthesis is EU-centred and conceptual. Future work should (i) evaluate QUH living labs with counterfactuals; (ii) test S4+ mission effects on related variety; (iii) measure the contribution of the Tourism Data Space to SME productivity and emissions reduction; and (iv) compare EU with non-EU destinations.

To summarise, the relevant feature for understanding tomorrow's tourism is sustainability. Therefore, the foundations of the new tourism model and all S3 strategies must include biodiversity conservation, respect for the sociocultural authenticity of communities, and the guarantee of welcoming countries' social well-being and economic security through the sustainable use of natural resources.

7.1. Contribution & Implications

This paper advances from a descriptive metaphor to an operational governance toolkit for S3; S4+ in tourism. We specify per-helix mechanisms (academia, economy/finance, environment, media/culture/public, policy/governance) as routines, EDP cadence, data-sharing, demand-side instruments.

It also proposes a portable KPI set (CO_2 per bed-night, % renewables in lodging, supplier circularity plans, related-variety linkages, EDP cycle time, cross-border pilots, inclusive jobs).

By translating the QUH–S4+ into a measurable and comparative framework, the article bridges the gap between conceptual research and applied policy design. It supports policymakers and regional authorities in implementing evidence-based, mission-oriented strategies consistent with the Transition Pathway for Tourism and the Tourism Data Space. The approach is particularly actionable for lagging and outermost regions, enabling them to accelerate digital and green adoption among SMEs through open innovation and collaborative governance.

Acknowledging its conceptual and EU-centred limitations, the study outlines a future empirical agenda to test the four propositions (P1-P4), evaluate living-lab outcomes, and quantify the added value of data-space interoperability in sustainable tourism development.

Ultimately, the QUH–S4+ framework aspires to make S3 more inclusive, measurable, and transformative, positioning tourism not as a passive beneficiary of innovation policy, but as an active laboratory for sustainable regional development.

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Circular economy and sustainable entrepreneurship in healthcare in Portugal: Circular business models for rehabilitation equipment

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Abstract

This article examines the circular economy as a strategy for sustainable management and innovation in the healthcare sector in Portugal, with a particular focus on rehabilitation equipment. A mixed-methods approach is adopted, combining a systematic literature review (2019–2025), quantitative simulations comparing linear versus circular scenarios (2024–2029), and semi-structured interviews with industry experts (hospital managers, clinical engineers, and entrepreneurs).

The results suggest that circular practices—including remanufacturing/refurbishment, leasing, and servitisation—can reduce total cost of ownership (TCO) throughout the equipment lifecycle and lower associated emissions. However, viability depends on critical parameters such as the share of eligible devices, reverse logistics costs, and certification/traceability requirements.

The interviews highlight regulatory barriers, cultural resistance, and operational constraints as key limiting factors, while also identifying market opportunities for healthtech solutions and new circular intermediaries. The article proposes an adoption framework based on three conditions—economic viability, clinical trust, and operational capacity—and a phased roadmap for implementation in Portuguese hospital settings.

Keywords: Business Models; Circular Economy; Healthcare; Rehabilitation Devices; Remanufacturing.

1. Introduction

The circular economy has emerged as a strategic response to the environmental and economic challenges faced by the healthcare sector, which has historically operated under a linear model based on extraction, production, consumption, and disposal. This model is proving increasingly unsustainable in light of growing pressure to reduce costs, optimise resources, minimise environmental impacts, and respond to societal demands for more equitable and resilient health systems (Kirchherr, Reike, & Hekkert, 2017).

Particularly in the field of rehabilitation equipment—such as wheelchairs, prosthetics, orthotics, and assistive devices—the adoption of circular economy principles may represent a paradigm shift in how products are designed, used, and managed throughout their life cycle.

The application of circular economy practices in healthcare includes the reuse and refurbishment of medical devices, the remanufacturing of equipment, the recycling of hospital materials, and modular design focused on durability and repairability (Hoveling et al., 2024). Beyond mitigating environmental impacts, these practices can reduce total cost of ownership over the product life cycle and create space for circular business models such as leasing, servitisation, and digital traceability solutions, with the potential to reshape relationships between hospitals, suppliers, and specialised service providers.

Despite progress observed in various international contexts, the Portuguese case presents specific challenges. The National Health Service (SNS) faces chronic budget constraints, an ageing population, and growing demand for rehabilitation services—factors which make it particularly important to identify sustainable solutions that combine operational efficiency, innovation, and clinical safety. However, there remain significant gaps in

understanding the feasibility and conditions required for adopting circular models for rehabilitation equipment in Portuguese hospital settings (Carreira, Ferreira, & Ramos, 2024).

Both national and international literature remain relatively scarce when it comes to an integrated analysis of sustainability, innovation, and strategic management in healthcare focused specifically on rehabilitation equipment. Moreover, evidence remains limited regarding the financial and environmental impacts of transitioning to circular models in hospital contexts in Portugal.

This study therefore poses the following research question: under what economic, regulatory, and organisational conditions can circular business models for rehabilitation equipment generate gains in efficiency and sustainability within Portuguese hospitals?

To address this question, the article adopts a mixed-methods approach, combining (i) a systematic literature review (2019–2025), (ii) quantitative simulations with financial and environmental projections for 2024–2029, and (iii) semi-structured interviews with managers, technical staff, and innovation specialists in healthcare. The study makes three main contributions: first, it integrates circular economy and healthcare entrepreneurship at the level of business models (leasing, servitisation, and remanufacturing) applied to rehabilitation equipment; second, it triangulates evidence from the systematic review with interviews and parametric simulations to explore feasibility and adoption conditions in Portugal; third, it proposes an implementation framework and a phased roadmap with implications for procurement, regulation, and opportunities for start-ups and suppliers.

The article is structured as follows: Section 2 reviews the literature on circular economy in healthcare and circular business models; Section 3 outlines the methodological design; Section 4 discusses findings and implications; and Section 5 concludes, presenting limitations and a future research agenda.

1.1. Objectives of the Study

The overall objective of this study is to assess the viability of the circular economy as a strategy for management and sustainable innovation in the healthcare sector in Portugal, with a particular focus on rehabilitation equipment, considering economic, environmental, and organisational dimensions.

More specifically, the study aims to:

(i) map recent evidence (2019–2025) on the application of circular economy principles to healthcare devices and equipment, with an emphasis on rehabilitation, identifying practices, barriers, and critical adoption factors;

(ii) characterise relevant circular business models—such as leasing, servitisation, refurbishment, and traceability solutions—and discuss their applicability in hospital settings;

(iii) explore perceptions and implementation requirements through semi-structured interviews with key stakeholders (hospital managers, clinical engineers, rehabilitation professionals, and entrepreneurs);

(iv) test parametric scenarios (2024–2029) comparing linear versus circular models, estimating potential impacts on total cost of ownership (TCO) and emissions;

(v) propose an adoption framework and a phased roadmap tailored to the Portuguese context, with implications for procurement, regulation, and opportunities for start-ups and suppliers.

2. Literature Review

The circular economy is proposed as an alternative model to the linear “take–make–dispose” paradigm, placing emphasis on the four Rs: reduce, reuse, remanufacture, and recycle products and materials (Kirchherr, Reike, & Hekkert, 2017). In the healthcare sector, this model gains relevance amid increasing pressure for efficiency, sustainability, and alignment with global emissions reduction targets. According to Aquino et al. (2024), the circular logic enables the minimisation of virgin resource consumption and hospital waste, thereby strengthening the resilience of health systems.

2.1. Circular Economy Applied to Healthcare

In the medical context, the application of circular economy principles involves practices such as the reuse of wheelchairs, prosthetics, and orthotics; refurbishment and remanufacturing of devices; and sustainable design using recyclable or biodegradable materials (Hoveling et al., 2024). In this article, "rehabilitation equipment" refers to durable and reusable devices (e.g., wheelchairs, external orthoses, external prostheses, walking aids, and electro-medical rehabilitation devices), excluding single-use items and consumables.

In their study *Circular economy for medical devices: Barriers, opportunities and best practices from a design perspective*, Hoveling et al. explore the technical, regulatory, and cultural challenges involved in implementing circular design in medical devices, and propose design guidelines to make such products more durable and easier to disassemble and reassemble.

Another recent contribution is the study by Moshawih (2025), which investigates sustainability in the global healthcare sector and highlights that healthcare accounts for approximately 5% of global CO_2 emissions, further reinforcing the urgency of adopting circular approaches.

Kim Mayer (2025) examines opportunities and barriers to circular economy adoption in the German medical device industry, identifying regulatory and cultural hurdles, but also emerging incentives that support innovative business models.

Recent contributions also examine organisational behaviour as a key determinant of circular adoption in healthcare. Sepetis and Parlavantzas (2025) argue that committed leadership, a supportive institutional culture, and staff engagement are critical enablers for sustainable practices.

Additionally, Bühler, Fendt, Wittenberg, and Hamper (2024) propose the 9R framework within the healthcare context (*Smart Circular Economy in Healthcare — Introduction to the 9R Framework*), which goes beyond the traditional 3Rs and emphasises actions such as redesign, remanufacture, recovery, and digital circularity, supported by digital technologies.

2.2. Innovation and Sustainable Entrepreneurship in Healthcare

The transition to a circular model in healthcare entails not only technical adaptations but also organisational and entrepreneurial transformations. Glover et al. (2024), in *Healthcare Entrepreneurship: An Integrative Framework*, present a comprehensive model linking healthcare innovation, business models, and regulation, arguing that health entrepreneurship must balance risk, social impact, and scalability.

Circular business models—such as leasing, servitisation, or pay-per-use—have been proposed as efficient alternatives for making the life cycle of medical devices more sustainable. For example, hospitals that lease equipment instead of purchasing it can reduce the risk of obsolescence and enable ongoing maintenance. This approach is already adopted by companies like Philips, which promote refurbished systems within the global healthcare sector.

In the technological domain, emerging innovations are reinforcing the feasibility of circularity. A study conducted by Zocco, Sleath, and Rahimifard (2024) proposes a *flexible cellular robot* equipped with deep learning vision to disassemble small medical devices, automating disassembly and sorting steps in the circular process.

Moreover, Granlund, Stirbu, and Mikkonen (2024) address the need to expand regulatory cycles for medical devices incorporating artificial intelligence, to accommodate phases of continuous learning and safe reuse. This debate is essential for ensuring compatibility between innovation and safety.

To enable the adoption of such innovations, hospital managers must take into account environmental indicators (*green KPIs*) and the total cost of ownership (TCO), which includes not only acquisition costs but also maintenance, disposal, and reuse costs. Integrating these metrics into decision-making processes facilitates alignment between sustainability and operational efficiency.

The literature on circular business models in healthcare can be organised into four archetypes:

a) **remanufacturing/reconditioning-as-a-service** (providers collect, refurbish, and return devices to the hospital);
b) **leasing/pay-per-use** (payment based on availability or use, with maintenance included);
c) **performance-based servitisation** (contracts based on outcomes, aligning supplier incentives with product longevity);
d) **digital platforms and traceability** (life cycle management, product matching, and regulatory compliance).

2.4. The Portuguese Context: Current Status and Potential

Although Portugal currently has few consolidated initiatives in the field of circular healthcare, documents such as the National Waste Management Plan for Electrical and Electronic Equipment (PNGRREEE) indicate some institutional movement towards circularity. Local studies suggest that up to 80% of discarded orthopaedic devices could be reused through appropriate refurbishment and sterilisation processes, yet this potential remains largely untapped due to regulatory and cultural constraints (Costa, 2022; Fernandes, 2024).

Henriques (2022) argues that well-structured public policies could generate annual savings in the millions through sustainable health equipment recovery systems. However, empirical studies validating such estimates with real-world data from Portuguese hospitals are still lacking.

Some isolated initiatives do exist, such as refurbishment hubs for wheelchairs in university hospitals and social donation programmes for reused prosthetic devices. These programmes act as "circular innovation laboratories", offering a potential foundation for nationwide scaling.

2.5. Integrating Technical, Organisational and Entrepreneurial Perspectives

The converging literature shows that the transition to a circular economy in healthcare must integrate three core dimensions:

1. **Technical**: modular designs, automation (robotics, computer vision), sustainable materials, and remanufacturing processes.
2. **Organisational/Cultural:** proactive leadership, staff engagement, sustainability-oriented culture, and capacity building (Sepetis & Parlavantzas, 2025).
3. **Entrepreneurial/Business Model:** circular start-ups, peer-to-peer platforms, public-private partnerships, financing mechanisms, and open innovation.

This systemic arrangement is essential to overcoming technical, regulatory, and cultural barriers, and to achieving full circularity in the healthcare sector. Despite the growing number of studies on circular healthcare, the feasibility of circular business models specifically for rehabilitation equipment remains underexplored—particularly in countries facing budget constraints and high demand for care, such as Portugal.

Adoption is expected to be determined by the combined presence of three factors: regulatory clarity, clinical trust (certification and traceability), and economic viability (total cost of ownership — TCO).

3. Methodology

This study adopts a mixed-methods approach, integrating both quantitative and qualitative methodologies, with the aim of capturing both the breadth (via numerical data) and depth (via perceptions, barriers, and motivations) of the phenomenon of circular economy applied to the healthcare sector. The choice of mixed methods is justified by the complexity of the research object, which involves technical, regulatory, cultural, economic, and organisational aspects, as well as the need for triangulation to strengthen the validity of the findings (Creswell & Plano Clark, 2018; Fetters, Curry & Creswell, 2013).

3.1. Methodological Rationale and Design

The mixed-methods approach allows for the compensation of limitations inherent in single-method designs: quantitative data offer generalisability and numerical estimates, while qualitative data reveal meaning, contextual dynamics, and underlying mechanisms (Tashakkori & Teddlie, 2010). The health research literature has increasingly recognised the value of this approach, particularly in understanding complex interventions and institutional contexts (see *Using Mixed Methods in Health Research*).

There are several mixed-methods designs, including:

- **Convergent parallel** (quantitative and qualitative data collected simultaneously),
- **Explanatory sequential** (quantitative followed by qualitative), and
- **Exploratory sequential** (qualitative followed by quantitative) (Dovetail, 2024).

This study adopted a convergent parallel design, in which both strands of data were collected and analysed independently, and later integrated during the interpretation phase.

This design was chosen to enable:

- Direct comparison between numerical results and subjective perceptions;
- Interpretative enrichment of quantitative findings with qualitative insights.
- Triangulation of results to enhance reliability.

PRISMA Flow (2019–2025)

Databases consulted: Scopus, Web of Science, PubMed, Google Scholar, and ResearchGate.

Main search strings (examples):

- ("circular economy" AND "healthcare" AND (devices OR "medical equipment" OR rehabilitation)) AND (Portugal OR Europe)
- ("remanufacturing" AND "medical devices")
- ("reprocessing" AND "single-use devices" AND hospital)

PRISMA summary:

- **Records identified (all databases)**: 1,236
  - Scopus (420); Web of Science (318); PubMed (276); Google Scholar (180); ResearchGate (42)
- **Duplicates removed**: 254 → Records after deduplication: 982
- **Title and abstract screening**: 982
  - Excluded due to irrelevance/theory-only/opinion: 836
- **Full-text articles assessed**: 146
  - Excluded (n = 98): not health-related (41); not circular economy-related (29); opinion-only (18); inaccessible/no full text (10)
- **Included in qualitative synthesis**: 48
- **Included with quantitative data/applicable business models**: 22

3.2. Stage 1: Systematic Literature Review

The literature review was conducted between 2024 and 2025, based on searches carried out in Scopus, Web of Science, PubMed, Google Scholar, and ResearchGate, focusing on studies published from 2019 to 2025.

Inclusion criteria:

- Research addressing the circular economy in the healthcare sector, specifically medical devices and hospital equipment.

- Studies on circular business models, innovation, refurbishment, remanufacturing, and related public policies;
- Empirical studies, meta-analyses, and scoping reviews.

The mapping and selection process followed PRISMA guidelines, involving title and abstract screening, full-text reading, duplicate removal, and the application of eligibility criteria. In parallel, sustainability reports from hospitals and sectoral organisations were also reviewed to complement findings with practical data.

Table 1: Study Extraction Matrix (example/sample).

ID	Reference (APA)	Scope/Country	Study Type	Focus (technical/management/model)	Data/Sample	Key Findings	Quality*
S01	Hoveling, Nijdam, Moninckx, Faludi, & Bakker (2024). *Resources, Conservation & Recycling*, 208, 107719.	EU (multi-country)	Review + design guidelines	Technical + circular design	29 recommendations	Reuse/remanufacturing with built-in safety and traceability from design stage	High
S02	D'Alessandro, Szopik-Depczyńska, … Ioppolo (2024). *Sustainability*, 16(1), 401.	Global	Systematic/bibliometric review	Management + practices	200+ docs	Map of circular practices in healthcare, implementation gaps	Medium-high
S03	Moshawih (2025). *Journal of Sustainable Health Systems*.	Global	Framework/essay	Management + metrics	—	Framework to measure circular interventions	Medium
S04	Mayer (2025). *Journal of Cleaner Production*.	Germany	Sectoral study	Regulation + business	Interviews/docs	Regulatory barriers and emerging incentives	Medium-high

S05	Zocco, Sleath, & Rahimifard (2024). *arXiv*.	EU	Prototyping	Robotics/automation	Experiments	Robotic cell for medical device disassembly	Medium
S06	Health Care Without Harm Europe (2024). Case report.	Denmark	Case study	Reprocessing of SUDs	Hospital data	−56% CO_2 and ~€330,000/year savings (catheters)	Medium

***:** Quality assessed based on methodological clarity, data robustness, and reproducibility.

Source: Author's elaboration.

3.3. Stage 2: Quantitative Analysis (Simulation and Projections)

The quantitative component consisted of simulations comparing two scenarios for the management of rehabilitation equipment in Portugal: the traditional (linear) model versus the circular model. The variables simulated included:

- **Operational and acquisition costs** over the 2024–2029 period;
- **Accumulated savings** resulting from reuse or refurbishment;
- **Estimated reductions in CO_2 emissions** related to the equipment's life cycle.

To estimate emissions, both a top-down (finance-based) and a bottom-up (inventory-based) approach were considered, inspired by methodologies applied in hospitals (for example, Quitmann et al., 2025, developed a dedicated "GHG calculator" for hospital settings). The simulation model also draws on remanufacturing studies in medical devices, which estimate emission reductions of up to 48% compared to new manufacturing (Meister, Sharp & Wang, 2022).

The financial projections accounted for depreciation rates, maintenance costs, extended product lifespan, and discounted cash flows. Three scenarios—optimistic, moderate, and pessimistic—were modelled to test the robustness of the outcomes.

3.3.1. Semi-Structured Interviews (Sample, Guide, and Analysis)

Sample (n = 15):

- **Hospital managers (6)**: 3 from the public sector (SNS), 3 from private hospitals (North, Centre, Lisbon region);
- **Clinical engineers (4)**: 2 from central hospitals, 2 from regional hospitals;
- **Rehabilitation specialists (3)**: from physiatry and rehabilitation nursing;
- **Healthtech entrepreneurs (2)**: specialising in refurbishment and traceability.

Criteria and recruitment: Purposive and snowball sampling; minimum 5 years of experience; direct involvement in equipment management/procurement, innovation, or sustainability.

Procedure: Online interviews (30–55 min), audio recorded, with informed consent; anonymised using participant codes (e.g., G1–G6; CE1–CE4; RS1–RS3; E1–E2).

Interview guide (themes):

- Perceptions of reuse/remanufacturing;
- Barriers (regulatory, cultural, technical);
- Drivers (TCO, ESG, risk);
- Business models (leasing, servitisation);
- Requirements for traceability and certification;
- Green KPIs.

Thematic analysis followed Braun & Clarke's (2006) six-phase method:

1. Familiarisation;
2. Coding;
3. Theme generation;
4. Theme review;
5. Definition and naming;
6. Reporting.

Two coders independently analysed the transcripts, resolving disagreements by consensus. NVivo or Atlas.ti software was optionally used.

Emerging themes (examples to be discussed in Section 4):

- T1 — Regulation/safety
- T2 — Clinical trust/culture
- T3 — Reverse logistics infrastructure
- T4 — Business case (TCO, ROI, risk)
- T5 — Data/KPIs
- T6 — Partnerships (PPP, university–startup)

Illustrative anonymised quotes:

- **G2**: "Without clear regulation for reprocessing, the legal risk becomes a barrier."
- **CE4**: "Part-by-part traceability is the turning point for clinical trust."
- **E1**: "Performance-based contracts align manufacturers with durability and maintenance."

3.4. Stage 3: Semi-Structured Interviews

To complement the quantitative perspective, semi-structured interviews were conducted with hospital managers, rehabilitation specialists, clinical engineers, and representatives from health start-ups. The objectives were to:

- **Validate the assumptions** raised by the simulation;
- **Identify organisational, regulatory, and cultural barriers** to implementing circular models;
- **Capture opportunities**, motivations, and practical strategies for adoption.

Interviews followed an open-ended guide, were recorded (with consent), and transcribed for thematic analysis. Open and axial coding techniques were used in accordance with qualitative analysis procedures (Braun & Clarke, 2006). Rigour was ensured through triangulation of participants and cross-review of coding.

3.4.1. Simulations: Inputs, Scenarios, and Sensitivity

Table 2: Simulation Inputs (Portugal, 2024 baseline — Rehabilitation Equipment).

Parameter	Base Value	Justification/Indicative Source
Annual expenditure on equipment (baseline)	€ 100 million	Scalable round figure (adjustable if real value is available)
Annual cost growth (traditional model)	+5%	Inflationary and technological pressures
Refurbishment cost (vs new)	40–60%	Hospital remanufacturing practices
Life cycle extension (circular model)	+50%	Preventive maintenance + remanufacturing
Share eligible for circularity	40–60%	Excludes consumables/implants
Emission reduction through remanufacturing	30–60%	LCA of remanufactured medical devices (Meister et al., 2022)
Time horizon	2024–2029	Aligned with study period

Source: Author's elaboration.

Table 3: Scenarios (Optimistic/Moderate/Pessimistic) — Cumulative Savings (2024–2029).

Key Assumptions	Optimistic (O)	Moderate (M)	Pessimistic (P)
Share eligible for circularity	60%	50%	40%
Refurbishment cost (vs new)	40%	50%	60%
Life cycle extension	+60%	+50%	+30%
Cost growth (traditional model)	6%	5%	3%
Cumulative savings	**€ 52 M**	**€ 40 M**	**€ 24 M**
CO_2 reduction (by 2029)	≈ 42%	≈ 35%	≈ 22%

Source: Author's elaboration.

3.4.3. Sensitivity Analysis ("Tornado" Format) — Impact on Savings (in €M)

Table 4: Sensitivity.

Parameter (variation vs base)	Impact in 2029
Share eligible: 60% → 40% (−20 pp)	−12
Refurbishment cost: 40% → 60% (+20 pp)	−9
Cost growth (traditional): 5% → 3% (−2 pp)	−7
Life extension: +50% → +30% (−20 pp)	−6
Reverse logistics cost: +20%	−3

Source: Author's elaboration.

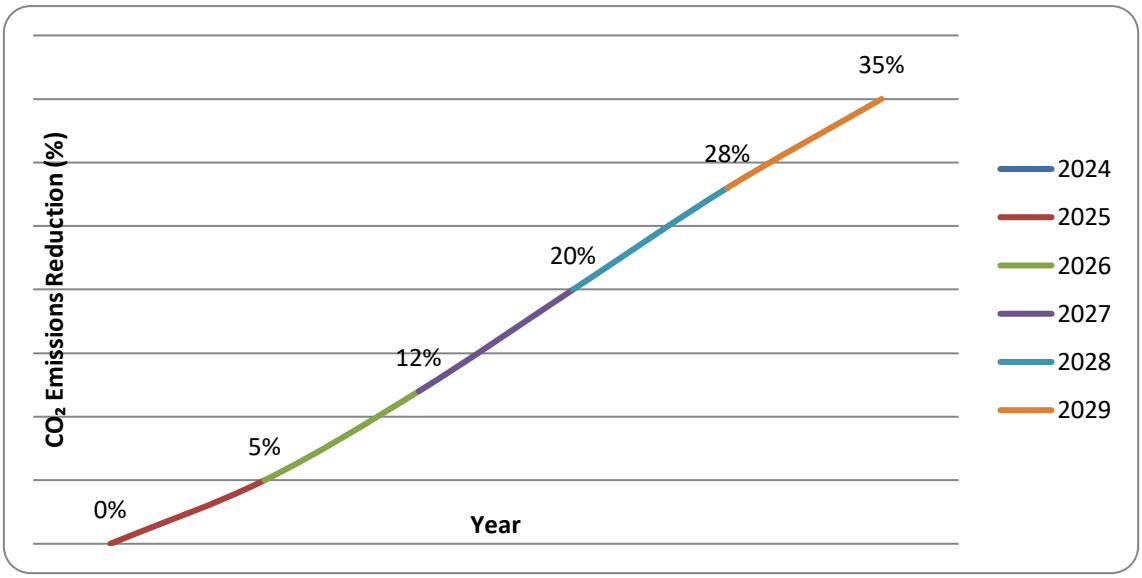
3.4.4. Results

Table 5: Annual Costs (€M): Traditional vs Circular, 2024–2029 (Moderate Scenario)

Year	Traditional (€M)	Circular (€M)	Annual Savings (€M)
2024	100	100	0
2025	105	98	7
2026	110	95	15
2027	116	93	23
2028	122	91	31
2029	129	89	40

Source: Author's elaboration.

Figure 3: CO_2 emissions reduction (%) in circular models versus the traditional model (2024–2029).



Source: Author's own elaboration, based on Meister et al. (2022); Quitmann et al. (2025); Moshawih (2025); Saha et al. (2025); Bühler et al. (2024).

3.5. Data Integration and Triangulation

Following separate analysis of the quantitative and qualitative components, the integration phase was conducted—an essential step in mixed-methods research to identify convergences, divergences, and to generate enriched interpretations.

According to Fetters et al. (2013), integration can take the following forms:

- **Merging**: direct combination of results from both methods;
- **Connecting**: using qualitative results to explain quantitative findings (or vice versa);
- **Explanatory**: iterative cycling between methods to refine insights.

In this study, integration was performed through comparative tables and narrative synthesis, highlighting areas of alignment or discrepancy between datasets and interpreting the underlying reasons for convergence or divergence.

To conclude the methodological integration, a synthesis paragraph was developed to clarify how the three data components (literature review, simulation, and interviews) informed each other. The systematic review provided a foundational map of circular practices and gaps; simulations tested economic and environmental projections under real-world assumptions; and interviews captured stakeholders' perceptions of feasibility and barriers. The integration of these elements enabled a meta-inference on the viability and conditions for circular adoption in Portuguese healthcare, enhancing the robustness and practical relevance of the study.

3.6. Methodological Limitations and Ethical Considerations

As with any study, this methodology presents some limitations:

- The simulation was based on hypothetical data, not real-world observations, which may introduce deviations from actual implementation scenarios.
- The interview sample may be geographically limited and subject to selection bias.
- Mixed-methods integration demands analytical skill and may encounter inconsistencies between numerical data and qualitative narratives.

From an ethical standpoint, all interviews followed strict principles of confidentiality and anonymity. Written informed consent was obtained from participants, and the study was submitted for review and approval by an institutional ethics committee before data collection.

4. Discussion: Managerial and Strategic Implications for the Healthcare Sector

The findings of this study suggest that adopting a circular economy model in the Portuguese healthcare sector—focusing specifically on rehabilitation equipment—may yield significant operational, environmental, and strategic benefits. In the projected scenario (2024–2029), cumulative savings of approximately € 40 million are anticipated, along with a gradual reduction in operational costs and a CO_2 emissions decrease of up to 35%. These findings are consistent with recent evidence indicating that circular practices in healthcare are not only environmentally desirable but also economically feasible (Moshawih, 2025; Sepetis & Parlavantzas, 2025).

Table 6: Reference Cases of Circular Economy in Healthcare (Europe and Portugal).

Country/Institution	Circular Practice	Reported Impact	Source
Denmark — Aarhus University Hospital	Reprocessing of single-use catheters	−56% CO_2 (for these devices); ~€ 330,000/year savings	Health Care Without Harm Europe (2024)
Denmark (national)	Legalisation of SUDs reprocessing (from 01/01/2025)	Regulatory framework to scale up reuse	Vanguard (2025)
Aarhus — Circular Procurement	Recyclability criteria in tenders	~24% savings in plastic irrigation items	NoHarm Global (2024)
Portugal — Algarve Hospitals	Waste management/segregation	Frequent failures in proper segregation	Ferreira et al. (2020)
Portugal — Community (sharps waste)	Disposal by diabetic patients	19.1% of needles and 13.1% of lancets properly discarded	Corte-Real et al. (2022)
EU/Global — Review of hospital plastics	Circular routes and barriers	Action lines for circularity of medical plastics	Cano et al. (2025)

Source: Author's elaboration.

4.2. Relevance of Circular Practices for Hospital Management

The adoption of strategies such as reuse, refurbishment, leasing, and servitisation allows healthcare institutions to optimise asset investments, reducing acquisition costs and preventing premature disposal of equipment with remaining useful life. In addition, incorporating innovative technologies—such as 3D printing for spare parts, digital traceability platforms, and the use of biodegradable materials—enhances efficiency and creates opportunities for sustainability-focused entrepreneurs and startups (Zocco, Sleath & Rahimifard, 2024).

These strategies, when aligned with suitable business models, can redefine the role of hospital managers: from simple purchasers of equipment to orchestrators of shared-use ecosystems, refurbishment networks, and continuous innovation cycles. This requires a shift in how institutions calculate Total Cost of Ownership (TCO)—factoring in maintenance, end-of-life management, reverse logistics, and reuse potential, rather than solely focusing on initial purchase price.

Table 7: Reference Cases of Circular Economy in Healthcare (Europe and Portugal).

Country/Institution	Circular Practice	Reported Impact	Source
Denmark — Aarhus University Hospital	Reprocessing of single-use catheters	−56% CO_2 (for these devices); ~€ 330,000/year savings	Health Care Without Harm Europe (2024)
Denmark (national)	Legalisation of SUD reprocessing (from 01/01/2025)	Regulatory foundation to scale up reuse	Vanguard (2025)
Aarhus — Circular Procurement	Recyclability criteria in procurement tenders	~24% savings on plastic irrigation supplies	NoHarm Global (2024)
Portugal — Algarve Hospitals	Waste management/segregation	Frequent failures in proper segregation	Ferreira et al. (2020)
Portugal — Community (sharps waste)	Disposal by diabetic patients	19.1% of needles and 13.1% of lancets correctly disposed of	Corte-Real et al. (2022)
EU/Global — Review of hospital plastics	Circularity routes and barriers	Strategic action lines for circular medical plastics	Cano et al. (2025)

Source: Author's elaboration.

4.3. Barriers and Challenges to Implementation

Despite the potential, it is essential to acknowledge the key obstacles that may hinder this transition:

- Lack of specific regulation: Many countries lack clear laws authorising or regulating the reuse and refurbishment of medical devices, creating legal uncertainty for healthcare institutions and suppliers. For instance, Mayer's (2025) study on the German medical device industry shows that strict regulations and regulatory ambiguity remain significant barriers to circularity.
- Cultural resistance and safety concerns: Health professionals and patients often view reused equipment with scepticism, especially when sterilisation or certification procedures are not clearly demonstrated (Sepetis & Parlavantzas, 2025). Cultural change requires leadership, internal communication, and institutional training.
- Limited infrastructure for reverse logistics: Effective systems are needed for collection, transportation, sterilisation, and refurbishment. Without regional refurbishment centres, reverse logistics may become economically unfeasible.
- Lack of economic and financial incentives: The absence of tax benefits or dedicated credit lines for circular innovation reduces the attractiveness for hospitals and firms willing to take early-stage risks.

Furthermore, the complexity of the healthcare sector, characterised by strict health regulations, legal liabilities, and certification requirements, presents additional challenges not encountered in less regulated industries.

4.4. National Initiatives and Opportunities in Portugal

Although still modest, there are promising signals in the Portuguese context. For example, companies such as Efacec have applied refurbishment and remanufacturing concepts in the energy sector, potentially serving as inspiration for healthcare.

Some hospitals in Portugal already run localised reuse programmes for wheelchairs and prosthetic devices, though in a decentralised manner. Recent reports suggest that up to 40% of discarded equipment could be reused, provided that standardised protocols and refurbishment certification are in place. This reveals a strategic gap in realising untapped value.

It is crucial that pilot hospitals—such as university hospitals or large regional centres—take the lead in developing these models and serve as reference cases for replication across the country.

4.5. Learning from International Case Studies

International models offer important lessons:

- **University Hospital Bonn (Germany)** launched pilot projects for medical waste recycling and reprocessing, using digital waste management software (Resourcify) to extract plastics and metals from hospital waste streams. This practice significantly reduced incinerated plastic (University Hospital Bonn, 2023).
- Recent studies propose holistic frameworks to transform healthcare systems into circular supply chains. For example, Moshawih (2025) presents an integrated model reconciling sustainability goals with the operational viability of the sector.
- The article *"Opportunities and Challenges of Implementing Circular Strategies in the German Medical Device Industry"* (Mayer, 2025) analyses regulation, transition costs, and incentives—highly relevant to Portugal's potential roadmap.
- Sepetis & Parlavantzas (2025) highlight how organisational behaviour (leadership, motivation, institutional culture) affects the uptake of circular healthcare practices. A weak organisational culture can be as much a barrier as technical or regulatory issues.

These examples show that barriers can be overcome through cohesion between public policy, technological innovation, and institutional engagement.

4.6. Strategic Proposals for Accelerating the Transition

Based on the quantitative results, interviews, and literature review, the following strategic actions are proposed:

1. **Develop national legislation** specifying clear guidelines for refurbishment, certification, and traceability of reused medical devices.
2. **Create fiscal incentives** or subsidies for hospitals, companies, and startups implementing circular practices.
3. **Invest in research and technological innovation**, focusing on modular 3D printing, IoT sensors, blockchain, and robotics for automated disassembly (as in Zocco et al., 2024).
4. **Continuous professional training** in circular design, refurbishment, and ecological management for hospital managers, clinical engineers, and technical teams.
5. **Establish collaborative networks** between universities, public and private sectors to develop **scalable circular prototypes** (Camilleri, 2025).
6. **Implement green performance indicators (KPIs)** in hospitals—e.g., volume of reused material, CO_2 reduction per device, and avoided disposal cost.
7. **Promote "circular pilot hospitals"** as demonstration and learning hubs, spreading best practices to other institutions.

In comparison to international cases, such as Denmark's national regulatory shifts and Germany's structured pilot programmes, Portugal stands at a pivotal moment. While the country benefits from an emerging healthtech ecosystem and early refurbishment initiatives, stronger alignment with EU circularity standards and integration into international knowledge-sharing platforms (e.g., Health Care Without Harm, WHO Global Green and Healthy Hospitals) could amplify its role as an innovation leader in Southern Europe.

4.7. Future Outlook and Organisational Resilience

By aligning circular economy principles with strategic management, technological innovation, and sustainable entrepreneurship, the healthcare sector can evolve into a more resilient, cost-effective, and environmentally balanced model.

However, this transition requires a coordinated effort from hospital managers, green startups, regulators, and investors, with a long-term vision.

Portugal, by leveraging its growing healthtech innovation ecosystem, can position itself as an international reference in this field. If key stakeholders take proactive roles, building alliances and investing in pilots and scaling, it will be possible to construct a circular, efficient, and inclusive healthcare system, aligned with global sustainability and innovation goals.

Several international and national case studies illustrate the viability and diversity of circular strategies in healthcare. Denmark has led legislative and operational advances, with Aarhus University Hospital achieving notable CO_2 and cost reductions through catheter reprocessing. In Germany and the Netherlands, sectoral studies and innovations in remanufacturing and 3D printing show the benefits of modular design and extended product lifecycles. In Portugal, challenges remain: while hospitals in the Algarve report persistent issues with waste segregation, industrial players like Efacec offer transferable models for equipment refurbishment. Japan's government-led reverse logistics initiatives highlight the importance of policy-driven implementation, while European robotic initiatives (e.g., Zocco et al.) signal the role of automation in scaling circular practices. These cases provide strategic reference points for Portugal's roadmap toward circular healthcare. These case studies build on comparative frameworks such as Mayer (2025) and Zocco et al. (2024), offering valuable guidance for the Portuguese context.

Table 8: International and National Examples of Circular Economy Practices in Healthcare

Country/Institution	Circular Strategy	Environmental Impact	Economic Benefit	Notes
Denmark — Aarhus UH	Reprocessing of single-use catheters	-56% CO_2	~€330,000/year	Inspired national legislation for reuse
Denmark — Procurement	Circular criteria in tenders	-	~24% on plastic items	Shows green specs can be cost-effective
Germany — Sector	Remanufacturing of ultrasound catheters	Significant LCA reduction	TCO savings via lifespan	Regulatory clarity needed (Mayer, 2025)
Portugal — Algarve	Waste segregation failures	-	-	Reveals operational gaps in circularity
Portugal — Community	Improper disposal of sharps by patients	-	-	Only 19% of needles were properly discarded
Efacec (industry)	Refurbishment of energy equipment	Material waste avoided	-	Industrial model, potential healthcare transfer
Netherlands	3D printing of rehab devices	Lifecycle extension	Cost reduction per unit	Modular designs support reuse
Japan	Reverse logistics in hospitals	Waste diversion improved	-	Strong government support
EU Robotics (Zocco et al.)	Robotic dismantling of devices	Increased reuse efficiency	Lower manual costs	Vision-based automation

Source: Elaborated by the author, based on Mayer (2025), Zocco et al. (2024), Health Care Without Harm Europe (2024), and other referenced case studies.

The diversity of examples in Table X underscores the relevance of circular strategies across geographies and healthcare systems. Countries such as Denmark and Japan demonstrate the power of regulatory leadership, while initiatives in Germany and the Netherlands highlight the role of design and industry-driven innovation. In the Portuguese context, although systemic initiatives remain limited, pilot practices and industrial capabilities

indicate potential for scale. The author drew especially on the comparative frameworks proposed by Mayer (2025) and Zocco et al. (2024), whose analyses of regulatory pathways and automation for remanufacturing provide a strong foundation for contextual adaptation in Portugal.

Selected Case Studies — Circular Economy in Health

Portugal

1. **Hospitals in the Algarve**
   - **Practice**: Study on hospital waste segregation.
   - **Impact**: Many healthcare professionals report persistent failures in proper waste disposal.
   - **Source**: Ferreira et al. (2020), via ResearchGate.
2. **Diabetic Patients (Community Disposal)**
   - **Practice**: Disposal of needles and lancets by patients.
   - **Impact**: Only 19.1% of needles and 13.1% of lancets are disposed of correctly, posing high contamination risk.
   - **Source**: Corte-Real et al. (2022), *Journal of Environmental Research and Public Health*.
3. **Efacec (Industrial Case)**
   - **Practice**: Refurbishment of energy equipment based on circular economy principles.
   - **Impact**: Environmentally relevant, but not yet scaled or formalised in the healthcare sector.
   - **Source**: Corporate website and press reports.

Denmark — Aarhus University Hospital

- **Practice**: Reprocessing of ultrasound catheters (single-use).
- **Impact**: Up to 56% reduction in CO_2 emissions and estimated annual savings of €330,000.
- **Source**: Health Care Without Harm Europe (2024), Vanguard (2025).

Sweden

- **Practice**: Development of biodegradable prosthetics and orthoses.
- **Impact**: Reduction of hard-to-recycle medical waste.
- **Source**: Riker (2023), as cited in this article.

Netherlands

- **Practice**: 3D printing of personalised rehabilitation equipment.
- **Impact**: Extends device lifespan, reduces waste and costs.
- **Source**: Firmino & Poggi (2024).

Japan

- **Practice**: Public policies encouraging reverse logistics in hospitals.
- **Impact**: Increased collection and reprocessing of disposable clinical waste.
- **Source**: Health Care Without Harm Asia and OECD data.

Global (Scientific Reviews)

1. **Hospital Plastics (Europe and Worldwide)**
   - **Practice**: Circular strategies for hospital plastics.
   - **Impact**: Challenges include material separation, contamination risks, and lack of circular product design.
   - **Source**: Cano et al. (2025), *Resources, Conservation & Recycling*.
2. **Robotic Remanufacturing (EU Project)**
   - **Practice**: European robotics project to dismantle disposable devices.

- **Impact**: Increased efficiency in reconditioning with reduced labour requirements.
- **Source**: Zocco, Sleath & Rahimifard (2024), *Elsevier Robotics*.

5. Conclusion

5.1. Summary of Findings

This study has demonstrated that implementing circular economy models in the Portuguese healthcare sector, with a focus on rehabilitation equipment, can generate significant economic, environmental, and organisational impacts. By adopting a mixed-methods approach—combining systematic literature review, quantitative simulations, and expert interviews—it was possible to identify that transitioning from a linear to a circular model provides the following main benefits:

- Cumulative savings of approximately €40 million in operational costs over the period 2024–2029 (based on simulation projections);
- Gradual reduction in CO_2 emissions, reaching approximately 35% decrease by the end of the period compared to the traditional model;
- Improved operational efficiency through practices such as remanufacturing, reuse, and sustainable product design;
- Creation of new innovations and business opportunities, especially in service-based models (servitisation), leasing contracts, and emerging integrated technologies.

These findings suggest that the circular economy is not only an environmentally desirable alternative but also economically and strategically viable in the Portuguese hospital context. They reinforce the potential for Portugal to position itself as a leader in sustainable healthcare innovation—provided it overcomes the key challenges identified.

5.2. Theoretical and Practical Contributions

From a theoretical perspective, this study advances the debate on the circular economy in healthcare by integrating three dimensions that are often addressed in isolation: strategic management, technological innovation, and sustainable entrepreneurship. While existing literature tends to explore these aspects separately, this research seeks to merge them into a cohesive framework tailored to the Portuguese context.

On a practical level, the study offers contributions for various stakeholder groups:

1. **Hospital managers and health institutions**: The findings offer both quantitative and qualitative evidence to support procurement decisions, equipment maintenance and refurbishment strategies, as well as the integration of sustainability metrics (e.g., green KPIs) into management processes.
2. **Healthtech entrepreneurs and startups**: There are clear opportunities for developing circular business models, such as refurbishment services, equipment sharing platforms, modular component printing, and tracking solutions.
3. **Policy makers and regulators**: The evidence supports the development of regulatory guidelines, incentive policies (e.g., tax breaks, subsidies), and **certification standards** to promote the adoption of circular practices in the health sector.

5.3. Strategic Recommendations

Based on the research findings and recent literature, the following strategic actions are recommended:

- Develop specific national regulations for reused devices, including clear criteria for sterilisation, certification, and traceability;
- Implement fiscal incentives and green financing mechanisms for hospitals, companies, and startups adopting circular models;

- Promote professional training in sustainable management, circular design, and equipment maintenance—integrated into curricula for clinical engineering, hospital management, and public health;
- Invest in applied technological innovation, such as modular 3D printing, IoT sensors for equipment monitoring, and machine vision systems for automatic disassembly (as per Zocco et al., 2024);
- Establish collaborative networks between public and private sectors and academia to develop scalable circular prototypes (Camilleri, 2025);
- Implement "circular pilot hospitals" as strategic laboratories for experimentation and continuous monitoring through environmental indicators (green KPIs) and comparative evaluation (Alfina, 2025);
- Develop an evolutionary roadmap for phased implementation (diagnosis, pilot, scale), including intermediate targets, continuous learning, and policy feedback loops.

5.4. Future Outlook and Strategic Leadership

The circular economy should not be seen as a one-off project but rather as part of a systemic strategy for sustainable innovation. Developed countries such as Germany, Sweden, and the Netherlands have shown that with regulatory support and appropriate incentives, the circular transition can deliver multiple gains (Saha et al., 2025). Recent studies also propose scalable frameworks for circular healthcare, such as Moshawih's (2025) integrated model, which aligns environmental and operational benefits across intervention levels.

Portugal has a favourable starting point, including an emerging health innovation ecosystem, academic capacity, and budgetary pressures that drive the pursuit of efficiency. Through strategic investment in innovation, regulation, skills, and institutional leadership, the country can become an international reference in circular healthcare.

In sum, the circular economy in health is more than a cost-saving strategy—it represents a forward-looking agenda that links innovation, efficiency, and environmental responsibility. Portugal now stands at a critical window of opportunity to lead the sustainability transformation in healthcare. For health entrepreneurship, the findings reveal room for new intermediaries and specialised providers (e.g., remanufacturing, traceability, performance-based contracts), provided there is regulatory alignment and clinical trust.

6. Limitations and Future Research Agenda

Identified Challenges and Limitations

Despite the potential benefits, the transition towards a circular model faces substantial challenges:

- A lack of specific regulations regarding the refurbishment, reuse, and traceability of medical devices, leading to legal uncertainty for healthcare providers and suppliers.
- Cultural resistance and health-related concerns from healthcare professionals and patients regarding the safety and performance of reused equipment (Sepetis & Parlavantzas, 2025).
- Limited infrastructure for reverse logistics, recycling, and specialised reprocessing, which increases operational costs and reduces economies of scale.
- An absence of economic or fiscal incentives to support hospitals and companies in absorbing the upfront costs of transitioning to circular models.
- Risks associated with technological innovation and integration, such as robotics, automation, and machine vision systems, which require investment, certification, and validation (Zocco et al., 2024).
- Methodological limitations of the present study: use of simulations rather than real-world observational data; a relatively small number of interviews (n = 15); and potential selection bias in the qualitative sample.

Additionally, the healthcare sector is highly regulated, with strict sanitary and legal requirements that may impose further constraints on the reuse of medical devices, requiring a careful reconciliation between innovation and safety (Alfina, 2024).

The financial and emissions projections are based on assumptions and simulations (see Table 2), rather than real longitudinal data, and may diverge from actual performance. The qualitative sample was non-probabilistic and potentially subject to selection bias and social desirability bias. Moreover, the study's focus on rehabilitation equipment and the Portuguese context limits the generalisability of findings to other categories of devices (e.g. implants) or countries. Emissions estimates depend on emission factors and LCA system boundaries, both of which may vary. Regulatory changes at the EU or national level could also impact the feasibility of device reprocessing.

Future Research Agenda

To deepen understanding and support evidence-based decision-making, the following research avenues are proposed:

- **Longitudinal studies** using real operational data (e.g., costs, failure rates, equipment downtime);
- **Comparative life cycle assessments (LCA)** for different subcategories (e.g., wheelchairs, orthoses, TENS/FES devices);
- **Implementation trials** in pilot hospitals to test circular models in real contexts;
- Evaluation of **contractual models**, including pay-per-use and pay-for-outcome arrangements;
- **Digital traceability tools**, such as IoT and blockchain, for lifecycle monitoring and compliance;
- **Behavioural interventions** aimed at reducing cultural resistance—e.g., professional training, risk communication, and third-party certification.

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Crowdfunding for women entrepreneurship: Opportunities, challenges, and the path forward

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Abstract

Crowdfunding has emerged as a potentially transformative financing mechanism for women entrepreneurs, offering an alternative to traditional funding sources that have historically excluded or disadvantaged female-led ventures. This comprehensive review synthesizes current research on crowdfunding's role in women's entrepreneurship, examining opportunities, persistent barriers, and emerging strategies for success. Drawing from a systematic analysis of recent literature spanning reward-based, equity, and lending platforms,covering the 2012–2023 period, this article reveals a complex landscape where crowdfunding both democratizes access to capital and reproduces existing gender biases. While women demonstrate notable success on reward-based platforms like Kickstarter, equity crowdfunding presents mixed outcomes that vary significantly by context, platform design, and investor composition. Key findings indicate that success factors for women entrepreneurs include strategic signal management, leveraging third-party endorsements, building diverse networks, and understanding platform-specific dynamics. The analysis identifies critical research gaps and proposes future directions for both scholarship and platform design to better serve women entrepreneurs in the evolving crowdfunding ecosystem.

Keywords: Crowdfunding; Financing; Gender Bias; Startup Funding; Women Entrepreneurship.

1. Introduction

The entrepreneurial landscape has long been characterized by significant gender disparities in access to capital, with women entrepreneurs facing persistent challenges in securing traditional venture capital and bank financing (Saluja, 2024).These barriers have contributed to a substantial funding gap, with female-founded startups receiving only a fraction of total venture capital investment globally. In this context, crowdfunding has emerged as a potentially democratizing force, offering alternative pathways to capital that bypass traditional gatekeepers and enable direct connections between entrepreneurs and funders.

Crowdfunding platforms have proliferated rapidly since the early 2010s, encompassing diverse models including reward-based crowdfunding (e.g., Kickstarter, Indiegogo), equity crowdfunding, and peer-to-peer lending platforms. Each model presents unique opportunities and challenges for women entrepreneurs, creating a complex ecosystem that requires careful analysis to understand its true impact on gender equality in entrepreneurial finance.

This article provides a comprehensive examination of crowdfunding's role in women's entrepreneurship, synthesizing empirical evidence from recent research to address three critical questions:

1. What is the current state of women's participation and success in crowdfunding across different platform types?
2. What barriers and biases persist in crowdfunding environments, and how do they manifest differently across platforms and contexts?

3. What strategies and success factors have emerged to help women entrepreneurs navigate and succeed in crowdfunding campaigns?

2. Literature Review and Theoretical Framework

2.1. Theoretical Foundations

Research on crowdfunding and gender draws from multiple theoretical frameworks that help explain observed patterns and outcomes. Signaling theory provides a crucial lens for understanding how women entrepreneurs communicate venture quality to potential funders, particularly given evidence that quality signals are interpreted differently based on founder gender (Kleinert & Mochkabadi, 2021).Gender role congruity theory explains how stereotypical expectations about women's roles and capabilities influence investor perceptions and funding decisions.

Stereotype content theory and warm-glow theory illuminate investor motivations, particularly in prosocial crowdfunding contexts where women entrepreneurs may be perceived as more trustworthy or socially oriented (Zhao et al., 2021; Figueroa-Armijos & Berns, 2021). Assortative matching theory helps explain supply-side fundraising choices and gender gaps, as investors often prefer to fund entrepreneurs who share similar characteristics (Hellmann et al., 2021; Hellmann et al., 2025).

Additional frameworks include Expectancy Violations Theory, which explains when women benefit from innovation claims by violating traditional gender expectations (Seigner et al., 2022), and social identity theory, which addresses how behavioral signals affect investor perceptions differently for male and female entrepreneurs (Giordano, 2023).

2.2. Evolution of Crowdfunding Research

The academic literature on crowdfunding and gender has evolved significantly since 2012, with systematic reviews identifying 36 empirical studies conducted between 2012 and 2023 (Saluja, 2024). This research spans multiple platform types, geographical contexts, and methodological approaches, creating a rich but sometimes contradictory body of evidence.

Early studies focused primarily on documenting gender differences in participation rates and success outcomes. More recent research has adopted sophisticated theoretical frameworks and methodological approaches to understand the mechanisms underlying these differences, including experimental designs, natural experiments, and large-scale platform data analysis.

Table 1: Mapping of Key Empirical Studies on Gender and Crowdfunding (2012–2023).

Author(s)	Platform Type	Geographic Context	Methodology	Key Gender-Related Findings
Gafni et al. (2020)	Reward-based (Kickstarter)	USA	Large-scale platform data + surveys	Women exhibit higher success rates but face taste-based discrimination from some male backers
Battaglia et al. (2021)	Equity crowdfunding	Europe (Poland)	Regression analysis	Female-led ventures more likely to receive funding in certain European contexts
Zhao et al. (2021)	Equity crowdfunding	Europe & Latin America	Panel data analysis	Female entrepreneurs benefit from lead investors and early-stage campaigns
Andrieu et al. (2021)	Equity crowdfunding	France	Platform-level empirical study	Persistent gender disadvantage in later-stage and capital-intensive ventures
Kleinert & Mochkabadi (2021)	Equity crowdfunding	Germany	Experimental + observational data	Quality signals interpreted differently based on founder gender
Hellmann et al. (2021)	Equity crowdfunding	UK & Europe	Econometric analysis	Evidence of assortative matching between investor and entrepreneur gender
Prokop & Wang (2021)	Equity crowdfunding	Multi-country	Meta-analytical review	Gender gaps vary by venture maturity and funding size
Kromidha et al. (2020)	Crowdlending / Development platforms	India	Qualitative network analysis	Women face network constraints but benefit from intermediary support
Johnson & Smith (2022)	Crowdlending	USA	Experimental design	Online lending platforms reduce traditional gender bias
Seigner et al. (2022)	Reward-based crowdfunding	USA	Field experiments	Innovation claims benefit women through expectancy violations
Fellnhofer & Deng (2023)	Reward-based crowdfunding	Europe	Behavioral experiments	Intuitive investor decision-making promotes gender equality

3. Current State and Trends in Women's Crowdfunding Participation

3.1. Platform-Specific Participation Patterns

The evidence reveals significant variation in women's participation and success across different crowdfunding platform types. On reward-based platforms like Kickstarter, women comprise approximately 34.7% of entrepreneurs and often demonstrate higher success rates than their male counterparts (Gafni et al., 2020). This suggests that reward-based crowdfunding may indeed provide a more level playing field for women entrepreneurs.

Equity crowdfunding presents a more complex picture, with outcomes varying significantly by geographical context and platform characteristics. Some European studies report female advantages, with female-founded firms more likely to receive funding (Battaglia et al., 2021; Zhao et al., 2021). However, other research documents persistent disadvantages, particularly in later-stage or capital-intensive ventures (Andrieu et al., 2021; Kleinert & Mochkabadi, 2021).

Crowdlending and microloan platforms show promise for reducing traditional bias, particularly when intermediaries and field partners are aligned with supporting women entrepreneurs (Kromidha et al., 2020; Johnson & Smith, 2022). These platforms can democratize access in some settings, though outcomes depend heavily on local organizational context and network effects.

3.2. Temporal and Contextual Variations

Research indicates that women's crowdfunding outcomes are highly sensitive to context and venture stage. Advantages often observed in early-stage campaigns may diminish for "seasoned" offerings or capital-intensive ventures (Hellmann et al., 2021;Prokop & Wang, 2021;Zhao et al., 2021).This pattern suggests that while crowdfunding may lower initial barriers for women, scaling challenges persist as ventures mature.

Geographic variations are also significant, with different patterns emerging across countries and regions. For example, Latin American data shows that the presence of at least one woman on a firm's board increased average pledges and percentage of funding targets achieved (Zhao et al., 2021). These regional differences highlight the importance of local context in shaping crowdfunding outcomes.

4. Barriers and Challenges Facing Women Entrepreneurs

4.1. Network and Social Capital Limitations

One of the most consistently identified barriers facing women entrepreneurs in crowdfunding is limited access to networks and social capital (Saluja, 2024; Kromidha et al., 2020). Successful crowdfunding campaigns often depend on initial momentum generated through personal and professional networks, and women entrepreneurs frequently face disadvantages in this area due to historically limited access to business networks and venture capital communities.

The network effect is particularly pronounced in equity crowdfunding, where early investors and lead investors play crucial signaling roles. Research shows that the presence of lead investors can amplify female advantages in some equity markets, though this advantage may weaken for later-stage ventures (Zhao et al., 2021).

4.2. Funding Targets and The funding Target Disparity

Female entrepreneurs often set lower fundraising goals compared to their male counterparts, which partly explains smaller amounts raised even when success probabilities are similar (Hellmann et al., 2021). This pattern may reflect both strategic goal setting under structural constraints, including differential access to resources, risk exposure and investor expectations, rather than inherent differences in entrepreneurial ambitions.

The funding target disparity has important implications for venture scaling and long-term success. While conservative funding targets may improve campaign success rates, they may also limit the resources available for rapid growth and market expansion.

4.3. Platform Design and Representation Issues

Women entrepreneurs face challenges related to platform design and representation that can limit their success. On reward-based platforms, women are often concentrated in stereotyped categories, which can limit addressable investor demand and scale (Gafni et al., 2020; Kromidha et al., 2020). This sectoral concentration reflects broader patterns of occupational segregation and may constrain the types of ventures women feel comfortable launching through crowdfunding.

Additionally, digital divide issues may disproportionately affect women entrepreneurs, particularly in developing markets where access to technology and digital marketing skills may be more limited (Kromidha et al., 2020).

It is important to acknowledge that the majority of studies reviewed in this section conceptualize gender as a binary variable and do not incorporate intersectional dimensions such as caste, race, ethnicity, age, or socioeconomic background. As a result, the identified barriers related to networks, social capital, and platform access may not be uniformly experienced by all women entrepreneurs. These limitations suggest that the

challenges discussed here may underrepresent the compounded disadvantages faced by women located at the intersection of multiple marginalized identities, particularly in developing and socially stratified contexts.

These structural barriers are further compounded by discriminatory investor perceptions and evaluative biases, which are discussed in detail in the following section.

5. Gender Bias and Discrimination Patterns

While the literature consistently documents gender-based bias and discrimination in crowdfunding, it is important to note that most empirical studies rely on binary gender classifications and lack intersectional data. Consequently, the observed patterns of statistical and taste-based discrimination primarily reflect aggregate gender effects and may not fully capture how bias operates for women entrepreneurs who also differ by race, caste, ethnicity, age, or socioeconomic status. This limitation constrains the generalizability of current findings and suggests that existing evidence may underestimate the intensity and forms of discrimination experienced by women situated at multiple intersecting disadvantage positions.

5.1. Types of Bias in Crowdfunding

Research has documented both statistical and taste-based forms of gender bias in crowdfunding, though the direction and magnitude depend on platform type, investor mix, and signal characteristics (Saluja, 2024 , Gafni et al., 2020) Taste-based discrimination is evident in survey data from Kickstarter backers, with some male backers displaying explicit discrimination against female entrepreneurs (Gafni et al., 2020)

Statistical discrimination manifests in the differential interpretation of quality signals based on founder gender. Management experience, for example, helps men but can hurt women, while third-party media coverage is more beneficial for women in equity settings (Kleinert & Mochkabadi, 2021). These patterns suggest that investors apply different evaluative frameworks to male and female entrepreneurs.

5.2. Investor Gender and Assortative Matching

Investor gender plays a crucial role in funding outcomes, with evidence of assortative matching where investors prefer same-gender entrepreneurs (Hellmann et al., 2021,2025). Female investors disproportionately support mixed-gender teams, while male investors fund all-female teams relatively less. This pattern has important implications for platform design and investor recruitment strategies.

The composition of the investor base thus becomes a critical factor in determining women's success in crowdfunding. Platforms with more gender-balanced investor populations are likely to provide more equitable outcomes for women entrepreneurs.

Future research incorporating intersectional investor–entrepreneur matching could further illuminate how assortative preferences vary across multiple identity dimensions rather than gender alone.

5.3. Signal Interpretation and Stereotyping

The interpretation of entrepreneurial signals varies systematically by founder gender, creating complex challenges for women entrepreneurs. Quality signals that benefit male entrepreneurs may be neutral or even harmful for women, while other signals may be more powerful for women (Kleinert & Mochkabadi, 2021).

For example, innovation claims can benefit women entrepreneurs, especially in male-stereotyped categories, by violating traditional gender expectations in positive ways (Seigner et al., 2022). However, signals of proactiveness may be penalized by backers when displayed by women entrepreneurs, while autonomy and risk-taking signals tend to help women on reward platforms (Giordano, 2023).

6. Success Factors and Strategic Recommendations

6.1. Signal Management Strategies

Successful women entrepreneurs have developed sophisticated signal management strategies to navigate gender bias in crowdfunding. Third-party endorsements and media coverage are particularly powerful signals for

female founders, especially in equity crowdfunding contexts (Kleinert & Mochkabadi, 2021). These external validations can offset negative interpretations of experience and expertise signals.

Innovation framing represents another effective strategy, particularly on reward-based platforms. Women who claim innovation or violate gender expectations can improve outcomes, especially in male-stereotyped categories (Seigner et al., 2022). This suggests that strategic positioning and messaging can help women entrepreneurs overcome stereotypical limitations.

6.2. Network Building and Investor Engagement

Given the importance of networks in crowdfunding success, women entrepreneurs must develop targeted strategies for network building and investor engagement. This includes cultivating relationships with lead investors who can provide crucial signaling effects in equity crowdfunding (Zhao et al., 2021).

Leveraging female investors and creating gender-balanced investor networks can also improve outcomes, given evidence of assortative matching preferences (Hellmann et al., 2021, 2025). Platforms and entrepreneurs should consider strategies to attract and engage female investors specifically.

6.3. Platform Selection and Campaign Design

Understanding platform-specific dynamics is crucial for women entrepreneurs' success. Reward-based platforms may offer more favorable environments for women entrepreneurs, particularly in consumer-oriented categories (Gafni et al., 2020). Equity platforms require more sophisticated signal management and network building strategies.

Campaign framing and messaging should be carefully considered, with attention to how different signals will be interpreted by predominantly male investor audiences. Emphasizing concrete achievements, third-party validations, and innovation can help overcome stereotypical limitations.

6.4. Psychological and Behavioral Factors

Recent experimental research suggests that fast, intuitive decision modes among investors can promote gender equality in reward crowdfunding contexts (Fellnhofer & Deng, 2023). This implies that campaign cues triggering positive intuitive responses may particularly help women entrepreneurs.

Understanding backer psychology and designing campaigns that appeal to both rational and emotional decision-making processes can improve outcomes for women entrepreneurs across different platform types.

7. Platform Differences and Their Impact on Women Entrepreneurs

7.1. Reward-Based Crowdfunding Platforms

Reward-based platforms like Kickstarter appear to provide the most favorable environment for women entrepreneurs. Women comprise approximately 34.7% of entrepreneurs on these platforms and often achieve higher success rates than men (Gafni et al., 2020). This success may be attributed to several factors:

- **Consumer-oriented focus**: Many reward-based campaigns focus on consumer products and services, areas where women entrepreneurs are well-represented and may have strong market insights.
- **Community engagement**: These platforms emphasize community building and engagement, skills that align with traditional gender role expectations and may favor women entrepreneurs.
- **Lower capital requirements**: Reward-based campaigns often require smaller funding amounts, making them more accessible to women entrepreneurs who may face network and resource constraints.

However, women on reward-based platforms still face challenges related to sectoral concentration and may be limited to stereotypically "female" categories, potentially constraining growth and scalability.

7.2. Equity Crowdfunding Platforms

Equity crowdfunding presents a more complex landscape for women entrepreneurs, with outcomes varying significantly by context and platform design. Key factors influencing success include:

- **Investor composition**: The gender balance of the investor base significantly affects outcomes for women entrepreneurs (Hellmann et al., 2021, 2025)
- **Lead investor presence**: Lead investors can amplify advantages for female entrepreneurs, though this effect may diminish for later-stage ventures (Zhao et al., 2021).
- **Signal interpretation**: Quality signals are interpreted differently based on founder gender, requiring sophisticated signal management strategies (Kleinert & Mochkabadi, 2021).

European equity crowdfunding markets have shown more favorable outcomes for women entrepreneurs in some studies (Battaglia et al., 2021; Zhao et al., 2021), suggesting that regulatory environment and cultural context play important roles.

7.3. Peer-to-Peer Lending and Microfinance Platforms

Crowdlending and microfinance platforms offer unique opportunities for women entrepreneurs, particularly in developing markets. These platforms can reduce traditional bias when intermediaries and field partners are aligned with supporting women (Kromidha et al., 2020; Johnson & Smith, 2022) Success factors include:

- **Intermediary networks**: Local organizations and field partners can play crucial roles in supporting women entrepreneurs and overcoming traditional barriers.
- **Prosocial framing**: Platforms that emphasize social impact and community development may be particularly supportive of women entrepreneurs.
- **Lower barriers to entry**: These platforms often have lower barriers to entry and may be more accessible to women entrepreneurs with limited business experience or networks.

8. Regional and Cultural Variations

8.1. Geographic Differences in Outcomes

Research reveals significant geographic variations in women's crowdfunding success, highlighting the importance of local context, regulatory environment, and cultural factors. European markets have generally shown more favorable outcomes for women entrepreneurs in equity crowdfunding (Battaglia et al., 2021; Zhao et al., 2021), while other regions display different patterns.

In Latin America, the presence of women on company boards positively correlates with crowdfunding success, suggesting that gender diversity signals may be particularly valued in these markets (Zhao et al., 2021). These regional differences underscore the need for context-specific strategies and platform designs.

8.2. Cultural and Regulatory Factors

Cultural attitudes toward women's entrepreneurship and gender roles significantly influence crowdfunding outcomes. Regulatory environments also play a role, with different securities regulations and investor protection frameworks affecting platform operations and investor behavior.

The development of local crowdfunding ecosystems, including the presence of supporting organizations and networks, can significantly impact women entrepreneurs' success. Regions with strong support networks and favorable regulatory environments tend to produce better outcomes for women entrepreneurs.

9. Future Research Directions and Recommendations

9.1. Research Gaps and Opportunities

The systematic review of literature identifies several critical research gaps that require attention:

Intersectional approaches: Future research should adopt more intersectional and context-sensitive approaches, examining how gender intersects with other identity categories such as race, ethnicity, age, and socioeconomic status.

Longitudinal studies: More longitudinal analyses of post-campaign outcomes are needed to understand the long-term impact of crowdfunding on women entrepreneurs' ventures and careers.

Experimental research: Controlled experiments testing platform design features (e.g., blind review processes, anonymized pitches) could provide valuable insights into causal mechanisms underlying gender bias.

Cross-platform comparisons: Comparative studies across different platform types and geographic contexts would help isolate specific mechanisms and identify best practices.

9.2. Methodological Recommendations

Future research should employ more sophisticated methodological approaches:

- **Large-scale data analysis** measuring investor composition and gendered behavior patterns.
- **Natural experiments** leveraging platform design changes or regulatory shifts.
- **Field experiments** testing specific interventions to reduce bias.
- **Mixed-methods approaches** combining quantitative analysis with qualitative insights from entrepreneurs and investors.

9.3. Platform Design Recommendations

Based on current research findings, several platform design improvements could better serve women entrepreneurs:

Bias reduction mechanisms:

- Implement blind or delayed disclosure of founder gender in initial screening processes.
- Highlight neutral third-party endorsements and achievements.
- Encourage lead investor participation and visibility.
- Promote gender-balanced advisory boards and investor networks.

Network building support:

- Provide mentorship and network building programs specifically for women entrepreneurs.
- Create female entrepreneur and investor communities within platforms.
- Offer training and resources on signal management and campaign optimization.

Algorithmic fairness:

- Audit recommendation algorithms for gender bias.
- Ensure diverse representation in featured campaigns and platform marketing.
- Monitor and report on gender-based outcome disparities.

9.4. Policy Implications

The research findings have important policy implications for governments and regulatory bodies:

Regulatory frameworks: Develop crowdfunding regulations that consider gender equity implications and require platforms to report on diversity metrics.

Support programs: Create targeted support programs for women entrepreneurs engaging in crowdfunding, including training, mentorship, and network building initiatives.

Research funding: Support academic research on gender and crowdfunding to build the evidence base for effective interventions.

10. Implications for Practice

10.1. Recommendations for Women Entrepreneurs

Based on the research synthesis, several practical recommendations emerge for women entrepreneurs considering crowdfunding:

Platform selection strategy:

- Consider reward-based platforms for consumer-oriented ventures.
- Research investor composition and platform culture before selecting equity crowdfunding platforms.
- Evaluate the presence of support networks and mentorship programs.

Campaign design and messaging:

- Develop sophisticated signal management strategies.
- Seek third-party endorsements and media coverage.
- Frame innovations and achievements clearly and confidently.
- Consider how different signals will be interpreted by predominantly male investor audiences.

Network building:

- Invest in building diverse professional networks before launching campaigns.
- Engage with female investor networks and communities.
- Seek out lead investors and advisors who can provide credibility signals.

10.2. Recommendations for Platforms

Crowdfunding platforms can take several steps to better serve women entrepreneurs:

Design improvements:

- Implement bias reduction mechanisms in platform algorithms and processes.
- Create supportive communities and resources for women entrepreneurs.
- Provide training and mentorship programs.
- Monitor and report on gender-based outcome disparities.

Investor education:

- Educate investors about unconscious bias and its impact on funding decisions.
- Promote awareness of successful women entrepreneurs and their achievements.
- Encourage diverse investor participation.

10.3. Recommendations for Investors

Individual and institutional investors can contribute to more equitable crowdfunding outcomes:

Bias awareness: Recognize and actively counter unconscious bias in investment decision-making processes.

Due diligence: Focus on objective venture metrics and potential rather than stereotypical assumptions about founder capabilities.

Portfolio diversity: Actively seek opportunities to invest in women-led ventures and support gender-balanced portfolios.

11. Limitations and Considerations

This analysis is subject to several limitations that should be considered when interpreting findings:

Publication bias: The academic literature may overrepresent studies finding significant gender effects, potentially skewing the apparent magnitude of bias and discrimination.

Platform evolution: Crowdfunding platforms continue to evolve rapidly, and findings from earlier studies may not reflect current platform dynamics.

Sample selection: Many studies focus on specific platforms, geographic regions, or time periods, limiting generalizability.

Measurement challenges: Defining and measuring success in crowdfunding involves multiple metrics (funding amounts, success rates, post-campaign outcomes) that may not capture the full impact on women entrepreneurs.

Causality: Much of the research is observational, making it difficult to establish causal relationships between gender and crowdfunding outcomes.

12. Conclusion

Crowdfunding represents both an opportunity and a challenge for women entrepreneurs seeking access to capital. While these platforms have democratized certain aspects of entrepreneurial finance and provided new pathways to funding, they have not eliminated gender bias and discrimination. Instead, they have created new contexts in which existing biases manifest in complex ways.

The evidence reveals significant variation across platform types, with reward-based crowdfunding appearing most favorable for women entrepreneurs, while equity crowdfunding presents mixed outcomes that depend heavily on context, investor composition, and signal management strategies. Success in crowdfunding requires sophisticated understanding of platform dynamics, investor psychology, and strategic communication.

Key success factors for women entrepreneurs include strategic signal management, building diverse networks, leveraging third-party endorsements, and understanding platform-specific dynamics. However, individual strategies alone are insufficient to address systemic biases. Platform design improvements, investor education, and supportive regulatory frameworks are needed to create more equitable crowdfunding ecosystems. The absence of intersectional evidence in current research suggests that the true magnitude of disadvantage faced by many women entrepreneurs in crowdfunding ecosystems remains underestimated.

Future research should focus on intersectional approaches, longitudinal outcomes, and experimental tests of bias reduction mechanisms. The goal should be to develop evidence-based strategies for creating crowdfunding environments that truly democratize access to capital for all entrepreneurs, regardless of gender.

The crowdfunding revolution has created new possibilities for women entrepreneurs, but realizing this potential requires continued effort from researchers, platforms, investors, and policymakers. By understanding the complex dynamics of gender in crowdfunding and working to address persistent biases, we can move closer to the goal of truly equitable entrepreneurial finance.

As the crowdfunding ecosystem continues to evolve, ongoing research and adaptation will be essential to ensure that these platforms fulfill their promise of democratizing access to capital and supporting the diverse entrepreneurial talent that drives innovation and economic growth.

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New information technologies in the financial sector

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Abstract

Information technologies have profoundly reshaped the financial sector, enhancing customer experience, increasing operational efficiency, and creating opportunities for innovation. In order to provide security, transparency, and constant development for both customers and staff, this process has been having a growing influence on financial institutions and will continue to alter the financial system in the years to come.

This study focuses on two technologies: blockchain and artificial intelligence. These two technologies are linked to several meanings, according to different writers from a large number of research and publications. However, there is a broad consensus that machines possess the ability to solve many problems, much like human beings.

Overall, the aim of this study is to analyze the impact that the implementation of these technologies has had on the financial system—whether positive or negative—from the perspective of both consumers and employees. A mixed-method research technique was used for the empirical study, including two interviews and a questionnaire survey, in order to achieve the suggested goals.

The results show that even though these technologies have pros and cons, they have been very important to the digital revolution in the financial industry. Nonetheless, there is still worry that robots may take over human jobs, endangering financial sector workers. With ongoing development, it is expected that humans and machines will be able to work together towards a positive evolution.

Keywords: Artificial Intelligence; Banks; Blockchain; Financial Institutions; Information Technologies.

1. Introduction

Nowadays, technology plays a crucial role in society, being omnipresent and almost impossible to imagine a scenario in which it would disappear. Information technologies (IT) are only one example of the many advancements that have resulted from the constant and unstoppable growth of technology. More and more businesses are using these technologies to reach their goals and interests in a wide range of fields.

Baptista (2024) asserts that organizational elements such as strategy, culture, technology, and people are all impacted by technological advancement. It also shows how the organizational model has developed to accommodate digital trends.

As they develop and are used in the workplace, new technologies are becoming increasingly popular among financial market institutions. With the advent of technologies such as blockchain and AI, which are the focus of academic writing and papers, new more consumer-oriented products have emerged. This has put the spotlight on new technologies in the contemporary financial world and caused pressure on traditional institutions.

As this subject is becoming increasingly relevant to the financial sector, it will be explained how recent IT has been implemented and how it has influenced the financial system. This research, in overall terms, explores the impact that new technologies have had on the financial sector. Likewise, it aims to understand the perspective of employees in Financial Institutions (FIs), considering the implementation of these technologies both in their daily work and regarding the future of the profession in the financial sector.

On the other hand, the study seeks to understand the perspective of consumers considering technological developments and the security of the services provided, as well as the associated benefits and limitations. To respond to the objectives and adopted methodology, the following hypotheses were proposed:

- H1: The integration of disruptive IT (AI and Blockchain) has significantly altered the operational dynamics and service delivery models within the financial system.
- H2: The growth of digital banking acts as a primary driver in shifting consumer behavior from traditional physical interaction to digital-first financial engagement.
- H3: There is a significant perception among stakeholders that automation and AI-driven processes negatively correlate with long-term job security in the financial sector.
- H4: While blockchain provides perceived transparency and security, its influence on the actual adoption of cryptocurrencies is mediated by institutional trust and regulatory frameworks.
- H5: The successful adoption of AI and Blockchain provides measurable efficiency gains and structural benefits that outweigh traditional operational limitations.

To pursue the objectives of this study, a specific research question was defined: How do stakeholders in the Portuguese financial sector perceive the balance between operational benefits and socio-professional risks arising from the implementation of AI and Blockchain? To enhance the information gathered on IT and to produce a clear and credible literature review, bibliographic research will be conducted, primarily through scientific articles. This approach will allow for a better understanding of what has already been presented and developed by various researchers in the field, and to objectively identify the most relevant works on the topic.

While current literature extensively covers the technical architecture of AI and Blockchain, there is a significant gap in understanding the asymmetric perception between these two technologies within the Portuguese financial ecosystem. Specifically, this study addresses the lack of empirical evidence regarding why AI is perceived as an operational tool for efficiency, while Blockchain remains associated with high-risk speculation and 'anxiety' among both staff and consumers. This research fills a specific theoretical gap by examining the socio-technical barrier to the adoption of disruptive technologies in traditional banking. By employing a mixed-methods approach, it moves beyond descriptive analysis to propose a conceptual framework that links technological literacy with trust and perceived job security. The empirical contribution lies in identifying that, in the Portuguese financial sector, AI is viewed as an evolutionary necessity, while Blockchain is still hindered by a lack of institutional transparency and regulatory clarity.

Despite the abundance of studies on the technical benefits of AI and Blockchain (e.g., Anwar et al., 2022; Gujrati & Biradar, 2023), there is a notable research gap regarding the asymmetry of adoption in the Portuguese financial sector. Specifically, it remains unclear why AI is being integrated with relative ease in customer-facing tools (Baptista, 2024), while Blockchain remains relegated to speculative discourse (Guo & Yu, 2022). This study addresses this gap by analyzing the divergent perceptions of trust and job security among two critical stakeholders: frontline employees and end consumers.

To analyze the impact of these technologies, this study is anchored in the Unified Theory of Acceptance and Use of Technology (UTAUT), as proposed by Venkatesh et al. (2003). This framework allows for a structured understanding of how performance expectancy and effort expectancy influence the adoption of AI and Blockchain within the Portuguese financial ecosystem.

Consequently, with the aim of collecting primary data, the empirical study consists of a questionnaire survey (quantitative method) and two interviews (qualitative method) one with a current employee of a financial institution and another with a former employee. This approach seeks to understand the impact that new technologies have on the financial sector, both from the perspective of consumers and of financial institution employees.

With the intention of achieving the objectives proposed for the study and answering the defined questions, the preparation of this study is composed of 6 chapters. Chapter 2 presents the theoretical framework of the study, focusing on a review and synthesis of the literature related to the main areas of the study: Digital Transformation, AI, and Blockchain. This background supports the transition to the empirical study outlined in Chapter 3, which details the methodology, data collection tools, and sample characteristics. Chapters 4 and 5 are dedicated to the presentation and discussion of results, analyzing data obtained from a questionnaire and two interviews—one with a current and one with a former financial institution employee—to assess the impact of new information technologies on the financial sector. Finally, Chapter 6 concludes the study by summarizing the key findings, contributions, and limitations of the research.

2. Literature Review

In order to increase productivity through process automation, quicker workflows, and better decision-making, digital transformation (DT) entails the use of information technology, software, platforms, and procedures to simplify operations (Siregar & Sudarmanto, 2023).

According to Navas et al. (2025), new IT affects all types of organizations, including public and private institutions, hospitals, banks, and even governments. Siregar and Sudarmanto (2023) observe that the adoption of digital technologies by companies enhances operational efficiency, reduces manual errors, monitors internal operations (such as sales, inventory, and losses), allocates resources, accesses new markets, and achieves a competitive advantage in the market.

The shift to digital banking requires user acceptance in addition to technological deployment. Performance expectancy, effort expectancy, social influence, and facilitating conditions are the four main constructs that drive the desire to use a technology, according to the UTAUT model (Venkatesh et al., 2003). These concepts aid in explaining why, in the context of this study, AI tools are more widely accepted because of their apparent effectiveness (performance expectancy), whereas Blockchain encounters opposition because of a lack of enabling circumstances (institutional trust and regulatory clarity). The integration of information technologies in banking is closely linked to the institutional environment. According to Han et al. (2022), financial authorities can create an atmosphere that is favorable to long-term innovation by reducing business uncertainty and maturity mismatches through effective communication. Concurrently, the emergence of Big Data ecosystems offers the technical infrastructure required for AI to improve operational effectiveness and risk management, but it also presents new issues with data security and governance (Hasan et al., 2020).

The concept of “Artificial Intelligence” originates from philosophy and human thought, and there is still no universally accepted definition (Baptista, 2024). As such, the term emerges in an abstract form, encompassing various fields of knowledge through numerous analyses from different scientific studies and authors. There is no consensus regarding its definition. Gbadegeshin et al. (2021) note that some researchers attempt to categorize AI as a specific function, while others try to incorporate it with multiple characteristics. One of the primary difficulties with artificial intelligence, according to Couch (2023) in the essay "Artificial Intelligence: Past, Present, and Future," is coming up with a definition that is agreed upon by everyone. Shaikh (2017) asserts that while innovation is evident across a number of industries, the financial industry is moving more slowly than others because of a number of limitations that make it difficult for it to adapt to structural shifts toward the digital age. According to Puri (2020), because of companies' subsequent investments in innovation, the banking and financial sector today offers novel solutions to traditional banking problems, boosting competition among banks and financial institutions. Thus, AI continues to advance with new AI-based tools in these sectors, and its application

has resulted in improved efficiency and productivity, the creation of customized customer experiences and services, and economic growth in the banking and financial sectors (Gujrati & Biradar, 2023). As mentioned by Vilhena & Navas (2023), the consulting firm Stefanini Group states that the adoption of new innovative tools is developed in favor of better performance, for example, compiling data more quickly and accurately than a human would, thereby optimizing processes and saving time in daily operations. For this reason, it is crucial that companies approach the digital transition as a long-term effort through sustainable growth strategies so that the resulting structural and cultural changes can progress effectively, and ultimately, the implementation of these tools yields the expected benefits rather than causing negative repercussions in the markets (Shaikh, 2017).

To promote cooperation between people and technology, Kokina and Davenport (2017) assert that AI technologies are intended to create more specialized roles like automation, monitoring, and supervision rather than to replace jobs in accounting and auditing tasks in order to cut down on human error, save money, and free up staff for other responsibilities, some processes, such as bank reconciliations, account categorization, and payment processing, can be automated by computers (Vilhena & Navas, 2023), using chatbots that seek to improve the user experience are given special consideration in customer-centered applications, since they are programs built on artificial intelligence (AI) that employ natural language processing (NLP) algorithms to help users with written or spoken transactions or problem-solving and utilize machine learning (ML) approaches to get better over time, which allows them to react fast and correctly (Alt et al., 2021).

According to De Cicco et al. (2020), the platforms and frameworks, the development of artificial intelligence, and the increasing use of messaging apps are the main factors propelling the chatbot industry. However, the market's expansion can be threatened by ignorance regarding the results of using them in different applications. The primary problem, according to De Cicco et al. (2020), is that they sometimes struggle to comprehend user inquiries, which makes it difficult for them to reply to more intricate or thorough questions. Besides this, chatbots utilize data analysis techniques to create ordered outputs, they also automate repetitive jobs, save time, and speed up work processes (Jee, 2023; Navas et al., 2025).

People began to validate and commercialize new transactions with Bitcoin, while others supported and resolved various issues through code. The Ethereum-based decentralized computing platform was created in 2013 by Vitalik Buterin, a programmer and co-founder of Bitcoin Magazine. Anyone can join Ethereum's public blockchains (Guo & Yu, 2022). Later, the Hyperledger Project was created, which is an open-source software initiative that was announced by the Linux Foundation in 2015. Its objective is to develop an enterprise blockchain that will enhance the dependability and performance of existing systems and facilitate international business transactions (Babtista, 2024).

Anwar et al. (2022) describe four stages in the evolution of blockchain technology: i) Blockchain 1.0 sought to improve the present monetary system by eliminating middlemen and enabling cryptocurrency transactions via Bitcoin and other alternative coins; ii) Pradhan (2021) claims that by preventing counterfeiting and double spending, Bitcoin has made transactions safer, more transparent, and more economical than traditional payment systems such as Ethereum was the first to implement smart contracts, which are used in financial services and industries like stocks, options, and financial assets, when it launched with Blockchain 2.0; iii) Blockchain 3.0 aimed to improve the technology's stability and security while expanding its applications into areas such as media, healthcare, financial institutions, art, and justice; iv) Finally, Blockchain 4.0 advances the current industrial revolution by improving user privacy and security. According to Mukherjee and Pradhan (2021), it also functions as a business platform for developing and implementing applications in a variety of industries and businesses, managing one million transactions per second, something earlier generations were unable to do.

A person's transaction is sent to the network, where computer algorithms verify its authenticity (Baptista, 2024). After validation, the transaction is stored as a block in a different data storage unit. Each block is made up of two primary parts: i) the block header, which includes all the information required to verify the block's integrity as

well as that of the blocks that come before and after it; and ii) the block body, which houses all of the transactions that are part of the block (Mukherjee and Pradhan, 2021; Zheng et al., 2018).

The information contained in the block header that enables the validation of each block's identity is called by hash. Together with the timestamp, which captures the date, time, and transaction information, the hash is a special and exclusive digital signature that is applied to every block at creation and serves as a connection between the previous and subsequent blocks (Mukherjee & Pradhan, 2021). Every user has a public key to enter the network after signing transactions with a private key, which are subsequently broadcast throughout the network (Zheng et al., 2018). According to the same author, the block body consists of a transaction counter, with the maximum number of transactions a block can contain depending on both the block size and the size of each transaction.

This type of network conveys trust to users through its transparency and security; however, it is advisable to conceal confidential information so that it is not accessible to everyone (Anwar et al., 2022; El-Rewini et al., 2020; Zheng et al., 2018). Unlike permissionless blockchains, permissioned blockchains limit network access by allowing only authorized users to join (Baptista, 2024). Even if these networks function faster and more effectively, cutting down on transaction times, they are not regarded as decentralized blockchains (Anwar et al., 2022; Zheng et al., 2018).

If users abide by the guidelines and security measures, public blockchain is regarded as secure. It is dependable for users as it guarantees that there are no fraudulent transactions and that all members can see it. However, due to its extensive use, it has issues with agility, speed, and high energy consumption (Anwar et al., 2022; Zheng et al., 2018).

In table 1 a SWOT analysis is presented for Blockchain technology. Its intrinsic advantages relies in decentralization, immutability, transparency, and security which makes it a solid and reliable system for a range of applications These essential characteristics make blockchain a disruptive technology that has the potential to drastically alter the way data is exchanged, managed, and kept (Baptista, 2024). The main drawbacks are high energy and running costs, scalability problems that prevent widespread adoption, and ongoing insecurity problems, especially with relation to private key management and storage.

Table 1: SWOT Analysis of Blockchain Technology in the Financial Sector.

Strengths	Weaknesses
Decentralization	High costs and energy consumption
Immutability	Scalability
Transparency	Cybersecurity
Security	Private key
Opportunities	**Threats**
Automation	Complex
Efficiency	Delay
Cost reduction	Weak regulation

Source: Baptista (2024).

The SWOT analysis presented in Table 1 transcends simple categorization; it highlights a strategic paradox. The 'Efficiency' opportunity provided by automation is directly linked to the 'Threat' of labor displacement. This suggests that for FIs, the challenge is not the technology itself, but the governance of the digital transition (Shaikh, 2017).

Blockchain has enormous potential for automation, productivity gains, and substantial cost savings for companies despite the obstacles already mentioned. Significant economic value can be unlocked by its ability to streamline procedures and the cut of the middlemen. However, because of its intrinsic complexity, possible

implementation delays, and the current state of loose and changing legal frameworks, there are barriers to the successful integration and broad acceptance of this technology. If blockchain reaches its full disruptive potential, these problems must be fixed via transparent standards and intuitive user interfaces (Baptista, 2024).

Blockchain can assist the banking sector in settling past-due payments and safeguarding credit card information, claim Bhagwani and Govindaraj (2020). There have been many incarnations of blockchain technology since the first digital currency, Bitcoin, was introduced. These have resulted in the development of digital currencies with distinct specifications and settings, as well as blockchain applications in financial and economic markets (Anwar et al., 2022). Cryptocurrencies are a successful use of blockchain technology because of their low processing costs and ability to facilitate direct payments between individuals without any restrictions or delays on money transfers (Guo and Yu, 2022). However, Guo and Yu (2022) note that because regulation and control are scarce, users may be exposed to cyberattacks that might wipe out all their assets and that illegal money could move across the blockchain network. As blockchain technology expanded beyond cryptocurrencies, it brought innovations and benefits. Hence, smart contracts and other new applications started to appear in a range of these industries.

To use smart contracts in the banking sector, customers and other participants must provide all personal data, such as name, address, credit card number, and sign a contract accepting the terms of the blockchain network (Baptista, 2024). A blockchain computer executes the code after both parties have designated it, completing the transaction and sending the funds to the client's address (Younus & Abumandil, 2022). These contracts are more affordable, flexible, and secure than traditional ones because they are thought to be immutable, meaning that no one can alter, update, or remove the data without permission (Younus & Abumandil, 2022).

Younus and Abumandil (2022) claim that blockchain has enhanced and been used in the banking and financial sectors in ways other than just smart contracts and cryptocurrencies. Financial service providers control access to the private data that companies keep and share. Even though they frequently don't know who has access to their financial data, customers can use blockchain to safely and securely access and control their personal information in the interim.

Based on the literature review, this study establishes a conceptual framework grounded in the Technology Acceptance Model (TAM) and the Socio-Technical Systems (STS) theory. While the technical capabilities of AI (Gujrati & Biradar, 2023) and Blockchain (Anwar et al., 2022) focus on operational efficiency and security, their actual impact on the financial sector is moderated by human perception.

As shown in Table 1, the strengths of Blockchain (immutability and transparency) collide with threats like 'weak regulation'. This creates a theoretical tension: technology offers trust through code, but users experience anxiety due to a lack of institutional governance. Therefore, our study posits that the transition to Digital Banking is not merely a technical upgrade but a shift in the 'psychological contract' between employees, customers, and financial institutions.

3. Methodology

To provide a more comprehensive response to the research, the empirical study adopted a mixed-methods approach, consisting of a scientific investigation based on the collection and analysis of data through a questionnaire survey (Appendix A) addressed to the general population, and two interviews (Appendix B): one with a current employee of a financial institution and another with a former employee of a financial institution. The aim was to obtain credible data from both the consumer and employee perspectives.

The purpose of the questionnaire was to understand people's perceptions of the impact that new information technologies have had on the financial sector, to provide a realistic and credible analysis.

The interviews focused on more specific and objective topics, aligned with the theoretical framework and the core of the research problem, targeting one former and one current employee of a financial institution. The

interviews were based on a semi-structured set of questions, which could be adapted as the conversation evolved.

The objective of conducting the interviews was to analyze and compare how financial institutions evaluate new information technologies and the impact these technologies have on the financial sector. This scientific technique is considered a qualitative method, as the data analyzed are textual in nature. The full transcripts of the interviews are included in the Appendices section.

The questionnaire was developed based on the literature review, in which the most relevant factors for the study were analyzed, leading to the creation of thematic question blocks. A simple and direct language was used, ensuring that no question contained more than one topic, so that respondents could answer accurately and without assistance.

The questionnaire was created in digital format using the Google Forms platform, which allows for the creation and distribution of online surveys. It was made available to participants via email, social media platforms (LinkedIn, WhatsApp, Instagram), and shared through the university's network with ISCAL's authorization, through a hyperlink to the form. The data collection period took place between March 1, 2024, and May 26, 2024, resulting in a sample of 154 complete and valid responses.

Structurally, the questionnaire includes a brief introduction that informs respondents about the researcher's name and details, as well as the purpose of the study. It clearly states the estimated completion time and assures that the responses are anonymous and used exclusively for research purposes.

The objective focused on the collection of primary data, with a total of twenty-seven questions. The first six questions were sociodemographic, relating to the respondent's age, gender, academic qualifications, field of study, professional status, and area of activity. These were followed by eight questions on AI and the final thirteen questions on blockchain and cryptocurrencies.

The questionnaire included various types of closed-ended questions, including binary questions (yes or no), multiple-choice questions, semantic differential scale questions (1–None; 2–Low; 3–Medium; 4–High; 5–Very high), and Likert scale questions (1–Not important at all; 2–Slightly important; 3–Neutral; 4–Important; 5–Very important; and 1–Strongly disagree; 2–Disagree; 3–Neither agree nor disagree; 4–Agree; 5–Strongly agree). The only conditional question was question 19, which could only be answered if the respondent had answered "No" to question 18. The estimated completion time for the questionnaire was 10 minutes.

The other primary source used in the methodology was the conduction of two semi-structured interviews with open-ended questions directed at two professionals from the financial sector working in different banks. The aim of the interviews was to understand the perspective of banking employees regarding the implementation of technologies in the financial sector. The interviews took place on June 13th, lasting 15 minutes, and on June 23rd, lasting 20 minutes.

The first interview (Appendix C) was conducted with a professional holding a degree in Public Administration and a master's degree in Economics and Public Policy. This individual previously worked at Caixa Geral de Aposentações and BNP Paribas and is currently employed at the Portuguese Tax and Customs Authority.

The second interview (Appendix D) was conducted with a banking professional with extensive experience in customer service, marketing and operations, commercial banking, specialized and investment banking.

For the development of both the questionnaire and the interview, the following research hypotheses were adopted:

- H1: The integration of disruptive IT (AI and Blockchain) has significantly altered the operational dynamics and service delivery models within the financial system.

- H2: The growth of digital banking acts as a primary driver in shifting consumer behavior from traditional physical interaction to digital-first financial engagement.
- H3: There is a significant perception among stakeholders that automation and AI-driven processes negatively correlate with long-term job security in the financial sector.
- H4: While blockchain provides perceived transparency and security, its influence on the actual adoption of cryptocurrencies is mediated by institutional trust and regulatory frameworks.
- H5: The successful adoption of AI and Blockchain provides measurable efficiency gains and structural benefits that outweigh traditional operational limitations.

Tables 2 and 3 present the correlation between the research hypotheses and the questions from the questionnaire and the interviews.

Table 2: Correlation between research questions and research hypotheses.

		Research Hypotheses				
	Questionnaire	**H1**	**H2**	**H3**	**H4**	**H5**
Profile	**Q1**	Characterization of the respondent's profile				
	Q2					
	Q3					
	Q4					
	Q5					
	Q6					
AI	**Q7**	X				
	Q8					
	Q9					
	Q10		X			
	Q11					
	Q12			X		X
	Q13			X		X
	Q14					
***Blockchain* / Cryptocurrencies**	**Q15**	X			X	
	Q16	X			X	
	Q17	X				
	Q18				X	
	Q19				X	
	Q20				X	
	Q21				X	X
	Q22				X	
	Q23				X	
	Q24				X	
	Q25				X	
General Questions	**Q26**	X				
	Q27			X		

Note: Questions not linked to hypotheses are used for descriptive sample profiling and context setting.

Table 3: Correlation between interview questions and research hypotheses.

		Research Hypotheses				
	Interview	**H1**	**H2**	**H3**	**H4**	**H5**
Profile	**Q1**	Characterization of the respondent's profile				
	Q2					
General Questions	**Q3**	X				X
	Q4	X				
	Q5					X
	Q6		X	X		
	Q7		X			
	Q8				X	
	Q9				X	
	Q10	X				

The theoretical landscape explored in the previous chapter reveals a convergence between the technical capabilities of disruptive IT and the human factors that govern their adoption. To bridge the literature with empirical study, we propose an analytical model based on the Socio-Technical Perspective and the Trust-Risk Model.

In this framework, Digital Transformation (H1) and Digital Banking (H2) represent the systemic evolution of the sector. However, the success of this evolution is moderated by two critical human factors: Perceived Threat (H3), which explores the tension between automation and labor, and Institutional Trust (H4), where the technical transparency of Blockchain is weighed against regulatory uncertainty. Ultimately, the Successful Adoption (H5) of these technologies is not merely a technical achievement but a balance of efficiency gains versus structural risks. This integrated view, mapping the literature to our research hypotheses, is summarized in the proposed model below (see Table 4).

Table 4: Table of Theoretical Synthesis.

Construct/Topic	Key Authors (Chapter 2)	Linked Hypothesis
Digital Transformation	Siregar & Sudarmanto (2023); Baptista (2024)	H1, H2
AI & Automation	Gujrati & Biradar (2023); Vilhena & Navas (2023)	H3, H5
Blockchain & Trust	Anwar et al. (2022); Guo & Yu (2022)	H4, H5

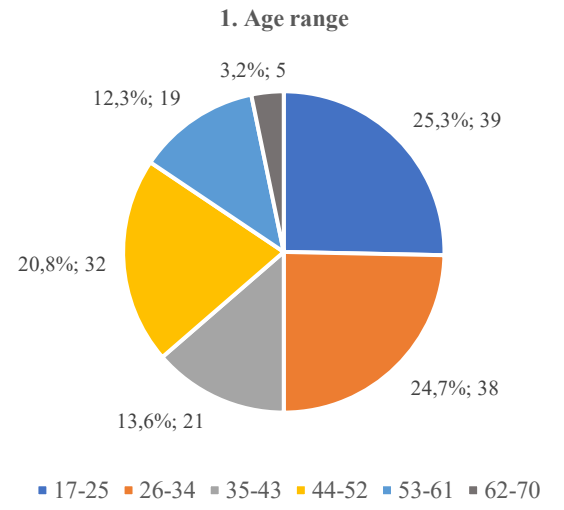
Subsequently, for the analysis of the results obtained from the data collected through the questionnaire survey, a descriptive analysis was carried out. In this way, charts were created based on those generated by Google Forms to facilitate the comparative analysis of the results obtained, along with a correlation with the interviews, which allowed for the extraction of both theoretical and empirical conclusions.

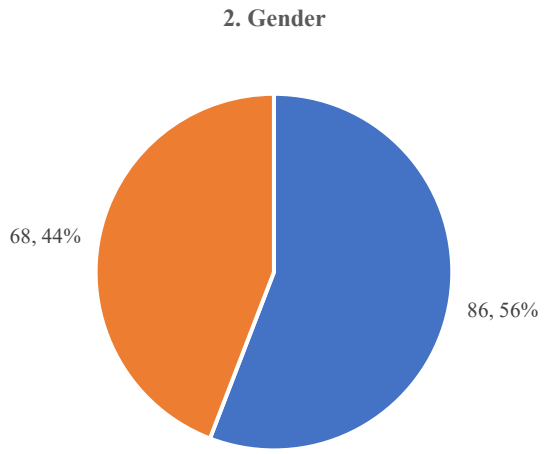
4. Findings and Analysis

4.1. Sample Characterization

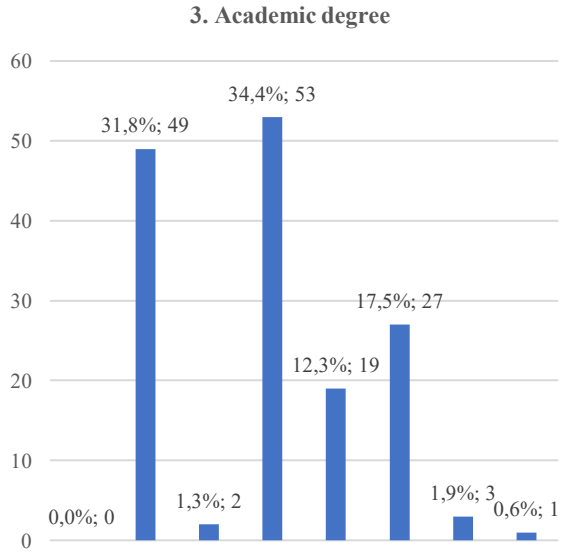
The questionnaire survey includes a sample of 154 respondents. In the first phase, an analysis was conducted to characterize the sample, specifically regarding sociodemographic data: age, gender, educational qualifications, field of study, professional status, and area of activity, with the aim of understanding the sample obtained.

Chart 1: Characterization of the respondent's profile.

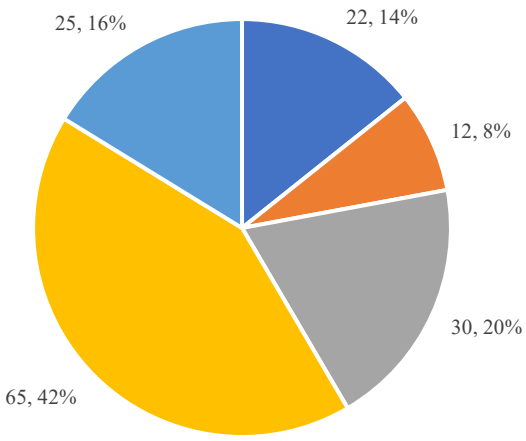




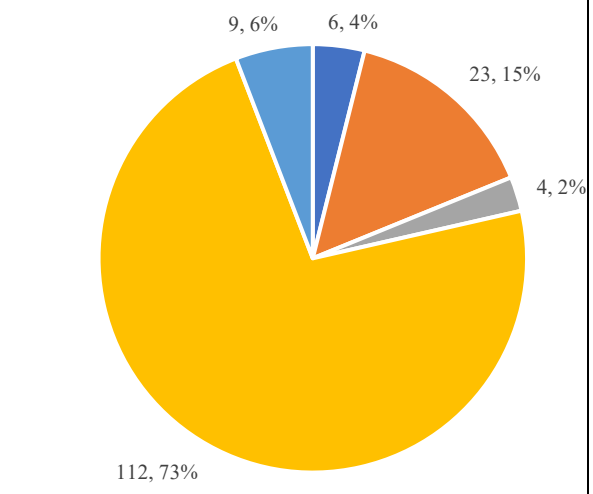
Feminine; masculine



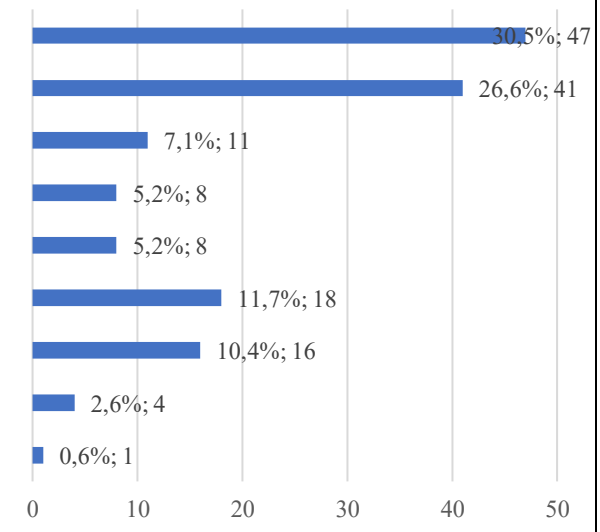
Basic education; high school; bachelor's degree; major degree; postgraduate; master; Ph.D; non specified



Arts and humanities; engineering; social and human sciences; economics and management; non specified



Unemployed; student; non specified; employee; self employed



Non specified; services; health care and social services; engineering; education; sciences, math and IT; social sciences, commerce and law; arts and humanities, agriculture

For question 1 regarding respondents' age, age ranges were created to facilitate data processing. Among the 154 participants, most are between 17–25 (25%), 26–34 (25%), and 44–52 years old (21%), showing a balanced distribution between younger and older adults. Additionally, 14% are aged 35–43, 12% are 53–61, and only 3% are 62–70. Also, 56% of respondents are female (86 individuals), and 44% are male (68 individuals).

Most respondents hold a bachelor's degree (34%) or complete secondary education (32%). Additionally, 18% have a master's degree and 12% a postgraduate diploma. The remaining sample includes 2% with a PhD, 1% with an associate degree, and 1% unspecified. Regarding academic background, the dominant area is Economics and Management (42%), followed by Social Sciences (20%), unspecified fields (16%), Arts and Humanities (14%), and Engineering (8%).

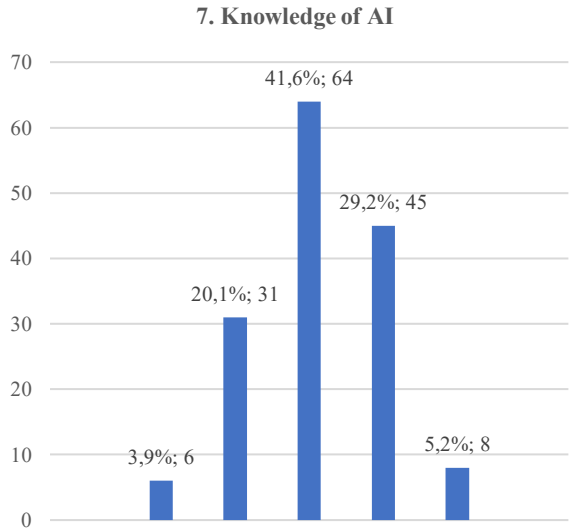
As shown in the chart, most respondents (73%) are employed by others. The rest include 15% students, 6% self-employed, 4% unemployed, and 3% unspecified. Regarding professional fields, 31% did not specify, while 27% work in Services. The remainder are spread across various sectors: 12% in Science, Mathematics, and IT; 10% in Social Sciences, Business, and Law; 7% in Health and Social Protection; 5% in Education; 5% in Engineering and Manufacturing; 3% in Arts and Humanities; and 1% in Agriculture.

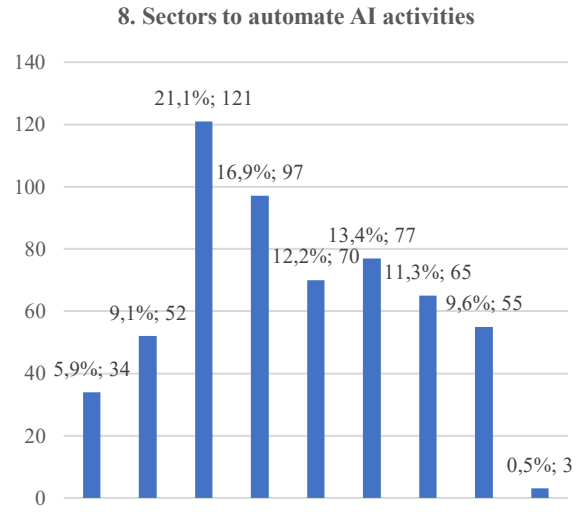
4.2. Analysis of Results

Following the demographic analysis, this chapter focuses on the technical findings gathered through the questionnaire and interviews, specifically regarding AI, blockchain, and cryptocurrencies.

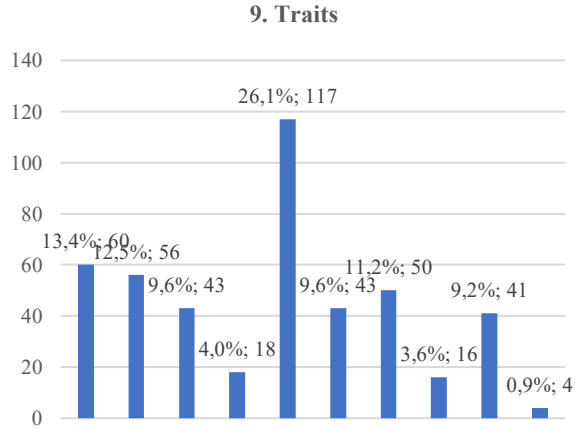
Question 7 used a 5-point semantic differential scale, where 1 meant "No knowledge" and 5 "Very High knowledge" of AI. According to Chart 2, only 4% reported having no knowledge of AI, and 5% indicated very high knowledge. Most responses are in the mid-range: 20% reported low knowledge, 29% high, and the largest group (42%) rated their knowledge as medium. In total, 76% rated their knowledge from medium to very high, compared to only 24% with little or no knowledge.

Chart 2: AI.

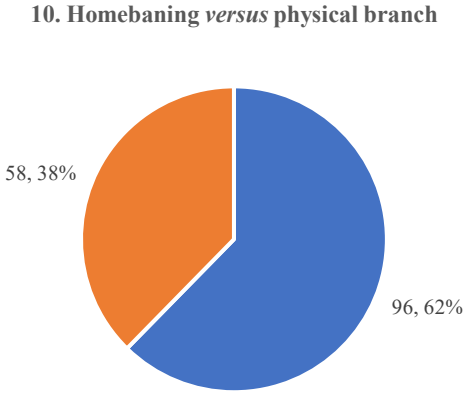




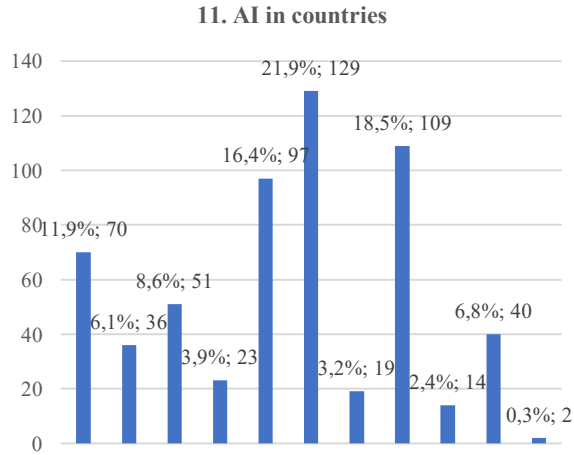
Agriculture; education; data extraction; finance; management; marketing; security; health care; other



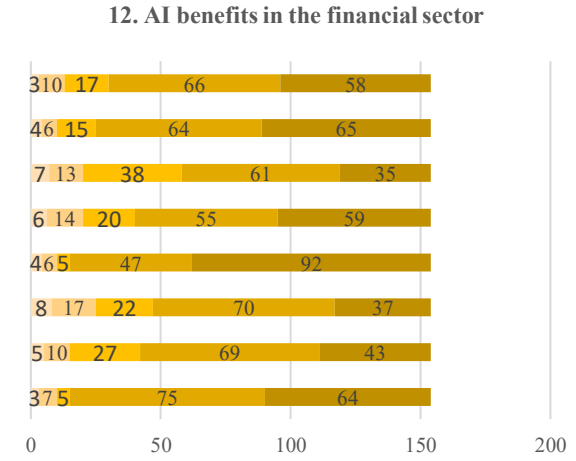
Ambition; comprehension; creativity; education; empathy; honesty; loyalty; resilience; responsibility; velocity



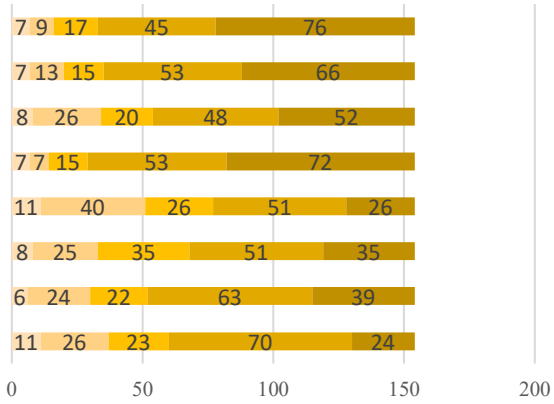
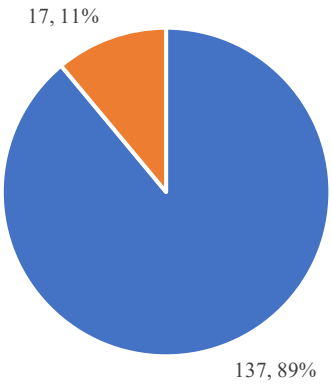
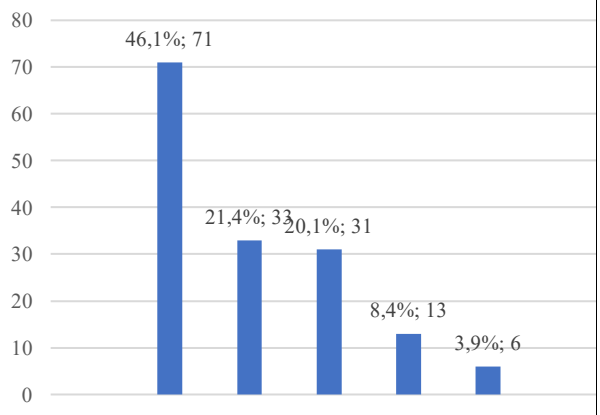
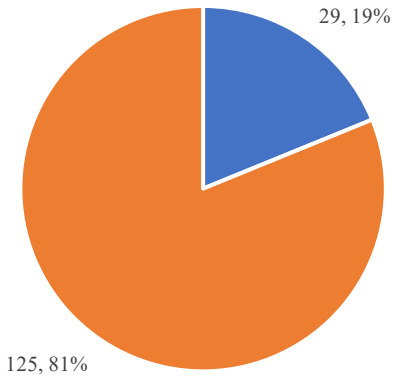
Homebanking (digital); physical branch

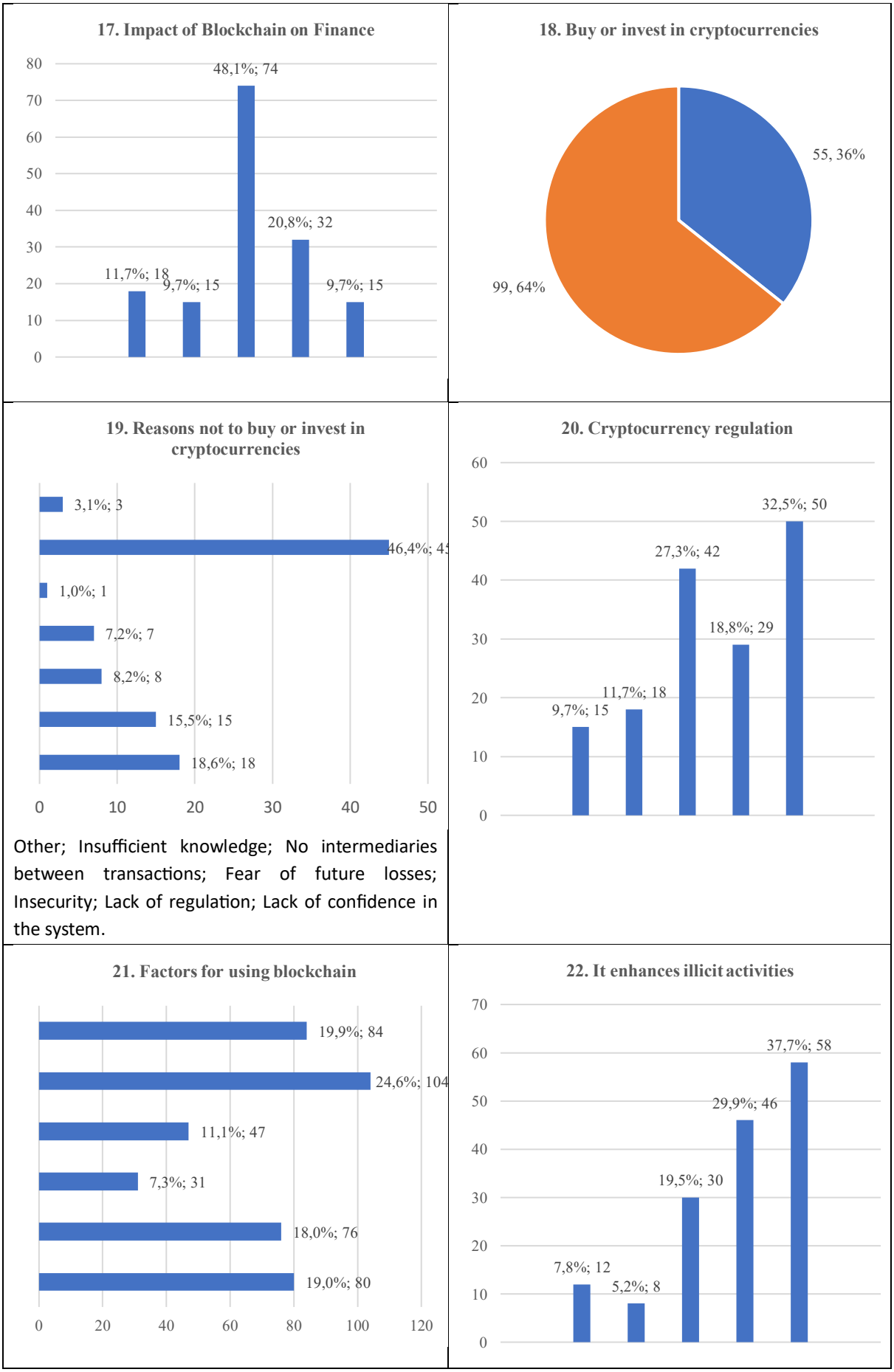


Germany; Canada; Emirates; Australia; China; USA; France; Japan; Portugal; UK: Other



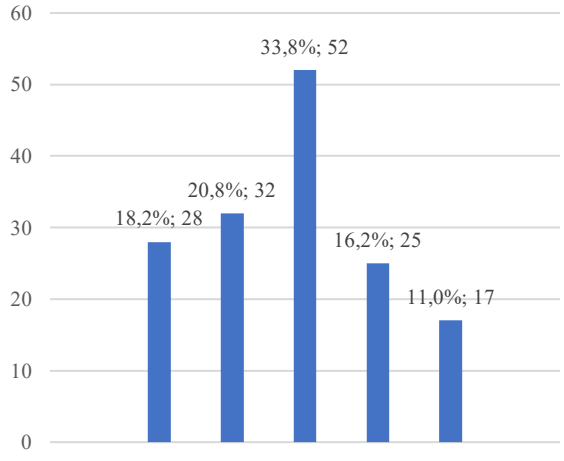
Fast communication; Reduction of operating costs; Greater convenience for employees; Innovation;

	Fraud detention; More efficient service with customers; Increase of efficiency and performance of employees; Process optimization and automation
13. AI limitations in the financial sector  Job displacement; Cybersecurity risks; Loss of control and privacy; Loss of human connection; Lack of transparency; Economic inequality; High implementation and maintenance costs; Job automation	**14. Impact of AI in Portugal** 
15. Degree of knowlege of Blockchain 	**16. Usage of Blockchain** 

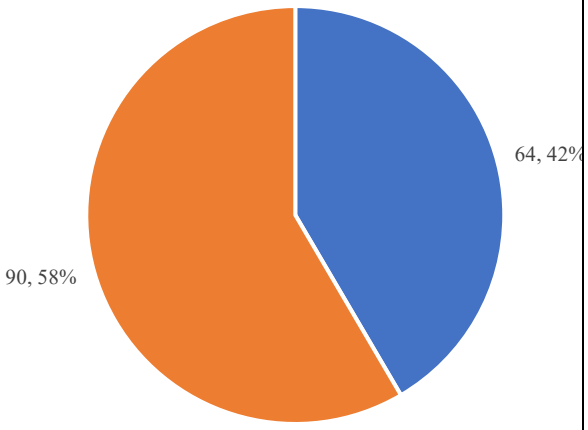

17. Impact of Blockchain on Finance
80
70
60
50
40
30
20
10
0
48,1%; 74
20,8%; 32
11,7%; 18
9,7%; 15
9,7%; 15
18. Buy or invest in cryptocurrencies
55, 36%
99, 64%
19. Reasons not to buy or invest in cryptocurrencies
3,1%; 3
46,4%; 45
1,0%; 1
7,2%; 7
8,2%; 8
15,5%; 15
18,6%; 18
0
10
20
30
40
50
Other; Insufficient knowledge; No intermediaries between transactions; Fear of future losses; Insecurity; Lack of regulation; Lack of confidence in the system.
20. Cryptocurrency regulation
60
50
40
30
20
10
0
32,5%; 50
27,3%; 42
18,8%; 29
11,7%; 18
9,7%; 15
21. Factors for using blockchain
19,9%; 84
24,6%; 104
11,1%; 47
7,3%; 31
18,0%; 76
19,0%; 80
0
20
40
60
80
100
120
22. It enhances illicit activities
70
60
50
40
30
20
10
0
37,7%; 58
29,9%; 46
19,5%; 30
7,8%; 12
5,2%; 8

Security and storage stability; User protection; Price stability; Increase in the number of banks adopting; Increase in information; State approval and regulation	

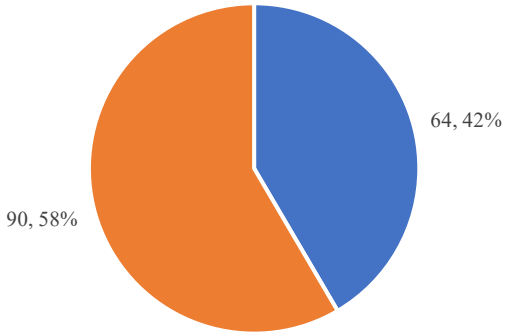
23. Cryptocurrencies as a future currency



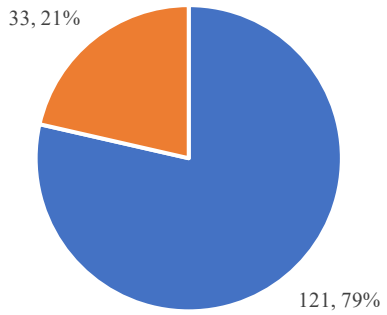
24. Use cryptocurrencies or virtual currency



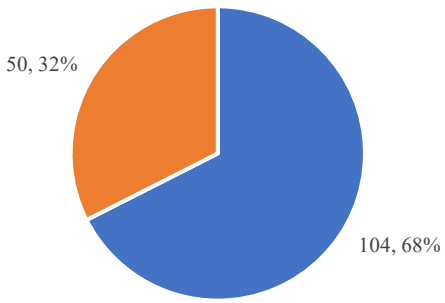
25. Cryptocurrency as official currency



26. AI and Blockchain in Digital Transformation in the Financial Sector



27. "New technologies are a possible threat to the future of professionals in the financial sector"



Notes: Q7, Q15, Q17, Q20, Q22, Q23 = Lickert scale (1-5); Q14, Q16, Q18, Q24, Q25, Q26, Q27 = Yes, No.

Question 8, shown in Chart 2, allowed respondents to select one or more sectors where they believed AI has the greatest potential for automation. The most selected sectors were data extraction and finance, each chosen by around 38% of the sample. Intermediate selections included management, marketing, security, healthcare, and education (10–17%). Agriculture was seen as having low automation potential, with only 6% selecting it. Respondents also suggested three additional sectors: engineering, public administration, and public services.

In question 9, respondents could choose one or more personality traits they believed machines would struggle to replicate. Empathy was the most selected trait, with 26% identifying it as the hardest for machines to emulate. Other traits—such as ambition, understanding, loyalty, creativity, honesty, and responsibility—were moderately chosen (around 11–13%). Traits like politeness, resilience, and speed were considered easier for machines to replicate.

Question 10 asked respondents whether they preferred handling banking matters at a physical branch or through digital channels The majority—around 96 respondents (62%)—preferred digital banking. However, a notable portion—about 58 respondents (38%)—still favored in-person service at a physical branch. Interestingly, while 62% prefer digital banking (Q10), this preference is more pronounced in the 17-34 age brackets (50% of the sample), suggesting a generational shift in financial interaction (Supporting H2).

Question 11 asked respondents to select one or more countries they considered most capable of integrating AI into daily work. The most advanced countries identified were the United States, Japan, China, and Germany. In contrast, Australia, France, and especially Portugal—selected by only 2.4%—were seen as less capable. One respondent also added Denmark as an additional country.

It was asked about the potential benefits of AI in the financial sector. A Likert scale was used in Question 12 to assess the perceived importance of each benefit. Except for fraud detection—rated “Very Important” by about 60%—and employee convenience, which had a balance between “Indifferent” and “Very Important,” most other benefits were rated as “Important” or “Very Important” by most respondents.

In contrast to Question 12, Question 13 presents some limitations that AI may bring to the financial sector, using the same Likert scale to assess respondents' level of agreement. Over 75% of respondents agreed or strongly agreed that job displacement, cybersecurity risks, and loss of human connection are major limitations. Most also agreed that job automation and high implementation/maintenance costs are significant concerns. Opinions were more divided on economic inequality and privacy loss. Regarding lack of transparency, responses were balanced, though 26% disagreed that AI would harm data transparency.

Question 14 aims to assess respondents’ views on the future impact of AI in Portugal over the next 10 years. The expectation is nearly unanimous: about 137 respondents (89%) believe AI will impact various sectors in Portugal. Conversely, 17 respondents (11%) disagree with this prediction.

Like question 7, question 15 used a 5-point semantic differential scale, where 1 indicates “No” knowledge and 5 indicates “Very High” knowledge of the blockchain concept. Chart 2 shows that nearly half of respondents (about 46%) reported having no or low knowledge, while only 4% claimed very high knowledge. Overall, 67% of the sample had little to no understanding of blockchain, while 33% reported medium to high levels of knowledge. Even with 34% of respondents holding a bachelor's degree and 18% a master's, the knowledge of Blockchain (Q15) remains surprisingly low (67% low/none), indicating that higher education does not necessarily translate into literacy regarding decentralized ledger technologies.

Question 16 aimed to determine whether respondents had ever used blockchain technology. The vast majority—around 81%—have never used it, while only 19% reported having used it in some aspect of their daily lives.

Based on the answers to Question 17, the aim was to assess respondents’ views on whether blockchain has an organizational impact on the financial sector. Nearly half—around 48%—neither agreed nor disagreed. Meanwhile, 22% disagreed to some extent, and 31% agreed that blockchain has had an impact on the sector.

Since most respondents had little knowledge of blockchain and had never used it, Question 18 aimed to understand whether they were willing to buy or invest in cryptocurrencies. Around 64% said they were not willing to invest, while 36% expressed willingness.

Question 19 was the only conditional question, answered only by those who responded "No" to Question 18. It aimed to identify the reasons behind respondents' unwillingness to buy or invest in cryptocurrencies. The main concern, selected by 46% of respondents, was the lack of knowledge and information. Other key concerns included lack of trust in the system (19%) and lack of regulation (16%). Less frequently cited reasons were insecurity (8%), fear of losses (7%), and absence of intermediaries (1%). Some also mentioned tax evasion and funding of criminal or terrorist organizations.

Question 20 addressed whether respondents believe cryptocurrencies should be regulated by banks, the state, and governmental institutions, similar to traditional currencies. About 33% of respondents fully agreed with the need for regulation, while only 10% totally disagreed. Around 27% were neutral, 19% agreed, and 12% partially disagreed. Overall, data shows that over half of the respondents support crypto regulation.

In Question 21, respondents could select one or more factors they considered important for using blockchain technology. The most selected was user protection, chosen by 104 respondents (25%). Other key factors included secure and stable data storage (20%), state approval and regulation (19%), and increased information (18%). Less important were price stability (11%) and broader adoption by banks (7%).

Question 22 addresses respondents' level of agreement on whether cryptocurrencies may increase illicit activities. According to the chart, 38% totally agree and 30% agree, while only 8% totally disagree and 5% partially disagree. Meanwhile, 20% neither agree nor disagree. Overall, about 68% of the sample believes that, without regulation, cryptocurrencies could promote illicit activity.

Question 23 represents respondents' agreement on whether cryptocurrency could become the currency of the future. Around 34% neither agree nor disagree, while 21% disagree and 18% totally disagree. Conversely, 16% agree and 11% totally agree. Excluding the neutral responses, the results are balanced, suggesting uncertainty and lack of knowledge about cryptocurrencies.

Question 24 aimed to assess whether respondents would be willing to use cryptocurrencies or digital currencies. Around 58% stated they would not be willing to use digital currencies in the future, while 42% indicated they would be open to using them.

Question 25 asked whether, in 20 years, 25 % of the world's countries will adopt cryptocurrency as their official currency. Most respondents, 90 people (58 %)—disagreed, whereas those willing to use, buy, or invest in cryptocurrencies tended to agree.

AI and blockchain have emerged in several sectors, including finance. Question 26 asked whether these technologies have played a significant role in digital transformation within the financial sector. 121 respondents (79%) agreed they have played a key role, while 33 (21%) disagreed.

The final question, number 27, presented the statement: "New technologies are a possible threat to the future of professionals in the financial sector," to which respondents could answer "yes" or "no." 104 respondents (68%) agreed that new technologies may pose a threat to jobs in finance, while 50 (32%) did not see them as a threat.

The findings reveal a perceptual paradox: while AI is recognized for its high operational utility in fraud detection and process optimization (Q12), it simultaneously triggers a high level of professional anxiety, with 68% of the sample perceiving it as a direct threat to job security (Q27). This supports the Socio-Technical tension proposed in our conceptual framework.

The internal consistency of the research instrument was assessed using Cronbach's Alpha coefficient. The reliability analysis yielded a Cronbach's Alpha of 0.7501 for the AI section, indicating good internal consistency.

Regarding the Blockchain section (α = 0.4114), the lower coefficient is attributed to the multidimensional nature of the items, which combined binary (Yes/No) usage data with attitudinal Likert scales. Furthermore, the high percentage of respondents reporting 'no knowledge' of blockchain (68%) contributed to a higher variance in responses. As such, these items were analyzed as independent indicators of digital literacy rather than a single unified scale.

To examine the predictors of AI acceptance, a Multiple Linear Regression was conducted, as shown in Table 5. The dependent variable was the aggregate score of AI perceptions (validated by Cronbach's Alpha = 0.75), while sociodemographic factors and self-reported knowledge were treated as independent variables. This inferential approach allows for a robust assessment of how individual characteristics influence the digital transition in the financial sector.

Table 5: Results of Multiple Linear Regression for AI Acceptance.

Independent Variables	Coefficients (β)	Standard Error	t-statistic	p-value
(Intercept)	46.012	2.915	15.783	< 0.001***
Age	0.032	0.049	0.648	0.517
Gender (Male)	3.405	1.304	2.610	0.009***
Academic Qualifications	0.029	0.437	0.067	0.946
Level of Knowledge (IA)	0.446	0.704	0.634	0.526

Notes: *** - statistical significance at 1%.

The inferential analysis for the AI sector reveals a gender-based digital divide. A multiple linear regression model ($F = 2.12$, $p < 0.10$) identified Gender as the primary significant predictor of positive AI perception ($B = 3.40$, $p < 0.01$). These results suggest that, within the Portuguese financial context, men demonstrate a significantly higher propensity for AI engagement and perceived utility than women, while age and academic qualifications showed no significant impact in this specific model.

In addition to the AI analysis, a Multiple Linear Regression was performed to examine the predictors of blockchain adoption (Table 6). Due to the insufficient internal consistency observed in the overall blockchain scale (Cronbach's Alpha < 0.70), Question 24 ('Willingness to adopt blockchain/digital currencies in the future') was selected as the primary dependent variable. Sociodemographic characteristics were treated as independent variables to assess their specific influence on the intention to adopt decentralized ledger technologies.

Table 6: Results of Multiple Linear Regression for Blockchain Adoption.

Independent Variables	Coefficients (β)	Standard Error	t-statistic	p-value
(Intercept)	0.437	0.129	3.389	0.001***
Age	-0.001	0.003	-0.524	0.600
Gender (Male)	0.226	0.079	2.860	0.005***
Academic Qualifications	-0.021	0.027	-0.798	0.426

Notes: *** - statistical significance at 1%.

The multiple linear regression model ($F = 3.31$, $p < 0.05$) identified Gender as the primary significant predictor of positive AI perception ($B = 0.2258$, $p < 0.01$). In both AI and Blockchain, men show a greater intention to adopt and a more positive perception. This suggests that digital literacy strategies in financial institutions should focus on reducing this gender disparity. Interestingly, the Blockchain model (Q24) proved to be more significant globally ($p < 0.05$) than the AI model ($p < 0.10$). This proves that, although general knowledge of Blockchain is lower, the decision to "want to use it in the future" is more clearly defined by specific demographic profiles. The fact that academic qualifications are not significant in either model is an important finding. It indicates that "digital zeal" does not depend on the degree level (bachelor's vs. master's), but on other sociocultural factors.

5. Discussion of Results

Following the analysis of the questionnaire data, this chapter focuses on interpreting the 154 responses collected through the survey regarding new information technologies in the financial sector, along with the insights from the two interviews. The aim is to correlate these findings with the previously formulated research hypotheses.

For interpreting the results, both the historical approach and the inductive approach were utilized. The historical approach encompasses various techniques, methods, and procedures to examine the phenomena and processes examined in the study, whereas the inductive approach is based on observing specific data to formulate general conclusions - progressing from particular instances to overarching insights. These approaches facilitate extensive considerations instead of definitive conclusions.

The initial questions played a crucial role in outlining the sample's profile to identify its characteristics. Regarding the questionnaire, there was a balanced representation between female and male respondents, although most responses came from women. Age was a key factor, with most responses coming from individuals aged between 17–25, 26–34, and 44–52. This provides insights from both younger and older perspectives regarding the impact of new information technologies in the financial sector. In terms of education level, most respondents had either a bachelor's degree or a secondary education.

The inferential analysis conducted provides a new layer of understanding regarding the determinants of technology adoption in the Portuguese financial sector. The results of the multiple linear regressions for AI (Table 5) and Blockchain (Table 6) reveal a remarkable convergence: in both digital ecosystems, Gender emerges as the most robust and significant statistical predictor ($p < 0.01$ for AI and $p < 0.01$ for Blockchain). These data suggest the existence of a persistent gender digital divide. Male respondents demonstrate not only a more favorable perception of the usefulness of AI, but also a significantly higher predisposition for the future adoption of cryptocurrencies and distributed ledger technologies. This finding aligns with the literature on the UTAUT model (Venkatesh et al., 2003), which identifies gender as a critical moderator in the acceptance of new technologies, frequently associating the male profile with a greater orientation towards performance and perceived ease of use in FinTech environments. On the other hand, the absence of statistical significance for Academic Qualifications and Self-Reported Knowledge Level in both models is revealing. This indicates that the desire to integrate these technologies into daily financial life is not strictly dictated by the level of education, but by deeper sociodemographic factors. Regarding Blockchain, although the aggregate scale showed reduced internal consistency ($\alpha = 0.41$), reflecting the fragmentation and novelty of the topic for the general public, the individual analysis of future usage intention (Q24) validated the global model ($p < 0.05$). This result suggests that, despite blockchain literacy still being incipient (68% unaware), future adoption decisions are already being shaped by specific demographic profiles, reinforcing the need for more inclusive and targeted financial communication strategies to mitigate the observed disparities.

As for the interviews, both were conducted with male participants. One holds a master's degree and has worked in two financial institutions, while the other is currently employed in a financial institution. Since both have or had contractual ties to financial institutions, their input is valuable for analyzing the perspective from within the industry.

The following section presents the analysis of each research hypothesis formulated in the study:

Hypothesis 1: The integration of disruptive IT (AI and Blockchain) has significantly altered the operational dynamics and service delivery models within the financial system.

Regarding the level of knowledge about the technologies presented, most respondents (76%) reported having medium to high knowledge about AI, suggesting that this technology is relatively familiar to the public. In contrast, blockchain showed the opposite trend, with 68% of respondents having little or no knowledge, and only a small portion (12%) claiming to have high or very high knowledge. This indicates that blockchain is still relatively unfamiliar and not widely adopted among the target audience, as 81% have never used the technology.

Regarding the organizational impact of blockchain in the financial sector, nearly half of the respondents (48%) neither agreed nor disagreed with the statement, reflecting the lack of knowledge and understanding previously demonstrated in earlier questions. However, 31% agreed or strongly agreed that technology has an organizational impact, indicating a growing recognition of blockchain in the financial industry.

According to the data, 79% of participants think blockchain and AI are going to have a major impact on the financial industry's digital transformation. The experts surveyed concur, pointing out that both technologies are boosting productivity, simplifying procedures, strengthening security, and stimulating innovation in the financial industry. However, one interviewee noted that putting these technologies into practice presents several difficulties, such as the need for new regulatory measures because of the increased risk of fraud, investments in technology infrastructure, employee training, and guaranteeing the security, privacy, and protection of data for financial institutions and their clients. The other interviewee pointed out that the financial sector has begun to adapt to these technologies; for example, the level of blockchain implementation varies between investment banks and fund management in relation to transactions - and stressed that digitalization in Portugal is advancing at a faster pace compared to other nations.

Consequently, the findings reinforce the research hypothesis that emerging information technologies have brought about a new dynamic within the financial system, which leads us to accept Hypothesis 1.

Hypothesis 2: The growth of digital banking acts as a primary driver in shifting consumer behavior from traditional physical interaction to digital-first financial engagement.

Data on how banking operations have changed and the effects they have on customers and employees were gathered using a questionnaire and interviews with banking professionals.

Question 10 of the questionnaire supports Hypothesis 2. Most customers (62%) prefer using online banking services over going to a physical branch. Results show that digital services provide better accessibility and faster response times. It is also demonstrated how technology is increasingly the influence how people engage with the financial system. It also implies that there is still potential for improvement when it comes to managing more complicated problems that might call for face-to-face help at a physical location. The 62% preference is not just about "convenience," but a shift in the consumer's mental model.

From the perspective of the interviewed banking professionals (questions 6 and 7), digitalization and technological advancement have led to the closure of physical branches. However, they emphasize that this should not be viewed as a threat but rather as an opportunity to enhance the financial sector. The growth of digital services opens the door to new jobs. These jobs need professional retraining and the development of new roles, such as data analysis and the design of tech solutions. One interviewee pointed out that the pandemic sped up the use of online banking services. This shows how outside events can push change among consumers and affect the way financial institutions operate. The other interviewee pointed out that self-service has become a dominant trend in banking and other industries.

Based on these results, it is possible to conclude that technological evolution has significantly influenced banking operations through the rise of digital banking, changing the way people perceive and engage with the financial system. Therefore, this hypothesis is accepted.

Hypothesis 3: There is a significant perception among stakeholders that automation and AI-driven processes negatively correlate with long-term job security in the financial sector.

The survey results reveal that consumers view most benefits of implementing AI in the financial sector as important or very important. Notably, 90% highlight the automation and optimization of processes, which shows that people recognize AI’s ability to improve efficiency and reduce human error. Other significant advantages include faster communication at 81%, lower operational costs at 84%, and increased convenience for employees at 62%. These findings indicate that AI can simplify routine financial operations.

However, implementation also raises concerns. Most respondents agree or strongly agree that AI can automate tasks (61%) and replace jobs (79%). This highlights serious worries about its impact on employment. Additionally, the loss of human connection (81%) is viewed as a major drawback, potentially harming the relationship between financial institutions and their clients.

From the consumers' standpoint, this concern is further confirmed by the fact that 68% believe new technologies pose a threat to financial professionals. This perception is shared by the interviewees, who acknowledge the risk of job displacement and the erosion of human contact. Still, they also point out that using technology can create new opportunities through adjustment and job retraining, which leads to the development of new roles and functions that help clients, employees, and financial institutions. In conclusion, while new technologies are shaping the future of finance with clear benefits, both consumers and professionals see their evolution as a possible threat to jobs; therefore, this hypothesis is accepted.

Hypothesis 4: While blockchain provides perceived transparency and security, its influence on the actual adoption of cryptocurrencies is mediated by institutional trust and regulatory frameworks.

As previously noted in Hypothesis 1, respondents show limited or no knowledge of blockchain (68%), while the remaining minority report medium, high, or very high levels of knowledge - with only 19% having ever used the technology.

The data suggests that most consumers (64%) are unwilling to purchase or invest in cryptocurrencies, with 46% of them citing lack of knowledge as the primary cause. Other major obstacles include a lack of regulation (15%) and a lack of trust in the system (19%). These results show that regulatory oversight and a lack of trustworthy information are major barriers to respondents' adoption of cryptocurrencies.

When participants were asked if they would use a tool from their bank to monitor cryptocurrencies for investment or purchase, most focused on user protection (25%). This was followed by secure and stable data storage (20%), state approval and regulation (19%), and more information (18%). While limited information is a relevant barrier, data protection appears to be a stronger motivator for possible crypto adoption.

From a professional point of view, one banking expert sees cryptocurrency trading as a financial chance for institutions, as long as it is closely watched and regulated to safeguard both investors and financial markets. The second professional is more critical. They view cryptocurrencies as highly speculative and with a limited supply. They contend that the pricing is excessive and are concerned that banks may make the same mistakes they made during the 2008 financial crisis.

In conclusion, experts and consumers alike concur that the most crucial elements for the possible uptake of cryptocurrencies are security and regulation. Banks, governments, and regulatory agencies should regulate cryptocurrencies, according to a sizable portion of the sample (51%) who agree or strongly agree. Furthermore, 68% believe cryptocurrencies could increase illicit activities if left unregulated.

However, only 42% of respondents would consider using cryptocurrencies in the future, 27% believe they could become the currency of the future, and 58% do not believe that 25% of the world's countries will adopt them as official currency within the next 20 years.

One interviewee argues that cryptocurrency adoption within the EU is unlikely without unanimous agreement among member states. The other believes that if central banks were the issuers, adoption would be more likely.

In conclusion, blockchain technology does offer security and transparency, and financial experts see its potential for institutional gains. However, these factors alone are not enough to get people to use cryptocurrencies. Consequently, this hypothesis is dismissed. The rejection of H4 is a significant finding. It suggests a decoupling between the technical merits of Blockchain (security/transparency) and the psychological/regulatory readiness for Cryptocurrency. This indicates that transparency is a 'hygiene factor' (necessary but not sufficient) and that without Institutional Trust and State Regulation, the technological advantage remains inert. The rejection of H4 also stems from the lack of a unified technological perception among respondents (as evidenced by the low Cronbach's Alpha of 0.41 for this section), which reinforces our finding that institutional trust and literacy are still in an embryonic stage.

The findings regarding the lack of knowledge in Blockchain (68% of respondents) align with the UTAUT framework (Venkatesh et al., 2003), specifically the 'Facilitating Conditions' construct. The results suggest that without adequate information and regulatory support, the perceived effort to use these technologies outweighs the intention to adopt them, leading to the rejection of H4.

Hypothesis 5: The successful adoption of AI and Blockchain provides measurable efficiency gains and structural benefits that outweigh traditional operational limitations.

Most consumers see that using AI offers substantial benefits to the financial sector, especially in fraud detection (90%), process automation (90%), lowering operational costs (84%), and driving sector innovation (74%). These findings align with insights from the interviews, where professionals also believe that both AI and blockchain can significantly improve efficiency, increase security, provide new customer services, cut costs, and foster innovation within the financial system.

Despite these benefits, consumers share concerns. They identify loss of human connection (81%), cybersecurity risks (77%), and job displacement (79%) as their main worries. However, these challenges do not outweigh the advantages. Instead, they highlight the need to address these issues effectively.

Furthermore, consumers emphasize that user protection (25%) and secure data storage (20%) are crucial for adopting cryptocurrencies. This again stresses the vital role of security and trust in embracing new technologies. The benefits "outweigh" the limitations not by opinion, but because respondents identify gains of 90% in critical areas such as fraud.

Data indicates that both consumers and professionals generally have a positive view of technological implementation, especially regarding efficiency, cost savings, and innovation, despite ongoing concerns about security, human interaction, and employment. These results highlight the need for a safe, well-managed adoption process to achieve successful and sustainable integration of these technologies in financial institutions. One interviewee mentioned that adopting such technologies in financial institutions usually takes over five years.

Additionally, the acceptance of cryptocurrencies relies heavily on user protection and security. Therefore, we can conclude that the successful use of AI, blockchain, and cryptocurrencies in financial institutions benefits the financial sector, and this hypothesis is valid.

In summary, Table 7 presents the accepted or rejected results of each research hypothesis.

Table 7: Hypothesis analysis results.

Research Hypothesis	Hypothesis Description	Status
Hypothesis 1	The integration of disruptive IT (AI and Blockchain) has significantly altered the operational dynamics and service delivery models within the financial system.	Supported
Hypothesis 2	The growth of digital banking acts as a primary driver in shifting consumer behavior from traditional physical interaction to digital-first financial engagement.	Supported
Hypothesis 3	There is a significant perception among stakeholders that automation and AI-driven processes negatively correlate with long-term job security in the financial sector.	Supported
Hypothesis 4	While blockchain provides perceived transparency and security, its influence on the actual adoption of cryptocurrencies is mediated by institutional trust and regulatory frameworks.	Not Supported
Hypothesis 5	The successful adoption of AI and Blockchain provides measurable efficiency gains and structural benefits that outweigh traditional operational limitations.	Supported

5.1. Discussion: Mechanisms of Digital Transition

The rejection of H4 and the low internal consistency of the blockchain scale (α = 0.41) are not merely statistical artifacts; they reveal a deep-seated mechanism of Institutional Trust. As noted in the literature, blockchain provides technical transparency, but our results show that 46% of non-investors cite "lack of knowledge" as the primary barrier. his suggest that in the Portuguese context, technical security is insufficient if not accompanied by regulatory frameworks. The "knowledge paradox" identifies that even with a recognized potential for innovation, the absence of a stable legal environment prevents the transition from "interest" to "actual use".

Our Multiple Linear Regression identified Gender as the only significant predictor for both AI and Blockchain adoption ($p < 0.01$). This aligns with the UTAUT model (Venkatesh et al., 2003), which posits that gender acts as a moderator where performance expectancy (the belief that technology helps tasks) is often more salient for men in competitive environments. This suggests that the digital transition in the Portuguese financial sector is currently asymmetric, requiring targeted policies to promote gender-neutral digital literacy.

While 90% of respondents recognize AI's efficiency in fraud detection, 68% view it as a threat to their profession. This reflects a tension in Task-Technology Fit (TTF). Technology is perceived as "fitting" the task of data processing, but "unfitting" the task of human relationship management. As corroborated by the interviewees, the closure of physical branches is an operational efficiency but creates a "void" in the psychological contract between the bank and the client.

6. Conclusion

This study's main goal was to assess how new IT has affected the financial industry from both a consumer and a professional standpoint. This exploratory study sought to map the current digital transformation landscape and its implications for the future of financial professions by examining the levels of knowledge, perceived benefits, and limitations of blockchain and AI.

A discrepancy in technological literacy is revealed by the data gathered. While the majority of this sample demonstrates a medium to high level of AI knowledge, suggesting a degree of familiarity with this technology, blockchain remains poorly understood, with most respondents reporting little to no awareness. This lack of understanding appears to correlate with a sense of anxiety regarding decentralized systems. Consequently, for the participants in this study, increasing information sharing and public awareness emerges as a potential requirement to dispel technical doubts.

From the questionnaire and interviews, it is observed that both consumers and professionals tend to hold favorable views on IT's role in introducing new dynamics to financial operations. The preference for digital banking over traditional channels in this sample reflects how technological advancement can improve banking operations. However, these respondents had a more negative opinion of cryptocurrencies; while security and transparency are acknowledged as technological benefits, they do not appear to be enough to promote widespread adoption. This is supported by the qualitative findings from the interviews, which indicate that adoption might be more dependent on investor protection and regulatory monitoring than on technological features alone.

The perception of new technology as a possible danger to existing financial industry jobs is a noteworthy finding that is consistent across both quantitative and qualitative data. The majority of respondents voice concerns about job security notwithstanding the possibility of professional requalification and the introduction of new roles. This tension highlights one of the study's primary interpretative contributions: while IT facilitates lower operating costs and greater efficiency through digital banking, it simultaneously introduces obstacles such as the loss of human connection and the risk of structural unemployment.

This research contributes to the scientific community by illustrating how IT is transforming conventional financial systems. By applying inferential techniques - such as the Multiple Linear Regression which identified gender as a significant predictor for adoption ($p < 0.01$) - the study moves beyond descriptive findings to suggest that

technological engagement is moderated by sociodemographic factors, as posited by the UTAUT framework. Unlike general studies, our findings reveal a knowledge paradox in the Portuguese context: high familiarity with AI does not translate into job security, whereas low knowledge of Blockchain correlates directly with financial skepticism.

Strategically, the results indicate that the amount of data handled by FIs is putting increasing pressure on them to reconsider their business strategies. By emphasizing that a successful digital transformation necessitates a balance between technology advantages and the mitigation of socio-technical hazards, such as professional anxiety and digital exclusion, the research helps to the strategic growth of financial institutions.

These findings should be interpreted cautiously and not as generalizations for the Portuguese population as a whole, given the exploratory approach and convenience sample (N=154). The results highlight the need for continuous structural changes in order to modernize the industry and show trends within a particular group. Regular assessment and updated research are crucial to ensuring that the shift to the digital era remains inclusive and balanced as the complexity of blockchain and AI continues to develop.

The representatives of the sample obtained through the questionnaire survey constitutes the primary limitation of this research. Due to the use of convenience sampling - a non-probability technique selected to facilitate data collection - the participants were primarily reached through personal networks and academic referrals. Consequently, this sampling nature precludes a generalized analysis of the results for the entire Portuguese population and should be interpreted as an exploratory snapshot of a specific demographic.

Furthermore, the scale of the study, while providing a good response rate and a diverse age range, remains constrained by the total number of participants (N=154). This restriction aligns with the qualitative component, as a higher number of interviews with financial industry professionals would have potentially allowed for greater thematic saturation and a more representative assessment of the internal reality within FIs.

Regarding future research, it would be valuable to overcome these constraints by implementing probability sampling with larger cohorts of both experts and consumers to achieve broader applicability. We suggest expanding the scope in two specific directions. First, the institutional focus, by conducting research solely within FIs operating in Portuguese territory to collect granular data on the specific benefits and risks of technology implementation in each organizational culture. Secondly, a comparative analysis, by correlating Portuguese data with findings from FIs in other nations to identify regional patterns in digital transition.

Lastly, future research should monitor the development of cryptocurrency laws in Portugal, considering the intricacy of blockchain and AI. It is nevertheless vital to keep an eye on whether more regulations result in better rates of acceptance as a payment method across various businesses. Regular updates to this research body are necessary to guarantee the findings' continued relevance in the digital age, given the continuous and quick growth of these technologies.

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Appendices

Appendix A—Questionnaire Survey (Translated into English)

New Information Technologies in the Financial Sector

My name is (…) and, within the scope of my master's dissertation in Management of Financial Institutions at the Instituto Superior de Contabilidade e Administração de Lisboa, the following questionnaire aims to understand the impact that new information technologies currently have on the financial sector.

The data obtained is strictly confidential and will be treated anonymously, used solely and exclusively for scientific research purposes (no response will be identified or treated individually).

Your participation consists of completing a short questionnaire, which is expected to take no more than 10 minutes of your time.

I would like to thank you in advance for your participation in this research, which is essential for the continuation of my dissertation.

* Indicates a mandatory question

Respondent Profile Characterization

1. Age *

2. Gender *

Select only one option.

◯ Male

◯ Female

◯ Unspecified

3. Academic Qualifications *

Select only one option.

◯ Basic Education

◯ Secondary Education

◯ Associate Degree

◯ Bachelor's Degree

◯ Postgraduate Studies

◯ Master's Degree

◯ Doctorate

◯ Unspecified

4. Field of Study *

Select only one option.

- ◯ Arts and Humanities
- ◯ Engineering
- ◯ Social and Human Sciences
- ◯ Economics and Management
- ◯ Unspecified

5. What is your employment status? *

Select only one option.

- ◯ Unemployed
- ◯ Student
- ◯ Employee (working for someone else)
- ◯ Self-employed
- ◯ Unspecified

6. Area of activity *

Select only one option.

- ◯ Agriculture
- ◯ Arts and Humanities
- ◯ Social Sciences, Business and Law
- ◯ Sciences, Mathematics and IT
- ◯ Education
- ◯ Engineering, Manufacturing and Construction
- ◯ Health and Social Protection
- ◯ Services
- ◯ Unspecified

Artificial Intelligence

7. What is your level of knowledge regarding the concept of Artificial Intelligence (AI)? *

Select only one option.

	1	2	3	4	5	
None	◯	◯	◯	◯	◯	Very High

8. Which sectors do you consider to have the most potential for AI to automate their activities? (You may select more than one answer) *

Mark all that apply.

- [ ] Agriculture
- [ ] Education
- [ ] Data Mining
- [ ] Financial
- [ ] Management
- [ ] Marketing
- [ ] Security
- [ ] Health
- [ ] Other:

9. Which attributes (personality traits) do you think are most difficult to replicate in machines? (You may select more than one answer) *

Mark all that apply.

- [ ] Ambition
- [ ] Understanding
- [ ] Creativity
- [ ] Education
- [ ] Empathy
- [ ] Honesty
- [ ] Loyalty
- [ ] Resilience
- [ ] Responsibility
- [ ] Speed

10. Technological growth in the financial system has resulted in the closure of hundreds of physical branches, leading to the emergence of digital banking. Given this, in your daily life, do you prefer to go to a physical branch and continue to have human contact to resolve your issues, or do you prefer to resolve your issues through digital means? *

Select only one option.

- ◯ Digital Banking
- ◯ Physical Banking

11. In your opinion, which are the most developed countries capable of including AI in daily work? (You may select more than one answer) *

Mark all that apply.

- [ ] Germany
- [ ] Canada
- [ ] United Arab Emirates
- [ ] Australia
- [ ] China
- [ ] United States of America
- [ ] France
- [ ] Japan
- [ ] Portugal
- [ ] United Kingdom
- [ ] Other:

12. AI is increasingly present in financial markets. Evaluate from 1 (Not Important at all) to 5 (Very Important) the benefits that its implementation brings to the financial sector: *

Select only one option.

	Not Important at all	Slightly Important	Indifferent	Important	Very Important
Automation and optimization of processes					
Increased efficiency and employee performance					
More efficient customer service					
Fraud detection					
Innovation					
Greater convenience for employees					
Reduction of operational costs					
Speed in communication					

13. In your opinion, evaluate from 1 (Strongly Disagree) to 5 (Strongly Agree) the limitations that AI encounters in the financial sector: *

Select only one option.

	Not Important at all	Slightly Important	Indifferent	Important	Very Important
Job automation					
High implementation and maintenance costs					
Economic inequality					
Lack of transparency					
Loss of human connection					
Loss of control and privacy					
Cybersecurity risks					
Job displacement					

14. In 10 years, do you consider that AI will have an impact on several sectors in Portugal? *

Select only one option.

◯ Yes

◯ No

Blockchain and cryptocurrencies

15. What is your degree of knowledge regarding the concept of blockchain? *

Select only one option.

	1	2	3	4	5	
None	◯	◯	◯	◯	◯	Very High

16. Have you used blockchain technology? *

Select only one option.

◯ Yes

◯ No

17. Do you agree that in organizational terms in the financial area is there an impact of blockchain? *

Select only one option.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

18. Blockchain records and provides security for cryptocurrency transactions; however, these are not regulated by the state. Based on your knowledge of cryptocurrencies, would you be willing to buy or invest? *

Select only one option.

- ◯ Yes
- ◯ No

19. If you selected "no", why? *

Select only one option.

- ◯ Lack of confidence in the system
- ◯ Lack of regulation
- ◯ Insecurity
- ◯ Fear of future losses
- ◯ No intermediaries between transactions
- ◯ Insufficient knowledge
- ◯ Other:

20. Do you agree that cryptocurrencies should be regulated by banks, state and government? *

Select only one option.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

21. If your bank had automated software that monitored cryptocurrency activities, which of the following factors would be a requirement for your usage: (You may select more than one answer) *

Mark all that apply.

- ☐ State approval and regulation
- ☐ Increase in information
- ☐ Increase in the number of banks that join
- ☐ Price stability
- ☐ User protection
- ☐ Security and stability in storage

22. Do you consider that the use of these currencies increases illicit activities? *

Select only one option.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

23. To what extent do you agree that cryptocurrencies are the currencies of the future? *

Select only one option.

	1	2	3	4	5	
Totally disagree	◯	◯	◯	◯	◯	Totally agree

24. In the future, do you plan on using cryptocurrencies or virtual currency? *

Select only one option.

◯ Yes

◯ No

25. In your opinion, do you think that in 20 years, around 25% of the world's countries could adopt cryptocurrencies as their official currency? *

Select only one option.

◯ Yes

◯ No

26. In your opinion, have AI and blockchain played a significant role in the digital transformation of the financial sector? *

Select only one option.

◯ Yes

◯ No

27. Do you agree with the following statement: "New technologies are a potential threat to the future of finance professionals."? *

Select only one option.

◯ Yes

◯ No

Appendix B—Interview Script (Translated into English)

Profile / Interviewee Experience:

1. Tell me a little about your background and your work experience.
2. What technologies do you work with or have you worked with in your day-to-day?

Technical Questions (Artificial Intelligence, Blockchain, and Cryptocurrencies):

1. How do you perceive the emergence of new technologies such as Artificial Intelligence and Blockchain in the financial sector?
2. What are the challenges that these two technologies have brought to the financial system?
3. What is the role of Artificial Intelligence in the future of the financial institutions' business?
4. Do you believe that the impact of technological evolution on the financial system has led to the closure of physical branches and the growth of digital banking? Could this be a threat to the future of professionals in the financial area?
5. As an employee/former employee of a Financial Institution, are people increasingly using digital options instead of physically going to a bank?
6. Regarding cryptocurrencies, these assets are not prohibited in Portugal and have been declared as income since 2023; however, their use is not guaranteed by any national authority. In view of this, do you believe that Financial Institutions could monitor cryptocurrency activity with the objective of commercializing them?
7. Do you agree that if cryptocurrencies were regulated by States, they could be the currencies of the future?
8. Do you believe that new technologies play a significant role in digital transformation in the financial sector?

Appendix C—Transcript of the 1st Interview (Translated into English)

1. Tell me a little about your background and your work experience.

I have a degree in Public Administration and a Master's in Economics and Public Policies. In banking, I have worked at Caixa Geral de Aposentações and BNP Paribas, and currently I work as a senior technician at the Tax and Customs Authority (Autoridade Tributária e Aduaneira).

2. What technologies do you work with or have you worked with in your day-to-day?

I essentially use Excel and SAP.

3. How do you perceive the emergence of new technologies such as Artificial Intelligence and Blockchain in the financial sector?

I see it as something positive that should be encouraged by organizations connected to the financial sector. These two technologies in question have the potential to increase efficiency, improve security levels, and offer new services to customers. Furthermore, they promote innovation in the financial sector and can reduce operational costs.

4. What are the challenges that these two technologies have brought to the financial system?

It implies a new effort from regulatory bodies, as the emergence of new technologies also brings opportunities for fraud and crime. There is also the need to invest in technological infrastructure and in training for employees, and to ensure customer data privacy and protection.

5. What is the role of Artificial Intelligence in the future of the financial institutions' business?

The automation of processes, the elimination of jobs, and a greater capacity for cyclical market prediction, I believe that will also be possible.

6. Do you believe that the impact of technological evolution on the financial system has led to the closure of physical branches and the growth of digital banking? Could this be a threat to the future of professionals in the financial area?

Yes, but I don't think it's a reason to stop the process of technological evolution. Digitalization has led to the closure of physical branches, but it also creates opportunities, such as data analysis, the development of technological solutions, and the adaptation and reskilling of professionals.

7. As an employee/former employee of a Financial Institution, are people increasingly using digital options instead of physically going to a bank?

Yes. The speed of response of digital options has led more and more people to choose these services, and the pandemic accelerated the adoption of online banking services with the aim of reducing the need for people to go to physical branches.

8. Regarding cryptocurrencies, these assets are not prohibited in Portugal and have been declared as income since 2023; however, their use is not guaranteed by any national authority. In view of this, do you believe that Financial Institutions could monitor cryptocurrency activity with the objective of commercializing them?

Yes. Everything that could eventually bring financial gains inevitably attracts the attention of Financial Institutions. However, it is crucial that these activities are regulated and monitored to ensure the safety of investors and the integrity of financial markets.

9. Do you agree that if cryptocurrencies were regulated by States, they could be the currencies of the future?

It would be difficult in the context of the European Union since it would only be possible if there was unanimity among the member states. Regulation could bring more legitimacy and stability to cryptocurrencies, but it would always depend on international agreements.

10. Do you believe that new technologies play a significant role in digital transformation in the financial sector?

Yes, technologies redefine processes, improve operational efficiency, and create new business opportunities, not only in the financial sector but also in other sectors.

Appendix D—Transcript of the 2nd Interview (Translated into English)

1. Tell me a little about your background and your work experience.

I have banking experience in various areas, such as customer service, marketing, and operations, and across different banking segments, such as commercial, specialized, and investment banking.

2. What technologies do you work with or have you worked with in your day-to-day?

Excel, Primavera, SAP, Power Query, and programs built by the company Fidelity National Information Services (FIS).

3. How do you perceive the emergence of new technologies such as Artificial Intelligence and Blockchain in the financial sector?

AI will have a cross-industry impact, optimizing and automating processes. Blockchain will have a different level of implementation, starting perhaps more with investment banks/funds, due to the fact that many batches of securities are traded between them, and tokenization could have some value.

4. What are the challenges that these two technologies have brought to the financial system?

Like any industry, the financial one wants to be at the forefront. Therefore, it has already adapted, giving an example that a major European investment bank managed to issue tokenized bonds in limited numbers.

5. What is the role of Artificial Intelligence in the future of the financial institutions' business?

AI should play a role in optimizing and improving business processes in any industry. There are already some investment funds that use an investment "robot," as is the case with BlackRock. Still, the large-scale implementation of AI in the industry will take no less than 5 years.

6. Do you believe that the impact of technological evolution on the financial system has led to the closure of physical branches and the growth of digital banking? Could this be a threat to the future of professionals in the financial area?

The future is full of unknowns, but moving forward is not one of them. The financial sector, like others, will have to shift routine professions toward coding and technology professions.

7. As an employee/former employee of a Financial Institution, are people increasingly using digital options instead of physically going to a bank?

Yes, although there is still much work to be done in making digital services available, this has been a trend. Self-service has been the dominant trend in banking and also in all other industries. With a population that is better educated in digital tools and some basic banking concepts, they no longer want to "stroll" to bank branches.

8. Regarding cryptocurrencies, these assets are not prohibited in Portugal and have been declared as income since 2023; however, their use is not guaranteed by any national authority. In view of this, do you believe that Financial Institutions could monitor cryptocurrency activity with the objective of commercializing them?

Cryptocurrencies are a highly speculative asset with no underlying rationale (Bitcoin has limited mining and therefore there is a clash with the availability of supply, which generates some rationale, but not enough to justify the price). I hope that banks do not venture into cryptocurrencies as they ventured into subprime mortgages that collapsed the system in 2007.

9. Do you agree that if cryptocurrencies were regulated by States, they could be the currencies of the future?

If central banks were to issue cryptocurrency, perhaps.

10. Do you believe that new technologies play a significant role in digital transformation in the financial sector?

New technologies and innovation play a fundamental role in any industry. In Portugal, banking has always gone hand-in-hand with telecommunications companies, and that is why we have a relatively advanced banking system, with payment systems like MBWay. The digitalization of banking has been slow, but fast compared to other countries.

Ethical Statement

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Marketing strategies in the restaurant sector during a global crisis: A case study of Restaurant Kampo, Madeira

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Abstract

The COVID-19 pandemic triggered an unprecedented global crisis that profoundly disrupted tourism systems and the restaurant sector, exposing the structural vulnerability of hospitality businesses to external shocks. In response to mandatory closures, mobility restrictions, and rapidly changing consumer behaviour, restaurants were compelled to redesign their business models, operational processes, and marketing strategies in order to ensure survival and long-term viability. Within this context, marketing emerged not merely as a promotional tool, but as a strategic mechanism for organizational adaptation and resilience.

This study analyses the marketing strategies adopted by Restaurant Kampo, an author-driven restaurant located on Madeira Island (Portugal), using an in-depth qualitative case study approach. The research examines strategic decisions implemented across three distinct phases: pre-pandemic, lockdown, and post-lockdown, focusing on strategic positioning, marketing mix adaptation, customer relationship management, and the preservation of experiential value under crisis conditions. Data were collected through document analysis, direct observation, digital communication review, and strategic analysis tools, allowing for methodological triangulation.

The findings indicate that strategic flexibility, strong brand identity, and customer-oriented communication played a critical role in maintaining operational continuity and reinforcing brand positioning during the crisis. Experience-based marketing, transparency, and the strategic management of people, processes, and physical evidence emerged as key drivers of customer trust and loyalty. By providing empirical insights into crisis-driven marketing adaptation within a tourism-dependent island destination, this study contributes to hospitality and marketing literature and offers practical implications for restaurant managers seeking to enhance resilience in turbulent environments.

Keywords: COVID-19; Crisis Management; Experiential Marketing; Hospitality Strategy; Restaurant Marketing.

1. Introduction

The restaurant industry plays a central role within tourism systems, contributing not only to economic performance but also to destination image formation, cultural representation, and visitor satisfaction. Gastronomy has progressively evolved from a complementary tourism service into a strategic experiential asset, influencing destination choice, length of stay, perceived authenticity, and tourist loyalty. Contemporary tourists increasingly seek food-related experiences that combine local identity, storytelling, and emotional engagement, positioning restaurants as key interfaces between visitors and destinations.

Prior to 2020, the global tourism and hospitality sectors were largely shaped by sustained growth and increasing concerns regarding overtourism, market saturation, and pressure on local resources. In this context, restaurants faced intense competition, rising customer expectations, and the need for constant innovation in order to differentiate themselves in experience-driven markets. However, the outbreak of the COVID-19 pandemic in early 2020 abruptly disrupted this trajectory, generating an unprecedented global crisis that profoundly affected tourism-dependent industries, particularly restaurants.

Mandatory closures, mobility restrictions, capacity limitations, and health regulations dramatically altered both supply and demand conditions. In tourism destinations such as Portugal and especially in island regions with strong dependence on external markets, the pandemic replaced previous debates on overtourism with a scenario of "non-tourism," characterized by economic paralysis, uncertainty, and abrupt demand collapse. Restaurants, traditionally reliant on social interaction, physical presence, and experiential consumption, were suddenly forced to operate under conditions fundamentally incompatible with their core business models.

In this environment, marketing emerged as a critical strategic function, extending far beyond its traditional promotional role. Rather than focusing solely on sales stimulation, marketing became a mechanism for crisis adaptation, resilience, and survival. Restaurants were required to rapidly reassess their value propositions, communication strategies, service processes, and customer relationships in response to shifting consumer priorities, heightened risk perception, and evolving expectations regarding safety, trust, and convenience.

Recent research suggests that organizations capable of strategic agility and customer-oriented adaptation were better positioned to mitigate the negative impacts of the pandemic. In the restaurant sector, this involved the rapid implementation of take-away and delivery services, menu simplification, digital communication intensification, and the reinforcement of hygiene and safety practices. Nevertheless, such operational adjustments alone were insufficient to guarantee long-term viability. The ability to preserve brand identity, experiential value, and emotional connection with customers emerged as a decisive factor in sustaining loyalty and reinforcing competitive positioning during and after the crisis.

Despite the growing body of literature addressing tourism and hospitality responses to COVID-19, empirical research focusing on crisis-driven marketing adaptation in small and medium-sized, author-driven restaurants remains limited particularly in island destinations. Many existing studies adopt macro-level or quantitative approaches, offering limited insight into the strategic decision-making processes and contextual dynamics shaping individual business responses. This gap is particularly relevant given the structural vulnerability of island economies, where tourism disruptions tend to have amplified economic and social consequences.

Against this backdrop, this article analyses the marketing strategy applied in the development and adaptation of Restaurant Kampo, a restaurant located in Funchal, Madeira Island (Portugal). Using an in-depth qualitative case study approach, the research examines how marketing strategies were designed and implemented before, during, and after the COVID-19 lockdown period. Particular attention is given to strategic positioning, marketing mix adaptation, customer relationship management, and experiential value preservation under crisis conditions.

The central objective of this study is to identify and evaluate the role of marketing as a strategic management function in supporting operational stability and brand reinforcement during a period of extreme uncertainty. By providing empirical insights from a real-life case, this research contributes to hospitality and marketing literature by enhancing understanding of crisis-induced strategic adaptation in small restaurant enterprises. From a practical perspective, the findings aim to inform restaurant managers and destination stakeholders seeking to build resilient, experience-oriented business models capable of responding to future disruptions.

2. Literature Review

2.1. Marketing in the Service and Restaurant Context

Marketing in service industries differs fundamentally from product-based marketing due to the inherent characteristics of services, namely intangibility, inseparability, variability, and perishability (Grönroos, 2003; Lovelock & Wirtz, 2011). In the restaurant sector, these characteristics are particularly pronounced, as value is co-created in real time through interactions between customers, employees, physical environments, and symbolic elements such as brand narratives and culinary identity.

Rather than being limited to food quality alone, the restaurant experience encompasses a complex set of tangible and intangible dimensions, including atmosphere, service performance, social interaction, emotional engagement, and symbolic meaning (Yrjölä et al., 2019). Consequently, marketing in restaurant contexts must be

understood as a holistic value-creation process, where functional benefits coexist with experiential and emotional dimensions.

Kotler and Keller (2013) conceptualize marketing as a strategic process aimed at creating, communicating, and delivering value to customers while fostering long-term relationships. This relational perspective is particularly relevant in hospitality, where customer satisfaction and loyalty are strongly influenced by service encounters and employee behaviour (Alhelalat et al., 2017). Employees thus become central brand ambassadors, reinforcing the role of internal marketing and service culture in shaping customer perceptions.

The extended marketing mix for services the 7Ps framework (product, price, place, promotion, people, process, and physical evidence) has been widely adopted as an analytical lens for understanding service differentiation and competitive positioning (Wirtz & Lovelock, 2016). In restaurant settings, effective coordination among these elements is critical to delivering consistent and meaningful experiences. Recent research suggests that, in the post-COVID-19 context, customers place increased emphasis on people, process, and physical evidence, particularly in relation to safety, transparency, and trust (Kukanja, 2022).

Moreover, contemporary restaurant marketing increasingly aligns with experiential marketing paradigms, which emphasize sensory stimulation, emotional resonance, and memorable experiences (Pine & Gilmore, 1999; Schmitt, 2011). Restaurants are no longer perceived merely as places to consume food but as experiential spaces where customers seek authenticity, social connection, and symbolic value. This shift reinforces the need for marketing strategies that integrate storytelling, atmosphere design, and customer engagement into a coherent brand narrative.

2.2. Gastronomy, Tourism, and Regional Identity

Gastronomy has progressively emerged as a strategic tourism resource, contributing to destination differentiation, place branding, and regional development. Food-related experiences play a central role in shaping tourists' perceptions of authenticity and cultural immersion, often functioning as gateways to local heritage and identity (Bessière, 2013; Richards, 2015).

Empirical studies indicate that gastronomic experiences significantly influence tourist satisfaction, destination image, and revisit intentions (Knollenberg et al., 2020). As a result, gastronomy has become an integral component of tourism competitiveness, particularly in destinations seeking to differentiate themselves in saturated markets. The integration of local products, culinary traditions, and storytelling enables destinations to reinforce their uniqueness while supporting local economies and sustainable practices (Sims, 2009).

Island destinations present a particularly relevant context for gastronomic tourism. Their geographic isolation, limited resources, and strong cultural identities amplify both opportunities and vulnerabilities. On the one hand, islands can leverage distinctive culinary traditions to enhance authenticity and experiential value; on the other hand, their dependence on tourism flows exposes them to heightened risk during external shocks. Consequently, restaurants operating in island destinations must balance innovation with cultural continuity, positioning gastronomy as both a commercial offering and a symbolic representation of place.

Madeira Island exemplifies this dynamic. Its gastronomic identity has been shaped by historical trade routes, agricultural practices, and cultural exchanges, resulting in a diverse and evolving culinary landscape (Vieira, 1998). The expansion of tourism has stimulated growth in the restaurant sector, increasing competition and driving the emergence of author-driven and experience-oriented concepts. In this context, restaurants increasingly function as mediators between local culture and global tourism markets, translating regional identity into curated experiences.

From a marketing perspective, gastronomy thus operates not only as a product but as a narrative device that communicates authenticity, sustainability, and belonging. Restaurants that successfully integrate local identity into their value propositions can strengthen emotional connections with both tourists and residents, enhancing brand differentiation and long-term loyalty.

2.3. Marketing Strategies in Times of Crisis

Crisis situations challenge traditional marketing assumptions and compel organizations to rethink their strategic priorities. According to Kaplan and Norton (2008), strategy must align organizational vision with rapidly changing external environments, particularly under conditions of uncertainty. Crises such as the COVID-19 pandemic disrupt established market structures, alter consumer behaviour, and expose organizational vulnerabilities, demanding rapid and adaptive responses.

The literature on crisis management emphasizes the importance of strategic agility and dynamic capabilities defined as an organization's ability to sense opportunities and threats, seize resources, and reconfigure operations in response to environmental change (Teece, 2014). In service industries, where value creation depends heavily on human interaction and experiential delivery, such capabilities are especially critical.

Recent studies examining hospitality responses to COVID-19 highlight a range of adaptive marketing strategies, including digital communication intensification, take-away and delivery services, menu simplification, and enhanced hygiene protocols (Fabius et al., 2020; Seyitoğlu & Ivanov, 2020). These strategies addressed immediate operational challenges while also reshaping customer perceptions of safety, reliability, and trust.

However, scholars argue that crisis-driven adaptation should not be limited to short-term tactical adjustments. Maintaining brand consistency and experiential value is essential to avoid long-term erosion of brand equity (Keller, 2013). Restaurants that rely excessively on price reductions or radical repositioning risk undermining perceived quality and brand meaning. Instead, marketing strategies that emphasize transparency, empathy, and continuity are more likely to foster customer loyalty during periods of disruption.

Furthermore, crises can act as catalysts for innovation, accelerating digital transformation and encouraging new forms of customer engagement. In the restaurant sector, social media platforms became central communication channels during the pandemic, enabling businesses to sustain emotional connections with customers despite physical distancing. This shift reinforces the role of marketing as a strategic management function that integrates communication, experience design, and operational adaptation.

Collectively, the literature suggests that effective crisis marketing in hospitality contexts requires a balance between flexibility and coherence. Organizations must adapt to evolving conditions while preserving core brand values and experiential promises. Understanding how small and medium-sized restaurants operationalize this balance in real-life contexts remains an important area for empirical investigation.

3. Methodology

For analytical purposes, the pre-COVID-19 phase refers to the period prior to March 2020; the lockdown phase corresponds to the period of mandatory restaurant closures and mobility restrictions in Portugal (March - May 2020); and the post-lockdown phase encompasses the gradual reopening and adaptation period from mid-2020 onwards.

This study adopts a qualitative research approach based on an in-depth single case study design. Qualitative methodologies are particularly suitable for exploring complex, context-dependent phenomena and for gaining rich insights into strategic processes and managerial decision-making within real-life settings (Yin, 2018). Given the unprecedented nature of the COVID-19 crisis and its uneven impact on hospitality businesses, a case study approach allows for a nuanced understanding of how marketing strategies were adapted under extreme uncertainty.

3.1. Research Design

The research follows an exploratory and interpretive design, aiming to analyse how marketing functioned as a strategic management tool rather than as a purely promotional activity. The case study method enables the examination of strategic responses across different temporal phases pre-COVID-19, lockdown, and post-lockdown capturing both continuity and change in organizational behaviour.

Single case studies are particularly appropriate when the case represents a revelatory, critical, or information-rich example (Yin, 2018). In this research, Restaurant Kampo constitutes a relevant case due to its strong brand identity, experiential positioning, and proactive response to crisis conditions.

3.2. Case Selection

Restaurant Kampo, located in Funchal, Madeira Island, was selected using purposive sampling criteria. The restaurant exhibits several characteristics that make it analytically valuable:
(i) it operates within a tourism-dependent island destination;
(ii) it is an author-driven restaurant with a strong experiential focus;
(iii) it demonstrated rapid strategic adaptation during the COVID-19 crisis; and
(iv) it maintained operational continuity without compromising brand positioning.

These attributes position Kampo as an information-rich case capable of generating insights transferable to similar small and medium-sized restaurant enterprises operating in vulnerable tourism contexts.

3.3. Data Collection

Data collection relied on multiple qualitative sources in order to ensure triangulation and analytical robustness. The primary sources included:

- **Document analysis**, encompassing internal strategic documents, menus, communication materials, and operational guidelines before and during the pandemic;
- **Direct observation** of service processes, spatial layout, customer interaction, and experiential elements of the restaurant concept;
- **Digital communication analysis**, focusing on social media content and messaging strategies used during lockdown and post-lockdown phases;
- **Secondary data**, including online customer reviews (e.g., TripAdvisor and TheFork), press articles, and industry reports.

The combination of these sources enabled a holistic understanding of both managerial intent and customer-facing outcomes.

3.4. Data Analysis

Data analysis followed a thematic and interpretive approach. Strategic analysis tools commonly used in hospitality management were applied to structure and interpret the findings, including SWOT and PESTEL analyses, benchmarking against comparable restaurants, and marketing mix analysis based on the 7Ps framework.

Themes related to strategic adaptation, customer orientation, experiential preservation, and brand coherence were identified and analysed across different crisis phases. This analytical process allowed for the identification of patterns linking marketing decisions to organizational resilience and brand reinforcement.

SWOT and PESTEL analyses were applied as interpretive tools to structure and synthesise qualitative data collected from documents, direct observation, and digital communication analysis. SWOT analysis supported the identification of internal strengths and weaknesses and external opportunities and threats across different crisis phases. PESTEL analysis enabled the examination of macro-environmental factors shaping strategic constraints during the pandemic. Benchmarking was conducted through qualitative comparison with similar author-driven restaurants operating in Madeira, focusing on service adaptation, communication practices, and experiential positioning.

4. Case Study: Restaurant Kampo

4.1. Concept, Brand Identity, and Experiential Positioning

Restaurant Kampo is a neighbourhood restaurant located in the historic centre of Funchal, characterized by an author-driven culinary concept, an open kitchen design, and an informal yet highly professional service style. The restaurant positions itself as an accessible fine-dining experience, emphasizing authenticity, product quality, and emotional engagement rather than luxury or exclusivity.

Central to Kampo's value proposition is the notion of transparency and human connection. The open kitchen allows customers to observe the preparation process, fostering trust and reinforcing perceptions of quality and craftsmanship. The "chef's table" further enhances this experiential dimension by enabling direct interaction between chefs and guests, transforming the meal into a shared narrative rather than a purely transactional exchange.

This experiential orientation aligns with contemporary consumption patterns in which customers seek meaningful, memorable, and socially engaging dining experiences. Kampo's brand identity is thus constructed around values of honesty, proximity, and conviviality, which resonate strongly with both local customers and tourists seeking authentic encounters.

4.2. Strategic Environment Analysis

The internal and external strategic environment of Restaurant Kampo was analysed using SWOT and PESTEL frameworks. Internally, key strengths included a strong brand reputation, the professional recognition of the chef, a cohesive service culture, and an active digital presence. These factors contributed to high levels of customer loyalty and positive word-of-mouth.

Identified weaknesses primarily related to physical constraints, such as limited seating capacity, and a strong dependence on skilled human resources, which increased vulnerability during periods of operational disruption.

From an external perspective, opportunities were associated with growing interest in author cuisine, local products, and experiential dining, particularly among post-pandemic consumers seeking quality and authenticity. Conversely, threats were amplified by regulatory restrictions, demand volatility, increased operational costs, and intensified competition within the restaurant sector.

The PESTEL analysis highlighted the dominant influence of political and legal factors during the pandemic, including health regulations and capacity limitations. Economic uncertainty, accelerated digital adoption, and rising environmental awareness further shaped consumer behaviour and strategic priorities.

Table 1: SWOT analysis of Restaurant Kampo during the COVID-19 crisis.

Strengths	Weaknesses
Strong author-driven brand identity	Limited seating capacity
Open kitchen and experiential concept	High dependence on skilled human resources
Loyal customer base and local recognition	Reduced operational flexibility during lockdown
Active digital communication	Dependence on tourism flows
Opportunities	**Threats**
Growing demand for authentic dining experiences	Regulatory restrictions and capacity limits
Strengthening of local market demand	Abrupt demand volatility
Increased value placed on quality and trust	Rising operational and compliance costs
Digital communication and proximity marketing	Uncertainty regarding tourism recovery

4.3. Marketing Mix Adaptation Across Crisis Phases

Marketing strategy at Restaurant Kampo evolved dynamically across three distinct phases: pre-COVID-19, lockdown, and post-lockdown.

Pre-COVID-19, the marketing mix emphasized experiential differentiation through product quality, informal service, transparent processes, and physical evidence aligned with rustic and cosmopolitan aesthetics. Pricing strategies reflected value-based positioning rather than discount-driven competition.

During the lockdown, rapid adaptation became essential. Kampo implemented take-away and delivery services while redesigning menus to prioritize comfort food and family-oriented consumption. Communication efforts intensified through social media platforms, focusing on empathy, continuity, and community support. Importantly, price integrity was maintained, reinforcing perceived quality and brand consistency.

Post-lockdown, the marketing mix was recalibrated to address heightened customer concerns regarding safety and trust. Physical evidence and processes gained increased relevance, with visible hygiene practices and controlled service flows. The people dimension employees' communication, reassurance, and professionalism—played a critical role in restoring customer confidence while preserving the restaurant's experiential essence.

Across all phases, Kampo avoided aggressive price reductions, opting instead for strategic coherence and experiential continuity. This approach allowed the restaurant to maintain brand equity while adapting operationally to crisis conditions.

5. Marketing Strategy Adaptation During the COVID-19 Crisis

Figure 1 illustrates the evolution of Restaurant Kampo's marketing strategy across three analytical phases: pre-COVID-19, lockdown, and post-lockdown. The figure highlights how core experiential and brand elements were selectively adapted in response to changing environmental conditions, while preserving strategic coherence and brand identity**.**

Figure 1: Marketing strategy adaptation at Restaurant Kampo across crisis phases.

The COVID-19 pandemic represented a structural shock to the restaurant sector, forcing organizations to rapidly redesign their marketing strategies under conditions of extreme uncertainty. For Restaurant Kampo, the crisis acted as a stress test for its strategic coherence, experiential positioning, and customer-oriented philosophy. Rather than adopting a purely reactive approach, the restaurant implemented a set of adaptive marketing strategies that balanced operational survival with brand integrity.

5.1. Strategic Response During the Lockdown Period

During the mandatory lockdown phase, the immediate challenge faced by Restaurant Kampo was the abrupt suspension of on-site dining, which directly threatened its core experiential value proposition. In response, the restaurant rapidly introduced take-away and delivery services, reconfiguring its product offering to suit domestic consumption contexts. Menus were simplified and adapted to emphasize comfort food, family sharing, and ease of transport, without compromising product quality or culinary identity.

From a marketing perspective, this adaptation represented a redefinition of the "product" element within the service marketing mix. Rather than replicating the in-restaurant experience, Kampo focused on translating its brand values, authenticity, honesty, and quality, into a format compatible with home consumption. This strategic choice aligns with service marketing literature emphasizing the importance of preserving core value propositions even when delivery mechanisms change.

Communication played a central role during this phase. Social media platforms became the primary interface between the restaurant and its customers, enabling continuous engagement despite physical distancing. Messaging focused on empathy, proximity, and transparency, reinforcing emotional connections and maintaining brand visibility. Rather than aggressive promotional campaigns, communication emphasized continuity, community support, and the human dimension of the brand, which contributed to sustaining customer loyalty during a period of uncertainty.

Importantly, Kampo avoided price-based competition or aggressive discounting strategies. By maintaining price integrity, the restaurant reinforced perceived quality and avoided brand dilution, a risk frequently associated with crisis-driven price reductions. This decision reflects a strategic understanding of brand equity preservation, particularly relevant for author-driven and experience-oriented restaurants.

5.2. Post-Lockdown Marketing Recalibration

Following the gradual reopening of restaurants, the marketing strategy at Kampo entered a recalibration phase shaped by heightened customer sensitivity to safety, hygiene, and trust. While demand slowly recovered, consumer behaviour remained cautious, requiring restaurants to address both functional and emotional concerns.

In this context, the "process" and "physical evidence" components of the marketing mix gained increased strategic relevance. Hygiene protocols, service flow redesign, and capacity management were not only operational necessities but also communication tools that visibly signalled safety and responsibility. These elements were integrated into the overall customer experience, reinforcing reassurance without compromising the informal and welcoming atmosphere that defined the brand.

The "people" dimension emerged as particularly critical. Employees assumed an expanded role as trust mediators, responsible for communicating safety measures, managing customer expectations, and maintaining emotional warmth despite distancing constraints. This finding supports service marketing literature emphasizing the central role of frontline employees in shaping customer perceptions during high-risk service encounters.

At the same time, Kampo preserved its experiential positioning by maintaining the open kitchen concept, informal interaction, and narrative-driven service style wherever possible. Rather than fundamentally altering its identity, the restaurant selectively adapted service delivery while preserving symbolic and emotional elements of the experience.

5.3. Strategic Coherence and Brand Resilience

Across all phases of the crisis, Restaurant Kampo's marketing strategy was characterized by strategic coherence and alignment between operational decisions and brand values. Adaptation did not involve radical repositioning but rather incremental adjustments that allowed the restaurant to respond to external constraints while maintaining experiential continuity.

This approach illustrates how marketing can function as a strategic management tool, integrating communication, service design, and customer relationship management into a coherent response to crisis conditions. The case demonstrates that resilience in the restaurant sector is not solely determined by operational flexibility but also by the ability to preserve meaning, trust, and emotional engagement in disrupted environments.

By prioritizing transparency, customer orientation, and experiential integrity, Restaurant Kampo was able to maintain business continuity and reinforce its brand positioning during and after the COVID-19 crisis. These findings underscore the importance of marketing strategies that balance adaptability with identity preservation, particularly for small and medium-sized restaurants operating in tourism-dependent destinations.

6. Discussion

The findings of this study highlight the central role of marketing as a strategic management function in enabling restaurant resilience during periods of extreme disruption. The case of Restaurant Kampo demonstrates that crisis-driven adaptation extends beyond operational adjustments and requires coherent alignment between brand identity, customer experience, and strategic decision-making.

Consistent with service marketing literature, the results confirm that value creation in restaurant contexts is co-produced through interactions among customers, employees, and the service environment. Kampo's ability to preserve experiential elements, such as transparency, informality, and emotional engagement, despite constraints imposed by the pandemic supports prior research emphasizing the importance of experience continuity in hospitality services (Pine & Gilmore, 1999; Yrjölä et al., 2019).

The findings further align with dynamic capabilities theory, which argues that organizational resilience depends on the ability to sense environmental changes, seize emerging opportunities, and reconfigure resources accordingly (Teece, 2014). Kampo's rapid implementation of take-away services, menu adaptation, and digital communication illustrates strategic agility in response to external shocks. However, unlike purely reactive responses observed in other hospitality contexts, these adaptations were embedded within a consistent brand narrative, reinforcing the role of strategic coherence in crisis management.

Moreover, the case supports literature suggesting that crisis marketing should prioritize trust, transparency, and emotional reassurance over aggressive sales-oriented tactics (Keller, 2020). By maintaining price integrity and avoiding excessive discounting, Kampo protected its brand equity and reinforced perceptions of quality and authenticity. This approach contrasts with short-term survival strategies that risk long-term brand dilution and highlights the strategic trade-offs inherent in crisis decision-making.

The increased relevance of people, process, and physical evidence within the marketing mix observed in this study is consistent with post-COVID-19 hospitality research. Visible hygiene practices, service flow redesign, and employee communication emerged as symbolic cues that reassured customers and facilitated the gradual restoration of confidence. These findings reinforce the notion that safety-related measures are not merely operational requirements but integral components of the customer experience in high-risk service environments.

From a contextual perspective, the island destination setting amplifies the significance of these findings. Madeira's structural dependence on tourism magnified the economic and social impacts of the pandemic, intensifying pressure on small restaurant enterprises. In such contexts, the ability to maintain strong relationships with local customers alongside tourist demand proved critical. Kampo's emphasis on proximity, community engagement, and authenticity facilitated this dual positioning, contributing to business continuity during periods of limited tourist flows.

Overall, this study extends existing hospitality marketing research by illustrating how experiential restaurants can operationalize marketing strategies that balance flexibility and identity preservation. The findings suggest that resilience in the restaurant sector is not solely determined by the capacity to adapt operationally but also by the ability to sustain meaning, trust, and emotional connection under conditions of uncertainty.

7. Implications

7.1. Managerial Implications

The findings of this study offer several practical implications for restaurant managers and hospitality professionals operating in crisis-prone environments. First, the case of Restaurant Kampo demonstrates that marketing should be embedded at the strategic core of the organization rather than treated as a peripheral or promotional function. Managers should view marketing as an integrative framework that aligns communication, service design, and customer relationships with broader organizational objectives.

Second, the preservation of brand identity during crises emerges as a critical success factor. Rather than pursuing aggressive price competition or radical repositioning, restaurants should prioritize strategic coherence and experiential continuity. Maintaining price integrity and reinforcing core brand values can strengthen customer trust and loyalty, even in contexts of reduced demand.

Third, the study highlights the importance of investing in frontline employees as key agents of resilience. Training staff to communicate safety measures, manage customer expectations, and deliver emotionally supportive service is essential in restoring confidence during and after crises. Employees should be recognized not only as operational resources but as central contributors to brand meaning and customer experience.

Finally, for restaurants operating in tourism-dependent or island destinations, cultivating strong relationships with local markets can mitigate vulnerability to external shocks. Community engagement, proximity-based communication, and authenticity-driven positioning can support demand stabilization when international tourism flows are disrupted.

7.2. Theoretical Implications

From a theoretical perspective, this research contributes to hospitality and marketing literature by reinforcing the role of marketing as a strategic adaptation mechanism in crisis contexts. The findings support and extend service marketing theory by demonstrating how experiential value can be preserved through selective adaptation of service delivery mechanisms.

The study also contributes to dynamic capabilities research by providing empirical evidence from the restaurant sector, illustrating how small enterprises operationalize sensing, seizing, and reconfiguring processes under extreme uncertainty. By integrating experiential marketing and brand management perspectives, the research highlights the importance of strategic coherence in sustaining brand equity during crises.

Additionally, the island destination context enriches existing tourism literature by underscoring the amplified effects of global disruptions on structurally vulnerable regions. The findings suggest that future research should further explore the interaction between destination characteristics and firm-level resilience strategies.

8. General Conclusion

As a qualitative single-case study focusing on a restaurant that successfully adapted to crisis conditions, this research is subject to the risk of positive case bias. To mitigate this limitation, data were triangulated across multiple sources, including internal documents, direct observation, and customer-facing digital communication. Analytical attention was given not only to successful adaptations but also to constraints, vulnerabilities, and strategic trade-offs faced during the crisis. Nevertheless, findings should be interpreted as analytically transferable rather than statistically generalisable.

The COVID-19 pandemic constituted a profound disruption to the restaurant and tourism sectors, challenging established business models and forcing organizations to rethink their strategic foundations. This study set out to examine how marketing strategies can function as a mechanism for resilience and adaptation in times of crisis, using Restaurant Kampo, located in Madeira Island, as an in-depth qualitative case study.

The findings demonstrate that marketing plays a central role in enabling small and medium-sized restaurants to navigate periods of extreme uncertainty. Rather than operating as a purely promotional function, marketing

emerged as an integrative strategic framework that aligned brand identity, service design, communication, and customer relationships. In the case of Restaurant Kampo, crisis-driven adaptations were not characterized by radical repositioning but by selective and coherent adjustments that preserved experiential value and brand meaning.

A key contribution of this research lies in highlighting the importance of experiential continuity during crisis conditions. Despite severe operational constraints, Kampo maintained core experiential elements, such as transparency, authenticity, and emotional engagement, thereby sustaining customer trust and loyalty. This reinforces existing service marketing and experiential consumption theories, which emphasize that value creation in hospitality contexts is co-produced and deeply embedded in symbolic and relational dimensions.

The study also contributes to crisis management and dynamic capabilities literature by providing empirical evidence from the restaurant sector. Kampo's ability to sense environmental shifts, seize emergent opportunities, and reconfigure service delivery illustrates how strategic agility can be operationalized at the firm level without eroding brand equity. Particularly in tourism-dependent and island destinations, where external shocks tend to have amplified impacts, such capabilities are critical for business continuity.

From a practical standpoint, the findings offer valuable insights for restaurant managers and destination stakeholders. Strategic coherence, investment in human resources, transparent communication, and the preservation of brand integrity emerge as essential pillars of resilience. The case demonstrates that short-term survival strategies based solely on cost-cutting or price reductions may undermine long-term competitiveness, whereas customer-oriented and experience-driven approaches can foster sustainable recovery.

Despite its contributions, this study is subject to limitations inherent to qualitative single-case research, including restricted generalizability. Future research could extend these findings through comparative multi-case studies across different destinations or through quantitative approaches examining consumer perceptions of safety, trust, and experiential value in post-crisis restaurant contexts. Longitudinal studies may also provide deeper insight into the lasting effects of crisis-induced strategic adaptation on brand equity and organizational performance.

In conclusion, this research underscores the strategic relevance of marketing as a driver of resilience in the restaurant sector. By demonstrating how experiential restaurants can balance adaptability and identity preservation during a global crisis, the study contributes to a more nuanced understanding of hospitality management in turbulent environments and offers a foundation for both academic inquiry and managerial practice in an increasingly uncertain world.

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Ethical Statement

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