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NAVIGATING SUSTAINABILITY IN THE BLUE ECONOMY:

INNOVATIONS, CHALLENGES, AND OPPORTUNITIES

2025

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PhD in Economic and Management Sciences

(Specialty in Management)

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UAlg FE
UNIVERSIDADE DO ALGARVE
FACULDADE DE ECONOMIA

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Statement of Work Authorship

I declare myself to be the author of this work, which is unique and unprecedented. Authors and works consulted are properly cited in the text and are included in the listing of references included.

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(Jennifer Nicole Elston)

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This work was financed by the European Union through Sustainable Horizons (HORIZON), from May 2023 to November 2024, with the Grant agreement ID: 101071300, DOI: 10.3030/101071300. Since December 2024 this work was financed by National Funds provided by the FCT - Foundation for Science and Technology, within the Ministry of Education, Science and Innovation, via the State Budget, and through the Studentship for Doctoral Research with the reference 2024.01284.BD.

To my mother, who always told me I could be anything I wanted to be. Our bond was one of friendship, laughter, and unconditional love.

“If ever there is a tomorrow when we're not together,

there is something you must always remember.

You are braver than you believe, stronger than you seem,

and smarter than you think!

But the most important thing is,

even if we're apart...I'll always be with you.”

A.A. Milne

I carry your love and belief in me always.

ACKNOWLEDGMENTS

A doctoral thesis is not merely the culmination of years of research, it is the product of countless moments of learning, perseverance, and the unwavering support of those who accompany us along the way. I am deeply grateful to all those whose contributions, guidance, and friendship have made this work possible.

First and foremost, I extend my deepest gratitude to my supervisors, Professor Hugo Pinto and Professor Carla Nogueira. This thesis is as much a reflection of your guidance as it is of my own efforts. Your insight, patience, and thoughtful advice have guided me through moments of doubt and complexity, helping me to navigate challenges and grow as a researcher. You taught me not only academic rigor but also the true meaning of collaboration and the responsibility of striving to make things better. It has been both a privilege and an honor to learn from you!

I am equally grateful to the University of Algarve and, in particular, the Faculty of Economics. I thank Professor Efigénio Rebelo and Professor Luís Coelho for their enduring support and for providing an academic environment where I could thrive. Professor Efigénio Rebelo, your dedication to this institution has created a space where values of trust and community prevail, and I am proud to have found within these walls a second family. Professor Luís Coelho, beyond your role as an educator, you have been a mentor and a friend, always offering encouragement and a steady hand in times of uncertainty.

I greatly appreciate CinTurs - Research Centre for Tourism, Sustainability, and Well-Being for their institutional support and research environment that enriched this work. I am especially thankful to Marlene Fernandes and Julieta Rosa for their tireless assistance and friendship that I will carry with me. I also wish to recognize Dra. Dalila Rebelo, Ana Afonso, and Rute Cristina, for their unfailing efficiency and kindness, as organizing a conference alongside them proved how much heart goes into their work.

This work was supported by the European Union through the Sustainable Horizons program and, subsequently, by the FCT - *Fundação para a Ciência e a Tecnologia*, through national funds and a doctoral studentship. I am grateful for the financial support that enabled this research to take place.

I am fortunate to have been surrounded by inspiring women whose example I will always carry with me. Professor Alexandra Teodósio, your resilience and brilliance as a scholar continue to inspire me, and I am profoundly grateful for the learning opportunities you provided. Professor Patrícia Pinto, thank you for your generosity in inviting me to collaborate in your projects and for your constant mentorship. I am also grateful to my colleagues Professor Pedro Pintassilgo, Professor Susana Pescada, Professor Eugénia Ferreira, Professor Dora Agapito, Vânia Sousa, João Encarnação and Filipe Lage for their knowledge sharing, encouragement, friendship and collaboration throughout this journey.

I also wish to extend my sincere gratitude to all individuals and organizations who contributed to this research, particularly the companies that responded to the survey and agreed to participate in interviews. Your openness, time, and willingness to share your experiences made this work possible. A special thank you to *Fórum Oceano*, the *Economia Azul* platform, S2AQUAcoLAB, and PROALGA, whose support in disseminating the questionnaire and engaging with the study was essential.

On a personal note, I am indebted to those whose support went beyond the academic sphere. Duarte Raminhos, my brother by heart, and Cristina Raminhos, my second mother, your unwavering belief in me has been my foundation. You have celebrated my achievements, picked me up in moments of doubt, and reminded me that I could endure even the most difficult times.

To my partner, Miguel Guerreiro, I owe more than words can express. Your love, patience, and unwavering support carried me through the most difficult moments of this journey. You walked this path with me, step by step, through every late-night research session, every wave of frustration, and every moment of doubt. From bringing midnight pizza to make sure I ate, to sitting through endless test runs of conference speeches, to reading what must have felt like a hundred versions of the same draft and even seeing my presentations at conferences you were always there. You reminded me to breathe, to laugh, and to keep going. This thesis is not only my achievement but ours.

My heartfelt gratitude also goes to Carina Jesus, my "twinzy", it simply wouldn't have been us if we hadn't ridden this rollercoaster side by side. Your friendship, guidance, endless support, and ability to make me laugh when I needed it most have been priceless. I am also profoundly grateful to my dear friends and colleagues João Martins, Catarina Ilhéu, Luís Inácio, João Ricardo, Hugo Gonçalves, and Célia Teixeira. Your understanding, your patience with my absences, and your unwavering support have meant more than I could ever put into words. To anyone I may have unintentionally forgotten to mention, please know that your presence, kindness, and encouragement have left their mark on this journey, and I carry that with me.

Finally, I must thank myself for persevering through moments of exhaustion, frustration, and doubt, for the countless nights of writing and rewriting, and for never giving up. Completing this thesis marks both an end and a beginning. It has taught me humility in the face of all I have yet to learn and sparked in me a deep curiosity and drive to continue exploring. As I reach the end of this chapter, I know this work is just the beginning of many paths yet to be created. May it inspire others to dare, to question, and to contribute to a more sustainable and innovative future, not by following well-worn paths, but by leaving new trails behind.

"Do not go where the path may lead, go instead where there is no path and leave a trail."

Ralph Waldo Emerson

ABSTRACT

How can the Blue Economy evolve to be both innovative and truly sustainable? What challenges and opportunities do firms face as they integrate environmental, social, and governance principles into ocean-based industries? And how can theory and practice come together to foster responsible growth in this vital sector? This thesis addresses these questions through a three-pronged investigation into the intersections of sustainability and innovation within the Blue Economy.

The first study presents a systematic literature review, identifying key trends, gaps, and opportunities in the fields of sustainability-oriented innovation and ocean-based economic activity. It highlights the need for clearer conceptual frameworks and stronger alignment between environmental imperatives and innovation drivers. Building upon these findings, the second study draws on survey data collected from Portuguese Blue Economy firms and employs Partial Least Squares Structural Equation Modeling (PLS-SEM) to explore how sustainability initiatives influence innovation, and how these innovations mediate economic, environmental, and social impacts. The results demonstrate that sustainability is not merely an obligation but a catalyst for innovation that enhances multidimensional performance. The final study builds on these perceptions through real-world case studies, exploring how innovative Blue Economy firms apply sustainability principles in practice. It validates best practices, identifies common barriers to implementation, and examines how these organizations reflect on and assess the impact of their sustainability and innovation efforts. These findings provide valuable guidance for companies striving to enhance their practices, and for policymakers aiming to foster a supportive environment for sustainable and innovative growth in the sector.

Collectively, these studies advance the theoretical understanding of sustainability-driven innovation within the Blue Economy, contributing to institutional theory and the triple bottom line framework, while offering evidence-based direction for policy and strategy development. This thesis bridges academic knowledge and practical application, underscoring the role of innovation as both an outcome and a driver for sustainable transformation. Ultimately, it charts a path toward a more resilient and inclusive Blue Economy, one that balances economic opportunity with environmental stewardship and social responsibility.

Keywords: Blue Economy; Sustainability; Innovation; Triple Bottom Line; Institutional Theory; Policy and Practice.

RESUMO

A Economia Azul, é entendida como o uso sustentável dos recursos marinhos para o desenvolvimento económico, a criação de emprego e melhoria do bem-estar humano, enquanto se salvaguarda a saúde dos ecossistemas oceânicos (World Bank & United Nations Department of Economic and Social Affairs, 2017). Tem vindo a ganhar crescente relevância no âmbito das políticas europeias e internacionais. A sua importância torna-se ainda mais evidente num contexto de urgentes desafios ambientais, tais como as alterações climáticas, a degradação da biodiversidade e a escassez de recursos naturais (Cisneros-Montemayor *et al.*, 2021). Paralelamente, existe uma necessidade crescente de transição para modelos económicos mais resilientes e sustentáveis, em linha com os Objetivos de Desenvolvimento Sustentável (ODS) das Nações Unidas, em particular o ODS 14 - Proteger a Vida Marinha (United Nations, 2020).

Apesar do reconhecimento do seu potencial, a implementação de práticas inovadoras e sustentáveis na Economia Azul enfrenta desafios significativos. A literatura aponta para a falta de quadros conceptuais sólidos que integrem de forma eficaz as dimensões económica, social e ambiental (Geissdoerfer *et al.*, 2018). Acrescem barreiras institucionais e organizacionais que dificultam a adoção de práticas sustentáveis por parte das empresas, bem como a resistência cultural à mudança e à inovação (DiMaggio and Powell, 1983). A nível empresarial, observa-se frequentemente a predominância de abordagens centradas no curto prazo, orientadas para a rentabilidade imediata, em detrimento de estratégias sustentáveis de longo prazo (Bocken *et al.*, 2014).

Neste contexto, esta tese procura contribuir para o avanço do conhecimento sobre o papel da inovação sustentável nas empresas Economia Azul, abordando as seguintes questões fundamentais: de que forma a sustentabilidade impulsiona a inovação nas empresas da Economia Azul? Quais são os principais fatores facilitadores e inibidores da integração de práticas sustentáveis e inovadoras? E que caminhos podem ser delineados para promover uma maior adoção de estratégias alinhadas com o desenvolvimento sustentável?

Este trabalho desenvolve-se em torno de três estudos complementares, organizados em formato de artigos científicos. O primeiro artigo apresenta uma revisão sistemática da literatura, tendo como objetivo evidenciar e sistematizar as principais linhas de investigação sobre inovação e sustentabilidade no âmbito da Economia Azul. A análise

da literatura revelou não só a dispersão conceptual existente, mas também a falta de estudos empíricos que explorem de forma integrada a influência da inovação sustentável no desempenho das empresas do setor. Este estudo destaca a pertinência de enquadrar a análise no âmbito do Triple Bottom Line (Elkington, 1998), conjugando os pilares económico, ambiental e social, bem como a relevância da Teoria Institucional (DiMaggio and Powell, 1983) para compreender as pressões externas que condicionam a atuação empresarial.

O segundo artigo apresenta uma investigação empírica desenvolvida junto de empresas portuguesas da Economia Azul. Com base num inquérito por questionário aplicado a um conjunto de empresas inovadoras identificadas através de plataformas e redes especializadas, como o Fórum Oceano, bem como beneficiárias de financiamento do Fundo Azul (DGPM, 2021, 2016). O questionário foi também divulgado através de fóruns e associações do setor, incluindo o portal Economia Azul, que colaboraram na sua disseminação interna aos seus associados. A análise dos dados, através da metodologia Modelação por Equações Estruturais baseada em Mínimos Quadrados Parciais (PLS-SEM), permitiu identificar a significância das relações entre a adoção de práticas sustentáveis, a capacidade de inovação e os resultados económicos, ambientais e sociais. Os resultados confirmam que as empresas que integram a sustentabilidade no centro da sua estratégia inovam mais e obtêm melhores desempenhos multidimensionais, reforçando a sua competitividade e contribuindo para a resiliência do setor (Bossle *et al.*, 2016; Nidumolu *et al.*, 2013).

O terceiro artigo centra-se na validação prática dos princípios identificados nos estudos anteriores, por meio da análise de estudos de caso em empresas portuguesas da Economia Azul. Esta análise permitiu identificar boas práticas, barreiras à implementação de estratégias sustentáveis e as dinâmicas de interação entre empresas, autoridades públicas e outros stakeholders. Verificou-se que, embora existam esforços relevantes no sentido da sustentabilidade, a ausência de mecanismos de monitorização estruturados e de métricas consistentes dificulta a avaliação do impacto das práticas adotadas. Este estudo reforça a importância das redes de colaboração e da partilha de conhecimento entre empresas, universidades e entidades públicas, enquanto fatores críticos para a promoção da inovação sustentável (Rupo *et al.*, 2018; Voyer *et al.*, 2018).

Em conjunto, os três artigos desta tese oferecem um contributo teórico e empírico relevante para o campo da Economia Azul, colmatando lacunas identificadas na literatura e respondendo a desafios práticos enfrentados pelas empresas do setor. Este trabalho reforça a ideia de que a inovação orientada para a sustentabilidade não deve ser encarada apenas como uma resposta a exigências externas ou regulamentares, mas antes como um motor estratégico de crescimento, diferenciação e resiliência organizacional. Além disso, a investigação evidencia a necessidade de um maior alinhamento entre políticas públicas, instrumentos financeiros e iniciativas empresariais, de forma a criar um ecossistema propício ao desenvolvimento de soluções inovadoras e sustentáveis.

Finalmente, esta tese apresenta recomendações práticas para empresas, decisores políticos e entidades reguladoras, destacando a importância de: (i) integrar a sustentabilidade nas estratégias empresariais de inovação; (ii) promover a capacitação organizacional e o desenvolvimento de competências; (iii) incentivar a criação de plataformas colaborativas intersectoriais; e (iv) desenvolver instrumentos de avaliação de impacto adaptados às especificidades da Economia Azul. Com estes contributos, pretende-se não só alargar o conhecimento científico neste domínio mas também apoiar a transição para um modelo de desenvolvimento mais equilibrado, inclusivo e orientado para o futuro, capaz de responder de forma eficaz aos desafios económicos, ambientais e sociais contemporâneos.

Palavras-chave: Economia Azul; Inovação Sustentável; Triple Bottom Line; Teoria Institucional; Desenvolvimento Sustentável; Empresas Marítimas.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AUV	Autonomous underwater vehicles
AVE	Average Variance Extracted
BE	Blue Economy
CAE	Portuguese Classification of Economic Activities
CSR	Corporate Social Responsibility
DGPM	Direção-Geral de Política do Mar
DGRM	Direção-Geral de Recursos Naturais, Segurança e Serviços Marítimos
DOI	Digital object identifier
ENEI	Estratégia Nacional de Especialização Inteligente
EREI	Estratégia Regional de Especialização Inteligente
EU	European Union
FAO	Food and Agriculture Organization
FCT	Fundação para a Ciência e Tecnologia
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GRI	Global Reporting Initiative
GVA	Gross Value Added
ICZM	Integrated Coastal Zone Management
MSP	Marine Spatial Planning
ODS	Objetivos de Desenvolvimento Sustentável
OECD	Organization for Economic Co-operation and Development
OSF	Open Science Framework
PLS-SEM	Partial Least Squares Structural Equation Modeling
PPPs	Public-private partnerships
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QCA	Qualitative Comparative Analysis
R&D	Research and Development
RBV	Resource-Based View
ROV	Remotely operated vehicles
SDG	Sustainable Development Goal
SIDS	Small Island Developing States
SLR	Systematic Literature Review
SOI	Sustainability-Oriented Innovation
STDEV	Standard Deviation
TPL	Triple Bottom Line
UNCLOS	United Nations Convention on the Law of the Sea
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change

CHAPTER 1 – GENERAL INTRODUCTION

1.1. Situating the Problem: Sustainability, Innovation, and the Blue Economy

In recent years, the Blue Economy has become a focal point for rethinking how societies reconcile economic development with environmental sustainability and social inclusion (European Commission *et al.*, 2024; OECD, 2024). It encompasses both established maritime sectors, such as fisheries, aquaculture, shipping, and coastal tourism, and emergent domains such as offshore renewable energy, marine biotechnology, and seabed mining (World Bank & UN DESA, 2017). Defined not only by its economic potential but also by its ecological dependencies, the Blue Economy reflects a growing international consensus that long-term prosperity requires a shift away from extractive, linear models toward integrated, circular, and innovation-driven approaches (Pauli, 2017; Voyer *et al.*, 2018).

Portugal, with its extensive Atlantic coastline and historical maritime identity, occupies a unique position in this context (Lopes, 2000). It is both a policy frontrunner, actively shaping EU maritime agendas, and a site of empirical experimentation with sustainability transitions across its coastal sectors (Fontes *et al.*, 2019; Pinto & Nogueira, 2018). Nevertheless, despite this momentum, the operationalization of sustainability remains uneven across marine industries. Ocean ecosystems are under increasing pressure from climate change, pollution, biodiversity loss, and overexploitation (Cao *et al.*, 2023; Cisneros-Montemayor *et al.*, 2022). Simultaneously, firms face growing institutional and societal expectations to respond proactively to these challenges through new strategic practices.

Innovation is increasingly positioned as a critical mechanism for addressing these pressures, not only as a tool for technological advancement or productivity growth, but as a pathway toward environmental and social responsibility (Geissdoerfer *et al.*, 2018; Bocken *et al.*, 2014). However, while policy frameworks such as the European Green Deal and UN Sustainable Development Goals (SDGs) offer normative direction, the firm-level pathways through which sustainability goals are translated into innovation strategies remain insufficiently understood, particularly within the diverse and fragmented landscape of ocean-based industries (Rupo *et al.*, 2018).

A growing body of research explores sustainability and innovation as distinct themes, but few studies have examined their intersection within the Blue Economy, especially from a business and strategic management perspective (Geissdoerfer *et al.*, 2018; Pinto *et al.*, 2015a). This omission is particularly salient for SMEs, which often face more acute resource constraints and institutional ambiguity than larger firms yet play a critical role in coastal economies (Voyer *et al.*, 2018).

Against this backdrop, this thesis investigates how firms in the Portuguese Blue Economy navigate the interplay between sustainability imperatives and innovation strategies. The research is situated within the academic field of Business Management, with a particular focus on strategy and organizational behavior, and engages with theoretical frameworks that view firms as embedded in institutional environments, structured by formal rules, social norms, and cognitive frameworks (Scott, 1995; DiMaggio & Powell, 1983).

A key insight from institutional theory is that firms are not only passive recipients of policy or societal expectations but also active agents in interpreting, adapting, and at times reshaping these pressures (Mahoney & Thelen, 2010). As institutions evolve through incremental processes such as layering or reinterpretation (Streeck & Thelen, 2005), firms may achieve institutional advantage by aligning strategically with new configurations of legitimacy, resources, and power (Oliver, 1991; DiMaggio & Powell, 1983).

While the concept of Sustainability-Oriented Innovation (SOI) becomes central in later chapters, this thesis begins from a broader inquiry into how firms in marine-based sectors respond to complex institutional and ecological challenges through innovation. Rather than starting with a predefined model of sustainable innovation, the research explores the evolving interaction between innovation practices and sustainability goals within the operational and institutional environments of the Blue Economy.

Through this lens, the thesis explores not only the drivers and barriers of innovation, but also how firm behavior reflects broader institutional transformations within Portugal's maritime economy. In doing so, it contributes to the understanding of how sustainability transitions are shaped "from below", through firm-level experimentation, coalition-building, and strategic adaptation.

1.2. Building the Theoretical Foundation: Sustainability, Innovation and Institutions

Sustainability, as a concept, originated in the environmental sciences and development studies but has since evolved into a core concern in business management. A foundational articulation of sustainability is provided in the Brundtland Report (1987), which describes sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". In business contexts, this definition has been adapted to encompass a tri-dimensional perspective, integrating environmental protection, economic growth, and social equity.

This tripartite approach is crystallized in the Triple Bottom Line (TBL) framework, introduced by Elkington (1998), redefines the role of firms by emphasizing value creation across three interdependent dimensions, profit, planet, and people. Within this model, sustainability becomes not a constraint, but a strategic orientation that broadens the performance frontier of businesses. As argued by Bocken *et al.* (2014), sustainability-oriented firms must reconfigure their business models to address both ecological and societal challenges while remaining economically viable.

However, the operationalization of sustainability at the firm level remains uneven and often superficial. While large corporations may adopt formal sustainability strategies in response to regulatory or reputational pressures, SMEs tend to engage with sustainability through informal or ad hoc practices due to resource limitations (Rupo *et al.*, 2018; Voyer *et al.*, 2018). Moreover, scholars such as Adams *et al.* (2016), Bocken *et al.* (2014), and Scott (1995), argue that the translation of sustainability principles into actual managerial routines is shaped by a complex interplay between institutional context, organizational capacity, and stakeholder expectations.

The implementation of sustainability also varies across sectors, particularly in the Blue Economy, where natural resource dependency and ecosystem fragility create heightened exposure to environmental risks (Cisneros-Montemayor *et al.*, 2022). In marine-based industries, sustainability is not only a normative goal but a condition for long-term business survival. Nevertheless, achieving this objective requires more than environmental compliance, it entails strategic transformation, cultural change, and innovation (Machado de Almeida & De Portugal, 2022).

Importantly, sustainability is not a static target but a dynamic and contested concept, whose meaning is constantly shaped by evolving institutional norms, scientific discourses, and societal values (Scott, 1995). As such, firms' sustainability journeys must be analyzed within their institutional environments, which influence how sustainability is understood, prioritized, and implemented. This aligns with the view of North (1991) that institutions not only constrain behavior but also structure incentives and define what constitutes legitimate action.

From a business research perspective, sustainability is increasingly viewed not as a peripheral concern but as a strategic orientation that can enhance competitiveness, reputation, and resilience (Adams *et al*., 2016; Porter & Kramer, 2011). This is particularly evident in policy-heavy and resource-sensitive sectors, such as the Blue Economy, where firms must align with both global frameworks (e.g., SDGs, European Green Deal) and local stakeholder expectations (OECD, 2024). As such, sustainability becomes a field of strategic action where firms navigate overlapping pressures, pursue legitimacy, and seek opportunities for differentiation.

In this strategic landscape, innovation has long been recognized as a central driver of competitiveness and strategic renewal in firms, particularly in the face of shifting institutional and environmental constraints. Within the field of business management, innovation is not confined to technological advancements alone but encompasses a broader set of strategic and organizational processes through which firms respond to change, capture value, and maintain relevance in evolving market and regulatory environments (Freeman & Soete, 1997).

At its core, innovation refers to the implementation of a new or significantly improved product (good or service), process, marketing method, or organizational method in business practices, workplace organization, or external relations (OECD/Eurostat, 2018). This foundational definition, advanced in the Oslo Manual, underscores that innovation includes not only technological invention but also changes in how firms manage, organize, and relate to markets and stakeholders (OECD/Eurostat, 2018). This perspective aligns with Schumpeter's (1934) theory of creative destruction, which emphasizes that innovation is the primary driver of economic development, enabling firms to disrupt existing market structures and create new growth opportunities. However, its manifestation in business strategy is far from uniform, as firms navigate different

degrees and dimensions of novelty depending on their sector, structure, and institutional embeddedness (Tidd & Bessant, 2021; Pinto *et al.*, 2018).

In this regard, the literature distinguishes between incremental innovation, which introduces modest improvements to existing technologies or processes, and radical or disruptive innovation, which redefines industry paradigms and often demands significant shifts in organizational routines and capabilities (Freeman & Soete, 1997; Abernathy & Clark, 1985). Disruptive innovation, as theorized by Christensen (1997), often begins at the margins of a market, targeting underserved or new customer bases, but eventually reshapes or supplants dominant market actors. Systemic innovation, by contrast, involves coordinated change across multiple firms, institutions, or sectors and often requires new infrastructures, governance models, or institutional arrangements (Geels, 2004).

Beyond degrees of novelty, innovation also varies by domain. In addition to technological and product innovations, firms engage in process innovations that reshape production or delivery methods, organizational innovations that reconfigure internal structures or external partnerships, and marketing innovations that create new ways of positioning products, reaching customers, or building brand value (OECD/Eurostat, 2018). These functional types are not mutually exclusive and often interact to enable broader strategic adaptation.

These forms of innovation are often particularly salient in complex, resource-constrained industries like the Blue Economy, where firms must adapt not only to ecological and technological pressures but also to institutional demands for transparency, collaboration, and sustainability (OECD/Eurostat, 2018; Boons & Lüdeke-Freund, 2013).

A growing body of literature has also highlighted the importance of social innovation as a means for firms to address societal needs through participatory, often cross-sectoral, solutions that generate public as well as private value (Moulaert *et al.*, 2013). These innovations tend to arise in contexts marked by market failures or institutional voids and are particularly relevant for firms operating in environmentally sensitive and socially embedded sectors such as fisheries, coastal tourism, or aquaculture. In these settings, innovation is not merely a tool for competitive advantage but a condition for legitimacy and license to operate (Bocken *et al.*, 2014).

From a strategic perspective, innovation is thus not a monolithic or technocratic process but a deeply contextual phenomenon, shaped by the firm's internal capabilities, its position within inter-organizational networks, and the broader institutional logics it must navigate (DiMaggio & Powell, 1983; Pinto *et al.*, 2015b). While large firms may benefit from economies of scale and R&D resources, SMEs which dominate many Blue Economy sectors often rely on informal knowledge-sharing, collaborative alliances, and proximity to stakeholders to sustain innovation efforts (Rupo *et al.*, 2018; Pinto *et al.*, 2018).

Understanding how firms in ocean-based sectors approach innovation, and how these efforts are mediated by institutional factors and sustainability goals, is therefore critical for explaining the uneven adoption of innovative practices across the Blue Economy (Voyer *et al*., 2018; Pinto *et al*., 2015a, 2015b). It also underscores the need for a nuanced conceptual framework that considers both the material and symbolic dimensions of innovation (Fagerberg *et al.*, 2013). Accordingly, the thesis frames innovation as a lens through which to explore how firms adapt institutionally, create multidimensional value, and undergo organizational transformation amid sustainability imperatives.

A more specific category of innovation central to this work is SOI offers a focused lens through which to examine innovation activities explicitly designed to contribute to environmental and/or social objectives while simultaneously ensuring economic viability (Adams *et al.*, 2016). It moves beyond traditional conceptions of innovation that primarily focus on economic performance, integrating sustainability goals into the very logic of how innovation is conceived, developed, and implemented within organizations (Bocken *et al.*, 2014).

Unlike conventional innovation, which may inadvertently produce negative externalities or address market needs without regard to environmental or social impact, SOI requires the rethinking of not only products and processes but also business models, value propositions, and stakeholder relationships (Boons & Lüdeke-Freund, 2013). In this view, innovation becomes both a means and an outcome of firms' strategic efforts to align competitiveness with sustainable development imperatives.

As noted by Bocken *et al.* (2014), SOI tends to emerge in contexts where institutional pressures, such as environmental regulations, shifting consumer expectations, or civil

society engagement, demand corporate responses that exceed short-term compliance and instead reshape organizational purpose. Firms pursuing SOI often engage in business model innovation, defined as the reconfiguration of a firm's value creation, delivery, and capture logic, to internalize external social or ecological concerns (Boons & Lüdeke-Freund, 2013). This reconfiguration may involve circular economy principles, stakeholder-inclusive governance models, or hybrid financial logics that balance profit with impact (Bocken *et al.*, 2014).

A central theoretical implication of SOI is that it challenges the trade-off narrative that has historically framed sustainability and competitiveness as opposites (Elkington, 1998; Porter & van der Linde, 1995). Instead, it suggests that innovation driven by sustainability constraints can be a source of differentiation, resilience, and long-term value creation (Geissdoerfer *et al.*, 2018). However, SOI also presents practical challenges, as it often entails high uncertainty, long time horizons, and the need for organizational learning across multiple dimensions, including technological, cultural, and institutional (Adams *et al.*, 2016; Bocken *et al.*, 2014).

This is particularly salient in the context of the Blue Economy, where firms operate within ecologically fragile environments and increasingly contested policy arenas. In such settings, sustainability is not only a reputational concern but a material determinant of access to resources, market positioning, and long-term survival (Cisneros-Montemayor *et al.*, 2022). As such, SOI represents both a strategic response to external pressures and an initiative-taking effort to shape future market and institutional conditions.

In line with the business management orientation of this thesis, SOI is treated not merely as an environmental or ethical imperative but as a managerial and strategic phenomenon, embedded in the routines, capabilities, and stakeholder relationships of firms. It requires both internal transformation and external engagement, positioning firms as active participants in the co-production of sustainable economic ecosystems (Boons & Lüdeke-Freund, 2013; Moulaert *et al*., 2013).

The behavior and strategies of firms do not emerge in isolation but are embedded within broader institutional environments composed of formal rules, informal norms, and shared belief systems (North, 1991). Institutions, defined by Douglass North (1991) as the “rules of the game” in a society, structure human interaction by shaping incentives, reducing

uncertainty, and providing meaning to organizational practices. These structures not only constrain but also enable specific forms of economic coordination and strategic action (Scott, 1995).

In the field of business management, institutional theory has become a key framework to understand why organizations conform to certain norms, adopt specific practices, and exhibit homogeneity across sectors (Greenwood *et al.*, 2008). DiMaggio and Powell's (1983) seminal work introduced the concept of institutional isomorphism, explaining how organizations within a field tend to resemble one another over time due to coercive (legal and regulatory), normative (professional and cultural), and mimetic (imitation under uncertainty) pressures.

Such pressures are particularly salient in sustainability and innovation contexts, where firms must respond not only to market logics but also to evolving environmental standards, social expectations, and policy frameworks. For example, regulatory compliance with decarbonization targets (coercive), the influence of industry associations (normative), and the imitation of perceived "green leaders" (mimetic) often converge to shape firm-level sustainability responses (DiMaggio & Powell, 1983; North, 1991).

Importantly, institutional theory allows us to move beyond resource-based or purely economic explanations of firm behavior, such as those provided by the resource-based view (RBV) (Barney, 1991), by highlighting how organizational action is influenced by the search for legitimacy, the socially accepted right to operate, rather than just efficiency or profit (Scott, 1995). This legitimizing imperative becomes central in complex fields like the Blue Economy, where firms operate in overlapping institutional regimes, national policies, European Union (EU) directives, global environmental norms, and must continuously align themselves with multiple stakeholder expectations (Cisneros-Montemayor *et al.*, 2022; Pinto & Nogueira, 2018; Pinto *et al.*, 2015a).

From this perspective, institutions are not static constraints but dynamic structures that evolve over time. They condition the possibilities for strategic behavior, but also offer firms a repertoire of symbols, discourses, and practices they can draw upon to frame innovation and sustainability efforts (Streeck & Thelen, 2005). In turn, firms are not passive recipients of institutional pressures, they may also function as institutional

entrepreneurs, agents who challenge, reinterpret, or reshape existing institutional arrangements to gain advantage or legitimacy (DiMaggio, 1988).

Institutional theory provides a critical lens for analyzing how SOI is shaped, enabled, or hindered by the institutional environments in which firms operate. Particularly within the Portuguese Blue Economy, where firms navigate a multi-scalar policy space and face differentiated regulatory and market conditions, understanding these institutional dynamics is essential to explaining both firm-level strategy and sectoral transformation (Pinto *et al.*, 2015a; Scott, 1995; North, 1991).

While this theoretical tradition has been instrumental in explaining institutional stability and conformity, more recent contributions have expanded the lens to include mechanisms of institutional change. Institutional theory traditionally emphasizes stability and path dependency, but newer perspectives highlight how institutions evolve over time. In this expanded view, institutions are not monolithic or immutable but can be subject to gradual transformation, driven by the actions of embedded actors such as firms, regulators, and civil society organizations (Streeck & Thelen, 2005; Mahoney & Thelen, 2010).

Streeck and Thelen (2005) classify institutional change through five incremental mechanisms: displacement (replacement of existing institutions), layering (introduction of new rules alongside existing ones), drift (neglect leading to altered impact), conversion (reinterpretation of institutional purposes), and exhaustion (gradual loss of effectiveness). These mechanisms do not require crises or ruptures, rather, they occur through everyday organizational practices, reinterpretations, and contestations.

Extending this line of thinking, Mahoney and Thelen (2010) emphasize that the pace and type of institutional change depend on the interplay between the characteristics of political coalitions, the discretion of actors, and the veto potential of institutions. In this view, institutional change is strategic, actors use ambiguity, reinterpretation, and gradual adaptation to realign institutional frameworks to their advantage.

In domains like the Blue Economy, where governance structures are fragmented, policies are multilayered, and norms are still in flux, this perspective is especially relevant (Elston *et al.*, 2024). Firms must constantly adapt to shifting environmental regulations, evolving social expectations, and policy frameworks such as the European Green Deal or global decarbonization agendas (Nogueira *et al.*, 2019). Institutional change in this context is

not externally imposed but co-constructed through organizational experimentation, stakeholder negotiation, and regulatory co-evolution (Pinto *et al.*, 2018).

Building on this, the concept of institutional architecture offers a useful lens lens to understand how sectoral systems are shaped by the relationships between different institutional domains, economic, scientific, technological, and political (Streeck & Thelen, 2005; Hall & Soskice, 2001). This approach emphasizes institutional configurations, that is, how different rules, norms, and policy instruments are interlinked to create enabling or constraining environments for strategic action.

Institutional architecture shifts the analytical focus from isolated institutions to the architecture of coordination between institutions and actors. In innovation-intensive fields, the structure of these architectures can determine the degree of coherence or fragmentation in governance, the effectiveness of policy instruments, and the potential for cross-sectoral collaboration (Mahoney & Thelen, 2010; Campbell, 2004; North, 1991).

This approach emphasizes how firms can strategically position themselves within institutional architectures to derive competitive and legitimacy-related benefits. Such alignment is not automatic, it results from deliberate organizational efforts to interpret and respond to evolving institutional demands, thereby strengthening their role in sustainability transitions (Bocken *et al*., 2014; Scott, 1995; Oliver, 1991).

For business management research, this perspective provides a powerful tool to examine how firms navigate institutional complexity, not merely as passive rule-takers, but as agents capable of adapting, shaping, and even constructing new institutional arrangements. This framework informs the analysis of how Portuguese Blue Economy firms respond to evolving sustainability and innovation pressures, and how their institutional positioning affects their capacity to transform.

1.3. Aligning Business Strategy with Sustainability in the Blue Economy

The integration of sustainability and innovation into business practice is no longer an optional or peripheral concern but a central element of strategic management, particularly in sectors shaped by ecological dependency, regulatory volatility, and societal scrutiny. In such contexts, firms are not merely economic actors, but institutional agents embedded

in complex governance systems, negotiating legitimacy, building capacity, and reconfiguring their value propositions in response to overlapping pressures (Pinto *et al.*, 2015b; Bocken *et al.*, 2014).

Traditional strategic management focuses on how firms gain and maintain competitive advantage. Nonetheless, in the Blue Economy, where firms operate in socio-ecological systems marked by interdependence and resource scarcity, competitive advantage must be understood not only in market terms but also in relation to firms' institutional positioning and their capacity to contribute to collective sustainability goals (Boons & Lüdeke-Freund, 2013).

This perspective reinforces the view that firms succeed not only by outperforming competitors but also by strategically aligning with shifting institutional architectures. In emerging or contested policy fields like the Blue Economy, organizational success depends on the ability to anticipate and adapt to institutional change (Pinto *et al*., 2015a), whether by forming partnerships, participating in knowledge networks, or redesigning business models to integrate sustainability goals (Hall & Soskice, 2001; Scott, 1995).

In a dynamic environment like the Blue Economy, firms often face institutional pressures to innovate not just for competitive advantage but to reshape markets and redefine industry standards. In line with Schumpeter's (1934) ideas on creative destruction, innovation becomes a tool for firms to align with new market realities and regulatory expectations, positioning themselves as leaders in sustainability-oriented transformation.

Grounded in the field of business management, this research focuses on how firms in the Blue Economy strategically and organizationally respond to sustainability transitions. It is informed by the recognition that innovation, whether technological, social, or organizational, is both a driver and a product of institutional evolution. Firms are not simply adapting to pre-existing structures, they are shaping the very conditions under which innovation and sustainability are defined, financed, and evaluated (Mahoney & Thelen, 2010; Streeck & Thelen, 2005).

The Blue Economy serves as a particularly salient empirical context for this investigation. Characterized by sectoral heterogeneity and institutional complexity, it brings together established industries and emerging ones, all of which are subject to rapid shifts in policy, technology, and stakeholder expectations (Cisneros-Montemayor *et al.*, 2022). Portugal,

with its strong maritime tradition and active participation in European sustainability agendas, offers a compelling national setting to examine how firms navigate these dynamics (Machado de Almeida & De Portugal, 2022; Fontes *et al.*, 2019).

By exploring how sustainability and innovation intersect within Blue Economy firms, this research contributes to both theory and practice. Theoretically, it extends business strategy literature by incorporating institutional theory and sustainability transitions into firm-level analysis. Practically, it provides grounded comprehensions into the capabilities, collaborations, and governance conditions that support innovation in resource-dependent sectors. These perceptions are particularly relevant for policymakers seeking to accelerate sustainability transitions, as well as for firms that must adapt not only to markets but to evolving institutional and ecological landscapes.

Ultimately, this section reinforces that addressing sustainability and innovation in ocean-based sectors is not simply about firm performance, it is about organizational resilience, strategic alignment, and institutional participation in broader transformations. It also positions the thesis as a contribution to ongoing debates in strategic management, institutional theory, and sectoral innovation systems, demonstrating the relevance of business scholarship to some of the most pressing sustainability challenges of our time.

1.4. Research Questions and Objectives

Building on the preceding theoretical framework, this section articulates the central research questions and objectives that guide the empirical investigation into how firms within ocean-based industries strategically engage with sustainability through innovation. Although sustainability and innovation have each been widely examined across diverse research streams, their convergence at the firm level, particularly within the Blue Economy, remains theoretically fragmented and empirically underexplored. Much of the existing scholarship has concentrated on macroeconomic policies, institutional frameworks, or environmental governance, often neglecting how companies themselves interpret and respond to sustainability pressures in their internal processes, strategic orientations, and stakeholder relationships (Geissdoerfer *et al.*, 2018; Rupo *et al.*, 2018; Pinto *et al.*, 2015b; Bocken *et al.*, 2014).

Addressing this gap, the present research adopts a firm-centered, strategy-oriented lens to investigate how business actors in the Portuguese Blue Economy make sense of,

internalize, and operationalize sustainability imperatives in their innovation practices. The research is theoretically grounded in institutional approaches that view organizations as embedded in rule-bound and socially constructed environments (Scott, 1995; DiMaggio & Powell, 1983), and it is attentive to the multi-level dynamics that shape firm behavior under regulatory, normative, and resource-based pressures. By situating the inquiry within this theoretical space, the thesis seeks to offer insight into how firms navigate environmental fragility, regulatory complexity, and the imperative for economic competitiveness.

The overarching aim of the research is to explore how sustainability concerns influence innovation processes in ocean-based industries and how these processes affect organizational outcomes across economic, environmental, and social dimensions. This investigation unfolds through three interconnected articles, each guided by a distinct set of research questions and methodological approaches but collectively contributing to a coherent understanding of firm-level responses to sustainability in marine contexts.

The first article lays the conceptual foundation for the thesis by conducting a systematic literature review of sustainability and innovation in the Blue Economy. It examines the question: How does innovation contribute to the development of sustainable practices in the Blue Economy, and what barriers exist to their widespread adoption?. The review highlights the fragmented nature of the literature and the lack of integrative theoretical frameworks that account for institutional and organizational complexity in ocean-based industries.

The second article builds upon this conceptual synthesis by employing a quantitative design to empirically examine Portuguese firms operating in key Blue Economy sectors. It addresses two related questions: (1) How does sustainability drive innovation in Blue Economy firms?, and (2) How does innovation mediate the impacts of sustainability on economic, environmental, and social outcomes?. Drawing on survey data collected from 40 Portuguese firms and employing Partial Least Squares Structural Equation Modeling (PLS-SEM), this study provides statistical evidence on the interactions between sustainability practices, innovation activities, and multidimensional firm performance.

The third article complements the quantitative findings with qualitative depth, using comparative case studies of five firms to investigate how innovation and sustainability

are enacted in practice. It explores the following questions: (1) How do firms in the Portuguese Blue Economy operationalize sustainability and innovation in their business practices?, (2) What are the key enablers and barriers influencing innovation in response to sustainability pressures?, and (3) How can these strategies be scaled and replicated across different Blue Economy sectors?. Through in-depth interviews, institutional website analysis, and triangulation with survey data, this article uncovers how firms respond to sustainability pressures, highlighting the strategic rationales, institutional constraints, and leadership approaches that underpin their innovation efforts.

Taken together, these three studies constitute a multi-method, multi-level exploration of the role of innovation in supporting sustainability transitions at the firm level. The thesis develops its argument progressively, from the synthesis of literature to the testing of theoretical relationships, and finally to the contextual interpretation of real-world practices.

In doing so, the research pursues several interrelated objectives. It aims to consolidate fragmented academic perspectives on sustainability and innovation in ocean-based industries, proposing a conceptual framework that accounts for sectoral and institutional specificity. It seeks to generate empirical evidence on how sustainability-related pressures are translated into innovation processes and how these in turn influence firm performance. It also aims to reveal the lived realities of firms, particularly in Portugal, as they attempt to align economic, environmental, and social goals. Through this integrated approach, the thesis contributes to the advancement of business management theory and provides perspectives for managers, policymakers, and stakeholders striving to foster sustainable growth in marine-based sectors.

1.5. Boundaries and Scope of the Research

While anchored in the disciplinary domain of Business Management, this thesis delineates a specific analytical focus on how firms in ocean-based sectors respond strategically to sustainability imperatives under institutional complexity. While it engages with themes commonly explored in environmental studies, innovation policy, and economic geography, the unit of analysis is firmly centered on the firm, its strategies, capabilities, and institutional interactions. The research is thus aligned with organizational and strategic management perspectives that emphasize firm behavior

under conditions of complexity, change, and institutional embeddedness (Pinto *et al.*, 2015b; Mahoney & Thelen, 2010; DiMaggio & Powell, 1983).

Empirically, the study focuses on the Portuguese Blue Economy, a context that serves as a rich empirical setting due to the country's maritime identity, long Atlantic coastline, and active role in European marine policy. Portugal's ocean-based sectors, ranging from traditional industries such as fisheries and maritime transport to emerging fields like marine biotechnology and offshore renewables, serve as a microcosm of broader dynamics shaping sustainability transitions in the Blue Economy (Machado de Almeida & De Portugal, 2022; Pinto *et al.*, 2015b). However, the empirical scope does not aim to provide exhaustive coverage of all sectors or firm types. Instead, the thesis adopts a selective and strategic approach, targeting firms with demonstrable engagement in sustainability and innovation practices.

Methodologically, the research design adopts a mixed-methods approach to triangulate findings across three distinct but interconnected studies. The first article conducts a systematic literature review to assess the state of academic knowledge and identify conceptual and empirical gaps. The second article applies a quantitative framework to analyze survey data from Portuguese firms using structural equation modeling. The third article adopts a qualitative case study design to explore in-depth organizational practices, decision-making processes, and contextual barriers. Together, these three studies constitute a multi-level design that progresses from conceptual synthesis to quantitative analysis and, finally, to contextualized qualitative understanding.

In terms of conceptual boundaries, the thesis does not begin from a narrow focus on SOI but develops this lens progressively, as it emerges from the theoretical synthesis and empirical findings. The research is not concerned with technical innovation per se, but with the strategic and organizational processes through which firms respond to sustainability challenges. This includes how they interpret external pressures, reconfigure internal capabilities, and form collaborative relationships. As such, innovation is understood not merely as a technological output but as a process embedded in institutional, social, and ecological systems.

The thesis also acknowledges important limitations. It does not attempt to develop a universal theory of sustainability and innovation in the Blue Economy but rather

contributes context-specific contributions grounded in a particular national case. Nor does it explore all possible drivers of firm behavior (such as cultural values or consumer demand), instead focusing on institutional, organizational, and strategic dimensions. The findings, while grounded in empirical data, must therefore be interpreted with appropriate caution and awareness of their contextual specificity.

Overall, the research offers a focused, theoretically grounded, and empirically rich exploration of how firms in the Portuguese Blue Economy navigate the complex terrain of sustainability and innovation. By delimiting its scope to firm-level strategic responses within a defined national and sectoral context, the thesis aims to contribute both to academic debates and to practical understanding of sustainability transitions in ocean-based industries.

1.6. Methodological outline and Article Architecture

This thesis is structured around three interrelated but methodologically distinct studies, each addressing a different dimension of how firms in the Blue Economy engage with sustainability and innovation. Together, these studies build a cumulative argument that integrates conceptual synthesis, quantitative modeling, and qualitative insight.

Chapter 1 introduces the research problem, presents the conceptual and theoretical foundations, outlines the research questions and objectives, delimits the scope of the study, and details the structure of the thesis. It establishes the strategic focus on firm-level responses to sustainability pressures within the Portuguese Blue Economy, situating the study within the field of Business Management.

Chapter 2, titled "Tides of Change for a Sustainable Blue Economy: A Systematic Literature Review of Innovation in Maritime Activities", conducts a systematic literature review of peer-reviewed research at the intersection of sustainability and innovation in the Blue Economy. Grounded in a PRISMA-guided methodology, it synthesizes 98 articles from 2015-2023 and aims to examine how innovation contributes to sustainable practices in marine-based sectors, and what barriers hinder their widespread adoption. The review maps key concepts and sectoral domains, identifies enabling and constraining factors for innovation in maritime activities, and highlights critical research gaps in stakeholder engagement, financing mechanisms, circular economy adoption, and the articulation of sustainability goals. The chapter concludes by identifying priority areas for

future research and policy support, underlining the importance of innovation in enabling a more sustainable and inclusive Blue Economy.

Chapter 3, "Waves of Innovation: The Role of Sustainability in Driving Impact in the Blue Economy - A PLS-SEM Approach", presents a quantitative analysis of 40 Portuguese firms operating in Blue Economy sectors. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), it examines the relationships between sustainability practices, innovation, and firm-level performance across economic, environmental, and social dimensions. The chapter highlights the mediating role of innovation and provides empirical evidence for theorized interactions developed in Chapter 2.

Chapter 4, "Charting the Course: Real-World Application of Sustainability and Innovation Principles in Portuguese Blue Economy Firms", adopts a qualitative case study methodology to deepen and contextualize the findings of the previous chapter. Drawing on semi-structured interviews, institutional website analysis, and triangulation with survey data, the study examines five firms from diverse maritime sectors. It identifies strategic drivers, institutional constraints, and managerial practices that enable or hinder SOI. The chapter explores how firms operationalize sustainability in practice and considers the conditions under which these strategies might be scaled or adapted across sectoral contexts.

Chapter 5 synthesizes findings across all three studies. It reflects on the theoretical and practical contributions of the research, acknowledges methodological limitations, and proposes avenues for future inquiry. The final chapter consolidates the thesis’s core argument, that firm-level engagement with sustainability and innovation in the Blue Economy is shaped by dynamic institutional conditions and must be understood through integrated conceptual and empirical perspectives.

This organizational structure is summarized in Table 1.1 below:

Table 1.1 - Summarizes the structure of the thesis, outlining the main focus and contribution of each chapter in alignment with the overarching research objectives

Chapter	Title	Content
Chapter 1	**General Introduction**	Research background, theoretical foundations, research questions and objectives, scope, and thesis structure.
Chapter 2	**Tides of Change for a Sustainable Blue Economy**	Systematic literature review of sustainability and innovation in the Blue Economy, mapping key concepts and sectoral domains, identifying enabling and constraining factors, and pointing to future research needs.
Chapter 3	**Waves of Innovation: The Role of Sustainability in Driving Impact in the Blue Economy - A PLS-SEM Approach**	Quantitative analysis using PLS-SEM to assess the relationship between sustainability, innovation, and performance outcomes in financial, environmental and social domains in Portuguese Blue Economy firms.
Chapter 4	**Charting the Course: Real-World Application of Sustainability and Innovation Principles in the Portuguese Blue Economy Firms**	Qualitative case study analysis of five Portuguese Blue Economy firms, based on semi-structured interviews, institutional website review, and triangulation with survey data. The chapter examines how sustainability and innovation are practiced on the ground, identifies common barriers and enablers, and offers insights into strategic adaptation across different contexts.
Chapter 5	**General Conclusion**	Integration of key findings, theoretical and practical implications, limitations, and directions for future research.

Source: Own elaboration.

CHAPTER 2 – TIDES OF CHANGE FOR A SUSTAINABLE BLUE ECONOMY: A SYSTEMATIC LITERATURE REVIEW OF INNOVATION IN MARITIME ACTIVITIES (PAPER ONE)[1]

Abstract

The Blue Economy, a dynamic field intertwining ocean sustainability, innovation, and economic progress, stands as a beacon of hope for fostering inclusive growth while advancing sustainable practices. This systematic literature review embarks on a journey to unravel the intricate relationship between innovation and sustainable practices within the Blue Economy, to uncover how innovation transforms and promotes sustainability and pinpointing barriers to adoption of innovative technologies and processes. By delving into the multifaceted landscape of sustainability and innovation studies within the Blue Economy, this study illuminates the potential of innovative approaches to drive sustainability in coastal and marine areas With global attention shifting toward ocean sustainability due to survival risks and resource scarcity, this study addresses two central questions: How does innovation drive sustainable practices within the Blue Economy, and what barriers prevent the widespread adoption of these innovations? Using this interrogation as a compass to navigate the existing literature, and through a comprehensive analysis of the role of innovation in promoting sustainable practices, this review aims to provide hints for the main directions for a sustainable Blue Economy.

Keywords: Blue Economy; Sustainability; Sustainable Development; Innovation; Blue Growth; Ocean resource management

2.1. *Introduction*

The oceans play a fundamental role in sustaining life on Earth, acting as vital reservoirs of biodiversity, resources, and ecosystem services supporting human well-being and environmental balance. However, the surge in human population and industrial advancements has significantly strained marine ecosystems, resulting in critical issues such as pollution, overfishing, biodiversity loss, and climate change (Proczek &

[1] **This paper is published in *Sustainability* and its structure follows this journal style. https://doi.org/10.3390/su162411141**

Garbarczyk, 2023; Mdlalose, 2022; Chen *et al.*, 2020; Li *et al.*, 2020; Upadhyay & Mishra, 2020).

Understanding transformations in marine environments, including institutional and ecological changes, is crucial for ensuring sustainable development (Banikoi *et al.*, 2023). These shifts not only affect biodiversity but also influence governance frameworks essential for fostering long-term sustainability.

In response to these challenges, the concept of Blue Economy has emerged as a sustainable approach to using marine resources for economic growth, improved livelihoods, and job creation, while preserving the health of the ocean (Penca, 2019; Soma *et al.*, 2018; Dziura & Cernota, 2015). According to the World Bank & United Nations Department of Economic and Social Affairs (2017), the Blue Economy refers to the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems. This definition underscores the balance between economic development and environmental conservation.

The Blue Economy comprises a variety of activities, including traditional sectors such as fisheries and marine transport, as well as emerging industries such as aquaculture, marine biotechnology, renewable energy, and coastal tourism. Each of these sectors presents opportunities for innovation to drive sustainability while addressing environmental challenges (Martínez-Vázquez *et al.*, 2023; Fusco *et al.*, 2022).

Grounded in ecosystem ingenuity[2], the Blue Economy leverages nature's innovative capacities to provide humanity with sustainable products, enhancing quality of life and supporting societal renewal. It responds to the urgency of the planet's limited renewal capacity. This approach counters the consequences of resource-wasting production practices, which lead to risks, crises, and developmental instability, uncertainty, and volatility (Nikitenko *et al.*, 2022). Governments in various countries have adopted policies and strategies to mitigate these challenges by fostering sustainable practices and promoting innovation in sectors such as marine biotechnology and renewable energy (Campana *et al.*, 2021; Martínez-Vázquez *et al.*, 2021; Dziura & Cernota, 2015). For example, advancements in marine biotechnology hold potential for developing

[2] Ecosystem ingenuity refers to the ability to harness or mimic the natural processes, functions, and adaptive capacities of ecosystems to design sustainable human solutions. It is particularly relevant in fields such as the circular economy, resource efficiency, and innovation (Nikitenko *et al.*, 2022).

sustainable products, while renewable energy technologies such as offshore wind offer cleaner energy solutions.

As governments, organizations, and communities worldwide embrace the Blue Economy concept, there is a growing recognition of the need to move beyond business as usual and consider economic development and ocean health as compatible propositions (Arzaman *et al.*, 2023). The research question, "How does innovation contribute to the development of sustainable practice in the Blue Economy, and what barriers exist to their widespread adoption?" is particularly significant owing to its focal point on the critical juncture of innovation and sustainability within the framework of the Blue Economy.

Innovation is essential for economic growth, job creation, and environmental protection within the Blue Economy framework. By exploring barriers such as resistance to innovation and financial uncertainties, this research aims to identify pathways for addressing the challenges that hinder the realization of a truly sustainable Blue Economy (Kyvelou & Ierapetritis, 2019).

This article systematically examines the Blue Economy framework, employing a structured approach to analyze the intersection of innovation and sustainability. Section 2 details the systematic literature review methodology, which forms the foundation for a robust analysis. Section 3 presents the key findings, mapping the current state of research and highlights its practical relevance. Section 4 explores the role of innovation in advancing sustainable practices within the Blue Economy, emphasizing its transformative potential. Finally, Section 5 synthesizes the findings, offering conclusions and actionable recommendations for future research. This comprehensive examination underscores how innovation can serve as a catalyst for sustainability, fostering a resilient and mutually beneficial relationship between humanity and marine ecosystems

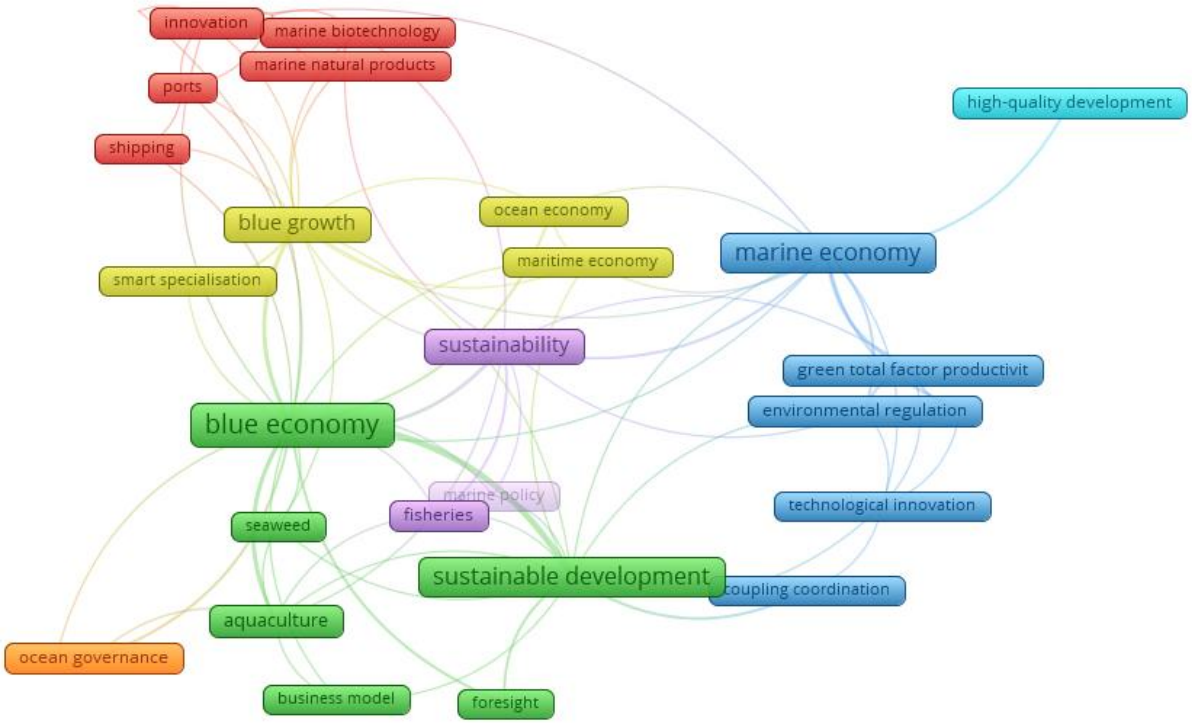
2.2. Materials and Methods

A systematic literature review (SLR) is a fundamental aspect of academic research across various disciplines. This study follows the guidelines of Tranfield *et al.* (2003) a methodological approach that serves as a cornerstone for evidence-based practice, offering a structured and rigorous framework for synthesizing existing knowledge, identifying gaps in research, and informing future investigations. By systematically searching, selecting, appraising, and synthesizing relevant studies, the SLR provides a comprehensive overview of current knowledge, facilitating evidence-based decision-making and advancing scholarly discourse.

To develop the keywords for this SLR, a preliminary exploratory analysis was conducted of existing studies on the Blue Economy. This initial review identified recurring terms and themes central to the intersection of sustainability, innovation, and economic activities in marine-related sectors. By analyzing frequently cited studies and their terminology, we synthesized a set of keywords to ensure a comprehensive and focused scope for this research.

The Blue Economy literature is described using varied and sometimes interchangeable terms such as “Ocean Economy”, “Marine Economy”, “Blue Growth”, and “Maritime Clusters” (Martínez-Vázquez *et al.*, 2021). These terms are used synonymously within the literature and underscore the need to address and comprehend them to ensure a comprehensive understanding of the concepts related to sustainable practices and innovation within the Blue Economy. Figure 2.1 illustrates the author keywords found in the literature related to the Blue Economy. It visualizes the interrelationship between innovation, sustainability, and the sectors involved in this economy.

Figure 2.1 - Keywords present in the Blue Economy literature



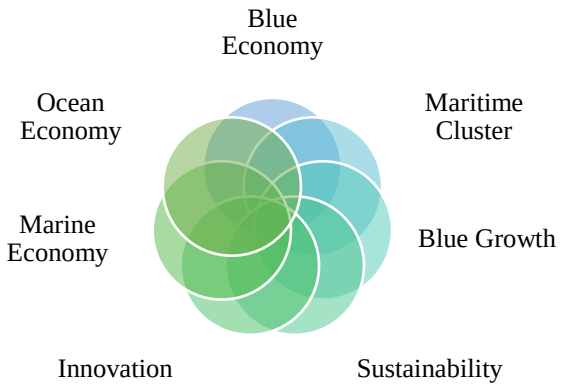
Source: Own elaboration, VosViewer output.

In figure 2.1. the connections emphasize the role of innovation in enabling sustainable practices across industries. This figure demonstrates the intricate relationship between

these fields, and the synonyms used within literature helping frame the scope of this review.

Figure 2.2. illustrates the keywords identified for inclusion in the systematic search, highlighting critical intersections such as innovation, sustainability, and marine economy. These keywords guide the literature review process by capturing the thematic scope of the Blue Economy and ensuring that studies relevant to sustainable practices and innovations are considered. This approach enhances the rigor and depth of the systematic review, providing a robust foundation for analyzing the interplay between innovation and sustainability within the Blue Economy.

Figure 2.2 - Keywords identified to be included in the search



Source: Own elaboration.

Scopus and Web of Science were selected as the primary databases for their extensive multidisciplinary coverage and access to high-quality, peer-reviewed articles relevant to the research objectives (Arzaman *et al.*, 2023; Cortez *et al.*, 2018; Abrizah *et al.*, 2013). The search string outlined in Table 2.1 was used to locate articles on how innovation contributes to sustainability in the Blue Economy.

Employing the search string delineated in Table 2.1, the aim was to shed light on the innovative methodologies and technologies pivotal in nurturing sustainable development and environmental preservation within the domain of the Blue Economy. Data extraction completed in October 2023 encompasses all articles identified during the initial phase of this review. The earliest publication within this dataset dates to 2015. This timeframe provides a thorough and up-to-date overview of the scholarly discourse at the intersection of the Blue Economy, sustainability, and innovation.

Table 2.1 - Composition of search string

Databases	Search String
Scopus	(TITLE-ABS-KEY ("blue economy" OR "blue growth" OR "marine economy" OR "ocean economy" OR "maritime cluster") AND TITLE-ABS-KEY ("Sustainab*") AND TITLE-ABS-KEY ("Innovat*")) AND (LIMIT-TO (DOCTYPE , "article")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "Journal")) AND (LIMIT-TO (PUBSTAGE , "Final"))
Web of Science	

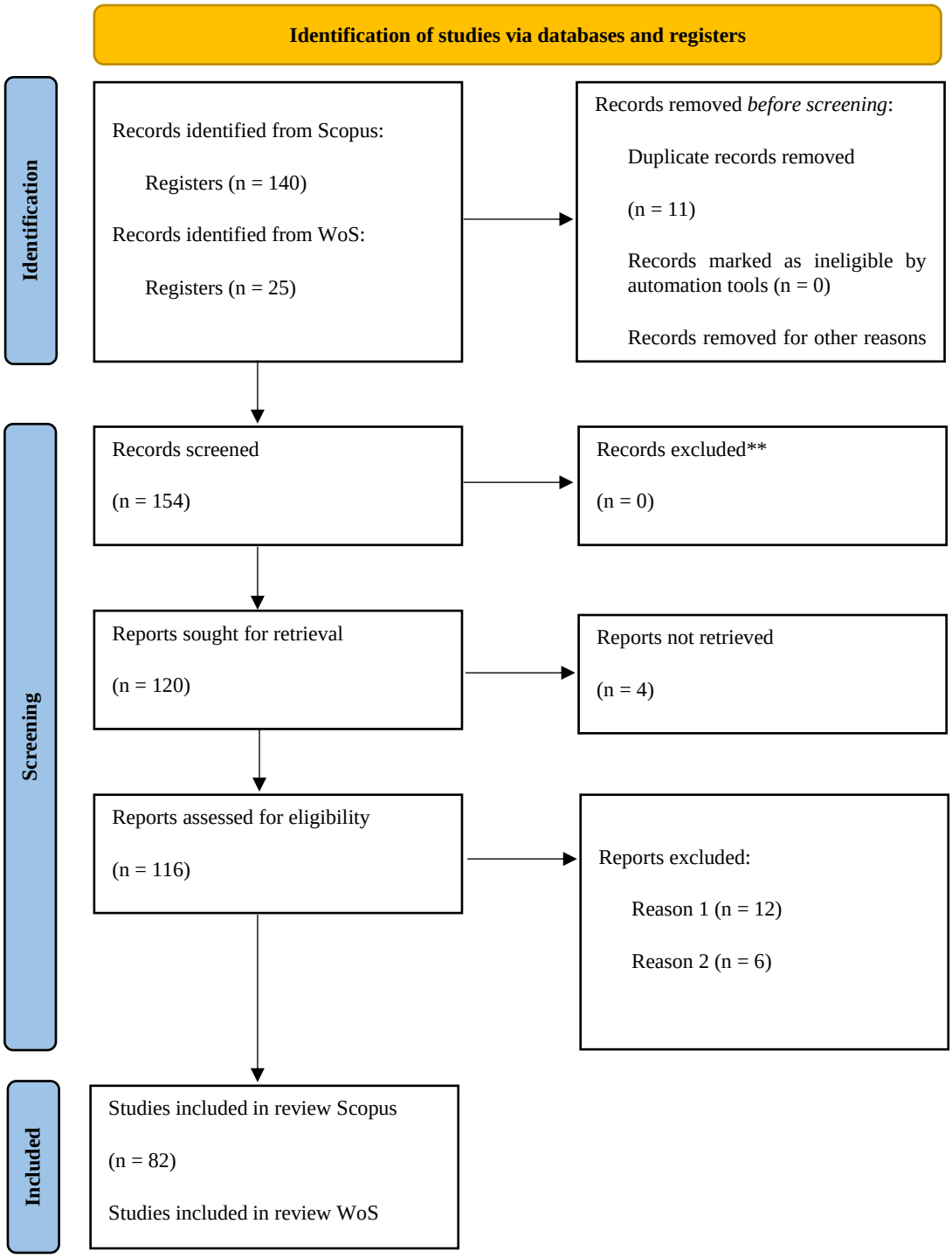
Source: Own elaboration.

Adhering to the structured guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method (Moher *et al.*, 2009), as delineated in Figure 2.3, the final sample analyzed for this research comprises 98 articles. Although not all 98 articles are directly cited in the results due to issues of repetition or relevance, they were included in the review process and contributed to the overall analysis. All 98 articles remain listed in the references for transparency.

This systematic review is registered with the Open Science Framework (OSF) to ensure transparency and adherence to best practices. The registration DOI is https://doi.org/10.17605/OSF.IO/J9BEX, to provide access to the review protocol, including the search strategy, inclusion/exclusion criteria, and planned analyses.

Figure 2.3. presents the PRISMA flowchart, illustrating the article selection process used in this systematic literature review. The flowchart details each step, from the initial identification of records through database searches to the final inclusion of articles in the review. This transparent visualization demonstrates the rigor of the selection criteria, helping readers understand how the final sample of 98 articles was determined based on relevance to the research question. The PRISMA method ensures that the review is comprehensive and methodologically sound, adhering to best practices for systematic literature reviews.

Figure 2.3 - PRISMA Flowchart, the systematic literature review process



Source: Own elaboration, adapted from (Moher *et al.*, 2009).

Selection of articles to include in this SLR was based on the direct relevance to the research question, with a specific emphasis on investigations into how innovation propels sustainable development within the Blue Economy while also identifying impediments to its adoption.

Table 2.2 - Eligibility and exclusion criteria for the SLR.

Criteria	Inclusion Criteria	Exclusion Criteria
Timeline	From 2015 to 28th of October	After 28th of October
Type of Literature	Peer-reviewed scientific articles	Conference proceedings, grey literature; non-peer-reviewed literature, Publications based on the same study, news items
Publication Status	Published and Available online	Published but resource not available online; other
Language	English	Non-English
General topics	Studies that provide an analysis and general issues concerning the economic development, innovation and the sustainable development in the Blue Economy or any activity or industry part of the Blue Economy	Studies that concern biological themes related to Blue Economy from diseases, farming techniques, and nutritional contents of produces of aquaculture or other farming activities. Studies that did not elaborate on innovation or sustainability in any way related to the blue economy.

Source: Own elaboration.

Table 2.2 outlines the eligibility and exclusion criteria applied to the systematic review, ensuring that only relevant and high-quality studies were included. Articles were selected based on criteria such as publication timeline, type of literature, publication status, language, and topic relevance. This structured approach excludes non-peer-reviewed and non-English studies while focusing on peer-reviewed articles that analyze the role of innovation in sustainable practices within the Blue Economy. These criteria were crucial in filtering the literature to ensure a focus on evidence-based findings that contribute to the objectives of this research.

2.3. RESULTS

2.3.1. Defining the Blue Economy

The concept of the Blue Economy has emerged as an application of the broader green economy paradigm, focusing specifically on the marine and coastal environment (Penca, 2019; Soma *et al.*, 2018; Dziura & Cernota, 2015). From the articles reviewed, a common theme is the Blue Economy's role in supporting both economic and environmental goals through innovation. The Blue Economy model highlights coastal regions as hubs for economic innovation, blue activities, and empowerment of resource-dependent communities (Mdlalose, 2022; Dziura & Cernota, 2015).

While there is no universally agreed definition across all 98 articles, the majority align with the view that the Blue Economy integrates economic activities and environmental

stewardship. Several sources (e.g., Proczek & Garbarczyk, 2023; Qi, 2022) emphasize that this framework must promote long-term sustainability through innovative practices that minimize environmental impacts.

The concept of the Blue Economy has been defined in various ways across the literature, reflecting its multidisciplinary and evolving nature. For instance, the World Bank emphasizes the Blue Economy as "the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems" (World Bank & United Nations Department of Economic and Social Affairs, 2017). In contrast, academic literature often highlights the ecosystem-based approach, focusing on the interconnectedness of ecological and economic systems (Hassanali, 2022).

Furthermore, definitions differ in their emphasis on specific sectors. While some focus on traditional industries such as fisheries and marine transport, others incorporate emerging sectors like marine biotechnology and renewable energy (Martínez-Vázquez *et al.*, 2021; Penca, 2019). Regional perspectives also influence definitions, with SIDS focusing resilience and equity to address their unique vulnerabilities (Benzaken *et al.*, 2022; Karani *et al.*, 2022).

These variations highlight the need for a comprehensive understanding that balances economic, social, and environmental priorities. However, they also present challenges in aligning stakeholders and measuring progress, as different definitions prioritize distinct objectives and indicators.

This paradigm shift recognizes the economy as a subsystem of society and nature, serving as a tool to achieve a socially just and environmentally stable future (Nikitenko *et al.*, 2022; Martínez-Vázquez *et al.*, 2021; Dziura & Cernota, 2015). Through sustainable business practices that respect both local resources and cultural traditions while responding to basic needs, the aim is to avoid negative impacts on the environment (Mdlalose, 2022).

The Blue Economy focuses on utilizing locally available resources in cascade systems, where the waste from one product becomes the input to create a new cash flow. This model imitates natural processes to achieve sustainable and environmentally friendly economic development (Hassanali, 2022; Penca, 2019).

The expansion of the Blue Economy paradigm is crucial at both national and global levels, particularly among Small Island Developing States (SIDS). Technological innovations, investment, and multilateral cooperation are facilitating progress in sectors related to the Blue Economy (Gerhardinger *et al.*, 2020). This momentum initiatives has led to such as the Sustainable Development Goal (SDG) number 14 "Life below Water", adopted in 2015, which emphasizes sustainable management and protection of marine and coastal ecosystems, scientific knowledge enhancement, and transfer of sustainable marine technologies (Hassanali, 2022; Penca, 2019).

Various definitions of the Blue Economy exist among organizations, with common features emphasizing ocean health, sustainability, equity, and resilience as core principles (Benzaken *et al.*, 2022). The World Bank (2017) and the United Nations (2015) agreed that the Blue Economy aims to move beyond business as usual and to consider economic development and ocean health as compatible propositions.

To conclude, the Blue Economy represents an emerging concept that promotes better oversight of ocean resources while highlighting the close relationship between oceans, climate change, and human well-being within marine and coastal regions through innovative approaches that drive sustainable development and resource management.

2.3.1.1. Key sectors and Activities in the Blue Economy

The Blue Economy encompasses a diverse range of economic activities directly or indirectly linked to the ocean, including traditional sectors such as fisheries, marine trade, and tourism, as well as emerging industries such as aquaculture, seabed extractive operations, marine biotechnology, offshore renewable energy, and bioprospecting (Martínez-Vázquez *et al.*, 2023; Proczek & Garbarczyk, 2023; Mdlalose, 2022; Qi, 2022; Sarwar, 2022; Meyer, 2021; Upadhyay & Mishra, 2020; Dziura & Cernota, 2015).

In the review of the literature, we found that innovation plays a key role in these sectors, driving sustainable development while promoting economic growth and job creation. For instance, aquaculture is increasingly leveraging technological advancements to enhance sustainable fish production, while renewable energy (e.g., offshore wind) is emerging as a major player in reducing carbon footprints within the Blue Economy.

The key sectors and activities within the Blue Economy, as identified in various literature and outlined by Martínez-Vázquez *et al.* (2023), include, but not limited to:

1. Living Resources: Encompasses fish, crustaceans, and mollusks, with a significant emphasis on fisheries and aquaculture. Technological innovations,

such as in sustainable aquaculture practices, are helping meet the growing global demand for seafood while preserving marine biodiversity (Rubilar & Cardozo, 2021).

2. Non-living Resources: Includes offshore oil, natural gas, and minerals such as gravel and sand. Innovations in cleaner extraction methods are critical for reducing the environmental impact of resource extraction.
3. Shipbuilding and Repair: The shipbuilding industry is embracing innovations aimed at reducing environmental footprints, such as the development of greener fuels and technologies that improve energy efficiency in vessels.
4. Maritime Transport: Maritime transport is crucial for moving goods globally, and innovations in fuel efficiency and emissions reductions are essential to ensure that this sector grows sustainably.
5. Coastal and Oceanic Tourism: Tourism remains a vital economic resource, but it is necessary to strike a balance between economic benefits and environmental conservation. Innovative eco-tourism models are emerging as a solution to this challenge.
6. Ecosystem Services: These include carbon sequestration, coastal protection, and biodiversity conservation. Digital tools and remote sensing technologies enhance the ability to manage and protect these critical services (Karani *et al.*, 2022).
7. Renewable Energy: Offshore renewable energy, including wind and wave energy, is one of the most promising sectors for innovation within the Blue Economy. The development of renewable energy sources is central to reducing reliance on fossil fuels and promoting sustainable growth.

The European Union's taxonomy regulation aims to classify economically sustainable activities with a focus on the marine environment, ensuring the sustainable use of marine ecosystem services while preventing or reducing inputs that harm marine environments (Schøning *et al.*, 2023). This regulation provides a standardized framework for determining which activities can be classified as sustainable, further supporting the goals of the Blue Economy.

These key sectors offer immense potential for innovation, and demonstrate a holistic approach, which can drive sustainable development while preserving ocean health and supporting coastal communities (Martínez-Vázquez *et al.*, 2023; Penca, 2019). This

supports the broader framework of the Blue Economy, which focuses on leveraging marine resources for both economic and environmental gains.

2.3.2. Sustainability

The importance of sustainability in the Blue Economy cannot be overstated, as it serves as a vital component for preserving ecological balance, minimizing environmental impact, and supporting economic activity within marine ecosystems without depleting resources (Cziesielski *et al.*, 2021; Penca, 2019). Sustainability within the Blue Economy framework is crucial for maintaining the health of marine and aquatic environments, ensuring the continuous availability of resources, and mitigating the negative effects of human activities on aquatic ecosystems (Mdlalose, 2022; Cisneros-Montemayor *et al.*, 2021; Pu *et al.*, 2021).

The genesis of sustainable development discussions can be traced back to the Conference on the Human Environment in Stockholm, 1972, where visions of sustainability emerged. Since then, sustainable development has evolved into a comprehensive agenda, transcending disciplines, and aiming to safeguard Earth's ecological systems from adverse human activities (Kitada & Bhirugnath-Bhookhun, 2019).

Sustainable development can be defined as the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs (Blažauskas *et al.*, 2015). Sustainability within the Blue Economy relies on innovations that minimize environmental impact while optimizing resource utilization. For instance, technological advancements in aquaculture contribute to more sustainable fish production by reducing bycatch and habitat destruction. In renewable energy, innovations in offshore wind and wave energy are playing a crucial role in lowering carbon emissions (Proczek & Garbarczyk, 2023; Rubilar & Cardozo, 2021). Collectively, these innovations ensure the sustainable use of marine resources while fostering economic growth. However, the success of these innovations depends on their ability to be scaled responsibly, ensuring long-term resilience in both ecosystems and economic frameworks (Hassanali, 2022; Qi, 2022).

In the context of the Blue Economy, sustainability encompasses the responsible use of marine resources to balance ecological preservation, economic development, and social equity (World Bank & United Nations Department of Economic and Social Affairs,

2017). This framework relies on innovations that address challenges such as marine biodiversity loss, resource depletion, and climate change impacts. For example, ecosystem-based aquaculture systems help reduce bycatch and enhance habitat conservation (Campana *et al.*, 2021; Rubilar & Cardozo, 2021), while offshore wind and wave energy technologies represent a transition to low-carbon solutions that mitigate climate change and foster economic opportunities in coastal regions (Campana *et al.*, 2021). These advancements highlight how the Blue Economy can balance economic growth with environmental sustainability and social well-being by integrating sustainable practices into marine industries (Y. Zhang *et al.*, 2023; Qi, 2022). However, the scalability and long-term resilience of these innovations remain critical to achieving a truly sustainable Blue Economy.

The incorporation of diverse sectors and geographic scopes within the Blue Economy underscores its focus on sustainability, with many of the articles in our review highlighting how innovation is central to achieving these goals (Franz *et al.*, 2021). The United Nations Decade of Ocean Science for Sustainable Development, as explained by Pace *et al.* (2023a), provides a platform to engage scientists in identifying critical oceanic priorities and advancing interdisciplinary approaches to achieve ocean sustainability within the Blue Economy framework by the year 2030.

The alignment of the Blue Economy with the SDGs, emphasizing that the Blue Economy concept is rooted in sustainability and its association with the 2030 Agenda action plan, which aims to achieve shared social, economic, and environmental priorities. The SLR reveals that six specific SDGs, namely SDG 3 (Health and Welfare), SDG 12 (Consumption and Responsible Production), SDG 14 (Life on Water), SDG 15 (Land Life), SDG 16 (Peace, Justice, and Strong Institutions), and SDG 17 (Partnerships and Means of Implementation) are most frequently linked to Blue Economy practices. These goals reflect the potential for economic sectors of the Blue Economy to use the SDGs as a parameter and core of sustainable development (Karani *et al.*, 2022; Martínez-Vázquez *et al.*, 2021).

The review of the existing literature confirms that these goals align with the growing body of research that calls for technological and policy innovations to support sustainable marine resource management. Many stressing that sustainable growth in these sectors can

be achieved by fostering collaboration between governments, industries, and local communities, using innovative technologies and practices.

The goals set by the UN for sustainable development showcase contemporary policies focused on economic competitiveness, sustainable innovation, renewable technologies, reducing emissions, and minimizing environmental impact (Spaniol & Rowland, 2022a, 2022b). Advancing a Blue Economy framework to promote the sustainable use of ocean resources entails integrating economic activities within effective ocean governance systems, complying with international agreements as the United Nations Convention on the Law of the Sea, and aligning with the 2030 Sustainable Development Agenda and Goals (Benzaken *et al.*, 2022).

By embracing sustainability principles in marine resource management, fostering collaboration among stakeholders, and promoting innovative solutions, the literature highlights that nations striving to develop ocean resources sustainably are simultaneously fostering economic growth. As nations strive to develop the ocean space in a sustainable manner, they are concurrently fostering economic growth. This growth serves as the foundation for realizing economic advantages within the Blue Economy and promoting blue growth (Qi, 2022; Kyvelou & Ierapetritis, 2019).

2.3.3. The Role of Innovation

The role of innovation within the Blue Economy is multifaceted, serving as a driving force behind new technologies, practices, and approaches that enhance the efficient utilization of marine resources (Upadhyay & Mishra, 2020; Dziura & Cernota, 2015). Innovations in the Blue Economy take various forms, ranging from radical to incremental, exploitative to explorative, each playing a pivotal role in ushering in revolutionary changes or reinforcing the dominance of established firms (De Ungria *et al.*, 2023; Rupo *et al.*, 2018).

Innovation is key in utilizing the undiscovered possibilities of marine and coastal resources, generating fresh business prospects rooted in clean, climate-resilient, and sustainable activities (Pace *et al.*, 2023a). For example, technological advancements in aquaculture are boosting sustainable seafood production, reducing the ecological footprint of fisheries, and providing new jobs in coastal regions (C. Wang & Li, 2020). Innovations in renewable energy, such as offshore wind technology, are helping reduce

carbon emissions while fostering economic growth. These innovations must be backed by collaborative frameworks that involve stakeholders at all levels, from local communities to international organizations. Innovation acts as a catalyst for promoting both closer collaboration and rivalry, encouraging the development of new business strategies while enhancing competitiveness within regional cooperation (Caswell *et al.*, 2020; Thompson, 2022).

Advancements of digital, physical, and biological realms facilitate advancements across various sectors, such as marine equipment, shipbuilding, ocean observation, and marine construction. These efforts are directed toward minimizing economic, ecological, and social trade-offs, emphasizing sustainable practices for both the economy and the environment (Mdlalose, 2022; Nikitenko *et al.*, 2022; Waheed, 2022; Kitada & Bhirugnath-Bhookhun, 2019; Pudzis *et al.*, 2018; Rupo *et al.*, 2018). Such initiatives not only contribute to economic growth but also address global crises such as climate change, food security, energy, natural resources, and medicines (Upadhyay & Mishra, 2020; Rupo *et al.*, 2018).

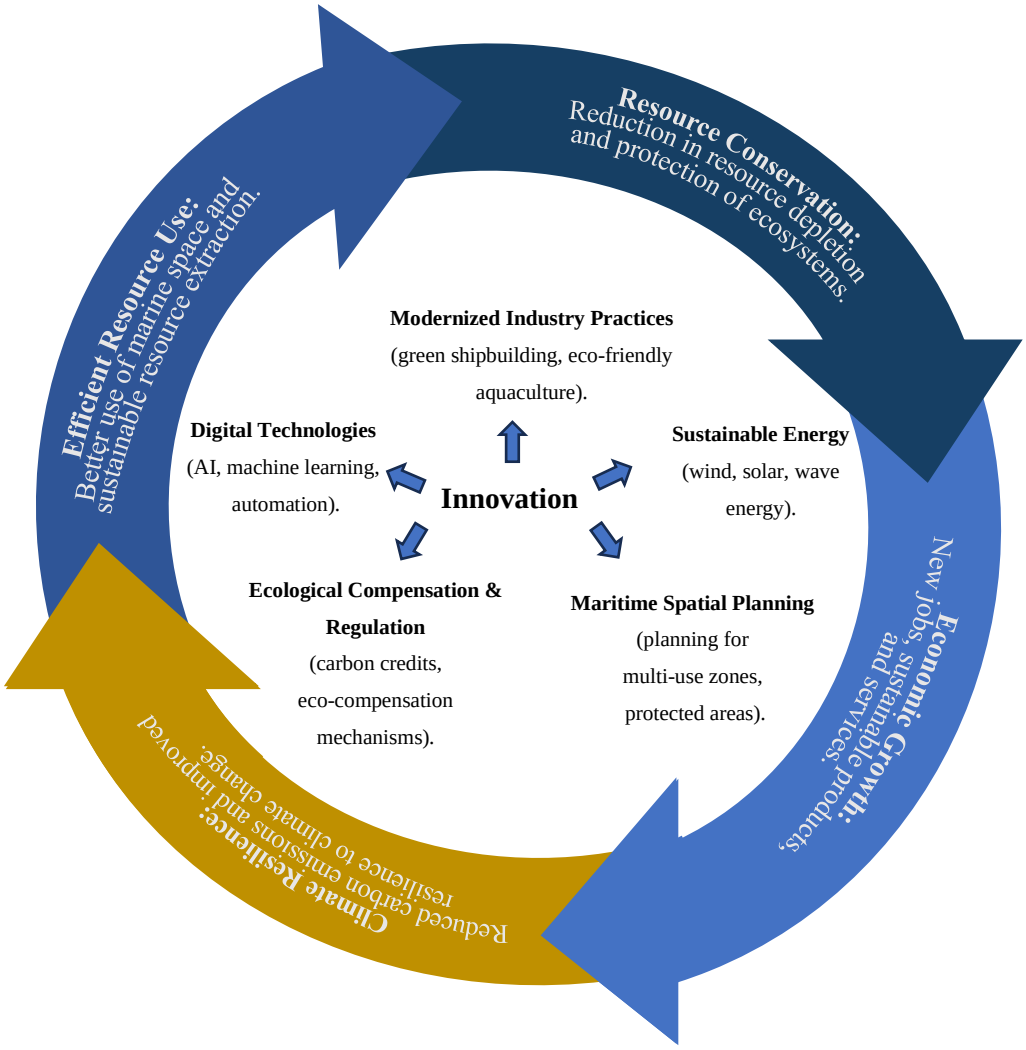
Marine engineering equipment and marine technology play an irreplaceable role in driving innovation within the Blue Economy. These tools enable sustainable practices, improve resource efficiency, and reduce environmental impacts across various sectors. For example, advancements in offshore wind turbines, wave energy converters, and tidal power systems are transforming renewable energy production (Pace *et al.*, 2023b). Technologies such as autonomous underwater vehicles (AUVs) and remotely operated vehicles (ROVs) revolutionize marine exploration by providing critical data for seabed mapping, biodiversity assessment, and resource monitoring (Pudzis *et al.*, 2018).

In maritime transport, green shipping technologies, including hydrogen-powered vessels and AI-driven navigation systems, are significantly reducing carbon emissions and improving operational efficiency (Nogué-Algueró, 2020). Meanwhile, advances in marine robotics and digitalization are optimizing aquaculture operations, improving productivity, and minimizing environmental impacts (Pace *et al.*, 2023b; Rubilar & Cardozo, 2021). These innovations highlight the potential of marine engineering and technology to foster sustainable growth while addressing the Blue Economy's pressing challenges.

However, despite their transformative potential, these technologies face challenges such as high development costs, technological dependency, and ecological risks (Ge *et al.*, 2022; Thompson, 2022). Collaborative strategies involving governments, industries, and research institutions are essential to promote sustainable scaling, ensure compatibility with marine ecosystems, and bridge the gap between innovation and practical implementation (Waheed, 2022; Caswell *et al.*, 2020).

Innovation plays a crucial role in transforming traditional Blue Economy practices, leading to better resource management and conservation (figure 2.4), and reduced environmental impacts (Nikitenko *et al.*, 2022).

Figure 2.4 - Innovations transforming traditional Blue Economy practices



Source: Own elaboration.

Figure 2.4. illustrates how innovation drives sustainability in the Blue Economy through a cyclical process. The central role of innovation in sectors such as sustainable energy, digital technologies, modernized industrial practices, ecological compensation, and maritime spatial planning leads to key outcomes: resource conservation, economic growth, climate resilience, and efficient resource use. The arrows between outcomes highlight their interconnectedness, showing how innovations enhance sustainable marine resource management and conservation, creating a balance between economic activities and environmental preservation.

By fostering the development of innovative technologies and approaches, innovation enables effective utilization of marine resources while creating new job opportunities and driving economic growth in a sustainable manner (Upadhyay & Mishra, 2020; Dziura & Cernota, 2015). Moreover, innovation enhances sustainable economic growth within the Blue Economy by driving competitiveness and fostering collaboration among nations and regions (Penca, 2019).

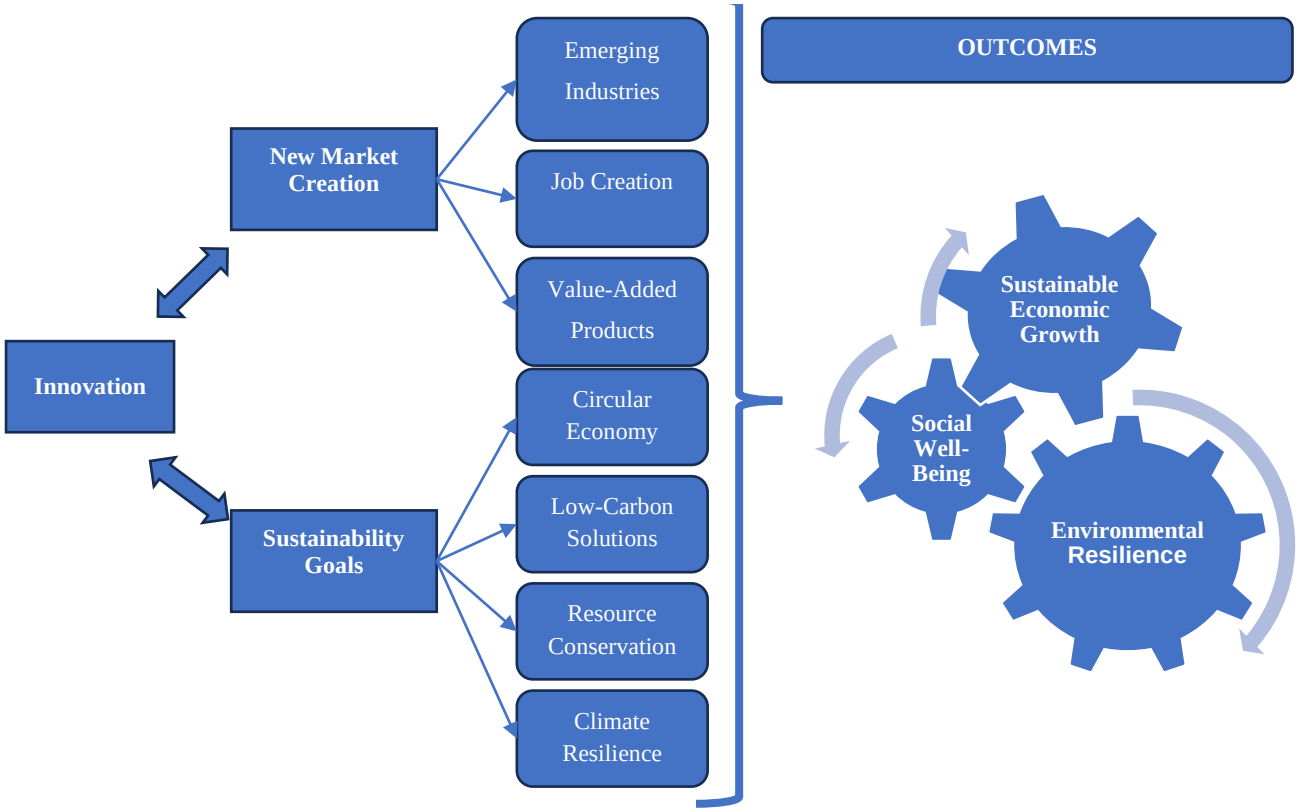
By embracing innovative practices, businesses can enhance efficiency, reduce costs, and develop new products and services that meet market demands sustainably. Innovation in the Blue Economy leads to the creation of value-added products and services, opening new markets and revenue streams (Nogué-Algueró, 2020). This not only boosts economic growth but also ensures long-term sustainability by aligning economic development with environmental preservation and social well-being (Proczek & Garbarczyk, 2023).

Figure 2.5 illustrates the dynamic interaction between innovation and its dual impact on new market creation and sustainability goals. Innovation drives the development of emerging industries, value-added products, and job creation, fostering economic growth. At the same time, it supports sustainability goals such as resource conservation, circular economy practices, and climate resilience. The feedback loops between new markets and sustainability demonstrate that progress in one area reinforces advancements in the other, ultimately leading to sustainable economic growth, environmental resilience, and social well-being.

Furthermore, innovation fosters collaboration in the Blue Economy by encouraging knowledge sharing, technology transfer, and joint research initiatives among stakeholders (Arzaman *et al.*, 2023; Cisneros-Montemayor *et al.*, 2021; Upadhyay & Mishra, 2020).

Collaborative efforts driven by innovation lead to the development of sustainable solutions to complex challenges through co-creation (Pace *et al.*, 2023b).

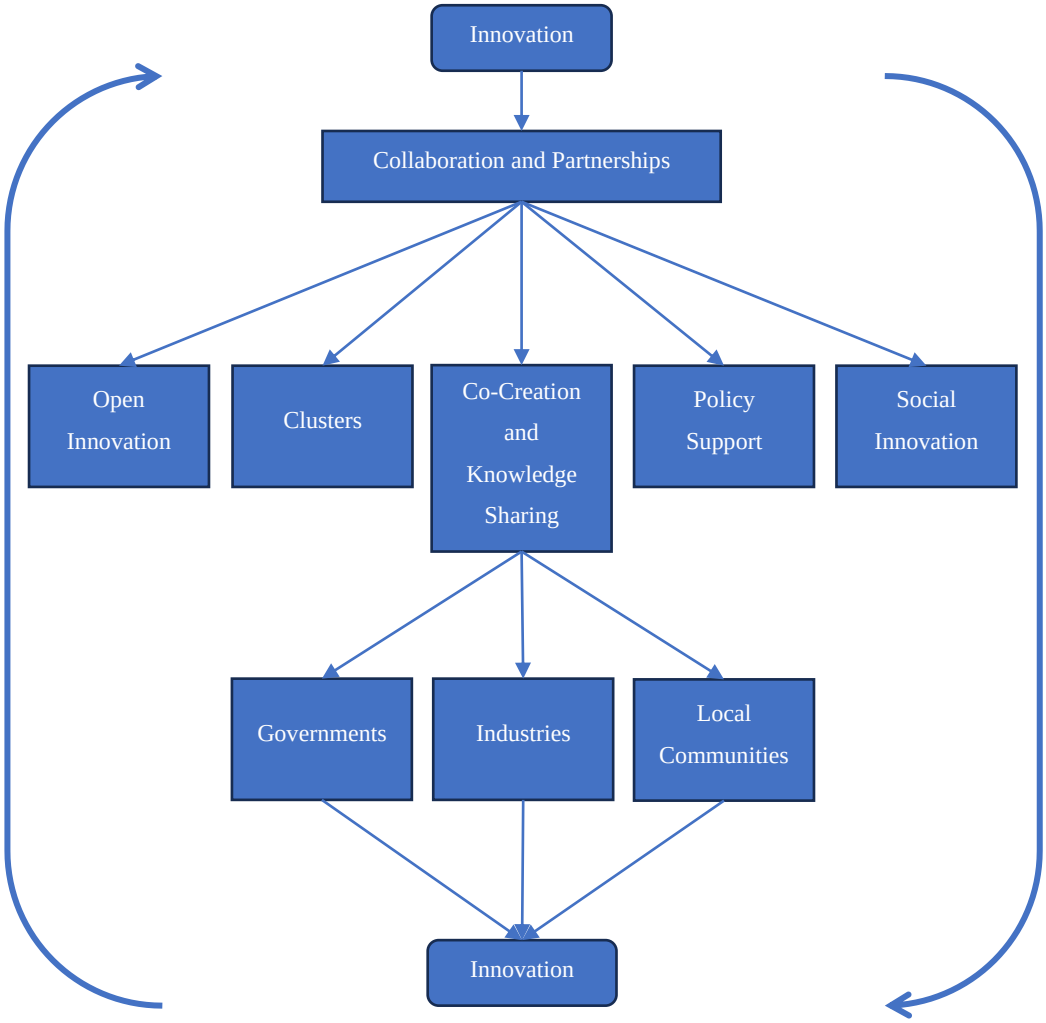
Figure 2.5 - Innovations driving new market creation and Sustainable Growth



Source: Own elaboration.

Collaboration on innovative projects enables organizations to pool their strengths, resources, and expertise to achieve shared objectives. Figure 2.6 demonstrates how innovation acts as a driving force behind various forms of collaboration and partnerships in the Blue Economy. The diagram highlights how innovation acts as a catalyst through which collaboration occurs, such as open innovation, policy support, and clusters. These collaborative efforts lead to co-creation and knowledge sharing, where stakeholders such as governments, industries, and local communities work together to solve complex challenges (Ge *et al.*, 2022; Karani *et al.*, 2022). The feedback loop emphasizes that these collaborative innovations further fuel progress toward sustainable development goals, creating a cycle of continuous improvement.

Figure 2.6 - Collaborative Innovation in the Blue Economy



Source: Own elaboration.

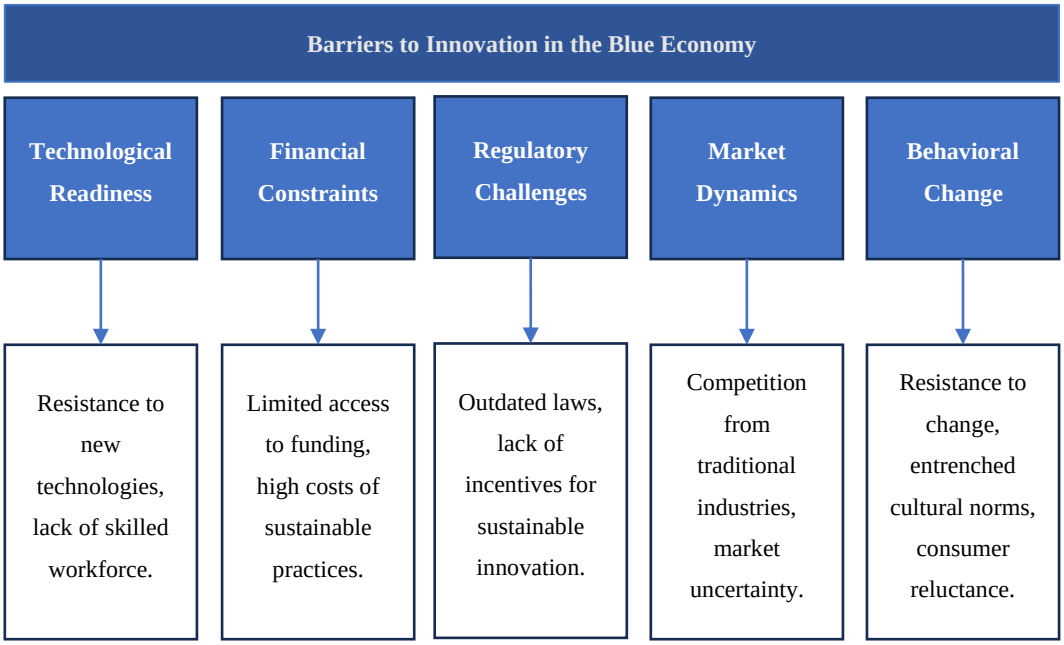
Policy innovation, social innovation, and open innovation plays pivotal roles in promoting stakeholder involvement and collaborations within the Blue Economy. Policy innovation is crucial for promoting sustainable marine resource management and facilitating community engagement. It can lead to economic opportunities, community engagement, and the generation of scientific knowledge essential for evidence-based decision-making (Arzaman *et al.*, 2023; Villaseñor-Derbez *et al.*, 2022; Z. Chen & Ma, 2020).

Social innovation in particular enhances smart, sustainable, and inclusive Blue Economy by fostering behavioral changes across institutional settings and encouraging bottom-up responsible inventiveness (Soma *et al.*, 2018). Open innovation serves as a cornerstone fostering collaboration and creativity among stakeholders, including scientists, fishers, ecologists, aquaculture producers, medical professionals, biohackers, feed producers,

entrepreneurs, investors, and governmental entities. This collaboration facilitates continuous learning, improvement, and drives technological and economic prosperity in marine-related sectors (Rubilar & Cardozo, 2021).

Despite the positive impact of innovation on resource management, conservation, economic growth, and collaboration in the Blue Economy, barriers hinder their widespread adoption (Figure 2.7). Challenges such as bureaucratic inefficiencies, modernization of legislation, financial support for sustainable practices, and the influence of powerful economic actors limit optimal utilization, management, and conservation of marine resources (Benzaken *et al.*, 2022; Gifford *et al.*, 2021; Upadhyay & Mishra, 2020; Penca, 2019).

Figure 2.7 - Barriers to Innovations widespread adoption in the Blue Economy



Source: Own elaboration.

Figure 2.7 outlines the main barriers to innovation within the Blue Economy, divided into five categories: Technological Readiness, Financial Constraints, Regulatory Challenges, Market Dynamics, and Behavioral Change. Each barrier is associated with specific challenges that hinder the adoption of sustainable innovations. These include resistance to new technologies, limited access to funding, unclear policies, competition from traditional industries, and reluctance to change cultural or consumer behavior. Addressing these barriers enables stakeholders to advance the broader adoption of sustainable practices in the Blue Economy, enhancing both economic and environmental outcomes.

Advancing innovation across sectors is critical to achieving sustainable growth in the Blue Economy, ensuring the alignment of economic activities with ecological and social objectives. Addressing resistance to innovation, sector rigidity, and financial risks is essential to fully realize the potential of innovations within the Blue Economy. Prioritizing science and research that caters to sustainable Blue Economy needs ensures pertinent knowledge guides decisions towards its realization (Pace *et al.*, 2023b).

The transformative power of innovation in the Blue Economy is evident in its ability to shift traditional economic paradigms towards sustainable practices that balance economic prosperity with environmental protection (Upadhyay & Mishra, 2020). The integration of innovation into the Blue Economy framework aligns with global SDGs.

Innovation within the Blue Economy is a catalyst for unlocking the potential of marine resources, driving economic growth, creating employment opportunities, preserving the environment, and fostering diverse collaborations. By embracing innovative approaches and technologies that prioritize sustainability and resilience, stakeholders can harness the full benefits of the Blue Economy while ensuring a harmonious balance between economic activities, social well-being, and ecological conservation (Arzaman *et al.*, 2023; Benzaken *et al.*, 2022; Upadhyay & Mishra, 2020)

2.4. Discussion

2.4.1. Key elements for a sustainable Blue Economy

2.4.1.1. Engage Stakeholders in Decision-Making

Stakeholder engagement is essential for inclusive and effective governance in the Blue Economy. Engaging stakeholders fosters intersectoral and intergovernmental collaboration (Arzaman *et al.*, 2023). By co-designing policy interventions, stakeholders, from local communities to industry leaders, can share ownership and responsibility for sustainable initiatives (Lyons *et al.*, 2023). This is particularly crucial in conservation efforts, where local knowledge and community engagement can lead to better regulatory compliance and long-term stewardship (Hassanali, 2022; Mdlalose, 2022; Cisneros-Montemayor *et al.*, 2021). Innovation in digital platforms, such as participatory decision-making tools, supports this integration by ensuring transparent and timely communication (Pace *et al.*, 2023b).

2.4.1.2. Infrastructures

Investment in sustainable infrastructure, including ports, logistics hubs, and renewable energy installations, is foundational for driving maritime connectivity, international collaboration, and ecological resilience (Volosiuk *et al.*, 2022). Innovative technologies, such as smart logistics systems and climate-resilient infrastructure materials contribute to this goal. Coastal communities benefit economically from improved infrastructure, while the ecological impact is minimized through green construction standards and eco-friendly technologies (Benzaken *et al.*, 2022).

2.4.1.3. Funding

Financial mechanisms, such as blue bonds and impact investments, are becoming central to funding the Blue Economy (Thompson, 2022). The innovation here lies in creating financial products that balance profit with sustainability goals. Revolving funds for coastal communities, for instance, provide both economic incentives for local industries (fishing, aquaculture) and contribute to environmental conservation (Proczek & Garbarczyk, 2023). Aligning these funds with international financing bodies ensures coherent efforts across national and global initiatives.

2.4.1.4. Environmental Data

Using environmental data is crucial for informed decision-making. Advanced technologies, such as remote sensing, geographic information system (GIS), and artificial intelligence (AI) based analytics, allow for more accurate monitoring of marine environments (Pace *et al.*, 2023b; Franz *et al.*, 2021; Blažauskas *et al.*, 2015). These tools enable stakeholders to assess the environmental impacts of their activities, implement regulatory frameworks, and measure progress toward sustainability goals. Co-created digital platforms foster cross-sector dialogue, promoting data-sharing and innovation in real-time responses within various socio-economic, political, and cultural contexts (Pace *et al.*, 2023b).

2.4.1.5. Maritime Spatial Planning (MSP)

MSP is pivotal in ensuring the optimal and sustainable use of marine spaces. By quantifying sector trade-offs, MSP minimizes conflicts between industries such as fishing, tourism, and energy, while promoting conservation (Kyvelou & Ierapetritis, 2019). Innovative MSP tools include ecosystem modeling software that simulates future scenarios and allows for adaptive management (Mdlalose, 2022). The cultural dimensions

of planning, such as including Indigenous knowledge, add another layer of innovation, integrating social equity into spatial decisions.

2.4.1.6. Development of Coastal Economic and Technological Strategies

Developing strategies that adapt to political, environmental, and market shifts are key for coastal resilience. These strategies, often driven by public-private partnerships and innovations in coastal technologies, help mitigate the impacts of climate change and ensure long-term sustainability (Caswell *et al.*, 2020). By integrating these strategies with holistic policy frameworks, decision-makers can create adaptive approaches that respond to dynamic marine ecosystems and shifting socio-political environments (Frohlich *et al.*, 2023; Martínez-Vázquez *et al.*, 2023; Karani *et al.*, 2022).

2.4.1.6.1 Ecosystem-based Approaches

Ecosystem-based approaches offer a holistic method for conserving marine resources by ensuring their sustainable use and maintaining ecological balance (Green Sea *et al.*, 2021; Vierros & Harden-Davies, 2020). These policies not only contribute to economic growth by supporting the livelihoods of coastal communities and developing markets for sustainable seafood products but also reflect a strong commitment to environmental stewardship. By fostering resilience to environmental changes and ensuring long-term sustainability, ecosystem-based approaches enhance the Blue Economy's reputation and attract responsible investment in marine sectors (Zhang *et al.*, 2023; Penca, 2019).

2.4.1.6.2 Smart Specialization Strategy

The Smart Specialization Strategy is a mission-oriented policy used at international, national, and regional levels to identify and capitalize on regional assets. By encouraging strategic investments that complement a country's or region's existing strengths, this strategy fosters competitive advantages and promotes future domestic capability (Gifford & McKelvey, 2019; Kyvelou & Ierapetritis, 2019). It focuses on fostering sustainable mobility, zero-residual technology, energy efficiency, and digital innovations, including blockchain technologies for marine industries (Pudzis *et al.*, 2018). This specialization enhances knowledge spillovers, promotes regional collaboration, and supports the development of resilient economies that are better equipped to manage environmental and market shifts (Meyer, 2021).

2.4.1.7. Mechanisms for Ecological Compensation and Regulation

A comprehensive framework of ecological compensation and regulation is essential for promoting sustainable practices across the Blue Economy. These mechanisms incentivize industries to minimize their environmental footprint by internalizing ecological costs and encouraging the preservation of biodiversity (Ni & Quan, 2023; Schneider *et al.*, 2022). By integrating tools such as carbon pricing, biodiversity offsets, and blue carbon credits, these regulatory systems ensure industries are held accountable for their environmental impacts while simultaneously promoting economic growth through sustainability (Ge *et al.*, 2022).

2.4.1.7.1. Compensation mechanisms

Compensation mechanisms play a vital role in preserving marine biodiversity and promoting ecosystem resilience. They extend beyond monetary compensation and include legal penalties, administrative measures, and environmental restoration mandates. These strategies aim to restore and conserve marine resources while maintaining the adaptability of oceanic ecosystems (Cziesielski *et al.*, 2021). For example, blue carbon credits provide an innovative way to tie economic rewards to the conservation of marine natural capital, allowing industries to contribute to both ecological restoration and financial sustainability (Qu *et al.*, 2016).

2.4.1.7.2. Ecological Taxation System

The ecological taxation system integrates environmental costs into the economic activities of marine industries, ensuring that externalities, such as pollution or resource depletion, are accounted for within market mechanisms. This approach incentivizes industries to adopt sustainable practices by making it more costly to engage in environmentally harmful activities (Karani *et al.*, 2022). By aligning taxation with environmental stewardship, this system helps to regulate industrial impacts on marine ecosystems, promoting a market-driven approach to sustainability.

2.4.1.7.3. Other Mechanisms

Additional mechanisms, such as eco-labelling and the pursuit of carbon neutrality, further support the Blue Economy by educating consumers and incentivizing industries to adopt sustainable practices (Karani *et al.*, 2022). Eco-labelling enables consumers to make environmentally responsible choices, while carbon neutrality goals encourage industries to offset their carbon emissions through conservation efforts or technological innovations

(Spaniol & Hansen, 2021). These efforts represent critical strides toward environmental stewardship and sustainable economic development within the marine sector (Villaseñor-Derbez *et al.*, 2022).

2.4.1.8. Clusters

Maritime clusters represent a dynamic organizational approach that orchestrates diverse maritime activities within a cohesive strategy. These clusters are composed of interconnected entities such as companies, suppliers, service providers, and research institutions, which collaborate to enhance the performance and growth of the maritime and marine industries (Volosiuk *et al.*, 2022; Koliousis *et al.*, 2018). Through shared infrastructure, knowledge exchange, and joint initiatives in research and development, these clusters foster cross-pollination of ideas and innovation, which are crucial for sustainable growth in regional development (Gifford *et al.*, 2021; Meyer, 2021).

By bringing together stakeholders from both the public and private sectors, maritime clusters promote cooperation and knowledge spillovers that lead to increased productivity and efficiency. These collaborative ecosystems not only advance the Blue Economy but also contribute to national competitiveness by encouraging the exploration of innovative solutions and optimizing resources at the regional level (Qi, 2022; Volosiuk *et al.*, 2022; Koliousis *et al.*, 2018; Paulauskas, 2018; Rupo *et al.*, 2018).

2.4.1.9. Circular Economy

The circular economy maximizes resource efficiency by turning waste into valuable inputs for other industries, mimicking natural systems (Nikitenko *et al.*, 2022; Rotter *et al.*, 2020; Paulauskas, 2018). This contrasts with the linear "take, make, dispose" model, prioritizing long-lasting design, maintenance, repair, and recycling (Paulauskas, 2018). Innovations in product design, maintenance, and recycling close the loop, minimizing waste and environmental degradation.

The concept of circularity within the Blue Economy encompasses two vital sustainability dimensions: environmental sustainability and supply sustainability. Environmental sustainability refers to practices that aim to use natural resources in a way that minimizes negative impacts on the environment, ensuring that the resources can continue to be available for future generations (Mdlalose, 2022). Additionally, supply sustainability is

also paramount, indicating the ability to maintain a continuous and stable supply of a resource over time without depletion or environmental harm (Rotter *et al.*, 2020).

Table 2.3 provides an overview of how innovation impacts sustainability across key Blue Economy elements. Each row outlines a specific element (e.g., Stakeholders, Environmental Data) and shows how innovation fosters sustainability in that domain, including environmental conservation, economic resilience, and social equity. For example, leveraging digital technologies such as remote sensing for environmental data allows for real-time decision-making, ensuring that marine resource extraction is balanced with conservation efforts. Similarly, the implementation of circular economy principles in sectors such as fisheries reduces waste and promotes resource efficiency. Through this table, stakeholders can identify actionable strategies that incorporate innovation into sustainable Blue Economy practices.

Table 2.3 - Impact of Innovation and influence on Sustainability in the key elements of Blue Economy

Key Elements	Innovation	Influence on Sustainability
Stakeholders	Implementing participatory decision-making processes, fostering multi-stakeholder governance models to support innovation in Blue Economy practices (Villaseñor-Derbez *et al.*, 2022; Cisneros-Montemayor *et al.*, 2021; Blažauskas *et al.*, 2015).	Enhances social acceptance of Blue Economy initiatives, fosters partnerships for sustainable development, promotes accountability, and aligns stakeholder interests with environmental conservation goals for long-term success (Arzaman *et al.*, 2023; Cisneros-Montemayor *et al.*, 2021).
Environmental Data	Utilizing advanced technologies such as remote sensing, GIS, and big data analytics for environmental monitoring (Pace *et al.*, 2023b; Franz *et al.*, 2021; Rubilar & Cardozo, 2021).	Enables informed decision-making, facilitates targeted interventions for environmental protection and resource management, supports ecosystem-based management (Franz *et al.*, 2021).
Coastal Economic and Technological Strategies	Developing adaptive and innovative technologies to mitigate climate change impacts and external economic pressures (Martínez-Vázquez *et al.*, 2023; Caswell *et al.*, 2020; Cappelletto *et al.*, 2018).	Promotes economic growth while ensuring long-term environmental resilience and minimizing ecological degradation (Zhang *et al.*, 2023; Karani *et al.*, 2022).

Circular Economy	Implementing circular business models that prioritize resource efficiency, waste reduction, and closed-loop systems to promote sustainable consumption and production practices (Rotter *et al.*, 2020; Paulauskas, 2018).	Reduces resource depletion, minimizes environmental impact, fosters innovation in sustainable product design, and contributes to a more resilient economy (Rotter *et al.*, 2020).
Infrastructures	Integrating green infrastructure designs and renewable energy solutions (offshore wind, wave energy) to enhance operational efficiency while minimizing environmental impact (Volosiuk *et al.*, 2022).	Facilitates sustainable practices in Blue Economy operations, improves connectivity, reduces carbon footprint, and increases resilience to climate change (Volosiuk *et al.*, 2022; Meyer, 2021).
Funding	Leveraging innovative financial mechanisms such as green bonds, public-private partnerships, and impact investments to support sustainable projects with positive environmental and social outcome (Thompson, 2022; Babb, 2015).	Enables the execution of sustainable projects by providing necessary resources for innovation adoption, technology deployment, and capacity-building programs (Benzaken *et al.*, 2022).
Maritime Spatial Planning	Using geospatial technologies, such as GIS mapping tools, ecosystem modeling software, and MSP to optimize resource allocation and resolve sea-use conflicts (He *et al.*, 2019; Kyvelou & Ierapetritis, 2019; Pudzis *et al.*, 2018).	Enhances ecosystem resilience by minimizing conflicts between marine sectors, promotes sustainable development, and safeguards biodiversity hotspots (Spaniol & Hansen, 2021; Pudzis *et al.*, 2018).
Mechanisms for Ecological Compensation and Regulation	Implementing mechanisms such as carbon pricing, biodiversity offsets, and eco-labeling schemes to promote environmental stewardship and regulate human activities (Frohlich *et al.*, 2023; Cziesielski *et al.*, 2021; Qu *et al.*, 2016).	Encourages responsible behavior, mitigates negative environmental impacts, promotes sustainable marine practices, and ensures compliance with environmental standards (Ge *et al.*, 2022; Cziesielski *et al.*, 2021).
Clusters	Formation of maritime clusters that bring together industries, researchers, and policymakers to foster innovation and encourage knowledge sharing (Volosiuk *et al.*, 2022; Koliousis *et al.*, 2018).	Stimulates innovation, fosters competitiveness, promotes knowledge exchange among stakeholders, and enhances regional development through shared infrastructure and collaboration (Qi, 2022; Meyer, 2021).

Resource Management	Adopting sustainable resource management practices, including responsible extraction methods, conservation strategies, and ecosystem-based approaches (Zhang & Yang, 2022; Green Sea *et al.*, 2021; Caswell *et al.*, 2020).	Ensures resource availability for current and future generations, balancing economic development with environmental protection through sustainable resource utilization strategies (Zhang *et al.*, 2023; Cappelletto *et al.*, 2018).

Source: Own elaboration.

2.4.2. Regional Perspectives on the Development of the Blue Economy

The Blue Economy has become a pivotal element in sustainable development, leveraging marine and coastal resources to balance economic growth, environmental preservation, and social equity. However, the pathways to its realization are not uniform across regions. Asia, Europe, and North America exhibit distinct approaches shaped by their economic priorities, governance frameworks, and technological capacities. This section examines the unique characteristics of the Blue Economy in these regions, identifying both their strengths and challenges.

2.4.2.1. Asia: Rapid Expansion Amidst Environmental Concerns

Asia is at the forefront of Blue Economy expansion, driven by its extensive coastline, rich marine biodiversity, and reliance on maritime industries. Coastal nations like China, Japan, and South Korea prioritize aquaculture, port development, and renewable marine energy to sustain economic growth. For instance, China has integrated the Blue Economy into its national strategies, emphasizing technological innovation and marine industry modernization (An *et al.*, 2022).

However, rapid industrialization has led to significant environmental challenges, such as habitat degradation, overfishing, and pollution (Zheng *et al.*, 2020). China's "maritime silk road" initiative and stricter environmental policies are steps toward mitigating these issues (Huo *et al.*, 2020). However, governance gaps and uneven technological adoption across countries remain barriers to regional cohesion in advancing the Blue Economy (Li *et al.*, 2020).

2.4.2.2. Europe: Innovation and Integration for Sustainability

Europe positions itself as a global leader in the sustainable Blue Economy, leveraging its robust governance frameworks and advanced research capabilities. The European Union's Blue Economy Strategy focuses on climate neutrality, ecosystem preservation,

and innovation-driven growth (Proczek & Garbarczyk, 2023). Key industries include offshore wind energy, marine biotechnology, and sustainable fisheries (Pace *et al.*, 2023b).

Europe's strength lies in its collaborative approach, promoting cross-border projects and stakeholder engagement (Benzaken *et al.*, 2022). The European Green Deal exemplifies efforts to integrate Blue Economy goals with broader climate action, creating synergies across industries and policies. However, the region still faces challenges in balancing industrial activities with ecological conservation, particularly in coastal ecosystems under pressure from tourism, shipping, and resource exploitation (Nogué-Algueró, 2020).

2.4.2.3. North America: Balancing Economic Potential and Environmental Sustainability

In North America, the Blue Economy is a vital component of economic strategies in the United States and Canada. The U.S. prioritizes offshore energy, fisheries, and maritime transportation, integrating technological advances to enhance sustainability (Fusco *et al.*, 2022). Canada takes a unique approach by incorporating social equity, particularly through the involvement of indigenous communities, into its Blue Economy policies. This focus on equitable transitions is evident in regions like Newfoundland and Labrador (Cisneros-Montemayor *et al.*, 2021).

Despite these advancements, North America grapples with reconciling industrial expansion with ecological preservation. Offshore oil and gas development often conflicts with climate commitments and environmental justice concerns. Addressing these tensions will require robust governance and long-term planning (Waheed, 2022).

To conclude, while Asia demonstrates rapid industrial growth and resource utilization, it faces environmental sustainability challenges that call for enhanced governance and cooperation. Europe excels in integrating sustainability with economic innovation, though ecological pressures persist. North America showcases diverse strategies, from technological innovation to inclusive policymaking, but struggles with aligning economic development with ecological commitments. These regional differences underscore the importance of tailoring Blue Economy strategies to local contexts while fostering global collaboration to address shared challenges.

This comparative analysis provides a nuanced understanding of how regional approaches to the Blue Economy reflect and respond to their unique environmental, economic, and social landscapes.

2.4.3. Identified Gaps in the Literature

This subsection examines the key gaps in existing research concerning the challenges discussed in the Blue Economy. The findings from the systematic literature review reveal several areas requiring further investigation and development to address the elements described in this section effectively.

2.4.3.1 Stakeholder Engagement

While stakeholder engagement is widely recognized as vital for inclusive governance, current studies focus more on theoretical frameworks than on practical implementation strategies. For instance, mechanisms for integrating marginalized communities, such as small-scale fishers or Indigenous populations, into decision-making processes remain underexplored (Arzaman *et al.*, 2023; Chen *et al.*, 2020). Furthermore, few studies examine the long-term effectiveness of participatory decision-making tools, leaving a gap in understanding how these platforms foster sustained collaboration and compliance (Zheng *et al.*, 2020; Kyvelou & Ierapetritis, 2019).

2.4.3.2 Sustainable Infrastructure

The literature highlights the importance of green ports and climate-resilient infrastructure, however, there is limited empirical analysis of their real-world economic and environmental impacts (Karani *et al.*, 2022; Qi, 2022). Research is sparse on scalable models that can be adapted to developing coastal nations, which often lack the financial and technological resources to implement such solutions (Nogué-Algueró, 2020; Seisdedos & Carrasco, 2020).

2.4.3.3. Innovative Financial Mechanisms

Although blue bonds and impact investments are frequently mentioned, studies rarely evaluate their effectiveness in achieving sustainability goals across diverse regions (Proczek & Garbarczyk, 2023; Tirumala & Tiwari, 2022; Wang *et al.*, 2020). There is also a lack of research on aligning local financial mechanisms with international frameworks to create cohesive funding strategies (Pace *et al.*, 2023b). The role of public-

private partnerships in enhancing financial innovation remains underexplored (Benzaken *et al.*, 2022; An & Li, 2020).

2.4.3.4. Environmental Data Utilization

While advancements in remote sensing, GIS, and AI-based analytics have revolutionized marine monitoring, few studies critically assess the accessibility and applicability of these technologies in resource-constrained regions (Pace *et al.*, 2023a; Cisneros-Montemayor *et al.*, 2021). Furthermore, there is insufficient attention to how co-created digital platforms can foster cross-sectoral data sharing, especially in regions with fragmented governance (Hassanali, 2022; Sarwar, 2022).

2.4.3.5. Maritime Spatial Planning (MSP)

MSP tools, such as ecosystem modeling software, are well-documented for resolving sector trade-offs (Kyvelou & Ierapetritis, 2019; Rupo *et al.*, 2018). However, the literature lacks longitudinal studies that assess the socio-economic and ecological impacts of MSP initiatives. Additionally, there is limited integration of cultural dimensions, such as Indigenous knowledge systems, into existing MSP frameworks (Schøning *et al.*, 2023; Soma *et al.*, 2018)

2.4.3.6. Coastal Economic and Technological Strategies

Adaptive strategies tailored to shifting political and environmental contexts are essential for coastal resilience. While public-private partnerships and innovative technologies have been discussed, there is a lack of comparative studies evaluating their effectiveness in diverse socio-economic settings (Gerhardinger *et al.*, 2020; Upadhyay & Mishra, 2020). Additionally, the integration of regional collaboration frameworks remains underexplored (Qi, 2022; Blažauskas *et al.*, 2015).

2.4.3.7. Ecosystem-Based Approaches

Although ecosystem-based approaches are heralded for their holistic conservation benefits, their scalability and adaptability across varying marine ecosystems are not well-addressed (Kitada & Bhirugnath-Bhookhun, 2019; Penca, 2019). Current research also cannot evaluate how these approaches balance economic growth with ecological preservation (Qu *et al.*, 2016), particularly in regions where marine resources are heavily exploited (O'Shea *et al.*, 2022; Campana *et al.*, 2021).

2.4.3.8. Compensation and Regulation Mechanisms

Mechanisms such as blue carbon credits and biodiversity offsets show promise, yet their adoption is hampered by limited empirical data on their effectiveness (Cziesielski *et al.*, 2021; Li *et al.*, 2020). Research often neglects the challenges of integrating such mechanisms into existing regulatory frameworks, especially in low-income nations (Nikitenko *et al.*, 2022; Cisneros-Montemayor *et al.*, 2021).

2.4.3.9. Maritime Clusters

Maritime clusters are recognized for fostering innovation through collaboration, however, there is insufficient research on their sustainability contributions within the Blue Economy (Wang & Li, 2020; Kitada & Bhirugnath-Bhookhun, 2019). Some studies highlight their role in enhancing regional development, such as leveraging shared infrastructure and inter-industry cooperation. Few studies explore the dynamics of knowledge spillovers in clusters or the role of cross-border collaborations in maximizing their impact (Banikoi *et al.*, 2023; Pudzis *et al.*, 2018).

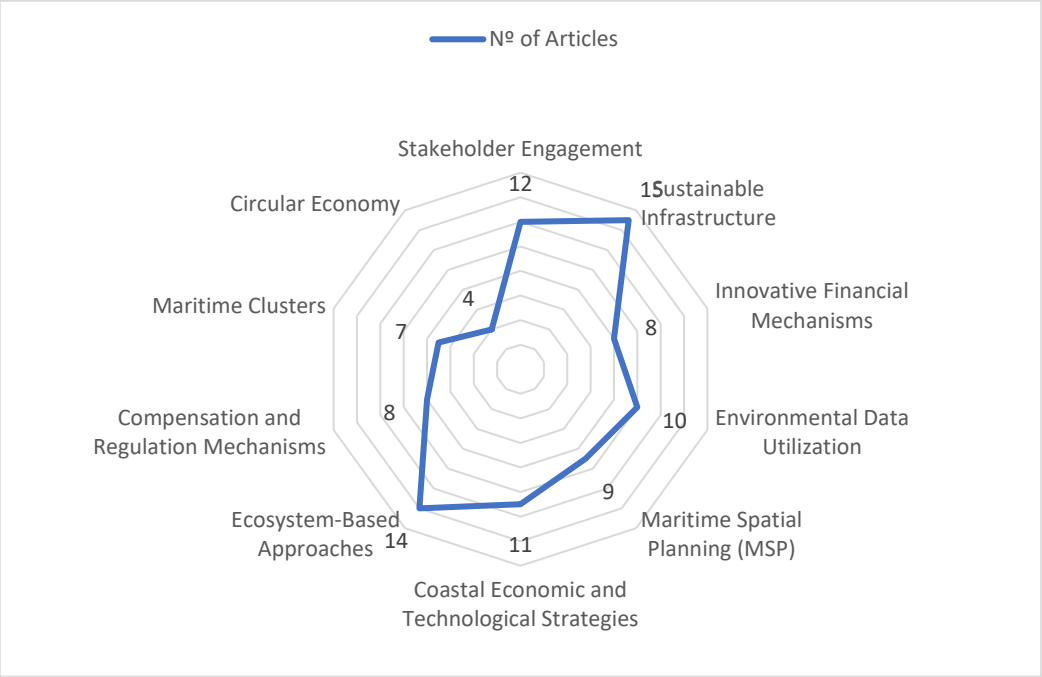
2.4.3.10. Circular Economy

The circular economy is gaining traction as a sustainable model for resource management, with its implementation in sectors like fisheries and aquaculture being discussed in recent studies (Rubilar & Cardozo, 2021; World Bank & United Nations Department of Economic and Social Affairs, 2017). However, research rarely addresses successful transitions from linear to circular models in marine industries. Limited case studies exist to illustrate how circular economy principles can be operationalized at scale (Pace *et al.*, 2023b; Pu *et al.*, 2021).

2.4.3.11. Literature Distribution Analysis

To provide transparency and rigor in how the key elements of the Blue Economy were identified, a distribution analysis of the 98 papers from the systematic literature review was conducted. Each paper was categorized based on its primary focus, aligning with the key elements described in this study. The results are presented in the radar chart (Figure 2.8), which visually summarizes the distribution of research efforts across the identified elements.

Figure 2.8 - Literature distribution analysis 98 articles



Source: Own elaboration.

As shown in figure 2.8, Sustainable Infrastructure (15 articles) and Ecosystem-Based Approaches (14 articles) emerge as the most frequently addressed topics in the articles included in the SLR. This significant representation highlights their foundational role in the Blue Economy, reflecting the focus of academic efforts on ensuring resilient infrastructure and promoting holistic ecosystem management. Additionally, Stakeholder Engagement (12 articles) and Coastal Economic and Technological Strategies (11 articles) receive substantial attention, underlining the emphasis on fostering collaborative governance and developing adaptive strategies to mitigate environmental and economic challenges.

Environmental Data Utilization (10 articles), Maritime Spatial Planning (MSP) (9 articles), and Innovative Financial Mechanisms (8 articles) demonstrate moderate levels

of research attention. These elements are instrumental for operationalizing the Blue Economy, particularly in optimizing resource allocation, improving decision-making through advanced data tools, and financing sustainable practices. However, the moderate representation suggests the need for further investigation into region-specific barriers, technological scalability, and effective integration into policy frameworks.

Compensation and Regulation Mechanisms (8 articles), Maritime Clusters (7 articles), and Circular Economy (4 articles) are the least explored areas in the literature. This limited representation reveals significant gaps, particularly regarding the practical implementation of circular economy principles and the potential of maritime clusters to drive innovation and regional development. The underrepresentation of these critical topics underscores the need for targeted research to unlock their contributions to sustainable economic growth and environmental conservation.

The radar chart illustrates an uneven distribution of research efforts across key elements, with critical gaps evident in areas such as Circular Economy and Maritime Clusters. Addressing these disparities is crucial for achieving a holistic, inclusive, and equitable approach to the Blue Economy. Furthermore, the disproportionate focus on certain elements, such as Sustainable Infrastructure and Ecosystem-Based Approaches, suggests an opportunity for interdisciplinary research to bridge underexplored areas with these well-studied domains.

This analysis provides an evidence-based foundation for prioritizing research efforts in the Blue Economy. By aligning future studies with underrepresented areas and integrating them with well-established elements, the Blue Economy can better advance sustainability goals and address persistent implementation challenges.

2.4.4. Long-Term Impacts and Future Directions

Innovation within the Blue Economy has proven instrumental in driving sustainable development, but long-term success will depend on addressing critical challenges. Scalability and inclusivity remain central issues. Technologies that thrive in well-funded regions often face adoption barriers in resource-constrained areas, particularly in developing coastal nations. Overcoming these challenges requires mechanisms for technology transfer, capacity building, and fostering inclusive access to innovation across diverse socioeconomic contexts (Benzaken *et al.*, 2022; Cisneros-Montemayor *et al.*,

2021). For example, innovations such as marine spatial planning (MSP) and renewable energy projects, which are effective in developed regions, may require significant adaptation to be successful in developing regions (Kyvelou & Ierapetritis, 2019).

Another critical factor is technological dependency. Innovations such as remote sensing, automation, and artificial intelligence have revolutionized marine resource management, but they create dependencies on advanced infrastructure and continuous technical support. This dependency can become a vulnerability if local governments or private stakeholders lack the resources to maintain and adapt these technologies (Rubilar & Cardozo, 2021). The rapid pace of technological advancement also introduces the need for constant policy adaptation and workforce training, which may strain less-developed regions that lack sufficient resources or expertise (Zhang *et al.*, 2023).

Environmental risks also deserve careful consideration. While innovations such as offshore wind farms and aquaculture offer sustainable alternatives, they can also pose unintended ecological consequences if not carefully managed. For instance, offshore renewable energy projects may disrupt marine biodiversity, particularly if marine spatial planning frameworks fail to keep pace with technological expansion (Pace *et al.*, 2023b). Similarly, even innovative aquaculture techniques may lead to over-exploitation or pollution if sustainability benchmarks are not strictly enforced (Zhang *et al.*, 2023; Caswell *et al.*, 2020).

Another pressing concern is social inclusivity. While innovations such as stakeholder engagement frameworks and co-designed policies have shown promise in promoting social equity, continuous evaluation is needed to ensure that these frameworks empower all relevant groups, particularly marginalized communities. Without initiative-taking measures to involve Indigenous groups, small-scale fishers, and coastal residents in decision-making, innovation could exacerbate existing inequalities in access to marine resources and economic opportunities (Arzaman *et al.*, 2023; Cisneros-Montemayor *et al.*, 2021).

Moving forward, international cooperation will play a key role in addressing these long-term challenges. As marine resource management technologies and innovations evolve, the need for global harmonization of policies and standards becomes increasingly important. Collaborative frameworks, such as those under the United Nations or the

World Bank, can help ensure that best practices are shared globally, and that developing regions are not left behind (Ge *et al.*, 2022). Multilateral efforts are crucial to advancing technology transfer, capacity building, and establishing uniform environmental and economic standards for marine sectors.

In conclusion, while innovation holds immense promise for driving the Blue Economy forward, its long-term success will depend on addressing key challenges related to scalability, technological dependency, environmental risks, and inclusivity. Developing holistic, inclusive governance frameworks and policies will be essential for ensuring that the Blue Economy can continue to grow sustainably and equitably (Ge *et al.*, 2022; Cisneros-Montemayor *et al.*, 2021; Kyvelou & Ierapetritis, 2019).

2.4.5. Policy and Governance Implications

The effective integration of innovative practices within the Blue Economy requires robust policy and governance frameworks. These frameworks must not only support the successful implementation of technological innovations but also ensure that such innovations are sustainable and inclusive. Governance systems at both the national and international levels will be pivotal in aligning the Blue Economy with global sustainability goals while fostering economic growth.

2.4.5.1 International Policy Frameworks

At the international level, foundational agreements such as the United Nations Convention on the Law of the Sea (UNCLOS) and the Sustainable Development Goals (SDGs) provide critical guidance for ocean governance. SDG 14 focuses specifically on the conservation and sustainable use of the oceans, seas, and marine resources (United Nations, 2015). As the Blue Economy evolves, these frameworks must adapt to new technological innovations, particularly in emerging sectors such as offshore renewable energy, marine biotechnology, and aquaculture. Effective international cooperation is needed to ensure that innovations align with environmental goals and do not exacerbate inequalities (Benzaken *et al.*, 2022). For example, initiatives as marine spatial planning (MSP), supported by international agreements, help balance competing demands for marine space while conserving biodiversity (Kyvelou & Ierapetritis, 2019).

2.4.5.2 National and Regional Policy Implementation

On a national and regional scale, Marine/Maritime Spatial Planning (MSP) and Integrated Coastal Zone Management (ICZM) are vital tools for regulating the use of marine spaces and promoting the sustainable coexistence of various industries (Ge *et al.*, 2022). Countries that have adopted comprehensive Blue Economy strategies, such as those in the European Union, provide successful examples of policy implementation. For instance, the EU Blue Growth Strategy fosters collaboration between private industries, research institutions, and governments to drive sustainable innovation (Benzaken *et al.*, 2022). However, challenges remain in ensuring that SIDS and low-income coastal nations can equally benefit from these innovations. Financial assistance and capacity-building programs from international bodies will be crucial in ensuring that less-resourced regions can actively participate in the Blue Economy (Pace *et al.*, 2023b).

2.4.5.3 The Role of Public-Private Partnerships

Public-private partnerships (PPPs) represent a key strategy for driving innovation within the Blue Economy. By offering tax incentives, subsidies, and grant funding, governments can encourage private-sector investment in sustainable marine industries. PPPs foster collaboration between public institutions and private companies, ensuring that innovations are aligned with long-term environmental sustainability and social equity (Proczek & Garbarczyk, 2023). These partnerships are especially important in sectors such as offshore renewable energy, where private investment can accelerate the development of sustainable technologies while public regulation ensures that environmental goals are met.

2.4.5.4 Regulation and Compliance

Governments play a central role in regulating marine industries to ensure sustainability. This includes enforcing environmental protection standards, regulating the extraction of marine resources, and establishing carbon pricing and biodiversity offsets to hold industries accountable for their environmental impacts (Ge *et al.*, 2022). Policies that support ecological compensation mechanisms, such as blue carbon credits and payment for ecosystem services, can incentivize sustainable practices in industries such as fisheries, tourism, and aquaculture (Qu *et al.*, 2016).

2.4.5.5 Capacity Building and Knowledge Transfer

A critical element of governance in the Blue Economy is the promotion of capacity building and knowledge transfer. International knowledge-sharing initiatives, such as workshops, research collaborations, and open innovation platforms, are essential for spreading best practices and ensuring that resource-constrained countries can benefit from sustainable innovations (Pace *et al.*, 2023b). These efforts can bridge gaps between developed and developing coastal regions, enabling all stakeholders to engage meaningfully in the Blue Economy (Benzaken *et al.*, 2022).

To sum up, the success of the Blue Economy relies not only on technological and business innovation but also on robust and adaptive policy frameworks. International agreements, national governance structures, and public-private partnerships all play essential roles in guiding innovation toward sustainable and inclusive development. As new technologies emerge, policymakers must ensure that regulatory frameworks evolve alongside them, promoting global equity and ecological resilience in the face of climate change (Benzaken *et al.*, 2022; Ge *et al.*, 2022).

2.5. Conclusion

The exploration of sustainability, innovation, and their impact on the Blue Economy reveals a complex interplay of factors influencing the utilization, management, and conservation of marine resources. The findings highlight the pivotal role of science and innovation in realizing the Blue Economy's full potential. Innovations in sectors such as marine biotechnology, aquaculture, and renewable energy are driving sustainable growth. However, bridging the gap between research and commercialization, prioritizing “fit-for-purpose” science, and promoting innovation across diverse sectors are essential for long-term development (Wang & Li, 2020).

The looming threat of the “tragedy of the commons” underscores the risk of unsustainable practices that threaten both marine ecosystems and sustainable development goals (Upadhyay & Mishra, 2020). Key factors such as climate change impacts, market fluctuations, and regulatory changes introduce complexities in resource allocation and policy formulation, potentially leading to unintended consequences (Carrà *et al.*, 2017). Moreover, the absence of a shared definition of the Blue Economy's geographical scope and industrial activities complicates the transition toward sustainability (Pace *et al.*, 2023b).

Challenges such as incomplete data, stemming from diverse sources, uncertainties, and biases, continue to impede effective decision-making processes (Karani *et al.*, 2022; Caswell *et al.*, 2020). Additionally, environmental degradation, regulatory misalignment, and insufficient stakeholder engagement further undermine the Blue Economy's potential to foster sustainable practices (Penca, 2019). Addressing these challenges involves embracing technological advancements, such as green technologies, digitalization, and sustainable energy solutions, to enhance efficiency and reduce environmental impact (Shi *et al.*, 2020).

The development of AI and machine learning (ML) holds significant potential for addressing these challenges and shaping the future trajectory of the Blue Economy. AI and ML can optimize fisheries management through real-time data analysis, enhance maritime safety with predictive navigation systems, and improve renewable energy efficiency through advanced modeling (Pace *et al.*, 2023a, 2023b). These technologies could also provide new tools for environmental monitoring and marine resource conservation, driving progress toward a more sustainable and resilient Blue Economy. While this study does not explore these technologies in depth, future research should examine their transformative potential to better understand their implications for sustainability and economic growth.

Multilateral cooperation is crucial, with collaboration among local communities, industries, and policymakers being key to achieving SDGs and fostering innovation adoption (Kyvelou & Ierapetritis, 2019). Harmonizing regulations and ensuring that the Blue Economy benefits both present and future generations requires the alignment of international efforts (Arzaman *et al.*, 2023). Furthermore, involving local communities in decision-making processes ensures social equity, cultural preservation, and sustainable development that supports the needs of coastal regions (Kyvelou & Ierapetritis, 2019).

Overcoming sector rigidity, financial risks, and scalability challenges is critical to unlocking the transformative potential of sustainability and innovation in the Blue Economy (Soma *et al.*, 2018). Embracing a comprehensive approach integrates economic, ecological, and social dimensions will be essential to achieving a Blue Economy (Soma *et al.*, 2018).

In conclusion, the journey towards sustainable growth and development requires urgent and concerted efforts to bridge knowledge gaps, foster collaboration, and overcome barriers. Continued research, policy refinement, and the collective commitment of all stakeholders are essential to unlocking the full potential of the Blue Economy. Through innovation, alignment with sustainable development goals, and diverse perspectives, we can foster a Blue Economy that thrives economically, safeguards the environment, and ensures social equity, a future where oceans and coastal regions flourish, supporting livelihoods, biodiversity, and prosperity for future generations.

Several research gaps remain unaddressed within the Blue Economy, particularly regarding the long-term impacts of sustainable practices and innovations on economic growth, employment, and environmental preservation (Karani *et al.*, 2022; Shi *et al.*, 2020; Cappelletto *et al.*, 2018). Addressing these research opportunities will allow stakeholders to formulate evidence-based strategies that ensure economic growth, environmental preservation, and social inclusivity within the Blue Economy.

While this study adds to the existing body of knowledge on the Blue Economy, it is essential to acknowledge several limitations inherent in the systematic literature review process. The reliance on English-language publications may have excluded valuable non-English research, leading to a potential limitation in the diversity of perspectives included (Walpole, 2019). Furthermore, the selection of keywords, databases, and inclusion/exclusion criteria could introduce biases that influence the study's findings.

Funding: J.E. was funded by Sustainable Horizons (HORIZON) with the Grant agreement ID: 101071300, DOI: 10.3030/101071300. H.P. is supported by the FCT (UIDB/04020/2020 and CEEC—INST/00052/2021/CP2792/CT0001).

Conflicts of Interest: The authors declare no conflicts of interest.

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CHAPTER 3 – WAVES OF INNOVATION: THE ROLE OF SUSTAINABILITY IN DRIVING IMPACT IN THE BLUE ECONOMY – A PLS-SEM APPROACH (PAPER TWO)[3]

Abstract

The Blue Economy, with its emphasis on ocean-based industries, is critical for achieving sustainable development. This study investigates the intricate relationship between sustainability, innovation, and their economic, environmental, and social impacts within Portugal's Blue Economy. Using Partial Least Squares Structural Equation Modeling (PLS-SEM), data collected from a survey of companies operating in this sector revealed that sustainability is a significant driver of innovation, which in turn mediates its impact across economic, environmental, and social dimensions. The findings confirm that innovation acts as both a direct outcome of sustainability efforts and a mechanism for amplifying its broader impacts, especially on economic and environmental performance. The study contributes to both theory and practice by highlighting the strategic integration of sustainability into organizational innovation processes and its role in enhancing multidimensional performance. By identifying critical pathways and barriers, this study offers valuable guidance for policymakers and industry leaders striving to enhance the long-term sustainability of the Blue Economy.

Keywords: Blue Economy, Innovation, Sustainability, Economic Impact, Social Impact, Environmental Impact.

3.1. Introduction

The Blue Economy represents a critical intersection of economic development and environmental stewardship, encompassing ocean-based industries such as fisheries, aquaculture, maritime transport, and renewable marine energy. The European Union's Blue Growth strategy emphasizes its pivotal role in fostering sustainable economic development while addressing pressing environmental challenges (European Commission *et al.*, 2024a).

[3] **This paper is currently under review in an international peer-reviewed academic journal, and its structure follows the formatting and stylistic guidelines of the journal to which it has been submitted.**

Sustainability, a cornerstone of the Blue Economy, is increasingly recognized as a driver of innovation. Sustainability-Oriented Innovation (SOI) highlights the transformative potential of aligning environmental and social challenges with business opportunities, fostering pathways for eco-efficient practices, such as resource optimization and renewable energy adoption (Llorca-Ponce *et al.*, 2021; Bossle *et al.*, 2016). For example, sustainable business model archetypes, such as "creating value from waste" and "substituting with renewables", have demonstrated the capacity to align competitive advantages with environmental objectives (Bocken *et al.*, 2014).

In resource-intensive industries like the Blue Economy, these shifts are particularly critical. The sector's dependency on finite marine resources and fragile ecosystems demands solutions that align economic growth with environmental sustainability and social equity (Demirel & Kesidou, 2019; Geissdoerfer *et al.*, 2018).
A number of challenges demonstrate this point: overfishing, habitat destruction, and marine pollution require firms to develop adaptive capabilities and integrate sustainability into their innovation strategies (Cisneros-Montemayor *et al.*, 2022). Doing so not only mitigates ecological risks but also fosters competitiveness and long-term value creation.

Institutional theory provides a relevant framework to understand how the formal and informal rules, as well as the pressures exerted by the institutional environment, shape the strategic decisions of firms in this sector (Lawrence, 1999).
This perspective helps explain how regulations, societal expectations, and industry norms push organizations toward SOI, particularly in sectors exposed to high environmental scrutiny (Cisneros-Montemayor, 2019; Nidumolu *et al.*, 2013).

Despite advancements, significant gaps persist in understanding how sustainability influences innovation and how these innovations mediate impacts across economic, environmental, and social dimensions in Blue Economy contexts (Behnam & Cagliano, 2017). This study explores how SOI can improve the economic, environmental, and social performance of Blue Economy firms by applying the triple bottom line (TBL) theory (Sesini *et al.*, 2020).

The TBL framework provides a comprehensive lens to assess the holistic impacts of SOI, going beyond just financial metrics to include environmental preservation and social equity. This integrated approach is particularly relevant in the Blue Economy, where the

long-term viability of ocean-based industries is closely tied to the health of marine ecosystems and the well-being of coastal communities (Cisneros-Montemayor, 2019). Prior studies suggest that firms operating in rapidly evolving sectors, such as the Blue Economy, must develop adaptive strategies that balance immediate competitiveness with long-term sustainability (Hu *et al.*, 2019).

In Portugal, the Blue Economy significantly contributes to the country's economic development and environmental stewardship. As a coastal nation with a long maritime tradition, Portugal's Blue Economy encompasses a range of ocean-based industries, including fisheries, aquaculture, maritime transport, and renewable marine energy (Machado de Almeida & De Portugal, 2022). These sectors play a crucial role in the national and regional economic strategies, particularly in meeting the European Union's sustainability targets. At the same time, Portugal's coastal communities are also vulnerable to the impacts of climate change, such as rising sea levels and extreme weather events (Carneiro, 2007).

This national context reinforces the urgency of embedding sustainability into innovation strategies, not only as a compliance response but as a proactive avenue for economic resilience (Fontes *et al.*, 2019). By leveraging sustainability as a driver of innovation, Portugal can position its Blue Economy as a model of resilience and sustainable development, contributing to the broader European Union's efforts to foster a thriving and environmentally responsible maritime sector.

This study examines the relationship between sustainability, innovation, and their impacts on Portugal's Blue Economy. Employing Partial Least Squares Structural Equation Modeling (PLS-SEM), it addresses two key questions: 1) How does sustainability drive innovation in Blue Economy firms? and 2) How does innovation mediate the impacts of sustainability on economic, environmental, and social outcomes? By integrating theoretical perspectives and empirical data, this research addresses critical gaps in understanding the mechanisms through which SOI enhances both the resilience and long-term performance of ocean-based industries.

The results contribute to academic literature by clarifying the role of innovation as a mediating force that strengthens the multidimensional outcomes of sustainability, particularly in financial, environmental, and social terms. From a practical standpoint, the

findings offer evidence to support more targeted strategies for firms and policymakers seeking to foster sustainability-driven innovation within the Blue Economy.

By unpacking the relationship between innovation and impact, this study provides a more detailed framework for understanding how sustainability can be operationalized at the firm level. The conclusions align with broader calls for a paradigm shift in which sustainability becomes a systemic driver of industrial and societal progress. In this context, the findings can support the development of more effective policy instruments and business models to strengthen the sector's long-term contribution to sustainable development.

3.2. Conceptual Framework and Hypothesis Development

3.2.1. Institutional Theory

This study investigates the integration of SOI within Portugal's Blue Economy, employing Institutional Theory and the TBL to explore how these interact within a unique geographical and regulatory context. We aim to unravel the complex mechanisms through which sustainability initiatives foster innovation and, subsequently, how these innovations influence and mediate the multidimensional impacts across economic, environmental, and social outcomes. By adopting a comprehensive approach, this research seeks to provide a deeper understanding of the interconnections between sustainability, innovation, and the holistic performance of organizations operating in the Blue Economy.

Institutional theory provides a framework to understand how the broader regulatory environment and institutional pressures can shape organizational behaviors and strategies within the Blue Economy (DiMaggio and Powell, 1983). This perspective suggests that firms operating in this context are subject to various expectations and compliance requirements that drive their decision-making. In the Blue Economy, these institutional pressures include adhering to environmental laws, global sustainability standards, and engaging with conservation efforts (Scott, 2014). Firms must navigate a complex regulatory landscape, comply with stringent environmental regulations, and collaborate with diverse stakeholders, such as government agencies, NGOs, and local communities, to ensure the long-term sustainability of their operations and the broader marine ecosystem (Oliver, 1991).

Institutional theory further emphasizes institutional isomorphism, where coercive (regulatory), normative (professional), and mimetic (imitative) pressures converge to shape organizational practices (DiMaggio & Powell, 1983). Particularly relevant for the Blue Economy, firms may adopt similar SOI as they respond to shared regulatory mandates and industry norms. However, firms are not merely passive recipients; they actively interpret, adapt, and potentially reshape these pressures, contributing to the ongoing evolution of institutional norms (Mahoney & Thelen, 2010).

The institutional theory framework indicates that these external pressures can lead to homogeneity in organizational behaviors, particularly in industries like the Blue Economy that face intense regulatory scrutiny (Oliver, 1991; DiMaggio and Powell, 1983). In Portugal, the European Union's maritime policies, such as the Marine Strategy Framework Directive, significantly shape the business practices of firms operating in this sector (European Commission, 2008). This institutional context influences the strategic decisions and sustainability-oriented innovations that these firms pursue, aligning with the hypotheses proposed in this study.

Importantly, the pressures exerted by institutional frameworks can foster a culture of innovation within firms, as they are required to adopt sustainable practices (Scott, 2014). This necessity drives the development of new business models and solutions that are environmentally sustainable and economically viable. By aligning their practices with institutional norms and regulatory requirements, firms are often compelled to innovate in ways that address sustainability challenges and contribute to the long-term viability of the Blue Economy.

Thus, institutional theory offers a valuable analytical lens, capturing not only compliance-driven behavior but also the strategic adaptations through which firms navigate and respond to sustainability transitions. These include efforts to align with institutional expectations in ways that enhance both resilience and innovation (Pinto *et al.*, 2023a; Adams *et al*., 2016; Scott, 1995; Oliver, 1991).

3.2.2. Sustainability-Oriented Innovation (SOI)

SOI refers to the process of developing new or improved products, services, or business models that explicitly integrate environmental and social considerations into the innovation process (Nidumolu *et al.*, 2013; Flores *et al.*, 2008). This approach aims to

create solutions that contribute to sustainable development by addressing both operational impacts and the long-term sustainability of resource use. SOI is particularly relevant in the context of the Blue Economy, where maritime sectors are inherently tied to natural ecosystems (Kennedy & Bocken, 2020; Adams *et al.*, 2016).

SOI posits that sustainability initiatives within firms drive and push them to innovate. Firms engaged in SOI are better positioned to respond to environmental challenges and regulatory changes, which is particularly relevant in the context of Portugal's maritime industry that faces significant economic dependency on the ocean and stringent European Union (EU) environmental regulations (Maier *et al.*, 2020; Schaltegger & Wagner, 2017). For example, the adoption of renewable energy solutions for maritime transport, as seen in Portugal's investment in research and development, has allowed firms to reduce their carbon footprint and meet strict emissions standards. Similarly, the implementation of innovative aquaculture techniques, such as closed-loop systems and integrated multi-trophic aquaculture, has enabled firms to minimize their environmental impact while maintaining productivity (Radhakrishnan *et al.*, 2023; Altenburg & Pegels, 2012). These examples illustrate how SOI has enabled firms in the Blue Economy to balance economic growth and environmental sustainability.

Given the sector's strong economic reliance on the ocean and the stringent EU environmental regulations, SOI enables these firms to maintain their competitiveness while also contributing to the ecological balance of the Blue Economy. By adopting innovative, eco-friendly solutions and integrating sustainability practices into their operations, these firms can not only comply with regulatory requirements but also proactively mitigate their environmental impact and position themselves as leaders in the sustainable development of the Blue Economy.

Integrating SOI within organizational strategies can foster dynamic capabilities, enabling firms not only to respond reactively but to anticipate environmental and social shifts proactively, thereby enhancing long-term resilience and competitiveness (Teece *et al.*, 1997; Geissdoerfer *et al.*, 2018).

To address the research objectives, we propose the following hypothesis:

H1: *Sustainability initiatives within firms operating in the Blue Economy positively influence innovation.*

The hypothesis is rooted in the concept of SOI, which posits that firms' sustainability initiatives spur them to innovate and create new solutions that incorporate environmental and social factors. By embracing SOI, companies operating in the Blue Economy can bolster their competitiveness, adhere to strict regulations, and contribute to the long-term sustainability of the maritime industry (Adams *et al.*, 2016; Altenburg & Pegels, 2012).

3.2.3. Triple Bottom Line (TBL)

The TBL framework compels organizations to comprehensively evaluate and balance their performance across three key dimensions: social, environmental, and financial (Stoddard *et al.*, 2012; Elkington, 1998). This holistic approach goes beyond the traditional focus on financial profits, recognizing that businesses have a responsibility to create positive impacts in their communities and on the natural environment in which they operate (Tamvada, 2020).

In dynamic and resource-sensitive contexts like the Blue Economy, applying the TBL can reveal trade-offs and synergies between economic profitability, environmental stewardship, and social equity, guiding firms toward integrated sustainability strategies that mitigate risks and leverage emerging opportunities (Cisneros-Montemayor *et al.*, 2022). The social dimension of the TBL encompasses the firm's contributions to and relationships with its stakeholders, including employees, local communities, and society at large. This can include measures such as workforce diversity, employee satisfaction, fair labor practices, and the company's role in supporting community development and well-being (Elkington, 1998).

The environmental dimension examines the firm's impact on natural resources, energy usage, waste management, emissions, and its overall environmental footprint (Elkington, 2002). Sustainable practices, such as the adoption of renewable energy, resource efficiency, and ecosystem conservation, are essential for achieving positive environmental outcomes.

The financial dimension represents the organization's economic performance and profitability, ensuring the long-term viability and competitiveness of the business. This component is crucial for enabling the firm to invest in and sustain its social and environmental initiatives, creating a virtuous cycle of value creation (Stoddard *et al.*, 2012; Elkington, 1998).

By simultaneously pursuing and balancing these three interconnected dimensions, organizations operating within the Blue Economy can create shared value for their stakeholders, the environment, and the broader maritime ecosystem (Spalding, 2016). This comprehensive approach supports the long-term sustainability of the Blue Economy, fostering economic prosperity while mitigating environmental degradation and promoting social equity (Cisneros-Montemayor, 2019). This holistic approach to assessing the impacts of business activities ensures that the economic benefits of innovation do not overshadow the necessary environmental and social considerations, which is vital for the long-term.

To address the research questions, we propose the following hypothesis:

- **H2a*:*** *Innovation positively influences economic outcomes.*
- **H2b*:*** *Innovation positively influences environmental outcomes.*
- **H2c*:*** *Innovation positively influences social outcomes.*

The proposed hypotheses suggest that innovation, as a result of sustainability-oriented initiatives, can directly influence the various dimensions of the TBL. Specifically, we expect that innovation will have a positive impact on economic, environmental, and social outcomes for firms operating in the Blue Economy.

In the intricate interplay of sustainability practices within the Blue Economy, innovation emerges not merely as an outcome but as a pivotal mediator that bridges the gap between sustainability initiatives and their multifaceted impacts. The TBL framework compels organizations to simultaneously pursue advancements across economic, environmental, and social dimensions (Sesini *et al.*, 2020). In this context, innovation acts as the linchpin that translates sustainability efforts into tangible outcomes that can be quantitatively and qualitatively assessed.

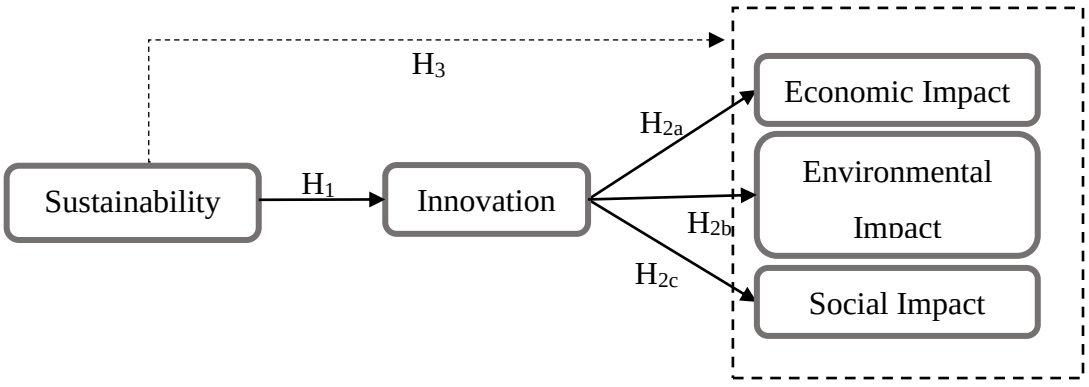
By embedding innovative practices at the core of sustainability strategies, firms are equipped to not only respond adaptively to environmental challenges but also to capitalize on economic opportunities and enhance social well-being (Wang & Zhang, 2019; Martínez & Rodríguez del Bosque, 2014). This mediation is critical, as it underscores the capacity of innovative processes to amplify and extend the benefits of sustainability initiatives, making them more comprehensive and impactful. Consequently, understanding the mediating role of innovation helps clarify the mechanisms through

which sustainable practices influence broader organizational performance and contribute to sectorial advancements. To address the research questions, we propose the following hypothesis:

- **H3a:** *Innovation mediates the relationship between sustainability and economic outcomes.*
- **H3b:** *Innovation mediates the relationship between sustainability and environmental outcomes.*
- **H3c:** *Innovation mediates the relationship between sustainability and social outcomes.*

By examining the mediating role of innovation, this study aims to uncover the nuanced mechanisms through which sustainability initiatives translate into multidimensional impacts within the Blue Economy. We anticipate that the strategic integration of innovative, eco-friendly practices will enable firms to enhance their performance not only in economic terms but also in environmental conservation and social responsibility (Figure 3.1). This holistic approach to sustainability underscores the interconnected nature of these dimensions, emphasizing the need for a comprehensive, systems-level understanding of the Blue Economy's transformation.

Figure 3.1 - Relationship between Constructs and Research Hypotheses



Source: Own elaboration.

By synthesizing SOI, Institutional Theory, and the TBL within the context of Portugal's Blue Economy, this research aims to provide detailed comprehension. into the multifaceted impacts of SOI. This theoretical grounding not only frames our empirical investigation but also enriches the academic discourse on sustainable practices in maritime industries. Each hypothesis is crafted to evaluate the relationships dictated by

these frameworks, ensuring a comprehensive understanding of the interplay between innovation and sustainability within this vital sector.

3.3. Methodology

3.3.1. Contextualizing Portugal's Blue Economy

Portugal is a coastal nation located in southwestern Europe, with a long and storied maritime history (Fontes *et al.*, 2019). As a member of the European Union Portugal's economy has a significant focus on the Blue Economy, which encompasses a range of ocean-based industries such as fisheries, aquaculture, maritime transport, and tourism. The country's extensive coastline, which stretches for 2500 km^2, has played a vital role in shaping its economic and cultural identity (Almeida *et al.*, 2024; Machado de Almeida & De Portugal, 2022).

Portugal's Blue Economy is a critical component of its overall economic landscape, contributing significantly to the country's GVA and employment, in 2021 representing 1.8% of the national GVA and 3.2% of the national employment (European Commission, 2024a). The sector includes resource-intensive industries that are closely tied to the health of the marine ecosystem, such as fishing and maritime transportation. However, these industries also face significant environmental challenges, including overfishing, habitat degradation, and marine pollution, which threaten the long-term sustainability of the Blue Economy (Machado de Almeida & De Portugal, 2022).

At the same time, Portugal's coastal communities are increasingly vulnerable to the impacts of climate change, such as rising sea levels and more frequent extreme weather events (Marinho *et al.*, 2019). Addressing these complex challenges requires a comprehensive approach that integrates sustainability into the innovation strategies of businesses operating in the Blue Economy (Badîrcea *et al.*, 2021).

Portugal has implemented several initiatives to promote a more sustainable Blue Economy. The country has strengthened regulations and enforcement measures to address issues like overfishing, habitat degradation, and marine pollution (Almeida *et al.*, 2024). For example, Portugal has adopted stricter quotas and monitoring systems for fishing activities, as well as implemented ecosystem-based management approaches in aquaculture. Additionally, the government has invested in research and development to support the adoption of innovative, eco-friendly technologies across maritime sectors,

such as renewable energy solutions for maritime transport (European Investment Bank, 2024). Portugal has also worked to enhance the resilience of its coastal communities by implementing climate change adaptation strategies, including measures to protect against rising sea levels and extreme weather events (Marinho *et al.*, 2019). These efforts demonstrate Portugal's commitment to balancing economic growth, environmental preservation, and social equity within its vital Blue Economy.

3.3.2. Research Design

This section introduces the quantitative study conducted to examine the role of sustainability in driving innovation and its associated impacts within the Blue Economy. Relying on a structured survey administered to firms operating in Portugal's maritime sectors, the research employs PLS-SEM to explore the hypothesized relationships between SOI and economic, environmental, and social performance.

The questionnaire was developed to operationalize the constructs identified in the conceptual framework, ensuring robust alignment with theoretical foundations and empirical evidence. Items were carefully designed to capture the dimensions of Sustainability, Innovation, and their associated Impacts (Economic, Environmental, and Social). These items were informed by prior studies and validated scales, drawing from established frameworks such as the Institutional theory, TBL and SOI.

Each measurement item reflects the underlying construct it represents, with questions designed to ensure clarity and relevance. The indicators address key aspects such as innovation strategy, performance management, and sustainability practices while exploring their impacts across multiple dimensions. The constructs and their corresponding indicators are detailed in Table 3.1.

Table 3.1 - Constructs and measurement items from questionnaire Sustainable Practices in Innovative companies of the Portuguese Blue Economy

Dimensions/Constructs	Observed Measurements / Variables / Indicators	Source
Innovation Strategy	INS1: To what extent is innovation important for the growth of your company?	Valdez-Juárez & Castillo-Vergara (2021); Mousavi *et al.* (2018); Behnam & Cagliano (2017); Teece *et al.* (1997); Porter & van der Linde (1995).
	INS2: How much has your company invested in R&D over the past 3 years (e.g., budget proportion, ongoing projects)?	Rosário & Dias (2022); González-Álvarez & Cabeza-García (2020); OECD (2019); Adams *et al.* (2016); Porter & van der Linde (1995).

	INS3: To what extent has your company adopted new technologies (e.g., AI, automation)?	Verdolini *et al.* (2021); Zhang *et al.* (2020); Geissdoerfer *et al.* (2018); Venkatesh *et al.* (2003); Teece *et al.* (1997).
Innovation Performance Management	INP1: How often does your company conduct regular evaluations and reviews of the impact of innovation?	Alomoto *et al.* (2022); Amui *et al.* (2017); Adams *et al.* (2016); GRI (2016); Bossle *et al.* (2016).
	INP2: To what extent does your company use data analytics to monitor the progress of innovation impacts?	Fontes *et al.* (2019); OECD (2019); Adams *et al.* (2016); GRI (2016); Joung *et al.* (2013).
	INP3: How frequently does your company develop sustainability reports and transparently communicate the results?	Machado de Almeida & De Portugal (2022); Villaseñor-Derbez *et al.* (2022); GRI (2016); Bocken *et al.* (2014); Elkington (1997).
	INP4: How often does your company engage stakeholders, including local communities, in assessing the impact of innovations?	Jiang *et al.* (2024); Villaseñor-Derbez *et al.* (2022); Cisneros-Montemayor *et al.* (2021); GRI (2016); Porter & Kramer (2011).
	INP5: To what extent does your company use internationally recognized assessment methodologies to evaluate innovation?	Rosário & Dias (2022); Verdolini *et al.* (2021); Silvestre & Ţîrcă (2019); Adams *et al.* (2016); GRI (2016).
Sustainability	SUS1: How important is sustainability to your company's overall strategy?	Verdolini *et al.* (2021); OECD (2019); Amui *et al.* (2017); Bocken *et al.* (2014); Elkington (1997).
	SUS2: How important is compliance with environmental regulations in your sustainability strategy?	González-Álvarez & Cabeza-García (2020); Silvestre & Ţîrcă (2019); Teece *et al.* (1997); Porter & van der Linde (1995)
	SUS3: How important is social responsibility to your company's sustainability strategy?	Jiang *et al.* (2024); Villaseñor-Derbez *et al.* (2022); Alomoto *et al.* (2022); Bocken *et al.* (2014); Elkington (1997).
	SUS4: How important is the use of renewable energy to your company's sustainability strategy?	European Commission *et al.* (2024a); Pudzis *et al.* (2020); Adams *et al.* (2016); Bocken *et al.* (2014).
	SUS5: How important is sustainable resource management to your company's sustainability strategy?	Villaseñor-Derbez *et al.* (2022); Amui *et al.* (2017); Adams *et al.* (2016); Bocken *et al.* (2014).
	SUS6: How important is circular economy practice to your company's sustainability strategy?	Rosário & Dias (2022); OECD (2019); Adams *et al.* (2016); Bocken *et al.* (2014).
	SUS7: How important is investment in research and development (R&D) to your company's sustainability strategy?	González-Álvarez & Cabeza-García (2020); Teece *et al.* (1997); Porter & van der Linde (1995).

Impacts (Economic)	EC1: Over the past 3 years, what has been the impact of your company's sustainable practices on job creation?	Villaseñor-Derbez *et al.* (2022); Alomoto *et al.* (2022); Porter & Kramer (2011); Elkington (1998).
	EC2: What has been the impact of your company's sustainable practices on economic growth?	Machado de Almeida & De Portugal (2022); Fontes *et al.* (2019); Teece *et al.* (1997); Porter & van der Linde (1995).
	EC3: What has been the impact of your company's sustainable practices on profitability?	Verdolini *et al.* (2021); Adams *et al.* (2016); GRI (2016); Bocken *et al.* (2014).
Impacts (Environmental)	ENV1: To what extent have your company's sustainable practices reduced pollution?	Pudzis *et al.* (2020); Geissdoerfer *et al.* (2018); Adams *et al.* (2016); Bocken *et al.* (2014).
	ENV2: What has been the impact of your company's sustainable practices on biodiversity conservation?	Jiang *et al.* (2024); Villaseñor-Derbez *et al.* (2022); GRI (2016); Porter & Kramer (2011).
	ENV3: What has been the impact of your company's sustainable practices on energy efficiency?	European Commission *et al.* (2024a); Verdolini *et al.* (2021); Bocken *et al.* (2014); Teece *et al.* (1997).
Impacts (Social)	SOC1: To what extent have your company's sustainable practices engaged the community?	Jiang *et al.* (2024); Villaseñor-Derbez *et al.* (2022); Alomoto *et al.* (2022); Porter & Kramer (2011); Elkington (1998).
	SOC2: What has been the impact of your company's sustainable practices on improving living conditions?	Villaseñor-Derbez *et al.* (2022); Cisneros-Montemayor *et al.* (2021); Adams *et al.* (2016); Bocken *et al.* (2014).
	SOC3: What has been the impact of your company's sustainable practices on education and awareness?	Jiang *et al.* (2024); Villaseñor-Derbez *et al.* (2022); Rosário & Dias (2022); GRI Standards; Elkington (1998).

Source: Own elaboration.

3.3.3. Data Collection

This study targeted firms within Portugal's Blue Economy, specifically selecting participants from the associates of *Fórum Oceano* and beneficiaries of the *Fundo Azul* initiative. These sources were chosen due to their integral roles in promoting sustainable maritime activities and innovation across national industries. Over a period of 6 months, surveys were distributed via email to over 150 companies identified through these networks. Participants were selected using a purposive sampling method to ensure representation across various sectors within the Blue Economy.

In conducting the survey[4], we utilized the EU platform for surveys (European Commission, 2024b), a tool endorsed by the European Union for its robust data collection capabilities and compliance with data protection regulations. This platform facilitated a streamlined approach to distributing the survey and collecting responses, ensuring consistency and reliability across all participants. Surveys were specifically addressed to key organizational figures, including CEOs, managers responsible for innovation and sustainability, or directors, to ensure that the responses reflected strategic visions and informed perspectives on the topics addressed.

Data collection was conducted between June 2024 and November 2024. To maximize engagement, the survey was followed up with reminder emails and phone calls to encourage participation. Despite these efforts, the response rate was 27%, with 40 companies providing complete responses. This rate is reflective of typical response rates in organizational surveys, especially in niche industries such as the Blue Economy. The potential impact of this response rate on the study's generalizability was mitigated by employing rigorous follow-up procedures and ensuring a broad geographic and sectoral representation among the respondents (Dillman *et al.*, 2014).

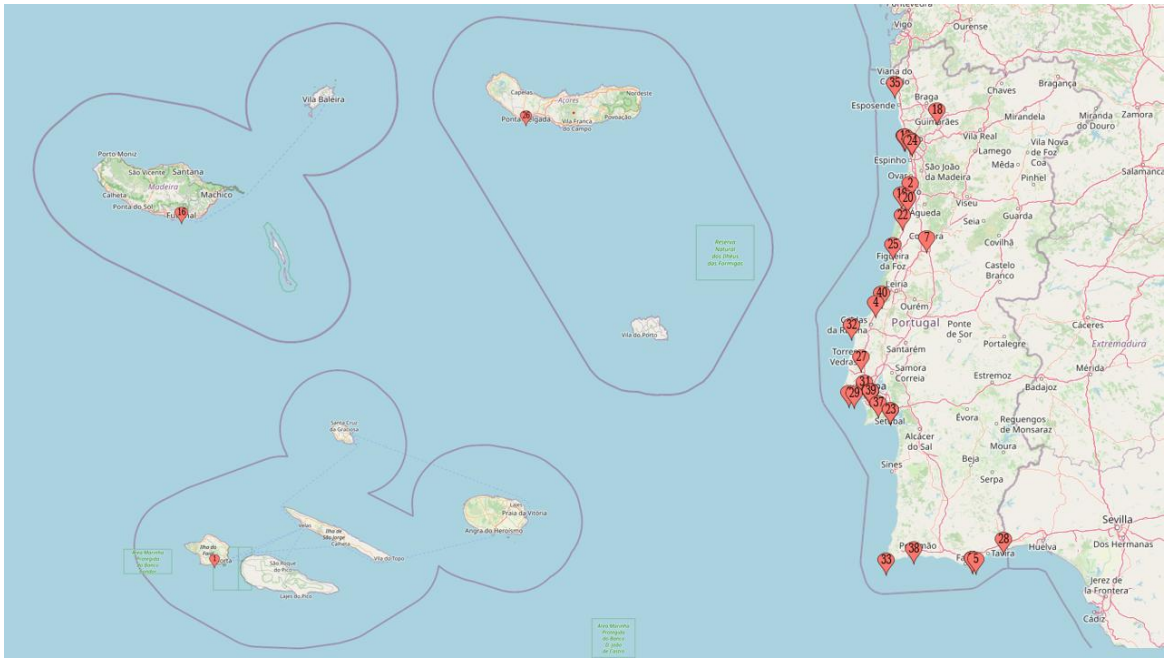
The methodology adhered to high ethical standards, a formal opinion was obtained from the Data Protection Officer of the University of Algarve, who confirmed that the study does not involve the processing of personal data and therefore does not require ethical approval under GDPR or national data protection law. Respondents were assured of confidentiality and anonymity to encourage honest and accurate responses. Participation was voluntary, and informed consent was obtained before beginning the survey. No incentives were offered to encourage response, maintaining the neutrality and integrity of the data collected.

To further enhance representativeness, the respondents' geographic distribution across Portugal was mapped using their postal codes. Figure 3.2 illustrates the regional coverage of the sample, ensuring a comprehensive analysis of spatial patterns across the country. By depicting firm engagement across various regions in Portugal, the visualization

[4] The complete version of the survey questionnaire is provided in Appendix B.

underscores the geographic diversity of the dataset and strengthens the credibility of the study's conclusions.

Figure 3.2 - Geographical distribution of respondents across Portugal



Source: Own elaboration.

The survey instrument employed a five-point Likert scale with varied response anchors tailored to the specific content of each question, ensuring the relevance and precision of the measurement. For questions measuring importance, the scale ranged from 1 ("Not important") to 5 ("Very important"). For questions assessing frequency or extent, the scale ranged from 1 ("Never") to 5 ("Always") or 1 ("Not at all") to 5 ("To a great extent"). For evaluative questions, the scale ranged from 1 ("Strongly disagree") to 5 ("Strongly agree"). Each scale was carefully chosen based on the question's context to capture the most accurate organizational behaviors and perceptions.

The questions were also accompanied by examples to provide respondents with a clear understanding of the context and intent of the inquiry. This was crucial for ensuring that responses were based on a consistent interpretation of the questions across all participants. These constructs were aligned with established frameworks for measuring sustainability and innovation impacts, incorporating best practices from prior studies (Correia & Sousa, 2022; Jennings *et al.*, 2024; Sarker, 2023).

A pilot test was conducted with a sample of 10 firms to validate the survey's clarity, relevance, and alignment with theoretical constructs. The feedback from the pilot test

highlighted areas for improvement, leading to minor refinements in wording and question structure to enhance precision and readability. Furthermore, two interviews with industry leaders helped assess the survey's applicability to real-world practices, ensuring that the questionnaire addressed sector-specific dynamics and challenges (Correia & Sousa, 2022). Following the data collection phase, the responses were prepared for statistical analysis.

3.3.4. Data Analysis Methods

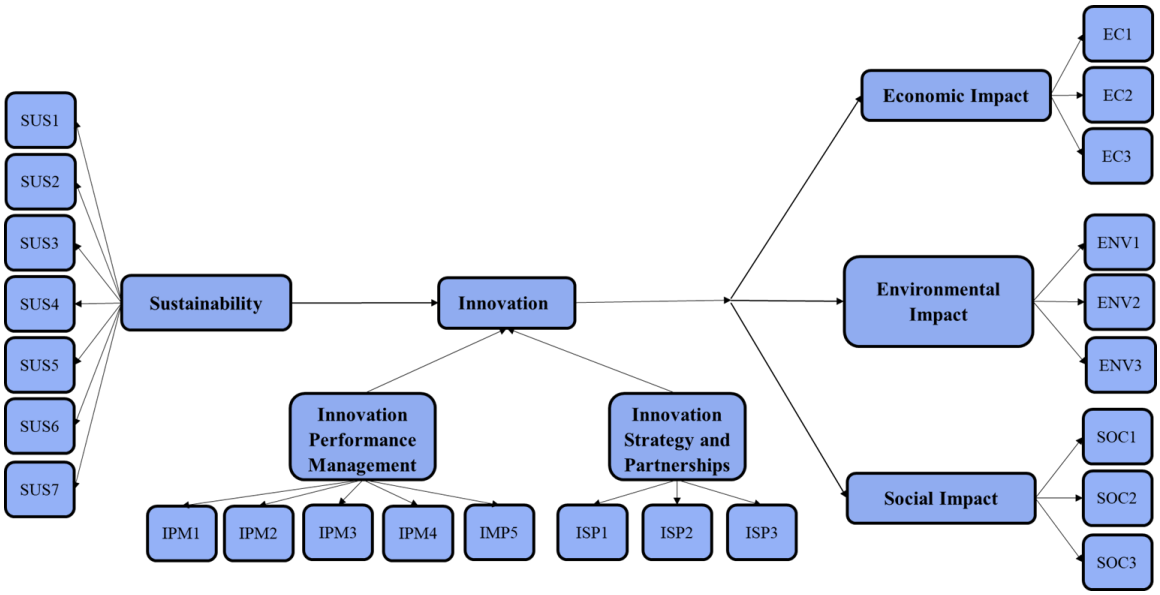
The analysis of the collected data was conducted using the statistical software tools such as SPSS version 29 and SmartPLS version 4 and includes descriptive statistics and structural equation modeling (SEM), with a focus on both measurement and structural model analyses (Ringle *et al.*, 2024).

The study included six main constructs: Sustainability, Innovation Performance Management, Innovation Strategy and Partnerships, Economic Impact, Environmental Impact, and Social Impact. All constructs were modeled as reflective constructs, except Innovation, which was modeled as a reflective-formative construct. This dual nature of Innovation allows its indicators to both uniquely contribute to and collectively reflect the construct (Diamantopoulos & Winklhofer, 2001).

The hypothesized relationships in the model were assessed using structural equation modeling (SEM). Due to its suitability for studies with small sample sizes, as recommended by Hair *et al.* (2011), the variance-based partial least squares (PLS) approach was utilized to perform SEM using SmartPLS 4. This method is particularly appropriate for developing theoretical relationships involving multiple exogenous constructs and assessing mediating effects simultaneously (Hair *et al.*, 2011).

To illustrate the relationships between constructs and their reflective/formative nature, the conceptual model used in this study is presented in Figure 3.3. This figure highlights the positioning of each construct and its corresponding indicators, offering a comprehensive overview of the research framework.

Figure 3.3 - Conceptual model of the Constructs and Indicators



Source: Own elaboration.

To begin the analysis, frequency distributions and percentile metrics were used to understand the sample distribution. Multicollinearity among the formative indicators of the Innovation construct was assessed using collinearity statistics to ensure the unique contribution of each indicator to the construct. For the reflective constructs, traditional reliability measures such as Cronbach's alpha and composite reliability were applied to assess internal consistency.

Convergent and discriminant validity were evaluated for all constructs. For reflective constructs, convergent validity was assessed using average variance extracted (AVE), while discriminant validity was confirmed using the Fornell-Larcker criterion. For the reflective-formative Innovation construct, redundancy analysis and indicator significance testing were used to evaluate its validity and appropriateness. Finally, using the PLS approach, structural equation modeling was employed to assess the hypothesized relationships and determine the paths within the model.

The sample size adequacy for this study was assessed using the A-priori Sample Size Calculator for Structural Equation Models (Soper, 2024). Based on the study parameters, an anticipated effect size of 0.5, a desired statistical power level of 0.8, six latent variables, 24 observed variables, and a significance level (α) of 0.05, the calculator determined that a minimum of 40 responses was required to detect the specified effects.

The study meets this minimum threshold, demonstrating sufficient statistical power for detecting medium-to-large effects.

However, the calculator also recommends a sample size of 100 to address the structural complexity of the model and enhance generalizability. While the current sample size of 40 falls below this recommendation, the study employs Partial Least Squares Structural Equation Modeling (PLS-SEM), which is robust to smaller sample sizes and particularly suited for exploratory research (Hair *et al.*, 2019). PLS-SEM is designed to maximize predictive accuracy and is less reliant on stringent distributional assumptions, making it appropriate for the constraints of this study.

Despite the limitations associated with a smaller sample size, the findings offer an initial understanding of the relationships between sustainability, innovation, and multidimensional impacts within Portugal's Blue Economy. Future research could expand the sample size to validate these findings across broader contexts and further strengthen generalizability.

3.4. Findings

3.4.1. Preliminary univariate analysis

3.4.1.1. Sample profile

The sociodemographic characteristics of the participating companies are presented in Table 3.2, providing a detailed overview of the sample. The analysis focused on key variables such as sector, company size, age, and recent innovation activities. This information helps contextualize the sample and highlights the diversity of firms operating within Portugal's Blue Economy.

The majority of respondent companies[5] were from the Blue bioeconomy, biotechnology, and research/education sector (32.5%), followed by Aquaculture (27.5%). The remaining participants represented Maritime industry (12.5%), Renewable energies (7.5%), Port

[5] The surveyed companies were categorized based on their self-reported sectors and their registered Portuguese Classification of Economic Activities (CAEs) in appendix C. This appendix provides a comprehensive list of CAEs, including their categorization into sectors such as Aquaculture, Bioeconomy, Biotechnology, R&D, Renewable Energies, and others. The distribution highlights the diversity of activities within the sample and the critical role of specific CAEs in driving innovation and sustainability in the Blue Economy.

activities (7.5%), Fishing (5.0%), Shipbuilding/repair (5.0%), and Maritime transport (2.5%).

Table 3.2 - Demographic analysis of participating companies

Category	Subcategories	Frequency (N)	Percent (%)
Sector	Aquaculture	11	27,50
	Port activities	3	7,50
	Blue bioeconomy, biotechnology, and research/education	13	32,50
	Shipbuilding (repair)	2	5,00
	Renewable energies	3	7,50
	Maritime industry	5	12,50
	Fishing	2	5,00
	Maritime transport	1	2,50
Company Size	Micro Company	33	82,50
	Small Company	4	10,00
	Medium Company	3	7,50
Company's Age	< 5 Years	3	7,50
	5 - 9 Years	15	37,50
	10 - 14 Years	7	17,50
	15 - 19 Years	6	15,00
	≥ 20 Year	9	22,50
Introduced Product Innovation in the Last 3 Years	Yes	30	75,00
	No	10	25,00
Introduced Process Innovation in the Last 3 Years	Yes	31	22,50
	No	9	77,50
Introduced Marketing Innovation in the Last 3 Years	Yes	22	55,00
	No	18	45,00
Introduced Organizational Innovation in the Last 3 Years	Yes	20	50,00
	No	20	50,00

Source: Own elaboration.

In terms of company size, the sample was predominantly composed of 33 micro companies, followed by 4 small companies and 3 medium-sized companies. This distribution mirrors the structure of the Portuguese economy, where 99.9% of enterprises are SMEs (INE, 2023), and micro-enterprises make up the vast majority (96.2%). This finding emphasizes the regional focus and local resource reliance of smaller enterprises within the Blue Economy sectors.

The age of the companies ranged from 1 to 65 years, with a mean age of 15.75 years (SD = 15.397). The distribution includes a mix of newly established firms (7.5%) and long-standing companies (22.5%), indicating a balance of fresh perspectives and experienced operations within the sample.

The majority of companies reported engaging in innovation activities over the last three years, as summarized below:

- Product Innovation: 75.0% of companies introduced product innovations.
- Process Innovation: 77.5% of companies introduced process innovations.
- Marketing Innovation: 55.0% of companies introduced marketing innovations.
- Organizational Innovation: 50.0% of companies introduced organizational innovations.

This high level of engagement in innovation highlights the adaptive nature of Blue Economy firms and their potential to drive sustainable growth through innovative practices.

3.4.1.2 Constructs' descriptive overview

The descriptive analysis of the dataset offered an overview of the central tendencies, dispersion, and distribution characteristics of responses for each construct. This analysis involved calculating the mean, standard deviation, skewness, kurtosis, and associated standard errors for the latent variables, as summarized in Table 3.3. These measures ensure an understanding of the data prior to the structural model estimation and hypothesis testing.

Table 3.3 - Descriptive statistics (N =40)

Latent Variables	N	Mean	Std. Deviation	Skewness	Std. Error	Kurtosis	Std. Error
Sustainability	40	4,0239	0,50111	-0,5220	0,374	-0,174	0,733
Innovation Strategy	40	3,3875	0,70447	-0,5180	0,374	-0,209	0,733
Innovation Performance Management	40	3,3550	0,92762	-0,4529	0,374	-0,273	0,733
Economic Impact	40	3,7083	0,66747	-0,9470	0,374	1,880	0,733
Environmental Impact	40	3,7333	0,90959	-0,6357	0,374	0,188	0,733
Social Impact	40	3,7333	0,62793	-0,1105	0,374	-0,489	0,733

Source: Own elaboration.

The results demonstrate varied perceptions of the constructs among the surveyed organizations, reflecting the multidimensional nature of sustainability, innovation, and impact within the Blue Economy:

- Sustainability exhibited the highest mean score (M = 4.0239), indicating that participants rated sustainability as a critical construct. The low standard deviation (SD = 0.50) reflects consistent perceptions of sustainability's significance across organizations, suggesting a strong alignment in recognizing its importance. The slight negative skewness (Skewness = -0.52) indicates that responses were slightly concentrated toward higher scores, while the near-zero kurtosis (Kurtosis = -0.17) suggests a relatively flat distribution.
- Environmental Impact demonstrated a high mean score (M = 3.73) but also showed the highest standard deviation (SD = 0.91) among all constructs, reflecting substantial variability in organizational approaches to environmental outcomes. The distribution for this construct was moderately skewed toward higher scores (Skewness = -0.64) with minimal kurtosis (Kurtosis = 0.19), indicating moderate variability in responses.
- Social Impact also achieved a mean score of M = 3.73, with a lower standard deviation (SD = 0.63) compared to Environmental Impact, indicating more consistent perceptions among respondents. The distribution was closer to normal, with a near-zero skewness (Skewness = -0.11) and slightly negative kurtosis (Kurtosis = -0.49), suggesting less variability in responses for this construct.
- Economic Impact achieved a mean score of M = 3.71, with a moderate standard deviation (SD = 0.67). Its distribution was negatively skewed (Skewness = -0.95),

suggesting a tendency for participants to rate economic impacts favorably. The kurtosis value (Kurtosis = 1.88) indicates a sharper distribution, reflecting less variability in responses compared to other constructs.

- Innovation Strategy had a lower mean score (M = 3.39) and moderate variability (SD = 0.70), suggesting a more diverse perception of strategic approaches to innovation within the sample. The skewness and kurtosis values (Skewness = -0.52, Kurtosis = -0.21) indicate a relatively normal distribution.
- Innovation Performance Management, with the lowest mean score (M = 3.36) and the highest standard deviation among innovation-related constructs (SD = 0.93), indicates less emphasis on systematic evaluation and management of innovation outcomes within the surveyed organizations. The negative skewness (Skewness = -0.45) and slightly negative kurtosis (Kurtosis = -0.27) reflect a wider dispersion in perceptions, highlighting potential areas for improvement in innovation processes.

The descriptive statistics reveal that sustainability-related constructs received higher mean scores, indicating that surveyed organizations perceive themselves as actively engaging with sustainability and its associated impacts. In contrast, the lower mean scores and greater variability observed for innovation constructs suggest that innovation practices are more unevenly implemented across firms, indicating challenges and opportunities for improvement in systematic innovation practices.

3.4.2. Structural equation modelling

3.4.2.1 Measurement model analysis

Structural Equation Modelling (SEM) is a statistical method used to evaluate complex relationships among latent variables (unobservable constructs) and observed variables (indicators) (Hair *et al.*, 2019). The measurement model analysis phase focuses on examining the reliability and validity of the latent variables to ensure the robustness of the subsequent structural model analysis. This study contains both first-order constructs and a second-order construct (Innovation), which is modeled as a reflective-formative construct. The analysis involved assessing reliability, convergent validity, discriminant validity, and collinearity for the first-order and second-order constructs.

The reliability and validity of the first-order constructs were assessed using established criteria (Hair *et al.*, 2019). These constructs include Sustainability, Economic Impact,

Environmental Impact, Social Impact, Innovation Strategy, and Innovation Performance Management. As shown in Table 3.4, all first-order reflective constructs demonstrated high reliability, with Cronbach's alpha and composite reliability (CR) values exceeding the recommended threshold of 0.70. Convergent validity was confirmed as the average variance extracted (AVE) for all constructs surpassed the minimum criterion of 0.50, indicating that each construct explains more than 50% of the variance in its indicators (Hair *et al.*, 2019). Additionally, all factor loadings exceeded 0.70, demonstrating strong individual indicator reliability. However, one indicator of Social Impact had a factor loading of 0.678, which, while slightly below the ideal threshold, was considered approximate enough and theoretically relevant for the construct.

Table 3.4 - Construct reliability and validity (first-order constructs)

Latent Variable	Items	Factor Loadings	Mean (M)	Standard Deviation (STDEV)	Cronbach's alpha	CR	AVE
Innovation Performance Management	INP1	0,786	0.751	0.146	0,891	0,904	0,698
	INP2	0,814	0.806	0.082			
	INP3	0,896	0.894	0.035			
	INP4	0,896	0.893	0.044			
	INP5	0,777	0.771	0.079			
Innovation Strategy and Partnerships	INS1	0,864	0.870	0.039	0,815	0,818	0,730
	INS2	0,886	0.885	0.042			
	INS3	0,813	0.799	0.088			
Sustainability	SUS1	0,764	0.767	0.062	0,894	0,900	0,610
	SUS2	0,757	0.734	0.143			
	SUS3	0,857	0.841	0.072			
	SUS4	0,781	0.758	0.118			
	SUS5	0,770	0.766	0.090			
	SUS6	0,774	0.767	0.096			
	SUS7	0,759	0.756	0.076			
Economic Impact	EC1	0,748	0.678	0.196	0,776	0,880	0,682
	EC2	0,907	0.889	0.148			
	EC3	0,814	0.768	0.198			
Social Impact	SOC1	0,678	0.598	0.324	0,711	0,858	0,594
	SOC2	0,888	0.788	0.279			
	SOC3	0,729	0.649	0.275			
Environmental Impact	ENV1	0,927	0.916	0.081	0,833	1,011	0,736
	ENV2	0,815	0.804	0.118			
	ENV3	0,828	0.805	0.121			

Source: Own elaboration.

Fornell & Larcker (1981) suggested that latent variables' square root of AVE should be higher than the correlation coefficients among the variables for ensuring discriminant validity. The results of this study, in Table 3.5, show that all the values of the square root of AVE were higher (as shown in bold) than the inter-variable correlations and thus, discriminant validity was confirmed for the first-order constructs.

Table 3.5 - Discriminant validity (first-order constructs)

Latent Variable	Economic Impact	Environmental Impact	Innovation Performance Management	Innovation Strategy and Partnerships	Social Impact	Sustainability
Economic Impact	**0,826**					
Environmental Impact	0,603	**0,858**				
Innovation Performance Management	0,379	0,427	**0,835**			
Innovation Strategy and Partnerships	0,350	0,166	0,484	**0,855**		
Social Impact	-0,192	-0,344	-0,340	0,003	**0,771**	
Sustainability	0,113	0,199	0,477	0,702	-0,063	**0,781**

Source: Own elaboration. Note: Square roots of average variance extracted (AVE) are shown on the diagonal.

A two-stage disjoint approach suggested by Sarstedt *et al.* (2019) was adopted in this study to form an Innovation second-order construct consisting of the latent variable scores of Innovation Performance Management and Innovation Strategy and Partnerships.

To assess the second-order construct, collinearity diagnostics were conducted, with all variance inflation factor (VIF) below the threshold of 5, indicating no multicollinearity issues (Hair *et al.*, 2019). Outer weights were examined to evaluate the relative contribution of each first-order construct to the second-order construct. The results, summarized in Table 3.6, confirm the reliability and validity of the second-order construct.

Table 3.6 - Construct reliability and validity after generating second-order constructs

Latent Variable	Items	Scale Type	Loadings/ Weights	Cronbach's alpha	AVE	VIF
Innovation	Innovation Performance Management	Formative	0,855	NA	NA	1,308
	Innovation Strategy and Partnerships		0,869			1,308
Sustainability	SUS1	Reflective	0,763	0,894	0,610	NA
	SUS2		0,775			NA
	SUS3		0,757			NA
	SUS4		0,761			NA
	SUS5		0,856			NA
	SUS6		0,783			NA
	SUS7		0,768			NA
Economic Impact	EC1	Reflective	0,750	0,776	0,679	NA
	EC2		0,909			NA
	EC3		0,806			NA
Social Impact	SOC1	Reflective	0,890	0,711	0,623	NA
	SOC2		0,628			NA
	SOC3		0,825			NA
Environmental Impact	ENV1	Reflective	0,920	0,833	0,740	NA
	ENV2		0,849			NA
	ENV3		0,807			NA

Source: Own elaboration.

The discriminant validity after the creation of the second-order construct was reassessed, Table 3.7, with the other first-order construct by following the rule of Fornell & Larcker (1981). However, the square root of AVE values of the second-order construct "innovation" was not available because this construct is a formative construct. The results of other first-order constructs demonstrated sufficient evidence of the discriminant validity of the latent variables.

Table 3.7 - Discriminant validity after generating second-order constructs

Latent Variable	Economic Impact	Environmental Impact	Social Impact	Sustainability
Economic Impact				
Environmental Impact	**0,725**			
Social Impact	0,274	**0,362**		
Sustainability	0,215	0,233	**0,302**	

Source: Own elaboration. Note: Square roots of average variance extracted (AVE) are shown on the diagonal in bold.

The results of the measurement model analysis confirm that the constructs in this study exhibit strong reliability and validity. These findings provide a robust foundation for the subsequent structural model analysis.

3.4.2.2 Structural model analysis

Structural model analysis was performed using SmartPLS version 4 (Ringle *et al.*, 2024) to estimate the path coefficients and evaluate the hypothesized relationships. The structural model analysis phase evaluates the hypothesized relationships among latent variables, allowing for an evaluation of the model's explanatory power and the strength of the relationships proposed in the theoretical framework.

The R^2 values reflect the proportion of variance explained by the independent variables in each construct. In this study, the R^2 value for Innovation was 0.471, indicating that sustainability explains 47.1% of the variance in innovation. This highlights sustainability's strong role as a driver of innovation, particularly in resource-intensive industries like the Blue Economy.

For Economic Impact ($R^2 = 0.182$) and Environmental Impact ($R^2 = 0.116$), innovation explains a modest but meaningful proportion of the variance. These results align with prior studies demonstrating that SOI can enhance profitability and reduce environmental harm through resource-efficient technologies (Verdolini *et al.*, 2021; Behnam & Cagliano, 2017). However, the R^2 value for Social Impact (0.049) is notably weaker,

reflecting challenges in achieving meaningful social outcomes through innovation alone (Table 3.8).

Table 3.8 - R^2 Values

Construct	R^2 Value	R^2 Adjusted
Innovation	0,471	0,457
Economic Impact	0,182	0,161
Environmental Impact	0,116	0,093
Social Impact	0,049	0,024

Source: Own elaboration.

The hypothesized relationships were evaluated using path coefficients derived from the structural model. The significance of these coefficients was determined using bootstrapping procedures with 5,000 resamples (Hair *et al.*, 2019). The results of the direct and indirect effects are presented in Table 3.9.

Table 3.9 - Results of structural model (direct and indirect paths)

	Paths	Beta	T statistics	P values	Results	Hypothesis
Direct	Sustainability → Innovation	0,686	6,830	0,000**	Supported	H1
Direct	Innovation → Economic Impact	0,427	2,579	0,010*	Supported	H2a
Direct	Innovation → Social Impact	-0,222	0,858	0,391	Not supported	H2b
Direct	Innovation → Environmental Impact	0,341	2,044	0,041*	Supported	H2c
Indirect	Sustainability → Innovation → Economic Impact	0,293	2,321	0,020*	Supported	H3a
Indirect	Sustainability → Innovation → Environmental Impact	0,234	2,061	0,039*	Supported	H3b
Indirect	Sustainability → Innovation → Social Impact	-0,152	0,836	0,403	Not supported	H3c

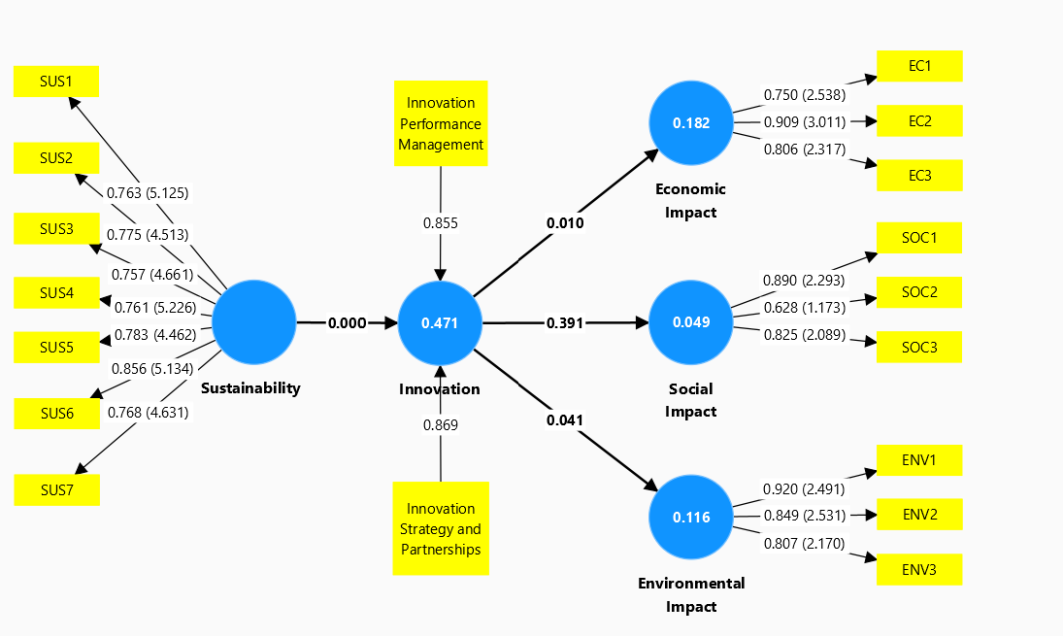
Source: Own elaboration. *Note: **p < 0.01, p < 0.05, based on two-tailed test; t = 1.96.

The findings indicated that the influence of Sustainability on Innovation was significant and positive ($\beta = 0.686$, $p < 0.01$), demonstrating that an increase in sustainability efforts substantially drives innovation. Similarly, the effects of Innovation on Economic Impact ($\beta = 0.427$, $p < 0.05$) and Environmental Impact ($\beta = 0.341$, $p < 0.05$) were positive and significant. However, the relationship between Innovation and Social Impact was not significant ($\beta = -0.222$, $p = 0.391$).

The results of the structural model analysis for indirect paths indicated that Sustainability had a significant indirect effect on Economic Impact (β = 0.293, p = 0.020) and Environmental Impact (β = 0.234, p = 0.039) through Innovation, supporting H3a and H3b. However, the indirect effect of Sustainability on Social Impact was not significant (β = -0.152, p = 0.403), meaning H3c was rejected. Since the direct effect of Innovation on Economic and Environmental Impacts was significant, the mediating role of Innovation was partial.

Figure 3.4 provides a visual summary of the structural model, depicting the relationships between Sustainability, Innovation, and their subsequent impacts on Economic, Environmental, and Social outcomes. The values in brackets next to each structural path represent the t-statistics from bootstrapping, indicating the significance of the estimated path coefficients. P-values below 0.05 are considered statistically significant. The Innovation construct, being formative, is composed of two dimensions, Innovation Performance Management and Innovation Strategy and Partnerships, and therefore displays outer weights rather than reflective loadings. Additionally, the R^2 values inside the circular nodes reflect the variance explained in each dependent construct.

Figure 3.4 - Structural model showing the relationships between Sustainability, Innovation, and their impacts on Economic, Environmental, and Social outcomes



Source: Own elaboration, SmartPLS 4 output.

3.5. Discussion

This study examines the interplay between sustainability, innovation, and their multidimensional impacts within the Blue Economy. The findings advance our understanding of how firms operationalize SOI to pursue economic and environmental objectives while addressing ongoing challenges related to social equity. Situated in the context of Portugal's Blue Economy, the study sheds light on both the current landscape of SOI and its transformative potential, alongside key limitations, offering implications with relevance beyond the national context.

The PLS-SEM results indicate a strong, positive effect size for the path between sustainability and innovation ($\beta = 0.65$, $p < 0.01$), underscoring sustainability's role as a stimulus for innovation within the company's strategy. This finding supports Institutional theory that reinforces the idea that external pressures, such as regulatory demands and stakeholder expectations, drive firms to innovate (Lawrence, 1999; Porter & Van Der Linde, 1995) However, the strength of this relationship is not merely theoretical, it underscores sustainability's ability to shift from a perceived compliance burden to a strategic asset.

Examples from Portugal's Blue Economy, such as the adoption of circular economy practices, resource-efficient technologies, and renewable energy solutions, illustrate this dynamic. For instance, advancements in microorganism-based aquafeeds have reduced operational costs while mitigating environmental harm (Sarker, 2023). These developments exemplify how firms leverage sustainability challenges to create innovation opportunities, transitioning from compliance burdens to strategic advantages. This reflects global patterns, where companies embedding sustainability into their core strategies demonstrate greater adaptability to market disruptions and resource constraints (González-Álvarez & Cabeza-García, 2020; Geissdoerfer *et al.*, 2018).

Innovation emerged as a significant enabler of both economic and environmental outcomes, reinforcing its dual role in enhancing financial stability and ecological stewardship. This dual impact reflects the logic of the TBL (Elkington, 1998), which posits that SOI can generate economic value while minimizing environmental harm. Beyond theoretical consistency, the findings highlight innovation's capacity to integrate these dimensions in practice, helping firms navigate the complexity of interconnected sustainability goals.

In the economic domain, innovations in aquaculture and offshore renewable energy have driven job creation, market expansion, and cost efficiency (Fontes *et al.*, 2019). For example, floating wind turbines not only lower carbon emissions but also create economic opportunities through supply chain diversification and workforce development (Bilgili & Alphan, 2022). Similarly, advancements in waste management and resource optimization have improved profitability while aligning with sustainability goals (Green Sea *et al.*, 2021). The importance of these results lies in their potential to reshape industry norms, proving that ecological innovation and financial performance are not mutually exclusive but mutually reinforcing.

From an environmental perspective, innovations have supported carbon reduction, biodiversity conservation, and ecosystem restoration. These findings validate prior research that underscores the role of innovation in aligning organizational objectives with ecological imperatives (Amui *et al.*, 2017; Bocken *et al.*, 2014). This evidence further challenges the outdated perception that environmental stewardship and profitability are at odds, providing a roadmap for firms seeking to reconcile ecological imperatives with economic performance (Verdolini *et al.*, 2021). The practical takeaway for firms is clear: environmental stewardship is not just a moral imperative but a strategic tool for mitigating risks and building long-term sustainability.

In contrast to its economic and environmental effects, the relationship between innovation and social outcomes was not significant ($\beta = 0.18$, $p = 0.07$). This outcome reflects existing critiques that many sustainability-oriented innovations often prioritize efficiency and ecological goals, while overlooking social equity and community well-being (Alomoto *et al.*, 2022; Bocken *et al.*, 2014). The findings suggest that firms may lack structured frameworks or incentives to address social dimensions comprehensively (Cisneros-Montemayor, 2019). This gap is particularly concerning given the role of social equity in achieving systemic sustainability, underscoring the need for a more inclusive and participatory innovation approaches.

The absence of significant social impacts highlights a gap in current innovation practices, which tend to focus on technological and operational advancements without addressing participatory approaches or equitable benefit distribution. For instance, while renewable energy projects often reduce environmental footprints, they may fail to engage local communities meaningfully, resulting in limited social benefits. For example, many large-

scale renewable energy projects in coastal areas focus primarily on environmental goals but neglect to incorporate the needs and knowledge of local communities (Kerr *et al.*, 2014). Addressing these gaps requires actionable frameworks that prioritize stakeholder participation.

This gap underscores the need for deliberate strategies to integrate social considerations into innovation processes. Approaches such as co-creation, stakeholder engagement, and equity-driven policies can help ensure that innovation delivers inclusive and equitable outcomes (Jones *et al.*, 2020; Shaffril *et al.*, 2017; Soma & Haggett, 2015). To illustrate, participatory innovation models have shown promise in fisheries management and marine conservation efforts, offering actionable strategies to bridge the gap between technological advancements and community well-being (Jennings *et al.*, 2024; Villaseñor-Derbez *et al.*, 2022).

The mediating role of innovation further emphasizes its importance as a mechanism for translating sustainability into tangible impacts. For economic and environmental outcomes, innovation serves as a crucial conduit, illustrating how sustainability pressures drive firms to develop resource-efficient technologies and novel business models. For example, circular economy practices, such as converting aquaculture waste into renewable feedstock, exemplify this mediation process (Correia & Sousa, 2022).

However, the absence of a mediating effect for social outcomes reiterates the limitations of existing frameworks in addressing equity and inclusivity. By failing to address these dimensions, firms risk perpetuating inequities and missing opportunities to align their strategies with broader societal goals, undermining the long-term viability of their sustainability efforts (Alomoto *et al.*, 2022; Cisneros-Montemayor, 2019).

This study contributes to the discourse on SOI by offering empirical evidence of both its potential and limitations. The findings provide practical implications for policymakers, industry leaders, and academics seeking to balance economic, environmental, and social objectives within resource-intensive industries. For policymakers, the implications are clear: targeted incentives and inclusive policies are essential to ensure that innovations align with systemic sustainability goals. For industry leaders, this research underscores the value of embedding equity into innovation strategies to maximize long-term impact.

These findings are particularly relevant for regions like Portugal and beyond, where sustainable development is not a choice but an imperative for resistance in the face of ecological, economic, and social pressures. The broader contribution of this study lies in its demonstration that SOI is not a one-size-fits-all solution. It must be tailored to address sector-specific challenges, engage diverse stakeholders, and deliver holistic outcomes that transcend traditional economic and environmental metrics.

3.6. Conclusion

This study offers a comprehensive exploration of the interplay between sustainability, innovation, and their multidimensional impacts within the Blue Economy, with a specific focus on Portugal's Blue Economy. The findings underscore the transformative potential of SOI in advancing economic and environmental objectives, while highlighting notable shortcomings in promoting social equity. These findings not only validate existing theoretical frameworks but also extend their relevance to the unique challenges and opportunities of the Blue Economy.

The results present clear implications for stakeholders aiming to foster sustainability and innovation in the Portuguese Blue Economy. Policymakers and industry leaders can draw on these findings to address current challenges and capitalize on emerging opportunities. For example, supportive policies, including R&D tax credits and subsidies for renewable energy, can significantly amplify innovation and align with environmental goals. This is evidenced by the success of offshore wind energy incentives in Scandinavia, where technological advancements and cost reductions have been driven by such policies (Bilgili & Alphan, 2022).

Investments in high-impact sectors such as aquaculture, offshore renewable energy, and sustainable waste management can drive economic growth while addressing ecological challenges. Initiatives like microorganism-based aquafeeds demonstrate the dual economic and environmental benefits of such advancements (Sarker, 2023). Embedding social equity in innovation through deliberate efforts to integrate equity-driven strategies, such as participatory innovation frameworks and workforce development programs, are essential to ensure inclusive benefits. Stakeholder engagement tools, as seen in community-based conservation models, provide templates for scalable adoption (Jennings *et al.*, 2024). Finally, by encouraging sectoral collaboration, partnerships across

academia, industry, and government can accelerate knowledge transfer and the adoption of best practices, particularly in resource-intensive and innovation-driven sectors.

This research contributes to the theoretical discourse by refining and extending frameworks in SOI by confirming the catalytic role of sustainability in driving innovation, reinforcing the relevance of SOI frameworks while emphasizing the need to incorporate sector-specific and context-dependent variables (Bocken *et al.*, 2014; Teece *et al.*, 1997). By identifying the limited influence of innovation on social outcomes, the research underscores a critical gap in current models and advocates for integrating participatory approaches and equity-driven policies into SOI strategies (Alomoto *et al.*, 2022).

While this study contributes to understanding SOI within the Portuguese Blue Economy, it also reveals four important areas for future research:

1. Deepening the social dimension: Future studies should examine how inclusive models, such as co-creation with communities or participatory governance, can help embed social equity more firmly into innovation strategies, particularly in sectors where community well-being is directly affected.
2. Longitudinal Studies: Exploring changes over time could provide a clearer picture of how sustainability and innovation interact as firms adapt to evolving environmental, regulatory, and market conditions around them.
3. Comparative Analyses: Broadening contextual comparisons across countries or industries could identify patterns and divergences in how SOI is implemented, helping to distinguish between context-specific strategies and those that may be more broadly applicable.
4. Policy Innovation: Researching policy design to assess how regulatory frameworks and incentive mechanisms shape firm behavior, with particular attention to how policy innovation can support long-term, systemic shifts toward sustainability.

The findings demonstrate that SOI is not merely an outcome or a response to external but can function as a strategic enabler for firms aiming to enhance their competitive advantage. At the same time, the results caution against treating innovation as a universal

solution, emphasizing the need for more inclusive and participatory approaches to address persistent gaps in social equity. While the use of PLS-SEM enabled a robust assessment of complex relationships, the reliance on cross-sectional survey data limits causal inference, and underrepresents informal or underreported social practices.

Providing a nuanced understanding of the mechanisms through which sustainability and innovation intersect, offering direction for policymakers and practitioners aiming to balance economic, environmental, and social goals in the Portuguese Blue Economy. By recognizing the strategic role of firms as agents of institutional change, and by grounding decisions in principles of equity and collaboration, stakeholders can better leverage the transformative potential of the Blue Economy. Doing so positions the sector not only as a source of growth, but as a global model for sustainable and inclusive development.

However, this study also acknowledges the limitations of current approaches within the Blue Economy. While the findings highlight the potential for sustainability-driven innovation to drive positive impacts, significant barriers may exist in implementing such strategies. Institutional pressures and challenges in achieving a true balance across the TBL dimensions could hinder the widespread adoption of SOI. Further research is needed to address these barriers and explore the contextual factors that may facilitate or impede the successful integration of sustainability and innovation within the Blue Economy. Addressing these limitations and implications can provide valuable guidance for policymakers and industry leaders to overcome the obstacles and effectively harness the power of innovation to foster a more sustainable and resilient Blue Economy.

Acknowledgements

The authors would like to thank all the firms that participated in the survey for their time, thoughtful contributions, and support throughout this project. J.E. research was funded by FCT with the grant agreement ID: 2024.01284.BD. H.P. is supported by the FCT (UIDB/04020/2020 and CEEC—INST/00052/2021/CP2792/CT0001).

Conflicts of Interest: The authors declare no conflicts of interest.

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CHAPTER 4 – CHARTING THE COURSE: REAL-WORLD APPLICATION OF SUSTAINABILITY AND INNOVATION PRINCIPLES IN THE PORTUGUESE BLUE ECONOMY FIRMS (PAPER 3)[6]

Abstract

The Blue Economy is a key sector for advancing sustainability and innovation, particularly in coastal nations where marine-based industries shape economic and environmental resilience. This study explores Sustainability-Oriented Innovation through an in-depth analysis of five leading Portuguese firms, selected from a broader dataset of 40 companies. Adopting a qualitative approach, it employs semi-structured interviews as the primary data collection method, supported by content comparison techniques and thematic coding using NVivo software. The findings indicate that stakeholder collaboration, circular economy principles, and renewable energy integration drive stronger sustainability performance, whereas financial constraints, regulatory inefficiencies, and bureaucratic hurdles limit broader adoption. Grounded in sustainability transition theories, the study underscores the importance of institutional support, stakeholder engagement, and adaptive business strategies in overcoming systemic barriers. These results provide practical direction for policymakers and business leaders, highlighting the need for streamlined regulation, targeted financial incentives, and cross-sector collaboration. By showcasing how firms embed sustainability into their strategies while managing hybridity tensions, the research contributes empirical evidence on sustainable business model innovation and offers direction for scaling sustainability efforts within the Blue Economy.

Keywords: Blue Economy, Qualitative Methods, Innovation, Sustainability, Barriers to sustainable innovation

4.1. Introduction

Contemporary societies face numerous challenges that necessitate modifying patterns, lifestyles, and production methods. While climate change is a pressing issue, it cannot be understood solely through an environmental lens (Banikoi *et al.*, 2023). Many challenges are linked to outdated economic structures. Modern capitalism has shown its limits,

[6] **This paper is submitted and currently under review in Journal of Cleaner Production and its structure follows this journal style.**

contributing to less harmonious, inequitable and unsustainable societies (Nogueira *et al.*, 2019). This is demonstrated by the policy initiatives of organizations like the European Commission, which aim to support environmental transitions, the circular economy, and green innovations (European Commission *et al.*, 2024).

Traditional business models that focus only on profit have shown their limitations. The potential for sustainable entrepreneurship is being increasingly recognized and researched in academic studies (Breuer *et al.*, 2018). Sustainable entrepreneurship endeavors are often discussed as hybrid businesses, as they face relevant tensions in reconciling their social and environmental goals with economic success (Matzembacher *et al.*, 2020).

The Blue Economy (BE) is a rapidly expanding sector encompassing industries that rely on marine and freshwater resources, including sustainable fisheries, renewable energy, biotechnology, and even tourism. It represents a critical domain for sustainable development, integrating environmental conservation with economic opportunities (Elston *et al.*, 2024). As global efforts to combat climate change intensify, fostering innovation and embedding sustainability principles within the BE have become paramount.

Various policy frameworks and academic discussions promote a sustainable BE. However, there is a gap in empirical understanding of how companies implement sustainability and innovation principles in practical operational contexts (Wenhai *et al.*, 2019). Previous research has often focused on conceptual discussions without deeply engaging with industry-specific challenges, best practices, and quantifiable performance outcomes (Kennedy & Bocken, 2020; Wenhai *et al.*, 2019; Voyer *et al.*, 2018). This study addresses that gap by examining innovative Blue Economy firms in Portugal that have successfully navigated sustainability transitions, providing empirical validation for sustainability and innovation theories.

Recent research underscores the scarcity of empirical evidence and the lack of theory regarding sustainable business models, their development processes, management mechanisms, challenges faced, and how entrepreneurs can create and capture various forms of value through new business models. The literature suggests that the existence of holistic business models is possible, where economic, environmental, and social value can all be present and mutually supportive (Choudhary *et al.*, 2021).

To move forward it is necessary to investigate alternative ways that entrepreneurs can develop new products, processes, and business models that create a positive impact on society, thereby minimizing possible tensions that may arise (Matzembacher *et al.*, 2020; Breuer *et al.*, 2018). Sustainable business management explores the ability of organizations to achieve environmental, social, and economic goals in commercial markets (Mdlalose, 2022).

However, there is a dearth of more comprehensive and integrated analyses examining how these firms cultivate a more sustainable value proposition, value creation, and value capture, as well as how they navigate potential tensions within their business models.

This article analyzes how selected firms in the Portuguese BE implement Sustainability-Oriented Innovation (SOI) through practical measures such as cross-sector collaboration, circular resource use, and the integration of renewable technologies. Rather than relying solely on technical innovation, these firms combine environmental goals with business strategy to address economic and regulatory challenges. The analysis focuses on how firms respond to institutional pressures and operational constraints, offering a grounded view of the private sector's role in maritime sustainability.

Empirically, this study draws on five in-depth case studies of leading Portuguese BE firms, using interviews with key stakeholders to understand how sustainability and innovation become embedded in business practices. By exploring their strategies, barriers, and aspirations, this research contributes to the broader conversation on how businesses can become catalysts for sustainable transitions, fostering collective prosperity and resilience in ocean-based economies.

4.2. Sustainability and Innovation in the Blue Economy

4.2.1. Theoretical Foundations of Sustainability in the Blue Economy

Sustainability within the BE extends beyond environmental conservation, encompassing economic and social dimensions that contribute to long-term resilience (Elston *et al.*, 2024). In this study, sustainability refers to practices that meet the needs of current stakeholders without compromising the ability of future generations to meet their own needs, aligning with principles defined by the Brundtland Commission (WCED, 1987). The Triple Bottom Line (TBL), framework emphasizes this balance of environmental responsibility, economic viability, and social well-being (Elkington, 1998), all of which

are essential in ocean-based industries where resource efficiency, biodiversity protection, and climate adaptation must align with economic development (van Hoof *et al.*, 2019).

Environmentally, sustainability in the BE focuses on responsible resource management, pollution reduction, and preserving marine ecosystems critical for climate regulation and economic productivity in sectors such as fisheries, aquaculture, and tourism (Kyvelou & Ierapetritis, 2019). However, unsustainable exploitation of marine resources, habitat destruction, and rising ocean temperatures continue to threaten these industries (United Nations, 2020).

Economically, sustainable business models aim to achieve profitability without degrading marine resources (Garlock *et al.*, 2024; Adams *et al.*, 2016), supported by instruments such as blue bonds, government subsidies, and impact investment funds that help enable firms to integrate sustainability into their financial strategies (Sarangi, 2023; Thompson, 2022; Cappelletto *et al.*, 2018).

Social sustainability emphasizes inclusive development that benefits coastal communities, ensures fair labor practices, and protects small-scale fisheries and indigenous knowledge (Cisneros-Montemayor *et al.*, 2021; Dziura & Cernota, 2015). Social impact refers to the measurable effects, both positive and negative, that business activities have on local communities and broader society, including improved livelihoods, reduced inequalities, and enhanced community resilience (Cisneros-Montemayor *et al.*, 2021). However, marginalized groups often face exclusion from decision-making, technological gaps, and displacement by large-scale industrial maritime activities (Jennings *et al.*, 2024).

While the concept of business models differs across literature, Osterwalder *et al.* (2005) define a business model as a conceptual tool consisting of a set of objects, concepts, and their relationships, which express the business logic of a firm, including value proposition, value creation/delivery, and value capture.

Sustainable innovation refers specifically to the development and implementation of new ideas, products, or processes that explicitly aim to achieve positive social and environmental outcomes alongside economic gains (Kennedy & Bocken, 2020; Adams *et al.*, 2016). Social innovation, a subset of sustainable innovation, involves novel strategies, concepts, or organizational models designed to meet social needs, foster

community empowerment, and enhance societal well-being (Cisneros-Montemayor *et al.*, 2021).

Sustainable business models, as defined by Kennedy & Bocken (2020), integrate these three pillars by aligning value creation and delivery with environmental and social objectives. Recent research highlights that sustainable business models leverage innovation to mitigate hybrid tensions between financial objectives and sustainability goals, by transitioning from traditional profit-oriented approaches to multi-stakeholder and sustainability-integrated models (Demirel & Kesidou, 2019; Breuer *et al.*, 2018)

These tensions are particularly evident in the context of hybrid organizations, which seek to combine commercial viability with environmental and social missions. Hybrid organizations operate under competing institutional logics and face persistent trade-offs between maximizing profit and delivering public or ecological value (Moizer & Tracey, 2010; Stubbs & Cocklin, 2008). In the Blue Economy, where firms must comply with strict regulatory frameworks while innovating for sustainability, hybridity becomes a defining feature of business strategy. This dual orientation often necessitates the development of novel organizational models that can navigate both market demands and mission-driven commitments.

The integration of these theoretical and empirical perspectives clarifies how sustainability in the Blue Economy must be approached holistically, balancing environmental, economic, and social priorities within firm-level strategies.

4.2.2. Innovation as a Driver of Sustainability

The innovation landscape in the maritime sector is characterized by advancements in technology, governance models, and business strategies that seek to enhance efficiency, reduce ecological impact, and foster resilience (Elston *et al.*, 2024). In this context, innovation is broadly defined as the introduction and application of novel processes, products, organizational practices, or marketing strategies aimed at creating added value and competitive advantage (Schumpeter, 1934). Building on Schumpeter's (1934) concept of the entrepreneur as an agent of change, firms in the BE apply product, process, and organizational innovations to align competitiveness with sustainability goals.

SOI has emerged as a critical framework that integrates environmental, social, and economic considerations into business strategy. Emphasizing long-term value creation SOI that aligns with sustainability goals (Breuer *et al.*, 2018; Adams *et al.*, 2016). In the BE, SOI manifests in eco-friendly maritime technologies, circular economy adoption, and digital solutions for marine conservation.

Innovation in the Blue Economy can take multiple forms, including radical, incremental, exploitative, and explorative types. Radical innovation represents disruptive advancements that redefine industry standards, such as the development of hydrogen-powered maritime transport or offshore floating solar farms (Valdez-Juárez & Castillo-Vergara, 2021; Rupo *et al.*, 2018). In contrast, incremental innovation involves gradual improvements in existing technologies, such as optimized fishing gear that reduces bycatch or energy-efficient ship propulsion systems. Incremental advancements provide immediate, cost-effective solutions that can be readily adopted by firms with lower financial risk (Shi *et al.*, 2020).

Exploitative innovation focuses on enhancing existing capabilities, optimizing operational efficiency, and improving sustainability performance through adaptive strategies. Many firms in the BE adopt exploitative innovations to improve waste management, optimize logistics, and integrate digital monitoring systems for ecosystem conservation (Behnam & Cagliano, 2017). Explorative innovation, on the other hand, involves the pursuit of new knowledge and experimental approaches, such as biomimicry-based marine engineering or the use of artificial intelligence for oceanographic research (Adams *et al.*, 2016). While explorative innovations hold substantial transformative potential, they are often constrained by high research costs, uncertain commercial viability, and regulatory limitations.

The relationship between SOI and the TBL framework provides a foundation for assessing the impact of sustainability-driven innovation on business performance (Llorca-Ponce *et al.*, 2021; Bossle *et al.*, 2016; Nidumolu *et al.*, 2013). The application of SOI in the BE has been widely examined through case studies that illustrate the best practices in sustainable business transformation.

Real-world applications of SOI within the BE include the adoption of bio-based materials in shipbuilding, the deployment of smart aquaculture systems, and the integration of

blockchain technology for supply chain transparency exemplify innovative approaches that reinforce sustainability objectives (Garlock *et al.*, 2024; Choudhary *et al.*, 2021; Cisneros-Montemayor *et al.*, 2021).

Despite these advancements, the transition to sustainability-oriented business models require systemic support from policymakers, investors, and industry stakeholders (Martínez-Vázquez *et al.*, 2021). Understanding these complexities is essential for analyzing the barriers and pathways to sustainability, as addressed in the following section.

4.2.3. Barriers for a Sustainable and Innovative Blue Economy

Despite growing momentum toward sustainability, numerous barriers hinder the widespread implementation of these principles in the BE. These challenges are multifaceted, spanning regulatory, financial, technological, and knowledge-related constraints that limit the ability of firms to fully integrate SOI and TBL into their operations and strategies (Elston *et al.*, 2024; Martínez-Vázquez *et al.*, 2021).

A primary obstacle is regulatory complexity and policy fragmentation. Multiple overlapping regulations at national and international levels create uncertainty, slow decision-making, and discourage investment (Almeida *et al.*, 2024; OECD, 2024, 2019). Additionally, lengthy bureaucratic processes further delay the deployment of innovative technologies and adoption of sustainable business models (Benzaken *et al.*, 2022; Penca, 2019).

Financial constraints also pose challenges as sustainable business transformation requires substantial upfront investments, which many small and medium-sized enterprises (SMEs) in the maritime sector struggle to secure (World Bank & United Nations Department of Economic and Social Affairs, 2017). The high capital costs associated with renewable energy infrastructure, circular economy initiatives, and low-carbon maritime technologies often deter firms from transitioning to more sustainable models, particularly in the absence of strong financial incentives or subsidies (European Investment Bank, 2021).

Technological barriers arise from the early-stage development of marine innovations, which remain commercially unviable without sustained R&D investment that could drive systemic change (Almeida *et al.*, 2024; Martínez-Vázquez *et al.*, 2021).

Organizational and cultural resistance often hinders the adoption of sustainable practices. Traditional industry norms, risk-averse corporate cultures, and a lack of sustainability-oriented leadership can impede the willingness of firms to embrace change (Porter & Kramer, 2011). Additionally, market reluctance is common, as customers, investors, and even policymakers prioritize short-term cost savings over long-term sustainability, especially when cheaper, conventional alternatives are available (Garcia *et al.*, 2007). This is particularly evident in cases where cheaper, conventional alternatives remain widely available, leading stakeholders to prioritize short-term cost savings over long-term sustainability benefits.

Knowledge and skills gaps further complicate these barriers, as insufficient expertise in sustainable practices, innovation management, and emerging technologies limits firms' ability to implement effective sustainability strategies. Limited access to specialized training, inadequate awareness about sustainability benefits, and the scarcity of qualified personnel skilled in sustainability-oriented innovation all contribute to slower transitions (OECD, 2019; Kyvelou & Ierapetritis, 2019).

Overcoming these barriers requires stakeholder education and sustained engagement, from raising consumer awareness to encouraging regulatory adaptation (Van Sumeren *et al.*, 2021). Many firms invest in outreach and partnerships to bridge knowledge gaps, but these efforts require institutional support and cultural shifts. Without broader alignment across industries and governance structures, the adoption of even the most innovative and cost-effective solutions will remain limited, delaying sustainability transitions in the BE.

4.3. Methodology

This article explores the practical implementation of SOI within the Portuguese BE, focusing on how firms integrate sustainability and innovation into their business strategies. Expanding on earlier quantitative research focused on sustainability and innovation in the Portuguese business environment, a survey was conducted involving 40 firms[7]. The initial study used PLS-SEM to identify factors influencing sustainability and innovation. Results demonstrated that sustainability drives firms to innovate, with

[7] The initial survey and PLS-SEM analysis are part of a separate quantitative study currently under review and are also presented in Chapter 3 of this thesis. Chapter 3 provides a quantitative exploration of the relationships between sustainability, innovation, and their impact on firms' economic, environmental, and social performance within the Portuguese Blue Economy.

innovation positively affecting environmental and economic outcomes, while social outcomes were not statistically significant. Although barriers to SOI were not analyzed in depth in the previous study, related survey questions captured firm-level perceptions of challenges such as financial constraints, regulatory issues, and stakeholder resistance. This article builds on those findings through semi-structured interviews[8] with stakeholders from five leading firms, identified as the most sustainable and innovative in the initial survey.

The rationale for the selection process is grounded in purposive sampling, specifically targeting firms that achieved the highest composite scores across key sustainability and innovation indicators from a comprehensive questionnaire applied to 40 companies operating within Portugal's Blue Economy. These indicators included factors such as the importance attributed to sustainability practices, levels of innovation strategy adoption, frequency of performance management activities, and the perceived impacts of SOI on economic, environmental, and social outcomes. Firms selected for this case study represent exemplary cases in these dimensions, ensuring the cases are information-rich and of high theoretical and empirical relevance (Bell *et al.*, 2019; Yin, 2018). By focusing on firms that excel in both sustainability and innovation, this study seeks to identify replicable models that can inform policy recommendations and industry strategies. This case study design (Yin, 2018) allows for in-depth, real-world exploration of organizational strategies, contextual factors, and sustainability transitions (Gerring, 2006).

To explore how firms integrate sustainability and innovation within the Portuguese Blue Economy, this study adopts a qualitative approach grounded in semi-structured interviews. The goal is to better understand the drivers, challenges, and strategic decisions that influence SOI in practice. Specifically, the research addresses the following questions: How do firms in the Portuguese Blue Economy operationalize sustainability and innovation in their business practices?, What are the key enablers and barriers influencing sustainability-oriented innovation in these firms?, and How can sustainability and innovation strategies Blue Economy effectively scale and replicate across sectors?

[8] The semi-structured interviews were guided by a predefined set of themes and questions. The full interview guide is available in Appendix D.

To ensure a comprehensive and systematic investigation, a semi-structured discussion guide was employed (Cachia & Millward, 2011), incorporating open-ended questions with prompts designed to elicit more detailed and reflective responses where appropriate (Blandford, 2013). This flexible but structured approach enabled interviewees to provide detailed reflections on their experiences, challenges, and strategic approaches, while maintaining consistency across cases (Bell *et al.*, 2019; Yin, 2018).

The discussion guide was specifically designed to examine six key themes[9] (table 4.1), derived from the literature review and initial survey findings, ensuring that the interviews remained focused while allowing participants to share nuanced perspectives. The interviews were conducted online via Zoom, recorded with participant consent, and later transcribed for analysis. Although online interviews have some limitations (Bell *et al.*, 2019), they offer advantages such as greater accessibility, flexibility in scheduling, and a more comfortable interview environment for participants.

Participants were not provided with the interview questions in advance, but they were given an overview of the topics to be discussed, ensuring spontaneous and candid responses. Top executives, including CEOs and company owners, were interviewed as of the selected firms. The interviews lasted between 45 and 90 minutes. The data was then transcribed and analyzed using NVivo software (QSR International Pty., Ltd., version 15, 2025).

The analysis followed a dual coding approach, employing both directed content analysis, where categories were derived from the literature review (Hsieh & Shannon, 2005), and open coding, where themes emerged inductively from the data. Coding is considered the starting point for qualitative data analysis (Bell *et al.*, 2019) and serves as a mechanism for interpreting meaning, reducing complexity, and organizing qualitative information into manageable segment (Namey *et al.*, 2007). Through this process, the study aimed to identify significant patterns and categorize interviewees' responses systematically.

To further refine the interpretative process, category ranking maps were created to highlight the most frequently referenced themes (Namey *et al.*, 2007). However, the number of occurrences within a category can be influenced by various factors, including

[9] A detailed representation of the coding framework and thematic node hierarchy developed in NVivo is provided in Appendix E.

the repetition of ideas by the same interviewee (Wong & Li Ping, 2008). Therefore, while this method provides an indication of thematic relevance, it should be considered an exploratory tool rather than a precise quantitative measure of preference or behavior (Vaismoradi *et al.*, 2016).

To enhance the reliability and validity of qualitative research, an audit approach was employed (Bryman, 2012). This involved systematic documentation of all research stages, including problem formulation, participant selection, interview transcripts, coding decisions, and data analysis processes. By maintaining a comprehensive and transparent research record, this study ensures rigorous methodological integrity, allowing for a robust interpretation of qualitative findings.

Table 4.1 - Categories identified and used in the NVivo coding process

Main Category/Theme	Subcategories
1. Contextual Information and Company Identity	1.1. History and Organizational Context 1.2. Description Products and Services 1.3. Core Values
2. Sustainability Strategy and Implementation	2.1. Environmental, Economic, and Social Sustainability 2.2. Integration of Sustainability into Business Strategy 2.3. Innovation as a Means to Achieve Sustainability 2.4. Navigating Sustainability Trade-offs
3. Innovation Practices	3.1. Innovation Processes and Strategies 3.2. Impact of Innovation on Business Performance
4. External Collaborations and Stakeholder Engagement	4.1. Partnerships with Universities and R&D Centers 4.2. Industry and Institutional Collaborations 4.3. Collaboration with Communities 4.4. Sustainability Communication and Literacy
5. Challenges and Barriers	5.1. Financial Resources 5.2. Expertise and Human Resources 5.3. Bureaucratic and Regulatory Barriers 5.4. Market and Cultural Resistance
6. Opportunities and Incentives	6.1. External Funding and Policy Incentives 6.2. Regulatory Changes Supporting Sustainability 6.3. Emerging Market, Tips and Business Opportunities

Source: Own elaboration.

To enhance the reliability and validity of findings, data triangulation was employed by integrating multiple sources of information. Data triangulation refers to the combination of primary data (semi-structured interviews) and secondary data, such as analysis of the information contained in the firms website, this analysis included:

- Primary Data: Semi-structured interviews with company representatives.
- Secondary Data: Institutional websites, publicly available information (Mission, Values, Products and Services).
- Comparative Analysis: Interview findings were systematically cross-referenced with prior survey data[10] to enhance analytical depth and validate patterns across cases, ensuring consistency and robustness in the interpretation of results.

Additionally, theoretical triangulation was applied by interpreting the findings through multiple theoretical lenses. This approach ensures that the study's conclusions are robust and grounded in well-established conceptual frameworks (Bell *et al.*, 2019; Gerring, 2006).

Qualitative Comparative Analysis (QCA) was applied to identify causal configurations linking sustainability strategies, barriers, and enablers to SOI outcomes (Hanckel *et al.*, 2021). Given the small sample size, the analysis focused on pattern recognition rather than data calibration.

All research procedures adhered to ethical guidelines for qualitative research, ensuring confidentiality, informed consent, and data security (Bell *et al.*, 2019). Participants were informed of the study's objectives before participation, and explicit consent was obtained for recording and transcribing interviews. To protect anonymity, company and participant identities were anonymized in the reporting of results. Additionally, the research was approved by the University of Algarves Research Ethics Committee, ensuring compliance with ethical research standards.

This methodological approach provides a rigorous and in-depth exploration of how firms in the Portuguese BE integrate sustainability and innovation into their business models. The next section presents the findings derived from this qualitative analysis, highlighting patterns, and strategic pathways and barriers.

4.4. Integrating Sustainability: Empirical Findings and Theoretical Discussion

This section presents the findings from the five case studies and interprets them through multiple theoretical lenses. The analysis is grounded in data triangulation, drawing from

[10] For transparency and to support the triangulation of findings, the key summary statistics of the survey data are included in Appendix F.

three main sources: (1) semi-structured interviews with company representatives, (2) publicly available information from the firms' institutional websites, and (3) quantitative survey data previously collected in the broader study. This approach strengthens the credibility of the findings and allows for a richer understanding of how firms operationalize SOI.

4.4.1. Case study description

To preserve confidentiality and respect the anonymity requested by participants, the five case study firms are referred to as B1 through B5 throughout this analysis. These designations, while coded, correspond to distinct organizational profiles within the Portuguese BE. These designations, while coded, correspond to distinct organizational profiles within the Portuguese Blue Economy (BE). Each firm was selected based on high scores in sustainability and innovation from the initial survey dataset, and their characteristics are summarized early in Table 4.2 to guide the reader. The company-specific data, including sector, size, turnover, derive from survey responses, and mission from the official institutional websites. These details provide necessary context to interpret the strategies, values, and innovation practices described in the interviews.

The first case, referred to as B1, operates at the intersection of shipbuilding and maritime transport. Its strategic focus lies in designing and manufacturing energy-autonomous, solar-electric vessels. Drawing from the interview data and reinforced by its high survey ratings on renewable energy implementation, B1 demonstrates a strong alignment with Porter's Competitive Strategy framework (1985), wherein environmental innovation serves as a key mechanism of differentiation in both product and brand identity.

B2, a biotechnology firm, applies biomimicry to develop sustainable water treatment systems and floating wetland technologies. Inspired by aquatic ecosystems, its innovation model mirrors Pathak's (2019) conceptualization of nature-based solutions. The firm's emphasis on ecological design, observed in its value statements and corroborated by strong survey scores on pollution prevention and water conservation, underscores the strategic role of environmental stewardship in business model innovation.

In contrast, B3 specializes in wind energy solutions tailored for off-grid applications in marine and coastal contexts. The firm positions its innovation within a broader energy transition agenda, supporting decentralization and sectoral adaptation to climate

challenges. This approach exemplifies the principles of Ecological Modernization Theory (Mol & Sonnenfeld, 2013), highlighting technological progress as a vehicle for reconciling growth and sustainability. Its interview responses are consistent with survey indicators showing high levels of investment in R&D and green technology adoption.

B4, an aquaculture company, prioritizes closed-loop systems and sustainable feed strategies that reduce ecological impact while meeting increasing seafood demand. With a sizable workforce and a strong market presence, the firm actively integrates the logic of the Circular Economy (Magalhães *et al.*, 2024; Geissdoerfer *et al.*, 2017), seeking not only operational efficiency but sectoral leadership in sustainable production. Its environmental and social impact ratings in the survey align with its declared mission to contribute to food security, biodiversity preservation, and rural development.

Finally, B5, a state-owned enterprise overseeing port activities and fish auctions, anchors its strategy in the modernization of port infrastructure and digital traceability. It frames its role as both a service provider and a steward of public interest. The integration of sustainable logistics and transparency measures aligns with the theoretical lens of Industrial Ecology (Graedel & Allenby, 1995), which promotes systemic efficiency through inter-organizational coordination and technological integration. The firm's public materials and survey data point to high scores in compliance, transparency, and infrastructure innovation.

To support the comparative analysis that follows, Table 4.2 summarizes the core attributes of each company, including sector, size, turnover, and stated mission. In addition, a word cloud (Figure 4.1) was generated from each firm's public value statements, offering a visual synthesis of the shared and divergent themes driving sustainability strategy within the Portuguese BE.

Table 4.2 - Case studies characteristics and description

Stakeholder	Industry Sector	Nº of employees	Company Turnover	Mission
B1	Shipbuilding & Repair; Maritime Transport	11 to 50 Employees	Up to 2 Million	Develop and manufacture eco-friendly, energy-autonomous vessels at competitive prices to expand their commercialization in nautical recreation, maritime tourism, river transport, and professional markets. Ensure satisfaction of customers, suppliers, and employees while optimizing shareholder results.
B2	Blue Bioeconomy & Biotechnology	11 to 50 Employees	Up to 2 Million	Providing innovative water treatment and sustainable wastewater solutions to protect the environment. Their portfolio offers biological technologies for water and air pollution tailored to businesses, public organizations, and industries. Focusing on functionality, efficiency, and cost-effective operation, they develop high-performance systems inspired by advanced aquaristics that outperform traditional urban treatment plants.
B3	Renewable Energy	Up to 10 Employees	Up to 2 Million	Democratize wind energy with specialized urban wind turbines. These turbines can also be applied in various locations, offering an alternative to traditional energy production. The solution addresses the need for decentralized energy generation, especially for sectors like aquaculture that operate 24 hours and require power beyond sunlight hours, where solar energy is insufficient.
B4	Aquaculture	51 to 250 Employees	10 to 43 Million	The company produces healthy seafood through sustainable aquaculture, reducing Europe's reliance on imports. It promotes animal welfare, resource efficiency, and aims to set sustainability standards. By lessening the impact on wild fish stocks and the environment, it ensures high-quality, safe fish, supports local development, and creates skilled jobs.
B5	Fishing; Port Activities	More than 250 Employees	10 to 43 Million	The State-Owned Enterprise, overseen by the Ministries of Agriculture and Fisheries and Finance, operates fishing ports and fish auctions, provides first-sale services of fish, and manages support infrastructures. It also engages in ice and cold storage production. Known for innovation, modernization, and sustainability, the company ensures compliance with public service requirements in fish auctions and manages fishing ports as a port authority.

Source: Own elaboration, company size, sector, and turnover based on survey responses; mission statements retrieved from company websites.

Figure 4.1 - Word Cloud of the core Values of the case studies

Source: Own elaboration, NVivo output.

The word cloud reveals the normative framing of sustainability within the case study firms. Dominant values such as innovation, sustainability, and responsibility suggest an orientation toward practices that are both eco-conscious and economically viable. Collaboration, transparency and integrity signal a strong ethical business conduct and stakeholder engagement, while resilience and equity reflect adaptive capacity and inclusion, concepts that align with Social Capital Theory (Dodd *et al.*, 2015).

This outward projection of values supports Resource-Based View (Barney, 1991), wherein competitive differentiation stems from unique internal capabilities. Nevertheless, given the dynamic nature of the BE, these capabilities must be continuously reconfigured, aligning with the Dynamic Capabilities Theory (Teece *et al.*, 1997). The strategic framing of values by the five firms reflects an intent not just to comply, but to lead sectoral transformation.

4.4.2. Overview of Sustainability and Innovation Strategy

Based on triangulated evidence from semi-structured interviews, company websites, and survey responses, the integration of sustainability within these firms' strategies emerges not merely as a response to external pressures, but as a deeply rooted organizational philosophy. NVivo coding revealed strong convergence between leader narratives, public mission statements, and strategic sustainability actions. Across the interviews, a consistent pattern was observed: sustainability is not driven by regulatory compliance or transient trends, but by the personal convictions of the firms' top leadership.

The owner of B2 remarked, *"Sustainability is not an optional goal, it is embedded into every stage of our product development… It has always been my dream to close the water cycle"*.

The CEO of B1 mentioned "… *I don't know, out of conviction or maybe even DNA, I have always placed great importance on the theme of sustainability"*.

The influence of senior leaders' values and experiences is clearly reflected in the strategic orientations of these firms, particularly in how they integrate sustainability into innovation. This pattern aligns with the assumptions of Upper Echelons Theory (Hambrick & Mason, 1984), which posits that organizational outcomes are shaped by top executives' personal characteristics and beliefs. This confirms that sustainability-committed leaders are more likely to integrate sustainability into strategy, not just for compliance or market advantage, but as a core value (Bennett *et al.*, 2018).

Each firm's innovation trajectory reflects a strategic approach tailored to its sustainability goals. These innovation types were identified through a combined analysis of interview narratives, NVivo-coded responses under "Innovation Strategy", and corresponding organizational materials available on institutional websites:

- B1 applies incremental innovation (Anderson & Tushman, 1990; Schumpeter, 1934), rather than completely redefining maritime transport, B1 builds upon existing naval engineering practices, introducing step-by-step advancements that transition away from fossil fuels.
- B2 employs explorative innovation (Benner & Tushman, 2003; March, 1991), venturing into new technological frontiers with biological water and gas treatment systems, using microalgae and leveraging biomimicry and experimental environmental solutions.
- B3 represents radical innovation (Anderson & Tushman, 1990; Schumpeter, 1934), revolutionizing wind energy generation by designing compact, decentralized wind turbines. Unlike conventional wind farms, their disruptive approach introduces a fundamentally new application of wind energy.
- B4 uses exploitative innovation (Benner & Tushman, 2003; March, 1991) to refine closed-loop water systems and boost production efficiency in aquaculture. Their focus on alternative feed ingredients and sustainable farming techniques

shows their commitment to improving existing practices rather than pursuing radical change.

- B5 also follows exploitative innovation (Benner & Tushman, 2003; March, 1991), integrating digital traceability systems and eco-friendly port infrastructure upgrades into fisheries management. Rather than introducing new, disruptive technology, B5 enhances and refines existing industry practices, improving efficiency, compliance, and sustainability outcomes.

Altogether, these findings illustrate that innovation is not an isolated function but a continuous, integrated process where technological advancement, resource efficiency, and resilience converge to form sustainable business models (Geissdoerfer *et al.*, 2018; Porter & Kramer, 2011).

4.4.2.1 Environmental Sustainability

Drawing from both interview responses and institutional websites, environmental and survey responses, sustainability is central to these firms' strategies, with a focus on low-impact production, circular economy principles, and decarbonization, aligning with global frameworks like the Paris Agreement (UNFCCC, 2015) and the EU Green Deal (European Commission *et al.*, 2024).

According to the survey, 87% of firms indicated that environmental sustainability is either "important" or "very important" in their strategic planning, aligning closely with the emphasis found in the interview data.

Decarbonization and renewable energy integration is one of the most significant approaches to environmental sustainability. B4's solar-powered infrastructure reduces carbon emissions by 35%, coupled with oxygen generators that eliminate liquid oxygen transport.

B5 has made strides in transforming its operations through sustainable port management initiatives, integrating renewable energy and energy-efficient systems to decarbonize operations "*We are committed to transparency, fish traceability, and supporting the conservation of marine resources, aligning with national and European sustainability policies"*. Traceability systems for fisheries management help prevent overfishing, ensuring that marine resources are harvested responsibly (FAO, 2020).

Carbon sequestration and circular economy solutions beyond energy efficiency, innovating solutions that actively reduce or offset carbon emissions. B2 has developed photobioreactors that capture CO_2, demonstrating an innovative approach to negative carbon footprint technology. This approach reflects the principles of nature-based solutions advocated in climate mitigation strategies, where biological processes, such as algae-based CO_2 absorption, help counteract industrial emissions (Pathak, 2019).

B4's land-based aquaculture model also contributes to marine conservation by preventing fish escape into the wild, a common issue in open-sea fish farming that can disrupt native ecosystems. By keeping production 100% on land and recycling seawater, mitigating risks related to genetic contamination and habitat destruction.

These efforts are further validated by survey findings, which show that 60% of the firms reported implementing green technologies, and 45% reported using renewable energy systems. The commitment of these firms to environmental sustainability is not just a compliance measure but an innovation-driven competitive advantage. By integrating innovative renewable energy solutions, carbon sequestration technologies, and circular economy models, these companies are actively redefining industry standards.

4.4.2.2 Economic Sustainability

Economic sustainability within the Blue Economy is intricately linked to innovation, resource efficiency, and long-term financial resilience. Interviewees consistently emphasized, corroborated by survey responses to the item on economic impacts of sustainability, that sustainability and profitability are mutually reinforcing (An & Li, 2020). By reducing operational costs, diversifying revenue streams, and differentiating through environmental leadership, these businesses demonstrate how sustainable practices drive economic value (Geissdoerfer *et al.*, 2018; Flores *et al.*, 2008).

Cost reduction through efficiency is a common strategy. B2's cork-based water systems require only annual maintenance, significantly lowering operating expenses, while B4 has seen revenues grow from €15 million to €40 million through efficiency gains and technology integration. Market expansion is also supported by sustainability-driven differentiation, B5's campaigns to promote undervalued fish species have raised their market value, benefiting both the company and local fishing communities.

In addition to growth, sustainability initiatives help mitigate financial risk. Companies investing in renewable energy and circular business models are better positioned to manage rising energy costs and regulatory changes. As B1 noted, *"Our electro-solar vessels ensure long-term financial stability in a future where fossil fuel dependency is no longer viable"*. B4's strategic approach *"We have been investing in R&D … and we are positioning ourselves ahead of the curve"*.

Survey data confirms this focus on cost-saving innovation, with over 70% of firms identifying reduced operational costs as a major benefit of SOI. These findings highlight that economic sustainability is not just about cost-cutting but also about strategic investments that ensure long-term profitability. By integrating sustainability at the core of their business models, market strategies, and innovation pipelines, these companies are future-proofing their operations while maintaining strong financial performance. These businesses illustrate their ability to balance economic viability with environmental responsibility and serves as a model for industries worldwide seeking to transition toward a more sustainable and regenerative economic framework.

4.4.2.3 Social Sustainability

Social responsibility is an essential element of sustainability, encompassing aspects beyond profit like community well-being, ethical practices, and inclusive development. The firms examined exhibit social engagement through collaborations with local organizations, workforce initiatives, and community-oriented projects, supported by interviews, coded values from firm websites (see Figure 4.1), and survey responses about social impact.

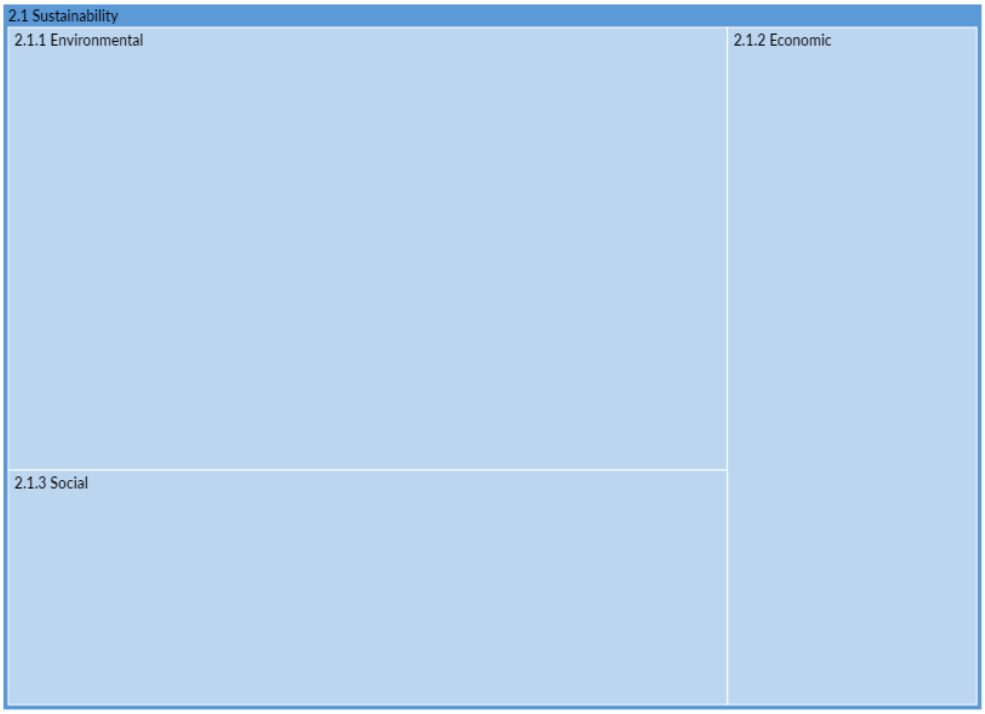
B5's weekly fresh fish donation program and support for small-scale fishermen illustrate how financial success can align with social impact. B2's floating cork islands not only address environmental challenges but also provide basic sanitation solutions in underserved communities, showing how eco-innovation can serve humanitarian purposes.

Internally, these companies foster employee well-being and inclusion. B4 has introduced programs to hire people with disabilities, along with free physiotherapy, fitness classes, and psychological support, reflecting a progressive approach to corporate social responsibility that links employee satisfaction to business success.

These initiatives prioritize employee health and well-being, demonstrating a progressive approach to corporate social responsibility (CSR) that recognizes the link between employee satisfaction, productivity, and business success. Beyond traditional CSR, some firms in this study have developed business models that actively solve social challenges (de Souza Barbosa *et al.*, 2023; Ismail, 2021).

The coding structure used in this chart was derived from predefined themes aligned with the TBL framework and validated through comparison with survey indicators. The NVivo hierarchy chart (Figure 4.2) reflects the relative frequency of interview references to each sustainability dimension. It is based solely on the qualitative coding of interview data. The chart highlights that while environmental sustainability dominates, social and economic dimensions are also significant, demonstrating a balanced commitment to holistic sustainability among Portuguese BE firms.

Figure 4.2 - Hierarchy Chart: Pillars of Sustainability



Source: Own elaboration, NVivo output.

The hierarchy chart shows that references to environmental sustainability account for approximately 48% of all coded references, with firms emphasizing decarbonization, renewable energy integration, and circular economy practices. Economic and social sustainability categories each represent around 26% of codes, with respondents

highlighting financial resilience, market positioning, community development, and employee well-being as key elements.

These proportions reflect the multidimensional nature of sustainability strategies adopted by the firms and illustrate a balanced, though environmentally weighted, approach to sustainable business practices (Kennedy & Bocken, 2020; Maier *et al.*, 2020).

4.4.2.4 Trade-off between Economic, Environmental and Social Sustainability

Balancing environmental, economic, and social sustainability is a key challenge for BE firms. While sustainability initiatives offer long-term competitive advantages, they often require substantial upfront investments. Interviewees consistently highlighted that sustainability is perceived as a cost in the short term but a strategic asset over time.

Companies recognize that investments in renewable energy, waste reduction, and responsible supply chains require upfront capital, but they lead to cost savings, efficiency gains, and stronger market positioning. As B4's CEO noted, *"I have to convince shareholders, but in most cases, the most sustainable option is also the most economical one in the long run"*. Similarly, B1 emphasized that high sustainability standards in vessel production are *"strategic and non-negotiable"* for financial optimization and customer satisfaction.

This qualitative evidence is strongly supported by the survey results: over 65% of firms rated economic sustainability practices (such as cost-saving innovation or diversification) as 'important' or 'very important', while over 70% agreed that environmental investments contributed positively to their long-term market position. This reflects how the perceived trade-off is not necessarily a zero-sum scenario, but rather a phased transformation where short-term costs yield long-term gains.

This highlights a common trade-off faced by sustainable businesses while environmentally friendly solutions often lower long-term costs and increase brand value, initial implementation tends to trigger financial strain, especially among SMEs. This confirms the dual framing of trade-offs as both a strategic decision (node 2.2.3) and a practical challenge (node 5.1.1 on financial resources). This can require significant initial investment that not all stakeholders immediately support (Matzembacher *et al.*, 2020). Firms see sustainability not as a cost, but as a way to boost efficiency, drive innovation, and create revenue opportunities.

Evidence from the case studies interviews shows that SOI not only prepares firms for future regulatory and resource challenges but also enhances efficiency and market resilience. One key factor in successfully balancing sustainability with financial health is engaging stakeholders, such as shareholders, investors, customers, and suppliers on the benefits of long-term sustainability investments (Kyvelou & Ierapetritis, 2019; Perrini & Tencati, 2006). This suggests that clear communication, financial modeling, and gradual implementation of sustainability measures can help reduce resistance to change and align stakeholders with long-term goals. This stakeholder dynamic also emerged in the interviews coded under the node 6.2 "Political and Regulatory Changes", where respondents emphasized the importance of external understanding and alignment.

4.4.3. Stakeholder engagement

4.4.3.1 Supplier Partnerships for Sustainable Sourcing

Ensuring sustainability throughout the supply chain emerged as a critical priority for the companies interviewed in this study. Several firms described taking proactive steps to encourage or pressure their suppliers to meet environmental standards particularly in areas such as carbon footprint reduction, responsible sourcing of raw materials, and waste minimization. This indicates an effort to diffuse sustainability practices beyond the firm's boundaries, influencing upstream actors within their value chain.

This demonstrates a top-down approach to supply chain sustainability, where companies function as change agents, encouraging their suppliers to adopt more transparent and environmentally responsible practices. As B4 shared, *"Suppliers weren't measuring their carbon footprint… I told them I wouldn't buy from them anymore if they didn't report it"*.

Most companies analyzed in this study operate in highly innovative sectors and, due to financial constraints and the novelty of their products, do not yet have the internal capacity to oversee all aspects of production and technological development in-house. As a result, collaborations with specialized suppliers have been imperative in bringing sustainable solutions to the market. These partnerships allow firms to leverage external expertise, access specialized technologies, and optimize production processes without bearing the full costs of internalizing every function. B2 noted, *"Our supplier network is crucial, they provide high-quality, eco-friendly materials that align with our sustainability principles"*.

These collaborations demonstrate that supplier engagement is not merely transactional but a catalyst for systemic change, supporting research by Schaltegger & Wagner (2017) on the role of collaborative networks in advancing sustainable innovation. The importance of supplier relationships also emerged in the NVivo coding structure under Node 4.1.2 (Figure 4.3), where 11 references were coded across five companies, indicating consistent attention to supply chain engagement as part of their SOI efforts.

Survey data reinforces this qualitative evidence: over half of the respondents indicated that collaboration with suppliers plays a moderate to high role in enabling their sustainability strategies, particularly in material sourcing and production optimization.

4.4.3.2 Community Partnerships and Social Impact

Beyond internal sustainability efforts, companies in the BE recognize the importance of actively engaging with local communities to promote environmental awareness and social responsibility. Many firms sponsor local projects, organize community initiatives to create a wider positive impact beyond their direct business operations.

For example, B5 has implemented education and awareness programs that directly involve local communities, ensuring that sustainability efforts extend beyond corporate operations to foster shared responsibility for marine conservation. *" We work with local fishermen and sector workers to provide training on best environmental practices, such as reducing fish waste and adopting selective fishing methods"*. B3 also runs community-driven projects that educate and engage the public on renewable energy solutions, while B4 sponsors regional initiatives to support community development and environmental sustainability.

These efforts illustrate how corporate sustainability extends beyond operational changes to active social engagement, reinforcing the idea that businesses must BE both economically successful and socially responsible. The recurrence of these themes across multiple interviews was also captured in the NVivo coding structure (Figure 4.3), with "Collaboration with Communities" emerging as a distinct node.

4.4.3.3 Collaboration with Universities and R&D Facilities

One of the key challenges businesses face in sustainable innovation is the lack of skilled professionals with expertise. To bridge this gap, many companies have developed strong

partnerships with universities and research institutions, ensuring access to knowledge, talent, and cutting-edge research.

Collaborating with academic institutions allows businesses to fill the void left by a lack of specialized workforce, while also ensuring that new technologies are developed and assessed in alignment with industry needs. All firms interviewed have actively engaged with universities and research centers, forming partnerships that support R&D, workforce development, and innovation scaling.

B4 noted, *"We work with universities to bring students into real-world sustainability projects, students gain experience, and we benefit from fresh ideas"*. Similarly, B1 and B2 emphasized that academic collaborations help refine technologies and keep companies at the forefront of innovation. B2 on research partnerships *"We collaborate with research institutions because sustainability is an evolving field. If we want to stay ahead, we need to be constantly learning and developing new solutions with academic experts"*.

These partnerships have yielded tangible outcomes, including the co-development of photobioreactors, sustainable aquaculture systems, and renewable energy solutions. B2 highlighted that their floating cork islands *"stem from long-term research collaborations, blending ecological materials with efficient water treatment"*.

By leveraging the expertise of academia and research facilities, companies ensure that their sustainability initiatives are not only scientifically validated but also commercially scalable, reinforcing the link between knowledge generation and industry impact. Stakeholder engagement plays a pivotal role in ensuring that sustainability efforts are holistic, impactful, and scalable (Pace *et al.*, 2023a). This strategic relevance is reflected in the NVivo coding output, which shows that collaborations with universities and R&D centers had the highest frequency of references across all external engagement categories (Figure 4.3).

By leveraging the expertise of academia and research facilities, companies ensure that their sustainability initiatives are not only scientifically validated but also commercially scalable, reinforcing the link between knowledge generation and industry impact. This strategic relevance is reflected in the NVivo coding output on figure 4.3, which shows that collaborations with universities and R&D centers had the highest frequency of references across all external engagement categories. Furthermore, 68% of the surveyed

firms reported formal partnerships with academic or research institutions, confirming the widespread role of knowledge exchange in advancing sustainable innovation.

Figure 4.3 - NVivo Hierarchy Chart: External Collaborations and Stakeholder Engagement

Source: Own elaboration, NVivo output.

4.4.4. Barriers Toward Sustainable Innovation

4.4.4.1 Financial Constraints: The Cost of Sustainability

One of the most prominent barriers to sustainable innovation, as highlighted during the interviews, is financial limitation. While participants acknowledged that sustainability represents a long-term investment, they also emphasized that the high upfront costs associated with clean technologies, renewable energy, and sustainable supply chains often place significant strain on financial resources, particularly for smaller firms.

B4 highlighted the need to *"convince shareholders"* of long-term returns, while B2 noted that *"banks and investors still see sustainable technologies as risky"*, making financing harder to obtain. Compounding this challenge, government funding programs often require businesses to co-finance a portion of investments. As B1 explained, *"Most funding programs cover around 75% of costs. For small companies, finding the remaining 25% can be impossible"*. This requirement disproportionately affects startups

and SMEs, which may not have access to the financial counterpart necessary to qualify for funding, effectively excluding them from sustainability incentives.

This financial gap creates a paradox, while sustainability is encouraged through incentives, the lack of complementary financial assistance means that many businesses cannot afford to take advantage of them. B3 noted that for startups, even partial self-financing can be *"a deal-breaker"*. In capital-intensive sectors, these constraints slow innovation, with firms relying on incremental progress or private partnerships.

These qualitative findings are reinforced by the NVivo analysis, where references to "financial resources" emerged as one of the most frequently coded nodes within the Barriers category (see Figure 4.4). This is further substantiated by the survey results, where 62.5% of respondents identified "limited financial resources" as a primary obstacle to implementing sustainable practices. Notably, among SMEs (firms with fewer than 50 employees), the percentage rises to 70%, confirming the disproportionate impact of funding gaps on smaller enterprises.

These difficulties reflect broader patterns identified by Boons & Lüdeke-Freund (2013) who highlight that despite long-term benefits, the financial burden of green innovation often deters investment. Addressing this barrier will require more inclusive funding mechanisms and financial instruments that prioritize long-term sustainability over short-term returns.

4.4.4.2 Lack of Human Resources and Skilled Workforce

Another common challenge identified is the difficulty in finding skilled professionals who specialize in sustainable innovation. Many companies report a gap in the labor market, where expertise in SOI is scarce and expensive to acquire.

B3 on the competition for sustainability talent *"Every company is looking for sustainability experts, but there aren't enough of them. The few who are available are often recruited by large corporations that can afford and offer higher salaries"*.

This shortage of sustainability professionals, engineers, and researchers slows down innovation, as companies are forced to invest additional time and resources in employee training and knowledge-building (Pace *et al.*, 2023a). Not only this, but the financial constraints are interconnected as they often cannot also compete with higher salaries that

are offered by larger corporations. Moreover, this challenge is tightly interlinked with financial constraints, as smaller firms struggle to compete for top talent in a market dominated by larger, better-resourced organizations.

This barrier was also strongly reflected in the survey results: 42.5% of firms reported difficulty in hiring personnel with sustainability-related technical expertise, while 30% highlighted internal training as a necessary but burdensome strategy to fill knowledge gaps. NVivo coding supports these findings, with "Expertise and Human Resources" emerging as a significant node within the challenges category (Figure 4.4). Respondents frequently emphasized the lack of available qualified professionals as a bottleneck to scaling sustainability initiatives. Together, these data streams reveal that talent scarcity is not only a standalone issue but also a systemic constraint that slows down the internalization of sustainability capabilities across the sector.

4.4.4.3 Lack of Government Support and Policy Incentives

While governments often position themselves as advocates of sustainability, many firms in the BE have encountered significant challenges when dealing with public funding mechanisms, procurement policies, and institutional inefficiencies. These barriers not only slow down innovation but also create financial strain for businesses that rely on government support to develop and scale their sustainable technologies.

The most common frustration centers on the *Fundo Azul* program, which operates on a reimbursement basis, forcing SMEs to front large investments without timely government repayment. As B1 explained, *"The reimbursement process takes so long that we've had to find alternative financing … we're still waiting on payments over a year later"*. Some interviewees also described this occurrence as very limiting to their ability to execute or scale sustainability projects, noting that excessive delays and administrative complexity created uncertainty and reduced the effectiveness of public funding mechanisms.

As a result, many firms are pushed to seek private financing, delay planned initiatives or reduce the scope of their sustainability efforts. Another common grievance is that even companies that have patented innovative sustainable solutions, often struggle to gain traction in the domestic market, as government institutions and public projects favor foreign suppliers over Portuguese manufacturers, B1 shared, *"The last boat purchased*

for a sustainable project was Spanish, failing the required specifications, but chosen for its lower price".

For SMEs, filing patents is a costly process, and without government-backed financial valorization, these businesses often struggle to convert their intellectual property into profitable ventures. Additionally, companies face inconsistent regulatory demands, with shifting requirements for environmental studies and certifications causing costly delays and uncertainty. As B4 noted, *"We waited two years for approval due to changing mandates on environmental impact studies, wasting time, money, and resources".*

These concerns are reflected in the survey results: 70% of firms rated the impact of sustainability practices on licensing, certification, or funding processes as "high" or "very high", confirming that regulatory procedures are widely perceived as obstructive. NVivo analysis reinforces these patterns: "Bureaucracy and Government Inefficiencies" was the most frequently coded node within the barriers theme, reflecting widespread frustration with institutional sluggishness, opaque procedures, and lack of inter-agency coordination (Figure 4.4).

Unpredictable changes in government policies cause delays, financial losses, and operational uncertainty. Companies face a cycle of enforcement and rollback of environmental regulations, creating bureaucratic inefficiency that hampers progress. These issues align with institutional transition challenges (Kemp *et al.*, 2007) by underscoring the importance of regulatory stability, timely support mechanisms, and consistent policy enforcement to ensure efficiency, trust, and progress in the BE.

4.4.4.4 Market Challenges and Consumer Misunderstanding of Sustainable Products

One persistent challenge for sustainability-driven businesses is the market's prioritization of cost over environmental benefits. Despite offering eco-friendly solutions, firms in the BE often face consumers who make purchasing decisions based on price. As B4 noted, *"At the end of the day, the price of the fish is what matters most... The EU survey positioned price, with 55%, as the most important factor for consumers, with sustainability last".*

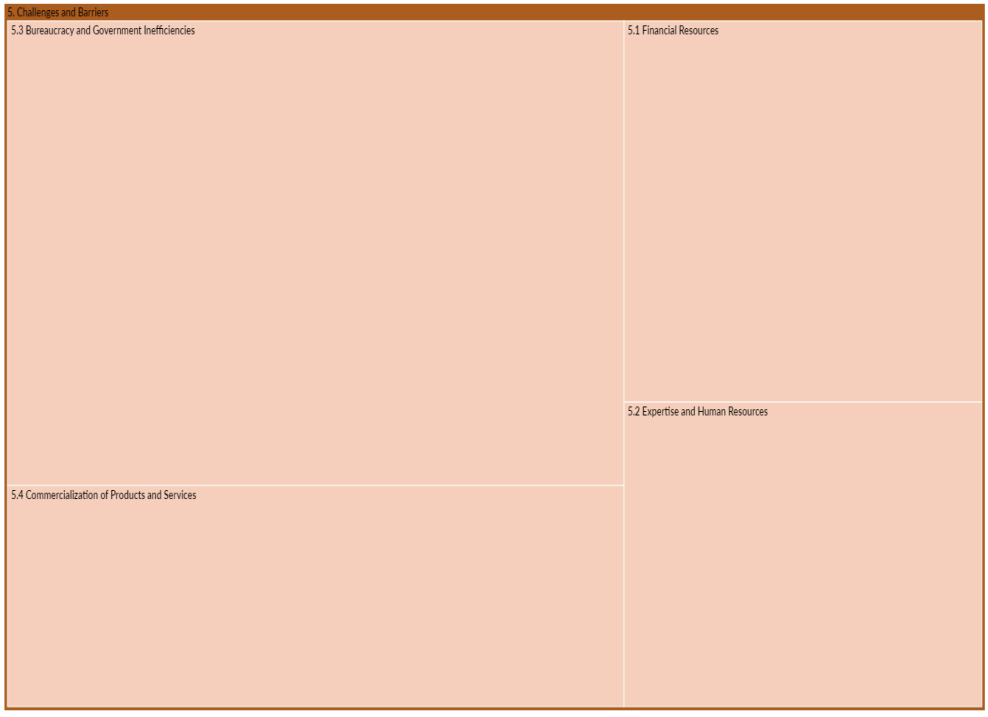
This disconnect limits the ability to secure price premiums for sustainable products, reducing incentives for continued innovation. Moreover, customers often fail to recognize

long-term financial benefits, requiring firms to invest in education. As B1 explained, *"We constantly explain that our boats pay for themselves through fuel savings in six years"*.

The difficulty in selling radical innovation, as B2 highlighted, stems from skepticism toward unfamiliar solutions. Market resistance to sustainability involves financial issues, perception, familiarity, and trust. Consumers assess new technologies based on potential benefits and barriers, affecting resistance and innovation success (Claudy *et al.*, 2015). Davies & Chambers (2018), found that sustainable products/services are often more expensive, leading to tension due to consumers' unwillingness to pay extra costs.

NVivo coding confirms that "Commercialization of Products and Services" emerged as a salient barrier in interview data, particularly regarding the difficulty of communicating the added value of sustainability features and overcoming entrenched consumer misconceptions (Figure 4.4). This qualitative evidence underscores that the success of sustainable business models depends not only on internal innovation but also on the pace at which consumer mindsets evolve, especially regarding value, durability, and long-term benefits.

Figure 4.4 - NVivo Hierarchy Chart: Challenges and Barriers



Source: Own elaboration, NVivo output.

Figure 4.4 provides a visual summary of the most cited barriers to sustainable innovation, highlighting the salience of bureaucratic inefficiencies, financial constraints, and commercialization challenges. These coded themes reflect the structural and cognitive obstacles that firms must navigate, pointing to the need for targeted interventions that address both institutional rigidity and market readiness.

4.4.5. Opportunities and Incentives for Sustainable Innovation

4.4.5.1. External Incentives and Financing

While financial constraints remain a barrier, there are increasing opportunities for sustainable financing, particularly through European Union funds, sustainability grants, and green investment initiatives. Companies that align their business models with TBL principles are more likely to attract impact investors and funding from sustainability-focused financial institutions.

The European Union has launched several funding mechanisms, through the EU Green Deal and BE Funds, aimed at supporting sustainable businesses, such as the Horizon Europe program, which provides grants for innovation in renewable energy, water conservation, and circular economy models. By participating in carbon credit markets and obtaining sustainability certifications, certain companies are capitalizing on their environmental initiatives. These efforts enable them to charge a premium for products that are certified as environmentally friendly.

Regarding this dimension, B4 highlighted the positive role of sustainability grants and funding programs in enabling innovation. "*We successfully applied for EU sustainability funding, which helped us implement energy-efficient systems in our aquaculture facilities. Without this support, we wouldn't have been able to make these upgrades so soon… in the last four years, around three million euros invested in R&D through approved projects".*

NVivo coding confirms the relevance of this theme, with "External Incentives and Funding" frequently cited by interviewees as a critical enabler of sustainable business model innovation. Furthermore, survey results corroborate this trend, with 62.5% of firms reporting having accessed national or EU sustainability funding, indicating that financial opportunity, when accessible, is already playing a practical role in scaling sustainable innovation. This triangulated evidence underscores that while funding gaps remain a key

barrier for many, targeted external support mechanisms can significantly accelerate sustainability transitions.

4.4.5.2. Political and Regulatory Changes

As climate change becomes a global priority, political landscapes are shifting toward stronger regulations that promote green business practices. Companies that adapt can gain competitive advantages, however excessive bureaucracy and regulatory uncertainty often hinder innovation.

Governments are introducing carbon reduction targets, emissions trading systems, and sustainability reporting. While such policies create incentives, firms emphasize the need for streamlined processes to avoid delays and inefficiencies. Some countries are beginning to favor local, sustainable businesses in public procurement, but as B2 noted, *"We develop sustainable solutions, but when bidding for government projects, we are often buried in paperwork"*.

Subsidies and tax incentives for renewable energy and waste reduction offer financial support still accessing them remains complex. B3 highlighted, *"There are incentives, but applying is incredibly complicated. If the government wants businesses to adopt sustainability, they need to make access to funds faster and more transparent"*.

NVivo coding supports these claims, with "Policy and Regulatory Barriers" repeatedly referenced by interviewees, not only in relation to bureaucratic delays but also procedural opacity and lack of coordination among institutions.
Moreover, survey data reinforces this perception: over 60% of respondents rated regulatory complexity as a "high" or "very high" barrier to innovation, and nearly half reported direct experience with delays in licensing or public funding access.

These challenges reflect broader critiques identified by Ecological Modernization Theory (Mol & Sonnenfeld, 2013), which emphasizes the need for coherent institutional frameworks and streamlined policy mechanisms to enable sustainable innovation.

4.4.5.3. Recommendations for Companies Pursuing Sustainability

The experiences of the five case study firms offer empirically grounded perspectives on how companies can effectively pursue SOI in contexts of regulatory uncertainty, financial constraint, and evolving market expectations. Rather than prescribing generic best

practices, the recommendations below highlight strategic lessons derived from real business adaptations, supported by both interview data and the comparative analysis of cases.

Embrace Incremental Innovation as a Strategic Entry Point

For firms with limited resources or high technical risk, incremental innovation, such as B1's stepwise vessel improvements or B4's aquaculture system optimization, offered a manageable entry point. These exploitative strategies build operational legitimacy and reduce resistance, serving as a platform for future scaling. Rather than viewing radical innovation as the only path, sustainability transitions can begin with smaller, high-leverage interventions that generate early proof of concept and stakeholder alignment.

Repurpose Existing Technologies Through Strategic Integration

B1 and B3 illustrate how adapting existing technologies can be just as transformative as inventing new ones. This reflects a dynamic capabilities logic: by integrating mature technologies into novel systems (e.g., electro-solar propulsion, urban wind), firms reduce R&D risk and time-to-market. The key lies not in technological novelty but in strategic integration that aligns with environmental performance goals.

Build Financial Resilience Beyond Grant Dependency

While public funding plays an important catalytic role, long-term strategic viability demands internal value creation. B1's framing of public funds as "a bonus, not the foundation" reflects a maturing sustainability mindset. Firms that develop self-sustaining models, via efficiency gains, niche differentiation, or stakeholder trust, are better positioned to withstand delays in reimbursement or shifts in policy.

Prioritize Strategic Flexibility and Iteration

Sustainability transitions are inherently uncertain. B2's approach of pursuing multiple innovation tracks and adjusting based on impact metrics illustrates the value of agility. Especially in early-stage markets, firms benefit from maintaining adaptive capacity, experimenting, learning, and pivoting as necessary, rather than locking into a single trajectory too early.

Use Collaborative Networks to Accelerate Learning and Scale

Across cases, external partnerships, whether with universities (B4), suppliers (B2), or public institutions (B5), were essential for bridging capability gaps. These ecosystems

reduce innovation costs, legitimize emerging technologies, and foster the co-production of knowledge. For SMEs in particular, collaboration offers a scalable alternative to internal R&D and accelerates time-to-impact.

Invest in Consumer Education and Demand Shaping

Technological innovation alone is insufficient when consumers lack awareness or trust. Both B2 and B5 emphasized the need to actively educate stakeholders, highlight life-cycle benefits, and overcome skepticism. This form of market engagement is central to diffusing eco-innovation and aligns with strategic marketing and branding approaches in sustainable business.

Diversify Financing Sources and Align with SDGs

Firms that proactively sought out alternative capital sources, such as EU green funds, carbon credit markets, or impact investors, were able to scale without sacrificing operational autonomy. Aligning business proposals with sustainability metrics not only increases funding eligibility but also enhances credibility among partners and end-users.

These strategic lessons reflect how innovation, resilience, and collaboration are co-constructed under constraint. They underscore that SOI in the BE is not a linear or templated process, but rather a negotiation of trade-offs, partnerships, and long-term positioning. To synthesize the findings, table 4.3 offers a comparative overview of the five case study firms, summarizing their innovation types, sustainability priorities, strategic enablers, key barriers, and distilled takeaways.

Table 4.3 - Comparative synthesis of the five case study firms, summarizing their innovation approaches, sustainability priorities, key enablers and barriers, and synthesized strategic lessons from real business practices.

Firm	Innovation Type	Sustainability Focus	Key Enablers	Main Barriers	Strategic Takeaway
B1	Incremental	Renewable marine transport	Technology recombination; visionary leadership	Bureaucratic delays; co-financing requirements	Adapt mature technologies to niche markets and reduce risk via incremental gains
B2	Explorative	Biomimicry-based water and air systems	R&D collaboration; mission-driven values	Consumer skepticism; scaling radical tech	Pair disruptive innovation with education and adaptive experimentation
B3	Radical	Decentralized wind energy	Product differentiation; lean structure	Talent scarcity; limited capital	Balance ambition with financial discipline and agile adaptation
B4	Exploitative	Closed-loop aquaculture & solar-powered efficiency	Public funding; CSR embeddedness; operational scale	Regulatory complexity; shareholder resistance	Use incremental change and grants to build proof and gain legitimacy
B5	Exploitative	Port decarbonization; digital traceability	Public mandate; stakeholder trust	Institutional rigidity; procurement bias	Leverage institutional legitimacy to shape market expectations and policy

Source: Own elaboration.

4.5. Conclusion: Advancing Sustainable Innovation in the Blue Economy

The strategic practices of five Portuguese Blue Economy firms illustrate how SOI becomes embedded within day-to-day business decisions, shaped by contextual realities, constrained by institutional barriers, and activated through collaboration. Drawing on triangulated evidence from semi-structured interviews, publicly available information, such as the institutional websites, and survey data, this article examined how sustainability is translated into operational practice, the barriers faced, and the extent to which their approaches offer scalable solutions for the sector.

Across all five cases, SOI emerges not as a symbolic commitment but as a strategic orientation, woven into product development, resource choices, and partnership strategies. Firms implement sustainability through a combination of circular economy principles, renewable energy integration, and process innovation, each tailored to environmental performance and long-term competitiveness. These practices are not uniform, but they share a common feature: they reframe sustainability from a compliance burden into a value-generating logic. Strategic alliances with research institutions, universities and ongoing engagement with local communities were consistently identified as structural enablers, not add-ons, critical for aligning innovation efforts with broader sustainability objectives (Davies & Chambers, 2018; Elkington, 1998).

These efforts are complemented by technological advancements, such as CO_2-capturing systems and renewable energy integration, which support environmental goals while preserving economic feasibility. These reflect not only the firms' operational pragmatism but also theoretical dynamics such as Schumpeter's creative destruction (Pfarrer & Smith, 2015), Green Innovation pathways (Rennings, 2000), and the ongoing Energy Transition (Verdolini *et al.*, 2021).

The analysis also reveals the tension between internal innovation capacities and external structural limitations. Enabling factors, such as knowledge exchange with universities, proactive stakeholder engagement, and the strategic reframing of sustainability as a competitive differentiator, are often undercut by persistent barriers. These include delayed reimbursements from public funding mechanisms, administrative burdens in licensing processes, and limited access to flexible financing, particularly for SMEs. These challenges mirror longstanding tensions in the literature on hybrid organizations (Moizer & Tracey, 2010; Stubbs & Cocklin, 2008), which grapple with reconciling financial

viability and mission-driven environmental and social objectives. The complexity of value capture, especially for firms pursuing and balancing social and environmental goals alongside profitability, remains a central difficulty (Wilson & Post, 2013). Regulatory fragmentation compounds these challenges (OECD, 2024, 2019), confirming the explanatory relevance of Institutional Theory in understanding how policy uncertainty diminishes firms' willingness to invest (Scott, 2008).

Certain practices, such as bio-based production systems, renewable energy integration, and closed-loop aquaculture, demonstrate high transferability under the right institutional and financial conditions. Nevertheless, replicability is contingent upon firm-specific capacities, access to specialized knowledge, and the stability of support mechanisms. From a theoretical perspective, the Resource-Based View helps illuminate why some firms achieve greater innovation traction: it is their embedded capabilities, accumulated learning, and stakeholder networks that create defensible advantage. The observed variation in adoption patterns also aligns with principles from diffusion theory, highlighting how firm size, absorptive capacity, and external legitimacy shape the pace of uptake. In parallel, inclusive governance and hiring practices signal the relevance of social capital in reinforcing trust, cohesion, and resilience, elements that may prove critical for sustaining long-term transitions in fragile coastal economies.

From a theoretical perspective, Dynamic Capabilities Theory (Teece *et al.*, 1997) offers a compelling lens for understanding why certain firms gain greater traction in innovation, it is their embedded capabilities, accumulated learning, and ability to adapt and reconfigure resources in response to changing environments that create defensible advantage. The observed variation in adoption patterns is also consistent with diffusion theory (Rogers *et al.*, 2019), highlighting how firm size, absorptive capacity, and external legitimacy shape the pace of uptake. In parallel, inclusive governance and hiring practices signal the relevance of social capital in reinforcing trust, cohesion, and resilience (Dodd *et al.*, 2015), elements that may prove critical for sustaining long-term transitions in fragile coastal economies.

Methodologically, the study’s conclusions are grounded in a robust triangulation of data sources. Interviewees perceptions were systematically cross-validated with publicly available corporate materials and prior survey data, allowing for a multi-layered understanding of how firms articulate and enact sustainability. This approach not only

enhances the internal validity of the analysis but also offers a replicable model for studying sustainability transitions in context-specific, industry-embedded settings.

At a broader level, the research points out how firms navigating the Blue Economy operate within hybrid institutional spaces, balancing environmental, economic, and social goals amid fragmented governance and uncertain funding landscapes. While frameworks such as Ecological Modernization (Mol & Sonnenfeld, 2013) and Market-Based Environmental Governance (Cashore, 2002) suggest that innovation can reconcile competing imperatives, the empirical reality underscores that such reconciliation depends on enabling ecosystems: stable regulation, strategic funding instruments, and cross-sectoral alignment. In their absence, even the most advanced innovations risk being constrained by context rather than propelled by it.

Building on the theoretical frameworks explored above, these findings carry direct policy implications rooted in empirical observation. The frictions and enablers identified across the five case studies directly inform the following recommendations, underscoring the need for structural reforms that align with the real-world dynamics of Blue Economy firms. Existing reimbursement-based funding models should be reconsidered in favor of more agile, upfront financing structures that lower barriers for smaller firms. Public procurement policies, the process through which the state acquires goods and services, should be strategically leveraged to prioritize domestic sustainable innovations, and greater coordination across regulatory bodies is essential to reduce administrative redundancy (Mazzucato, 2018). These recommendations are grounded not in abstract policy theory, but in the concrete frictions repeatedly cited by firms at the forefront of sustainable innovation in Portugal's maritime economy.

Companies that embed sustainability as a strategic orientation, rather than as a reactive response to compliance, display a stronger capacity to navigate uncertainty, establish strategic partnerships, and develop resilient forms of competitive differentiation. In the cases examined, several companies achieved this through brand identity, trust-building with stakeholders, and innovation continuity despite delays in public support. University collaborations helped bridge technical knowledge gaps (Markard *et al.*, 2012), supplier partnerships facilitated access to sustainable technologies and resources, and community engagement enhanced legitimacy, all reinforcing the relevance of stakeholder theory and the integrative logic of the TBL (Freeman & McVea, 2005; Elkington, 1998).

This research has reinforced the need to critically interrogate the assumptions embedded in sustainability theory, particularly regarding scale, replicability, and equity. It also highlights the importance of methodological triangulation and context-sensitive analysis in capturing the complexity of sustainability transitions within industry. While the cases studied demonstrate promising practices, they also expose systemic limitations that require more than firm-level action, pointing to the need for integrated, multi-level approaches to sustainable development in the Blue Economy.

Reflecting on the empirical evidence, this study reinforces that SOI cannot be reduced to linear models or singular explanatory frameworks. Instead, it is a negotiated, context-specific process shaped by institutional fragmentation, resource constraints, and strategic trade-offs. The comparative analysis of the five case studies reveals how innovation often emerges from constraint rather than abundance, illustrating the creative and adaptive strategies firms use to align values with operations. This underscores the need for multi-level, ecosystem-aware approaches to sustainability and innovation. In doing so, the study advances theoretical discussions around business model innovation and institutional adaptation in ocean-based industries.

In theoretical terms, this study contributes to discussions on business model innovation, strategic hybridity, and stakeholder-based value creation in the context of ocean-based industries. It also sheds light on how firms develop adaptive strategies under institutional uncertainty and resource constraints, a relevant concern in strategic management literature. Practical contributions include actionable evidence on the conditions that enable or hinder sustainability transitions in a high-dependency coastal nation.

While the research yields context-rich evidence, it is important to acknowledge its scope. The five case studies, selected for their relevance and diversity, offer comparative perspectives but do not claim statistical representativeness. Future research could expand this inquiry by incorporating additional case studies across geographies and subsectors, and by further exploring how policy networks, international trade, and global market dynamics influence strategic responses to sustainability imperatives. Only through such cumulative work can the Blue Economy shift from isolated good practices to a systemic transformation.

Acknowledgements: The authors acknowledge the support and collaboration of all individuals interviewed and surveyed within the Portuguese Blue Economy. J.E. research was funded by FCT with the grant agreement ID: 2024.01284.BD. H.P. is supported by the FCT (UIDB/04020/2020 and CEEC—INST/00052/2021/CP2792/CT0001).

Declaration of competing interest: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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CHAPTER 5 – GENERAL CONCLUSION

5.1. Summary of Main Findings

The empirical and conceptual work presented in this thesis contributes to an evolving understanding of how firms navigate the interconnected challenges of sustainability and innovation within the institutional terrain of the Portuguese Blue Economy. Rooted in the fields of strategic management and institutional theory, the analysis foregrounds Sustainability-Oriented Innovation (SOI) not merely as a set of technical adjustments, but as a strategic and organizational response to complex and often contradictory demands arising from environmental risk, regulatory fragmentation, and evolving stakeholder expectations.

This section revisits the research questions that guided the thesis, drawing on findings from all three empirical studies. While each study focused on different aspects of sustainability and innovation in the Blue Economy, their findings intersect across the research questions, allowing for an integrated synthesis. First, in response to the research question posed in Chapter 2, How innovation contributes to the development of sustainable practice in the Blue Economy?, and what barriers hinder its broader adoption?, the thesis finds that innovation is both a reactive and generative mechanism. Particularly in ecologically sensitive sectors such as fisheries, marine logistics, and those heavily dependent on ecological stability (e.g., coastal tourism), innovation functions as a conduit through which firms reinterpret compliance requirements, market signals, and legitimacy imperatives into strategic choices (Douma & Schreuder, 2017). This challenges linear models of innovation adoption and instead supports a more embedded view of innovation as shaped by institutional architectures and organizational capacity.

In examining how innovation contributes to the development of sustainable practice in the Blue Economy, the research shows (based on case study evidence) that adaptation is often driven by immediate exposure to resource depletion or ecological risk. However, the nature of the innovation adopted tends to be incremental rather than radical. This aligns with literature review findings from Chapter 2, which highlight that SMEs often lack both the absorptive capacity and financial flexibility to implement systemic changes. Barriers to broader adoption include institutional overload, where overlapping policy frameworks and short time horizons undermine consistency (Laranja & Pinto, 2023), limited financial and absorptive capacity among SMEs (Rupo *et al.*, 2018; Voyer *et al.*,

2018), and the absence of sectoral coordination platforms capable of diffusing innovation (Vieira *et al*., 2021; Pinto & Nogueira, 2018; Fagerberg *et al.*, 2013). These observations are consistent with recent EU-level strategies under the European Innovation Agenda and Blue Economy Observatory, both of which emphasize cross-sectoral missions and inter-organizational learning (European Commission 2023, 2022; DGPM, 2021; Pinto *et al.*, 2015a).

Second, Chapter 3 explores the reverse dynamic: how sustainability acts as a driver of innovation, and how innovation mediates impacts across the Triple Bottom Line. Rather than acting solely as a constraint, sustainability often becomes a driver of strategic renewal, particularly for firms capable of reinterpreting environmental and social demands as opportunities for differentiation and future resilience. Firms, in this context, operate under hybrid logics, and often face hybrid tensions, as they balance economic imperatives with reputational risk, public accountability, and stakeholder engagement (Bocken *et al.*, 2014; Elkington, 1998). These logics are not static but evolve as firms interact with policy shifts, civil society expectations, and transnational sustainability frameworks such as the SDGs and the European Green Deal (European Commission, 2019). This finding reinforces the mission-oriented innovation literature (Mazzucato, 2015; Greenwood *et al*., 2008), which suggests that firms can align themselves with broader societal goals, provided that institutional infrastructures allow for such positioning.

Third, Chapter 4 investigates how firms operationalize SOI in real-world settings, based on qualitative data from five case studies of Portuguese Blue Economy firms. The evidence reveals considerable heterogeneity in how sustainability principles are embedded in business models, ranging from procedural compliance to strategic integration. Larger firms tend to have more formalized approaches, supported by access to formal R&D networks, international partnerships, and policy engagement. In contrast, many SMEs depend on informal knowledge flows and relational legitimacy at the local level. Despite the existence of coordination initiatives such as *Fórum Oceano*, these mechanisms are often underutilized as platforms for scaling and horizontal learning. The Atlantic Social Lab pilot studies corroborate that transformative capacity in these settings depends not only on technical innovation, but on distributed learning, digital infrastructures, and collaborative governance (Pinto *et al.*, 2023b, 2023c; Vieira *et al.*, 2021).

Taken together, the findings of this research point to a model of SOI that is emergent, situated, and institutionally embedded. Innovation in this context emerges not as a neutral or purely technical process, but as one that is socially situated and institutionally structured, shaped by multi-level governance architectures and sectoral logics (Adams *et al*., 2016; Mahoney & Thelen, 2010). Firms that are most effective in mobilizing innovation for sustainability are those that successfully navigate these layered institutional demands, often with limited resources and under conditions of uncertainty. Nonetheless, this remains an uneven and contested process, marked by institutional incoherence, capability asymmetries, and policy uncertainty (Laranja & Pinto, 2023; Geels, 2004).

In response, this research calls for a more integrated view of innovation and sustainability, one that recognizes the importance of firm-level agency while also addressing the enabling or constraining effects of the broader institutional environment. This aligns with a growing body of knowledge emphasizing the need for "concerted agency" between public and private actors to address societal challenges that exceed the reach of individual firms or fragmented policy regimes (Laranja & Pinto, 2023; Mazzucato, 2021). Only through such coordinated approaches can SOI transcend niche experimentation and contribute to systemic transformation in line with sustainability transitions theory and the UN's Decade of Ocean Science (UNESCO, 2021; Geels, 2014).

5.2. A Strategic Management Perspective

Throughout the thesis, SOI is framed as a strategic phenomenon shaped by the interdependence between firm capabilities and institutional structures. From a management perspective, the findings underscore that firms do not merely react to external sustainability mandates but actively interpret, navigate, negotiate, and in some cases, reshape the institutional arrangements that govern their sectors. In doing so, they position themselves within evolving ecosystems of regulation, funding, legitimacy, and public value.

In ecologically sensitive and institutionally complex domains such as the Blue Economy, firms are exposed to overlapping expectations from environmental regulation, innovation policy, and societal scrutiny (Cisneros-Montemayor *et al*., 2022; Geels, 2014). This layered governance environment creates both opportunities and coordination challenges. The findings reveal that firms adopt differentiated strategies based on their embeddedness

within governance networks, access to resources, and legitimacy with stakeholders. These patterns reinforce the need for a contextualized understanding of firm behavior, particularly in semi-coordinated market economies like Portugal, where firms must interpret fragmented institutional signals (Salgueiro *et al.*, 2022), one that recognizes strategy as emerging from the firm's position within institutional architectures (Hall & Soskice, 2001), and not only from internal competencies.

Institutional theory provides an essential lens to explain this positioning. As North (1991) contends, institutions establish the incentive structures through which firms evaluate strategic options. However, as Mahoney and Thelen (2010) demonstrate, these structures are not fixed, they are contested, interpreted, and gradually transformed by actors within the system. This theoretical view is especially pertinent in the Portuguese Blue Economy, where policy agendas around sustainability and innovation are highly dynamic, with multiple public and semi-public entities playing overlapping roles (Pinto *et al*., 2023b; Vieira *et al.*, 2021).

Within this landscape, public strategies and platforms, such as the *Fórum Oceano*, the managing entity of the Portuguese Sea Cluster and the *Agenda do Mar* coordinated by the *Fundação para a Ciência e a Tecnologia* (FCT), form the strategic scaffolding through which firms engage with sustainability transitions. *Fórum Oceano* serves as Portugal's national maritime cluster, facilitating collaboration and internationalization across ocean-based sectors. The organization is responsible for aligning firms and research institutions to drive competitiveness and innovation within the Blue Economy (ANI, 2025; Fórum Oceano, 2025). Meanwhile, FCT's *Agenda do Mar* establishes funding priorities and research directions focused on marine science, sustainability, and technological advancement (FCT, 2019).

Furthermore, policy instruments such as the ENEI (*Estratégia Nacional de Especialização Inteligente*) and EREI *(Estratégia Regional de Especialização Inteligente)* strategies signal Portugal's intent to coordinate innovation with territorial and sectoral priorities (DGPM, 2021, 2016). Nevertheless, the effectiveness of these instruments in supporting Blue Economy firms depends on their integration with sector-specific platforms and their ability to overcome bureaucratic inertia and fragmented governance (Laranja & Pinto, 2023).

Theoretically, these observations build on Scott's (1995) three institutional pillars, regulative, normative, and cognitive, by illustrating how firms engage with each in distinct strategic ways. Some respond primarily to regulatory compliance (e.g., emissions or traceability), while others mobilize normative alignment with sustainability goals to differentiate themselves in the marketplace. Still others reinterpret dominant institutional logics, co-developing new governance models internally or in collaboration with public actors.

This pluralistic engagement with institutions opens space for what Mazzucato (2018) describes as mission-oriented innovation: a reconfiguration of state-firm relations in which the public sector does not merely correct market failures but actively co-creates missions that guide innovation and value creation. In this light, firms in the Blue Economy are not just implementers of sustainability goals, but can act as institutional entrepreneurs, helping define and evolve the missions themselves, so long as the institutional frameworks allow room for experimentation, reflexivity, and strategic alignment.

Thus, the thesis affirms that SOI is not simply an outcome of external pressure or internal conviction. It is a form of strategic positioning, shaped by the interplay of institutional architectures, organizational resources, and perceived legitimacy. Recognizing this complexity allows for a richer understanding of how firms contribute to, co-shape, and are constrained by public value agendas in sectors undergoing ecological and regulatory transformation.

5.3. Limitations and Critical Reflections

Although empirically grounded and theoretically informed, this research has boundaries that shape not only its methodological scope, but also the generalizability and interpretation of its findings. These limitations are not only methodological but also epistemological, reflecting the complex and contested nature of innovation and sustainability themselves (Raworth, 2017; Scott, 1995).

Methodologically, the research design is primarily qualitative and interpretive, drawing on document analysis, public data, and case-based evidence from a limited number of firms (see Chapter 3, section 3.3 and Chapter 4, section 4.3). While this allows for in-depth exploration of firm-level dynamics and institutional embeddedness, it also constrains the extent to which findings can be generalized across the heterogeneous sectors encompassed by the Blue Economy. Moreover, the reliance on publicly available

information, though appropriate given the emphasis on transparency, legitimacy, and external signaling, inevitably introduces a bias toward firms that are already engaged in some form of sustainability discourse. This may exclude actors who operate with more implicit or informal sustainability strategies, disconnected from dominant public sustainability agendas or national innovation ecosystems (Pinto *et al.*, 2023b).

In addition, the research does not adopt a longitudinal approach, which limits the ability to assess how sustainability and innovation strategies evolve over time, particularly in response to shifting policy conditions or external shocks (Fagerberg *et al.*, 2013). Given the increasing volatility of the environmental, regulatory, and geopolitical landscape in which ocean-based firms operate, future research would benefit from a temporal perspective capable of capturing both firm-level learning and institutional adaptation across different cycles of change (Diercks *et al*., 2019). This aligns with Mahoney and Thelen's (2010) typology of gradual institutional change, which highlights mechanisms such as layering and conversion that are often only observable across extended timeframes.

Conceptually, the thesis operates within the framework of institutional theory and strategic management, which offers a robust lens for analyzing the interaction between firms and their environments. However, it does not exhaust the range of explanatory frameworks that could be applied. Perspectives from political ecology, socio, technical transitions, or ecological economics may provide complementary perspectives into the broader structural forces, such as global power asymmetries or planetary boundaries, that shape sustainability transitions in ocean-based sectors (Diercks *et al.*, 2019; Kattel & Mazzucato, 2018; Raworth, 2017).

Another important boundary concerns the level of institutional analysis. While the thesis engages with national platforms, such as the *Fórum Oceano*, FCT's *Agenda do Mar*, and the ENEI and EREI strategies, its primary focus is on the firm as the unit of analysis. Consequently, it does not delve deeply into the internal dynamics, funding structures, or governance mechanisms of these platforms. A detailed institutional ethnography of these spaces could reveal how coordination, priority-setting, and strategic alignment unfold in practice. As noted by Kattel and Mazzucato (2018), the effectiveness of mission-oriented innovation policy depends not only on high-level goal-setting but also on the feedback

loops, experimental mechanisms, and institutional learning capacities embedded in implementation processes.

Finally, the research recognizes but does not fully resolve the tension between normative aspirations and operational constraints. While sustainability is widely invoked as a guiding principle, its translation into actionable strategies often depends on institutional coherence, access to knowledge and capital, and the availability of appropriate policy instruments (Fagerberg *et al.*, 2013). The findings suggest that, in many cases, firms must navigate overlapping mandates, ambiguous expectations, and fragmented incentives, a challenge rooted in policy discontinuity and institutional fragmentation, as highlighted in recent literature (Laranja & Pinto, 2023; Pinto *et al.*, 2023b). Addressing this challenge requires not only managerial agility but also rethinking how public and private actors share responsibility for sustainability outcomes, including through co-governance models and adaptive policy mechanisms (Raworth, 2017).

Critically recognizing these limitations does not diminish the thesis's contributions but rather situates them within the broader landscape of academic inquiry and policy experimentation. Acknowledging these boundaries underscores the complexity of the subject matter and opens new space for future research to extend, challenge, or refine the findings presented here. In doing so, it aligns with the scholarly position that complexity in socio-technical transitions requires layered, multi-actor, and multi-temporal analysis (Diercks *et al.*, 2019; Mazzucato, 2018; North, 1991).

5.4. Outlook and Policy Recommendations

The findings of this research, while grounded in firm-level analysis, carry wider implications for national strategy, innovation policy, and sustainability governance in Portugal's maritime domain. The Blue Economy represents not only a policy priority but also a field of institutional experimentation, where competing logics, economic development, ecological preservation and public legitimacy must be continuously negotiated. This section reflects on how the research findings intersect with national institutional frameworks and offers forward-looking recommendations to address the strategic and structural challenges identified.

A central issue emerging from the research is the fragmentation of institutional architectures. Despite the presence of robust national strategies, such as the *Estratégia Nacional para o Mar 2021–2030* (DGRM, 2021), the *Agenda do Mar* by FCT, and the

ENEI and EREI smart specialization frameworks, firms continue to report difficulty in navigating overlapping mandates, accessing coordinated support mechanisms, or translating strategic agendas into actionable innovation (Laranja & Pinto, 2023). While *Fórum Oceano*, managing entity of the Portuguese Sea Cluster, provides an important platform for inter-organizational dialogue and cluster coordination, its effectiveness in aligning funding priorities, research agendas, and business strategies remains uneven and at times more symbolic than substantive (Pinto *et al.*, 2023b; Vieira *et al.*, 2021).

This gap between strategic ambition and institutional delivery points to the need for a coherence-building function, not to centralize governance, but to facilitate alignment, continuity, and horizontal learning across a dispersed innovation system. Particularly for SMEs, who often lack the bandwidth to interface with multiple fragmented initiatives, the perceived inaccessibility or opacity of these platforms reduces their strategic relevance. Instruments such as the ENEI and regional EREI strategies signal an intent to align innovation with sectoral and territorial priorities but often fall short in creating durable channels for co-creation and feedback between the public and private sectors (Laranja & Pinto, 2023).

From a management strategy perspective, these findings underscore the importance of building mission-oriented innovation ecosystems, institutional architectures deliberately structured to pursue long-term societal goals through coordinated public and private action (Mazzucato, 2021). This involves not only funding and regulatory clarity but also demand-shaping, dynamic public-sector capabilities, and support for platforms that foster experimentation and reflexivity (Kattel & Mazzucato, 2018). Instruments such as FCT's research agendas, Portugal 2030, and the European Blue Economy Observatory could be more explicitly mobilized in support of missions around decarbonization, ecosystem regeneration, and sustainable marine food systems (European Commission, 2024a).

Such a transformation requires new interfaces between firms, science, and policy. A key insight from the Atlantic Social Lab pilot programs is that innovation and digitalization only generate systemic change when embedded in relational infrastructures, spaces that foster collaboration, trust, and learning across public institutions, civil society, and the private sector (Pinto *et al.*, 2023a, 2023c). These platforms must be designed not simply as project repositories but as dynamic arenas for strategy-making and governance.

Crucially, the thesis finds that scaling SOI is not primarily a technological challenge, but one of organizational capacity, institutional design, and legitimacy-building. Financial incentives alone are insufficient; firms require access to trusted coordination mechanisms, supportive infrastructures, and future-oriented planning processes. While projects such as those piloted by the Atlantic Social Lab offer promising prototypes, they must be structurally embedded within the national innovation system to transcend isolated experimentation.

This future-facing approach must also be rooted in Portugal's maritime identity and geopolitical positioning. As Ernani Lopes (2000) argued, the ocean is not only a natural resource but a strategic axis of national development, requiring an integrated vision across territorial, economic, and cultural domains. In a complementary spirit, Tiago Pitta e Cunha (2014) emphasizes that the sea is both an ecological responsibility and a generative opportunity, capable of reconciling public purpose with economic competitiveness. These perspectives frame the Blue Economy not as a discrete sector but as a strategic platform for national transformation, demanding both institutional ambition, coordination and courage.

The present research thus reinforces the view that firms must be understood not merely as policy recipients but as institutional entrepreneurs, actors capable of interpreting, translating, and at times reshaping sustainability imperatives into viable strategies. However, the capacity to act strategically is highly contingent on enabling institutional conditions. The coordination failures and capacity gaps documented throughout this research underscore the urgent need for a next generation of public-private interfaces: collaborative spaces, shared governance frameworks, and long-term co-investment strategies designed with mission coherence and strategic foresight.

The research highlights a set of strategic levers, rooted in firm-level dynamics and institutional coordination gaps, that could strengthen the enabling environment for SOI in Portugal's Blue Economy. These are not isolated policy suggestions, but interdependent components of a more coherent and adaptive innovation system, aligned with the thesis's central insight: that firms require not only internal capability, but access to consistent, navigable institutional architectures to transform sustainability imperatives into competitive strategy.

1. **Create an institutional coordination mechanism for SOI -** Establish a dedicated function, potentially under the leadership of *Fórum Oceano*, to align public-private, and research actors around shared sustainability missions. This mechanism would address the effects of institutional fragmentation and overlap documented in the thesis, where firms struggle to navigate multiple uncoordinated platforms and policy instruments (Laranja & Pinto, 2023; Pinto *et al.*, 2023b; Vieira *et al.*, 2021). The goal is not centralization, but mission coherence and integration across dispersed governance layers.

2. **Reposition *Fórum Oceano* and FCT as strategic transnational platforms** Expand the mandate of the *Fórum Oceano* and FCT's Agenda do Mar from funding and convening to translating high-level goals into actionable pathways for firms, especially SMEs. This responds to the thesis's finding that firms often experience national strategies as distant and symbolic. These platforms can bridge that gap by offering contextualized support, brokering partnerships, and aligning resources with sector-specific needs.

3. **Institutionalize foresight and co-missioning processes -** Embed strategic foresight and scenario planning into Blue Economy governance, enabling firms and stakeholders to co-define missions around key challenges such as ocean health, low-impact maritime logistics, or circular aquaculture. This responds to the observed lack of long-term planning and visioning processes. Strategic foresight would help shift the policy architecture from reactive compliance to anticipatory governance, reinforcing the entrepreneurial orientation of firms (Mazzucato, 2021).

4. **Design structured feedback and learning mechanisms -** Develop permanent feedback channels for firms to inform the design and adaptation of key instruments such as *Portugal 2030*, *Horizon Europe*, and blue-sector R&D initiatives. These mechanisms should go beyond consultation to include iterative evaluation including indicators of equity, contextual relevance, and cross-sectoral learning**.** This addresses the thesis's observation that policy design often lacks iterative feedback loops between implementers and users, limiting effectiveness and legitimacy (Kattel & Mazzucato, 2018).

5. **Foster a culture of experimentation and institutional learning -** Support living labs, regulatory sandboxes, and cross-sector innovation pilots that allow for controlled experimentation, fast learning, and scaling of emerging practices. These tools address the challenge of institutional inertia and allow both firms and public institutions to engage with uncertainty productively. The thesis confirms that experimentation is not just technical, it is relational and organizational, requiring trust, capacity, and space for failure (Pinto *et al.*, 2023c).

These five levers converge toward a single imperative: to build an innovation system that is not only instrument-rich, but institutionally coherent, reflexive, and strategically aligned. Rather than multiplying new programs or instruments, Portugal must now focus on building the connective tissue that allows its diverse assets, policy, research, industry, and civic engagement, to function as a coherent and learning system. If successful, such an approach would not only advance sustainability goals in the Blue Economy but reaffirm Portugal's legacy as a maritime nation whose global identity is inseparable from its ability to innovate at sea (Lopes, 2000; Pitta e Cunha, 2014).

5.5. Future research directions

Building on the findings and limitations of this thesis, several promising avenues emerge for advancing research on SOI in the Blue Economy. These directions reflect the complexity of institutional environments, heterogeneity of firm capacities, and the shifting demands of sustainable transformation.

First, there is a need for longitudinal research to examine how firms' SOI strategies adapt over time in response to changing institutional, ecological, and market conditions (Douma & Schreuder, 2017). The dynamic nature of innovation and sustainability pressures, particularly in ocean-based sectors, calls for research designs that can capture organizational learning, institutional engagement, and strategic renewal over time. This would allow greater insight into the temporal mechanisms of institutional change, such as layering, conversion, or drift (Mahoney & Thelen, 2010).

Second, future research should deepen the institutional analysis of coordination platforms, such as *Fórum Oceano* and FCT's *Agenda do Mar*. While these entities are recognized as strategic actors in national maritime governance, little is known about their internal processes, power dynamics, or impact on firm-level innovation (Vieira *et al.*,

2021). Institutional ethnographies or governance network studies could illuminate how coordination, priority-setting, and legitimacy construction occur within these platforms.

Third, comparative research across national and regional contexts would expand the generalizability of SOI frameworks. Examining how institutional architectures in other EU maritime nations shape innovation practices could reveal important differences and convergences in how sustainability is governed across coastal economies (Mazzucato, 2021). This line of research would also help identify best practices for transnational coordination and alignment with European missions, such as those articulated in the European Green Deal and Horizon Europe (European Commission, 2021, 2020).

Fourth, future research could explore the structure and function of cross-sectoral innovation ecosystems, where knowledge, technologies, and practices diffuse across boundaries between industries such as fisheries, logistics, renewable energy, and biotechnology. Understanding how these ecosystems emerge, stabilize, and contribute to systemic sustainability transitions would deepen understanding of collaborative innovation dynamics in the Blue Economy (Diercks *et al.*, 2019; Geels, 2014).

Finally, the intersection of policy design and firm strategy remains an under-explored area. The case studies in Chapter 4 point to regulatory bottlenecks and fragmented support mechanisms that constrain innovation. Future studies should investigate how different policy instruments, such as green procurement, innovation subsidies, and mission-driven funding, affect firm behavior (Kattel & Mazzucato, 2018). In parallel, examining how firms shape, resist, or co-create regulatory frameworks could deepen understanding of the policy–firm interface as a site of co-evolution.

Together, these research directions point toward a more nuanced and ambitious agenda for SOI scholarship, one that moves beyond static firm-level models and toward dynamic, policy-integrated systems thinking. By incorporating temporal perspectives, deepening institutional analysis, and engaging with cross-sectoral and transnational dynamics, future research can contribute not only to academic theory-building, but also to the practical design of innovation systems capable of addressing 21st-century sustainability challenges.

5.6. Closing Reflection

The present research investigated how firms in Portugal's Blue Economy respond to, and help shape, the evolving demands of sustainability and innovation. Grounded in strategic management and institutional theory, it has argued that SOI should not be understood merely as a technical adaptation or policy compliance mechanism, but as a strategic orientation, one that is constructed, interpreted, and operationalized through a dynamic interplay between firm agency, institutional architectures, and stakeholder expectations.

Across the three empirical articles, the research demonstrates that firms vary significantly in their capacity to internalize sustainability goals. This variation reflects not only internal capabilities but also their positioning within governance networks, proximity to decision-making processes, and access to platforms that confer legitimacy. Thus, innovation does not follow a universal model but rather emerges from a contextually situated process of negotiation, often constrained by institutional fragmentation and asymmetries in knowledge, influence, and resources.

By applying this lens, the thesis makes several contributions. Conceptually, it advances a management-oriented view of institutional embeddedness, bridging traditional distinctions between compliance, strategy, and value creation. Methodologically, it integrates multi-scalar analysis, connecting firm-level action with national and European policy ecosystems. Practically, it offers recommendations that move beyond the implementation of policy instruments to focus on institutional coordination, learning infrastructures, and strategic alignment.

Importantly, the thesis reinforces the idea that firms are not only reactive entities responding to policy stimuli but can be institutional entrepreneurs, actors that reinterpret rules, build coalitions, and contribute to redefining the very frameworks within which they operate (Mahoney & Thelen, 2010; Scott, 1995). This reframing of the firm as a strategic agent within sustainability transitions is especially relevant in policy-intensive sectors like the Blue Economy.

Looking forward, this work positions itself within a growing body of literature that sees innovation not as an end in itself, but as a means for strategic transformation, particularly in the face of grand societal challenges (Mazzucato, 2021). In an era defined by climate urgency, geopolitical complexity, and social inequality, the ability to align economic

competitiveness with ecological responsibility becomes a core challenge for both firms and states.

The Portuguese Blue Economy, with its long-standing maritime heritage, strategic Atlantic positioning, and research capabilities, offers a unique context in which to test and scale new models of value creation, ones that link national development with sustainability and innovation as intertwined missions.

As Ernani Lopes (2000) foresaw, Portugal's future is inseparable from the sea, not only as a physical frontier but as a strategic horizon. Building on this vision, this thesis affirms that the sustainability transition will depend not only on policies or technologies, but on the strategic choices of firms, the design of enabling institutions, and on the combined capacity of firms and institutions to coordinate, learn, and lead in conditions of institutional and ecological uncertainty. It is to this long-term and collaborative project that this thesis seeks to contribute.

As explored at the outset of this thesis, the Blue Economy represents both a profound opportunity and a pressing challenge to reconcile economic activity with ecological boundaries and social responsibility. What began as an inquiry into how firms respond to sustainability pressures evolved into a deeper understanding of how innovation serves as both a mechanism for adaptation and a marker of institutional change.

Through literature synthesis, empirical data, and real-world cases, this research has demonstrated that SOI is not merely an ideal but an emerging strategic reality, one shaped from the ground up, by firms navigating uncertainty with creativity and resilience. Returning to the central question of how theory and practice can converge to enable sustainable development, this thesis offers one possible pathway and leaves the door open for many more to follow.

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APPENDICES

APPENDIX A – PUBLICATIONS, COMMUNICATIONS AND ACTIVITIES RESULTING FROM THIS RESEARCH

1. PUBLICATIONS [11]

1.1 PUBLISHED

Elston, J., Pinto, H., & Nogueira, C. (2024) Exploring Sustainable development in the blue economy: concepts, challenges, and solutions (exploratory lit. review). *Ualgoritmo Edição Especial: Sustainable Horizons.* Universidade do Algarve, 2024. *https://joom.ag/3c0d/p6*

Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of change for a sustainable blue economy: A systematic literature review of innovation in maritime activities. *Sustainability*, *16*(24), 11141. https://doi.org/10.3390/su162411141

1.2 UNDER REVISION

Elston, J., Pinto, H., & Nogueira, C. (2025). Waves of innovation: the role of sustainability in driving impact in the blue economy – A PLS-SEM approach. *Marine Policy*

Elston, J., Pinto, H., & Nogueira, C. (2025). Charting the course: Real-world application of sustainability and innovation principles in the Portuguese blue economy firms. *Journal of Cleaner Production*

2. COMMUNICATIONS IN SCIENTIFIC CONFERENCES AND MEETINGS

2023

Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of change for a sustainable blue economy: A systematic literature review of innovation in maritime activities. Doctoral day – Faculty of Economics, University of the Algarve. Faro, July 27.

[11] **Note:** Additional publications and academic outputs produced during the doctoral period, but not directly related to this thesis, can be consulted in the author's full academic CV.

Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of change for a sustainable blue economy: A systematic literature review of innovation in maritime activities. IMET – Institute of Marine and Environmental Technology. Baltimore - USA, November.

2024

Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of change for a sustainable blue economy: A systematic literature review of innovation in maritime activities. 'BEING SEA-EU' Conference. University of Malta, June 10-12.

Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of change for a sustainable blue economy: A systematic literature review of innovation in maritime activities. Closing ceremony of the Sustainable Horizons (SHEs), Santiago (Chile), June 12th at the Universidad Andrés Bello (UNAB).

Elston, J., Pinto, H., & Nogueira, C. (2024). Tides of change for a sustainable blue economy: A systematic literature review of innovation in maritime activities. 17th Annual Meeting of the Portuguese Economic Journal (PEJ) Conference. University of Algarve, Faro, July 5-7.

Elston, J., Pinto, H., & Nogueira, C. (2024). Waves of innovation: the role of sustainability in driving impact in the blue economy – A PLS-SEM approach. Doctoral day – Faculty of Economics, University of the Algarve. Faro, December 13.

2025

Elston, J., Pinto, H., & Nogueira, C. (2025). Waves of innovation: the role of sustainability in driving impact in the blue economy – A PLS-SEM approach. AHTMM Conference, Faro, June 30 to July 4.

3MT (Three Minute Thesis) Competition, University of Algarve — Selected as one of the finalists representing the PhD in Management program, communicating the core of the doctoral research to a non-specialist audience. Final round held on April 5th, 2025.

Elston, J., Pinto, H., & Nogueira, C. (2025). Charting the course: Real-world application of sustainability and innovation principles in the Portuguese Blue Economy firms. *Paper submitted to the BEING SEA-EU Conference*, Cádiz, Spain, October 22 to 24th, 2025. (https://sea-eu.org/being-sea-eu-conference/)

Elston, J., Pinto, H., & Nogueira, C. (2025). Charting the course: Real-world application of sustainability and innovation principles in the Portuguese Blue Economy firms. *Paper submitted to the TMS 2025 Conference – Tourism and Management Studies International Conference*, Faro, Portugal, November 12 to 15th 2025. (https://tms2025.ualg.pt)

Elston, J., Pinto, H., & Nogueira, C. (2025). Charting the course: Real-world application of sustainability and innovation principles in the Portuguese Blue Economy firms. *Paper submitted to the XIX International Conference on Overarching Issues of the European Area*. Porto, Portugal, June 17 to 21st 2025. (https://tms2025.ualg.pt)

C3. ORGANIZATION OF EVENTS, CONFERENCES AND PARTICIPATION IN ACTIVITIES

2023

Blue Route Project — Investigation of sustainable practices and technologies in Norwegian aquaculture and other Blue Economy sectors. Participation in a Blue Economy debate with students of the Blue Route Project (On site: University of the Arctic, Norway, October 2023).

UpBlue Bright FLAD Project — Knowledge exchange seminars and research visits at the Institute of Marine and Environmental Technology (IMET) and University of Maryland Baltimore County (UMBC). Included a visit to the Blue Crab industry to study strategies for managing invasive species in Portugal and explore best aquaculture technologies (Baltimore, USA). Activity in collaboration with S2Aqua and IPMA.

ClimateU — Ambassador of a national event aimed at raising student awareness and mobilizing collective climate action. The event promotes making sustainability a transversal theme across all university courses in Portugal (University of Algarve, 17th November 2023).

2024

Part of the organization committee *Greening Our Campus: Building Sustainable Projects for a Better Future* — Collaborative brainstorming event focused on generating project ideas to enhance campus sustainability (University of Algarve).

SEA-EU Task 5.2: SWOT Analysis of Coastal Areas — Application of an ecosystem-based approach and Integrated Coastal Zone Management (ICZM) to analyze Portugal's coastal areas. Presentation of results at the SEA-EU Conference (Malta, June).

SEA-EU Goes Greener, Task 4.4: Green Chart Workshop — Workshop on integrating sustainability into research, academia, and policymaking (on site: University of Gdansk, Poland, June 5–8).

PEJ 2024 — Part of the main organization committee of the *17th Annual Meeting of the Portuguese Economic Journal*, held and organized by the Faculty of Economics, University of Algarve; CEFAGE - Centre for Advanced Studies in Management and Economics; and CinTurs - Research Centre for Tourism, Sustainability and Well-being. Faro, July 5-7.

MEDCRABNET — Mediterranean Network for Blue Crab Value Chain — Participation in this initiative aimed at fostering collaboration across Mediterranean countries to manage and valorize the blue crab. The project promotes the exchange of best practices and regional cooperation in addressing the challenges posed by invasive species. It also focuses on supporting micro, small, and medium-sized enterprises (MSMEs), contributing to economic growth and job creation in the Mediterranean fishing industry (in collaboration with GFCM – General Fisheries Commission for the Mediterranean).

2025

Doctoral Student Representative, Faculty of Economics — Serving as the elected representative of the doctoral students from the Faculty of Economics in the *Colégio Doutoral* of the University of Algarve, contributing to institutional dialogue and the development of doctoral education.

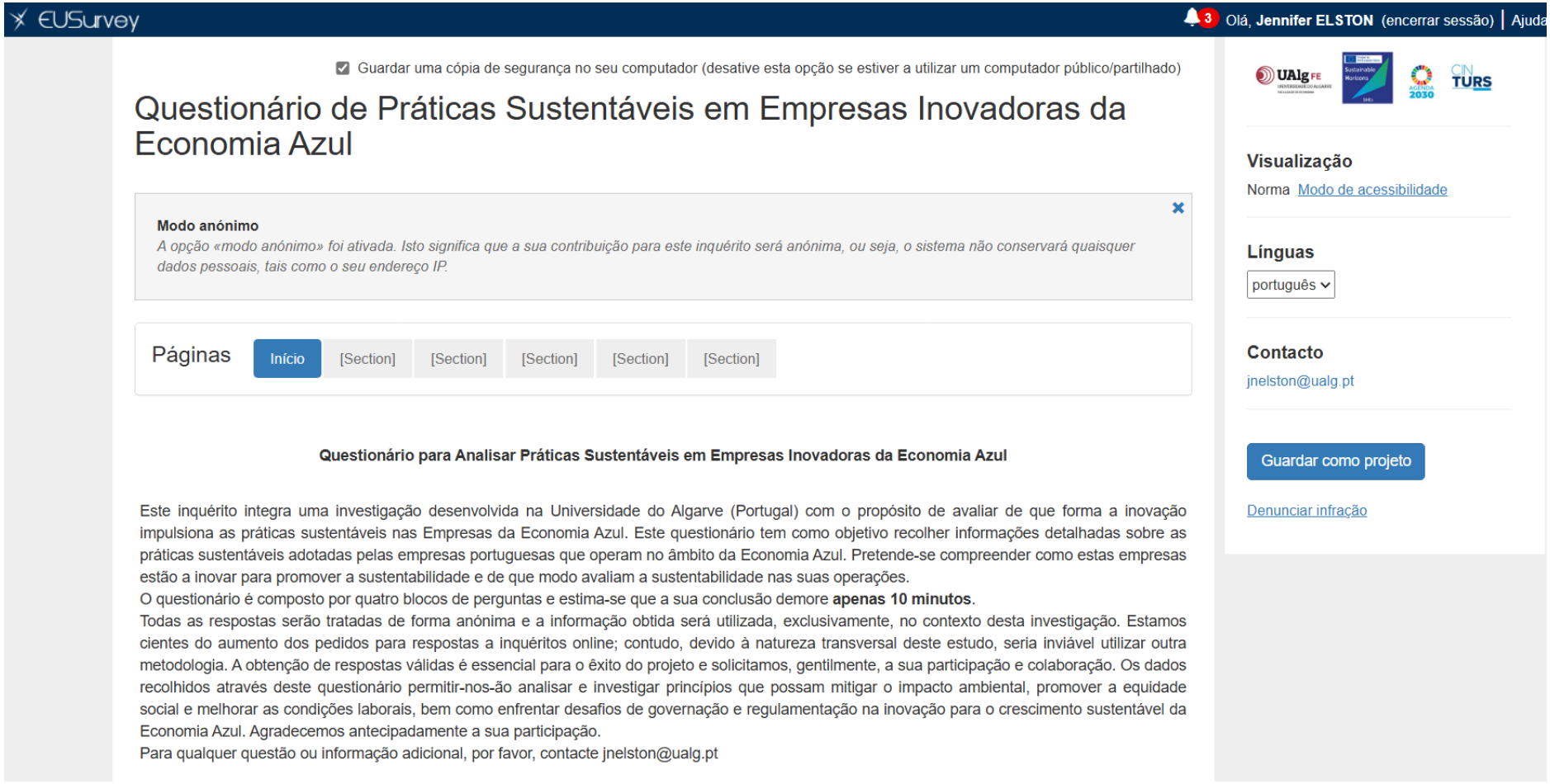
SEA-EU Task 4.2: Call for Student-Led Projects — Organization of the SEA-EU initiative in the University of Algarve aimed at fostering inclusion, diversity, sustainability, multilingualism, digital transformation, and social entrepreneurship across partner universities and communities in Europe. Key areas addressed include gender equality, climate equity, multilingual learning, digital collaboration, and societal impact.

SOFTCRAB — PT2030 Project — Participation in a collaborative project focusing on innovating soft-shell crab production for Southern European markets. The project aims

to improve cultivation methods and commercialize high-value products. The consortium includes AtlantikFish, University of Algarve, and S2AQUA collaborative laboratory (Portugal). Project Kick-off 15th of April 2025.

APPENDIX B – SURVEY INSTRUMENT (PAPER 2)

https://ec.europa.eu/eusurvey/runner/Inovacao_Sustentavel_2024



1 Secção 1: Dados da Empresa

* 1.1. Nome da empresa:

* 1.2. Setor da empresa (escolha um):
Entre 1 e 2 seleções

- [ ] Aquicultura
- [ ] Atividades portuárias
- [ ] Bioeconomia azul, biotechnologia e investigação/educação.
- [ ] Construção (reparação) naval
- [ ] Energias renováveis
- [ ] Exploração de petróleo e gás offshore
- [ ] Indústria marítima
- [ ] Logística verde
- [ ] Outro
- [ ] Pesca
- [ ] Transporte marítimo
- [ ] Turismo

1.2.1. Se respondeu outro, qual:

* 1.3. Classificação das Atividades Económicas (CAE) da empresa:

1.4. Quais são os principais produtos ou serviços oferecidos pela sua empresa na economia azul?

	Produto/Serviço
*1	
*2	
*3	

* 1.5. Localização da empresa (Localidade):

* 1.5.1. Código-postal:

* 1.6. Em que ano foi fundada a empresa:

* 1.7. Dimensão da empresa:

- ○ Até 10 Funcionários
- ○ 11 a 50 Funcionários
- ○ 51 a 250 Funcionários
- ○ Acima 250 Funcionários

* 1.8. Volume de Negócios da empresa:

- ○ Até 2 Milhões
- ○ 2 a 10 Milhões
- ○ 10 a 43 Milhões
- ○ Acima dos 43 Milhões

1.9. Durante os últimos 3 anos, a sua organização introduziu algum dos seguintes tipos de inovação?

	Sim	Não
*Produto	○	○
*Processo	○	○
*Marketing	○	○
*Organizacional	○	○

1.10. Durante os últimos 3 anos, a sua organização envolveu-se em alguma das seguintes atividades de cooperação para inovação? Se sim por favor indique o nome da instituição/organização.
(Caso não queria responder nalgum campo insira "NA")

	Nome
*Cliente / Consumidor	
*Fornecedores de equipamentos, materiais, componentes ou software	
*Cooperação com universidades ou outras instituições de ensino superior	
*Cooperação com consultores, laboratórios comerciais ou institutos privados de I&D	
*Cooperação com concorrentes ou outras empresas do seu setor	
*Cooperação com o governo ou institutos públicos de investigação	

Anterior Seguinte

2 Secção 2: Práticas Sustentáveis

2.1. Qual a importância da sustentabilidade para a Estratégia sua empresa?
Restabelecer a posição inicial

Nenhuma — Alta

1 — 5

2.2. Qual é a importância das seguintes áreas na sua estratégia de sustentabilidade?
(1 = Nenhuma, 5 = Muito Alta)
no mínimo 1 linha(s) de resposta

	Nenhuma (0%) 1	Baixa (25%) 2	Média (50%) 3	Alta (75%) 4	Muito Alta (100%) 5
*2.2.1. Descarbonização	○	○	○	○	○
*2.2.2. Transparência e relatórios de sustentabilidade	○	○	○	○	○
*2.2.3. Prevenção da poluição da água	○	○	○	○	○
*2.2.4. Cumprimento das regulamentações ambientais	○	○	○	○	○
*2.2.5. Responsabilidade Social	○	○	○	○	○
*2.2.6. Criar novos produtos e serviços mais sustentáveis	○	○	○	○	○
*2.2.7. Gestão de riscos climáticos	○	○	○	○	○
*2.2.8. Redução dos custos	○	○	○	○	○
*2.2.9. Conservação da biodiversidade	○	○	○	○	○
*2.2.10. Uso de energias renováveis	○	○	○	○	○
*2.2.11. Implementação de tecnologias verdes	○	○	○	○	○
*2.2.12. Gestão sustentável de recursos	○	○	○	○	○
*2.2.13. Economia circular	○	○	○	○	○
*2.2.14. Engajamento da comunidade	○	○	○	○	○
*2.2.15. Educação e conscientização ambiental	○	○	○	○	○
*2.2.16. Parcerias com instituições de pesquisa (research centers)	○	○	○	○	○
*2.2.17. Investimento em P&D	○	○	○	○	○
*2.2.18. Outros	○	○	○	○	○

Caso tenha respondido outros, por favor, especifique:

2.3. Qual o nível de adoção de tecnologias verdes pela sua empresa? (Por exemplo, tecnologias para redução de emissões de carbono, uso de energias renováveis, implementação de sistemas de energia solar)
Restabelecer a posição inicial

Muito Baixo — Muito Alto

1 — 5

2.4. Em que medida a sua empresa implementa a gestão sustentável de recursos? (Por exemplo, práticas de conservação de água, reciclagem, gestão de resíduos, uso eficiente de materiais)
Restabelecer a posição inicial

Muito Baixa — Muito Alta

1 — 5

2.5. Qual a frequência com que sua empresa pratica economia circular? (Por exemplo, reutilização de materiais, minimização de resíduos, recuperação e regeneração de produtos)
Restabelecer a posição inicial

Nunca — Sempre

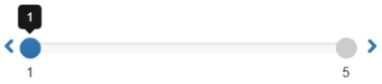
1 — 5

Anterior | Seguinte

3 Secção 3: Inovação e Tecnologia

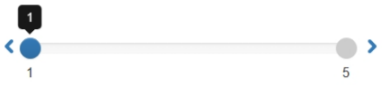
3.1. Importância da inovação para o crescimento da sua empresa?
Restabelecer a posição inicial

Nunhuma — Alta



3.2. Nos últimos 3 anos, quanto a sua empresa investiu em Pesquisa e Desenvolvimento (P&D)? (Proporção do orçamento dedicada a P&D, número de projetos de P&D em andamento)
Restabelecer a posição inicial

Muito Baixo — Muito Alto

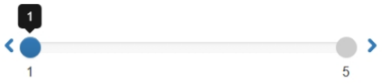


3.3. Qual o nível de adoção de novas tecnologias na sua empresa? (Implementação de novas tecnologias, utilização de IA)
Restabelecer a posição inicial

Muito Baixo — Muito Alto

3.4. Em que medida a sua empresa colabora com instituições de pesquisa e universidades? (Parcerias com universidades, projetos conjuntos com institutos de pesquisa)
Restabelecer a posição inicial

Nunca — Sempre



3.5. Com que regularidade a sua empresa mede o impacto da inovação na sustentabilidade?
(1 = Nunca, 5 = Sempre)
no mínimo 1 linha(s) de resposta

	Nunca 1	Raramente 2	Ocasionalmente 3	Frequentemente 4	Sempre 5
*3.5.1. Acompanhamento de indicadores-chave de desempenho (KPIs)	○	○	○	○	○
*3.5.2. Realização de avaliações e revisões regulares	○	○	○	○	○
*3.5.3. Utilização de dados e análises para monitorizar o progresso	○	○	○	○	○
*3.5.4. Desenvolvimento de relatórios de sustentabilidade e comunicação transparente dos resultados	○	○	○	○	○
*3.5.5. Envolvimento de partes interessadas, incluindo comunidades locais, na avaliação de impacto	○	○	○	○	○
*3.5.6. Realização de auditorias externas para validar o impacto da inovação	○	○	○	○	○
*3.5.7. Utilização de metodologias de avaliação de impacto reconhecidas internacionalmente	○	○	○	○	○
*3.5.8. Outros	○	○	○	○	○

Caso tenha respondido outros, por favor, especifique:

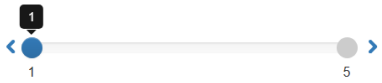
Anterior Seguinte

4 Secção 4: Impacto económico, ambiental e social

4.1. Nos últimos 3 anos, qual o impacto das práticas sustentáveis da sua empresa na criação de empregos? (Por exemplo, novas contratações devido a iniciativas sustentáveis, criação de novos postos de trabalho, aumento do quadro de funcionário)

Restabelecer a posição inicial

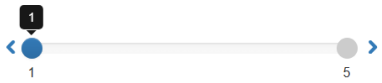
Muito Negativo — Muito Positivo



4.2. Qual o impacto das práticas sustentáveis da sua empresa no crescimento económico? (Por exemplo, aumento de receita devido a práticas sustentáveis, expansão do mercado, atração de novos investidores)

Restabelecer a posição inicial

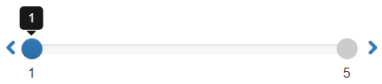
Muito Negativo — Muito Positivo



4.3. Qual o impacto das práticas sustentáveis da sua empresa na rentabilidade? (Por exemplo, redução de custos operacionais através de eficiência energética, aumento da margem de lucro)

Restabelecer a posição inicial

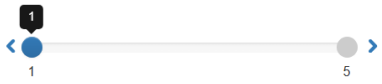
Muito Negativo — Muito Positivo



4.4. Em que medida as práticas sustentáveis da sua empresa reduziram a poluição? (Por exemplo, redução de emissões de CO2, diminuição de resíduos sólidos, tratamento de efluentes)

Restabelecer a posição inicial

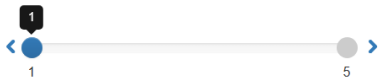
Muito Baixo — Muito Alto



4.5. Qual o impacto das práticas sustentáveis da sua empresa na conservação da biodiversidade? (Por exemplo, iniciativas de proteção de habitats naturais, programas de replantio, preservação de espécies ameaçadas)

Restabelecer a posição inicial

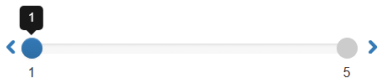
Muito Baixo — Muito Alto



4.6. Qual o impacto das práticas sustentáveis da sua empresa na eficiência energética? (Por exemplo, adoção de fontes de energia renovável, uso de tecnologias de baixo consumo, otimização de processos energéticos)

Restabelecer a posição inicial

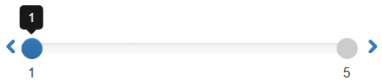
Muito Baixo — Muito Alto



4.7. Em que medida as práticas sustentáveis da sua empresa envolveram a comunidade? (Por exemplo, projetos comunitários, programas de voluntariado, parcerias com ONGs locais)

Restabelecer a posição inicial

Mutio Baixo — Muito Alto



4.8. Qual o impacto das práticas sustentáveis da sua empresa na melhoria das condições de vida? (Por exemplo, políticas de igualdade salarial entre homens e mulheres, melhoria das condições de trabalho, programas de saúde e bem-estar)

Restabelecer a posição inicial

Muito Baixo — Muito Alto

1 (1 — 5)

4.9. Qual o impacto das práticas sustentáveis da sua empresa na educação e conscientização? (Por exemplo, uso de rotulagem ecológica, campanhas de conscientização ambiental, programas de formação sobre sustentabilidade)

Restabelecer a posição inicial

Muito Baixo — Muito Alto

1 (1 — 5)

Anterior | Seguinte

5 Secção 5: Barreiras à Inovação

5.1. Quão significativas são as restrições financeiras para a inovação na sua empresa? (falta de capital, dificuldade de acesso a financiamentos)

Restabelecer a posição inicial

Nada Significativas — Muito Significativas

1 (1 — 5)

5.2. Em que medida os desafios regulatórios afetam a inovação na sua empresa? (Legislação ambiental restritiva, burocracia excessiva)

Restabelecer a posição inicial

Muito Baixo — Muito Alto

1 (1 — 5)

5.3. Qual o nível de resistência à mudança na sua empresa? (cultura organizacional conservadora, falta de apoio interno para novas iniciativas)

Restabelecer a posição inicial

Muito Baixa — Muito Alta

1 (1 — 5)

Conclusão

Agradecemos por dedicar seu tempo a completar este questionário. As suas perceções ajudar-nos-ão a compreender melhor as práticas sustentáveis das empresas inovadoras da Economia Azul que operam em Portugal e contribuirão para o desenvolvimento de um quadro abrangente para a tomada de decisões informadas na Economia Azul.

Se deseja receber os resultados deste inquérito, por favor, deixe o seu endereço de e-mail aqui:

APPENDIX C – SURVEY SAMPLE CHARACTERIZATION (PAPER 2)

Economic Activities of the Surveyed Companies

The list below shows the industry classification codes of the 40 firms that responded to the survey.

CAE	Description
70220	Consultancy activities for maritime and fisheries management
1130	Cultivation of aquatic plants and vegetables used in aquaculture
10893	Manufacture of specialized feeds for aquaculture species
21100	Research and development in marine pharmaceuticals
10204	Processing and preservation of aquaculture products
72110	Research and experimental development in marine biotechnology
03210-R3	Marine aquaculture
10913-R3	Manufacture of sustainable aquaculture feed
10201-R3	Processing of marine and aquaculture-derived food products
3111	Marine fishing and resource harvesting
86230-R3	Development of renewable energy solutions in the maritime sector
85591-R3	Training and education in marine and Blue Economy-related fields
72190	Research and development in natural sciences applied to marine sectors
47750	Retail of reused maritime or aquaculture equipment
63110	Data hosting and analytics for marine and aquaculture operations
3111	Fishing operations
94995	Support and advocacy for organizations in the Blue Economy
10840	Production of aquaculture-specific feed
41200	Construction of aquaculture facilities
74900	Professional and technical services for Blue Economy innovations
10201	Processing and preservation of seafood products
52220	Logistic services for ports and water-based transportation
3210	Aquaculture operations
46382	Wholesale fish and aquaculture products
46494	Wholesale of biotechnological goods for marine applications
30112	Building and repair of vessels for aquaculture and marine activities

30120	Maintenance and repair of ships and boats for Blue Economy use
31150	Development of precision instruments for marine and aquaculture use
47600	Retail of specialized equipment for marine and aquaculture industries
26200	Manufacturing technologies for marine resource monitoring
85591	Training and education for marine sustainability and innovation
74100	Design services for marine-related technologies
28110	Manufacturing turbines for offshore renewable energy
71120	Engineering consultancy for maritime and aquaculture infrastructure
52291	Maritime agency services
52240	Cargo handling for maritime and aquaculture operations
52102	Warehousing for marine and fisheries industries
52292	Logistics support for marine and aquaculture operations
47410	Retail of advanced technologies for marine innovation
64202	Holding companies managing Blue Economy-related enterprises

*Please note that in Portugal a company can have more than one Portuguese Classification of Economic Activities (CAE), this is a compilation of all CAEs of the companies questioned.

APPENDIX D – INTERVIEW GUIDE (PAPER 3)

Used for semi-structured interviews with 5 firms presented in Chapter 4.

Guião de Entrevista para Casos de Estudo da Economia Azul

Entrevista dirigida às cinco empresas que obtiveram os resultados mais elevados no questionário sobre sustentabilidade e inovação.

Contextualização dos Resultados do Questionário

Antes de iniciarmos a entrevista, gostaríamos de apresentar uma síntese estruturada dos principais resultados obtidos através do questionário aplicado a 40 empresas da Economia Azul portuguesa. Este grupo abrange diversos setores económicos, nomeadamente aquacultura, transporte marítimo, energias renováveis, pescas, biotecnologia e investigação e desenvolvimento, com especial destaque para a produção farmacêutica à base de algas.

Principais Barreiras à Inovação Sustentável

- Restrições financeiras: Identificadas como a principal barreira, registaram uma média de 3,68 numa escala de 1 a 5.
- Desafios regulamentares: Particularmente destacados pelas empresas dos setores com utilização intensiva de recursos, refletindo a complexidade e exigência da conformidade normativa.
- Resistência à mudança: Apesar de apresentar menor relevância global, manteve-se um obstáculo significativo em setores mais tradicionais.

Práticas de Sustentabilidade mais Relevantes

- Adoção de tecnologias verdes: Cerca de 60% das empresas adotaram práticas sustentáveis destacadas pela implementação de energias renováveis, sistemas de economia circular e tecnologias de eficiência energética.
- Eficiência e redução de desperdícios: Destaca-se particularmente o setor biotecnológico pela adoção eficaz de tecnologias sustentáveis que contribuem para uma maior eficiência de recursos.
- Envolvimento comunitário: Apresentou-se moderado (média de 3,85), sendo mais expressivo em regiões costeiras, devido à proximidade e dependência dos recursos locais.

Impactos das Práticas Inovadoras

- Impactos económicos: Foram particularmente significativos, com aproximadamente 70% das empresas a reportarem benefícios económicos substanciais decorrentes das suas iniciativas sustentáveis.

- Impactos ambientais: Foram destacados pelas empresas como um resultado importante das suas práticas inovadoras, contribuindo positivamente para a preservação ambiental.
- Impactos sociais: Estes impactos foram menos evidenciados pelos respondentes, não atingindo relevância estatística significativa.

Outros Resultados Relevantes

- Parcerias e colaboração: A cooperação com universidades e instituições de investigação foi apontada como essencial para impulsionar práticas inovadoras.
- Dimensão das empresas: Empresas maiores indicaram possuir maior facilidade em ultrapassar as barreiras financeiras e regulamentares devido à disponibilidade superior de recursos internos.
- Contexto regulatório e político: Foram identificadas lacunas importantes nas estruturas políticas e regulatórias, percebidas como limitantes para o desenvolvimento da inovação sustentável.
- Oportunidades futuras: Setores emergentes como biotecnologia e energias renováveis destacaram oportunidades ainda não plenamente exploradas na Economia Azul, sublinhando a necessidade de reforçar apoios políticos e financeiros para acelerar o desenvolvimento sustentável.

Este enquadramento visa fornecer um ponto de partida claro e estruturado para explorar detalhadamente estas temáticas durante as entrevistas individuais.

Guião de Entrevista – Casos de Estudo

1. Sustentabilidade e Estratégia de Inovação

- Poderia descrever brevemente o percurso da empresa e como a sustentabilidade se tornou um elemento central na vossa estratégia organizacional?
- Quais foram as principais inovações implementadas pela empresa nos últimos anos?
- Como avaliam os impactos económicos, ambientais e sociais destas iniciativas inovadoras?
- Qual o papel desempenhado pelas colaborações externas (universidades, entidades governamentais ou outras empresas) no desenvolvimento das vossas práticas inovadoras?

2. Desafios e Oportunidades

- Quais foram os maiores desafios encontrados pela empresa ao implementar práticas sustentáveis? Destacaria algum obstáculo inesperado?

- Como ultrapassaram essas dificuldades e que lições consideram mais relevantes deste processo?
- Existem tecnologias ou métodos que se tenham mostrado particularmente eficazes? Poderia dar um exemplo?
- Que oportunidades ainda não exploradas identifica na Economia Azul, e como poderá a vossa empresa vir a aproveitá-las?

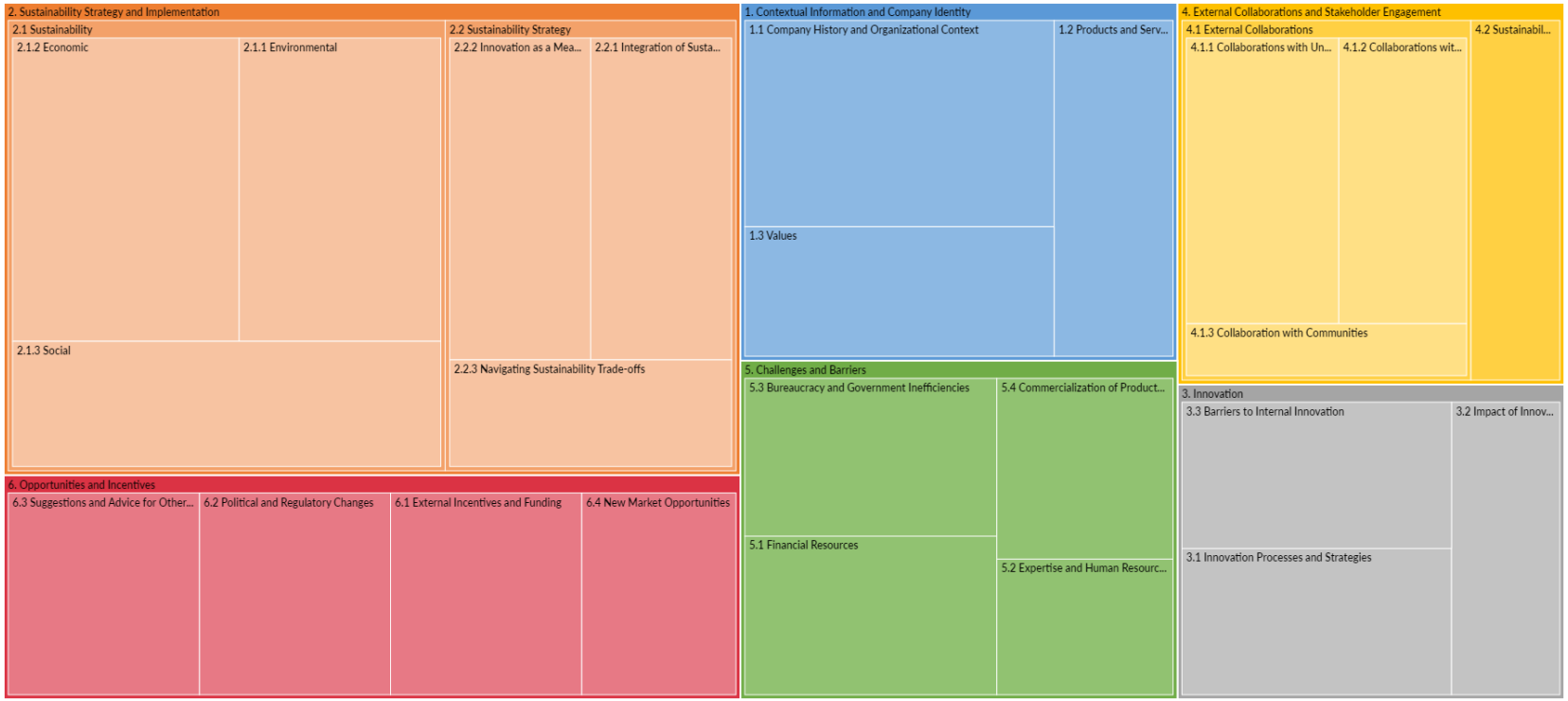
3. Impacto e Envolvimento dos Stakeholders

- De que forma envolvem as comunidades locais e outros stakeholders nas vossas iniciativas de sustentabilidade?
- Poderia dar um exemplo concreto de como o feedback dos stakeholders influenciou ou modificou as práticas da empresa?
- Como gerem o equilíbrio entre crescimento económico e sustentabilidade? Poderia partilhar algum exemplo específico de decisão desafiante neste sentido?

4. Perspetivas Futuras e Recomendações

- Como imagina a evolução da empresa nos próximos 5 a 10 anos no que respeita à inovação sustentável?
- Que mudanças a nível político ou que apoios externos considera essenciais para acelerar a inovação sustentável na Economia Azul?
- Que recomendações daria a outras empresas que pretendem apostar na inovação sustentável?

APPENDIX E – INTERVIEW CODING FRAMEWORK (PAPER 3)



Source: Own elaboration, NVivo Output.

This visual represents the coding structure developed from the thematic analysis of semi-structured interviews, using NVivo software. The hierarchy demonstrates the key themes and subthemes that emerged from participants' responses, grouped into six main domains: (1) Contextual Information and Company Identity, (2) Sustainability Strategy and Implementation, (3) Innovation, (4) External Collaborations and Stakeholder Engagement, (5) Challenges and Barriers, and (6) Opportunities and Incentives. Each block reflects the relative frequency and organization of references coded to that theme.

APPENDIX F – SURVEY SUMMARY (PAPER 3)

The following structure outlines the key sections and thematic focus of the quantitative survey administered to participating companies. This instrument was designed to capture firm-level practices related to sustainability strategy, innovation practices, external collaborations, and perceived challenges and opportunities.

The survey consisted of both Likert-scale and categorical questions and was thematically aligned with the qualitative interview guide used in the same research project. Although the detailed analysis of the survey data is presented in Chapter 3 (Paper 2), the structure is included here in the appendix F to support transparency and coherence in the triangulation process presented in Chapter 4 (Paper 3). This allows readers to clearly see how the quantitative data supports and complements the qualitative findings.

Survey Summary Report of 40 Participating Firms

Types of innovation implemented:

- 75% of the companies implemented product innovation.
- 77.5% have implemented process innovation.
- 55% have implemented marketing innovation.
- 50% have implemented organizational innovation.

Company Size Distribution:

Among the 40 firms that participated in the survey:

- 42.5% are classified as micro enterprises
- 42.5% as small enterprises
- 15.0% as medium-sized enterprises

This distribution ensures a representative view of SMEs (Small and Medium-sized Enterprises) and allows for comparative insights across company sizes throughout the analysis.

Sustainability - Respondents were asked to rate various sustainability areas on a scale from 1 (no importance) to 5 (very high importance). The results below reflect both the

average rating and the percentage of companies that assigned the highest possible score (5).

Sustainability in company strategy:

Average: **4.20** - *50% rated it as very important*

Decarbonization:

Average: **4.13** - *37.5% rated it as very important*

Transparency & sustainability reporting:

Average: **3.95** - *30% rated it as very important*

Water pollution prevention:

Average: **4.03** - *40% rated it as very important*

Compliance with environmental regulations:

Average: **4.53** - *60% rated it as very important*

Social responsibility:

Average: **4.33** - *52.5% rated it as very important*

Sustainable product/service development:

Average: **4.42** - *55% rated it as very important*

Climate risk management:

Average: **4.20** - *45% rated it as very important*

Cost reduction through sustainability:

Average: **3.98** - *30% rated it as very important*

Biodiversity conservation:

Average: **4.25** - *47.5% rated it as very important*

Use of renewable energy:

Average: **4.15** - *40% rated it as very important*

Green technology implementation:

Average: **4.38** - *52.5% rated it as very important*

Sustainable resource management:

Average: **4.30** - *50% rated it as very important*

Circular economy:

Average: **4.10** - *32.5% rated it as very important*

Community engagement:

Average: **3.98** - *30% rated it as very important*

Environmental education & awareness:

Average: **3.98** - *30% rated it as very important*

Partnerships with research institutions:

Average: **4.30** - *45% rated it as very important*

Investment in R&D:

Average: **4.22** - *40% rated it as very important*

Adoption of green technologies:

Average: **3.70** - *17.5% rated it as very important*

Implementation of sustainable resource management:

Average: **3.92** - *27.5% rated it as very important*

Innovation Practices - Respondents rated the frequency or importance of various innovation-related practices on a scale from 1 (low/never) to 5 (very high/very frequent). Results reflect the average score and the percentage of companies that selected the highest score.

Circular economy practices:

Average: **3.95** - *35% apply it very frequently*

Importance of innovation for company growth:

Average: **4.25** - *52.5% rated it as very important*

Investment in R&D over the last 3 years:

Average: **4.08** - *37.5% invested at the highest level*

Adoption of new technologies:

Average: **3.98** - *25% scored it as very high*

Collaboration with research institutions/universities:

Average: **4.13** - *50% reported strong collaboration*

Monitoring & Evaluation of Sustainability Impact - This section explores how companies assess and track their sustainability performance. Ratings were given on a scale from 1 (not done at all) to 5 (done extensively).

Tracking KPIs (Key Performance Indicators):
Average: **3.60** - *20% do this extensively*

Regular evaluations and reviews:
Average: **3.60** - *17.5% rated this as very frequent*

Use of data and analytics to monitor progress:
Average: **3.68** - *25% gave the highest score*

Sustainability reporting and transparent communication:
Average: **3.35** - *15% operate at a high level*

Stakeholder involvement (e.g. local communities):
Average: **3.20** - *Only 5% deeply integrate this*

External sustainability audits:
Average: **2.50** - *12.5% conduct these regularly*

Use of internationally recognized impact assessment methods:
Average: **2.95** - *12.5% apply such methodologies*

Impact of Sustainability Practices - Companies were asked to assess the impact of their sustainability practices on different areas of business and society. Ratings were based on a scale from 1 (no impact) to 5 (very strong impact).

Job creation:
Average: **3.59** - *12.5% observed very strong impact*

Economic growth:
Average: **3.70** - *10% reported strong contribution*

Profitability:
Average: **3.83** - *15% experienced high returns*

Pollution reduction:
Average: **3.73** - *25% observed environmental benefits*

Biodiversity conservation:

Average: **3.70** - *25% reported meaningful impact*

Energy efficiency:

Average: **3.78** - *25% reported major improvements*

Community engagement:

Average: **3.28** - *10% rated the impact as very strong*

Improvement in living conditions:

Average: **3.75** - *22.5% gave top rating*

Education and awareness:

Average: **3.73** - *20% rated it as very impactful*

Barriers to Innovation - Respondents assessed how much certain challenges hinder innovation within their companies, using a scale from 1 (no barrier) to 5 (very significant barrier).

Financial constraints:

Average: **3.68** - a **moderate to significant** barrier

→ *25% rated this barrier as very significant*

Regulatory challenges:

Average: **3.40** - *10% identified it as very significant*

Resistance to change:

Average: **2.40** - *Not considered a major barrier by most companies*