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Regional Dynamics and Economic Sustainability of Mariculture Firms in Portugal: A Financial Performance Analysis

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Abstract: This study provides a comprehensive analysis of the financial performance of aquaculture firms in Portugal from 2013 to 2022, considering regional, age, and size dynamics. Using financial data from the ORBIS database, key performance indicators are calculated to assess the industry's economic sustainability, regional disparities, and firm-level effects. The analysis reveals insights into the resilience of aquaculture firms in navigating economic challenges, such as the COVID-19 pandemic, and highlights the importance of tailored policy interventions to support regional development and industry competitiveness. Age trends show the influence of industry experience on financial performance, with older firms demonstrating higher turnover and profitability. Size trends indicate the advantages of economies of scale for larger firms, while smaller firms exhibit agility and innovation. This study contributes to the understanding of aquaculture economics in Portugal, providing valuable implications for policymakers, industry stakeholders, and aquaculture firms. By considering regional, age, and size dynamics, stakeholders can develop comprehensive strategies to enhance the sector's long-term sustainability and resilience in an increasingly dynamic market environment. Recommendations are provided for policymakers to support regions with lower performance metrics, enhance infrastructure development, and promote workforce productivity to foster balanced economic growth across the aquaculture sector in Portugal.

Keywords: mariculture; blue growth; economic sustainability; regional policy

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1. Introduction

The concept of the blue economy, introduced by Gunter Pauli in "The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs" [1], emphasizes sustainable development in ocean-based economies, aiming for low carbon emissions, resource efficiency, and equitable growth [2,3]. Blue Growth focuses on economic growth from marine resource exploitation while preventing environmental degradation [4]. It includes sectors such as mariculture, fisheries, maritime transport, marine biotechnology, seabed mining, and renewable energy [5].

In Portugal, mariculture has faced challenges like geographical constraints, foreign competition, and regulatory complexities [6]. However, the country's favorable natural conditions provide significant potential for high-quality species production. Thus, mariculture's growth is deemed inevitable to meet rising market demands amidst declining natural fish stocks.

Sustainability in mariculture involves balancing economic profitability with environmental conservation. Corporate sustainability practices emphasize transparency, stakeholder engagement, and forward-thinking strategies [7]. Financial performance indicators, such as profitability and liquidity ratios, are crucial for assessing the economic sustainability of mariculture firms.

This study aims to analyze the financial performance of mariculture firms in Portugal from 2013 to 2022, using financial data from the ORBIS database. By examining regional, age, and size dynamics, the study provides insights into the resilience and sustainability of

the mariculture sector in an increasingly competitive market. The findings offer valuable implications for policymakers, industry stakeholders, and mariculture firms, highlighting the importance of tailored policy interventions to support regional development and industry competitiveness.

By acknowledging challenges such as regulatory complexities and geographical limitations, the paper underscores the importance of integrated approaches to sustainability that balance economic, environmental, and social considerations.

Following the introduction, Section 2 reviews the literature; information on the data source and methodology is provided in Section 3; Section 4 presents the results, Section 5 discusses the results and in the Section 6, some conclusions are drawn.

2. Literature Review

Mariculture research primarily focuses on production and economic aspects, often utilizing on-farm trials and sustainable livelihood frameworks [8–13]. However, Integrated Multi-Trophic Aquaculture (IMTA) systems are increasingly recognized for their potential to enhance sustainability in mariculture. Studies discuss the implementation of IMTA and its environmental and economic assessment, as well as challenges and methodologies for sustainability evaluation [14–17].

There is a growing body of literature examining global mariculture development patterns, projected impacts of climate change, and strategies for expanding ocean food production under changing environmental conditions [18–21]. In this context, efforts to enhance resource management and carbon sequestration efficiency in the mariculture sector are explored, along with the evolution of mariculture policies and spatial planning for sustainable development [22–25].

Some studies highlight the social and economic implications of mariculture practices, including their effects on income distribution, livelihoods, and community well-being [26–29]. For example, the concept of blue foods and their role in achieving sustainable food systems is being explored, emphasizing the demand for seafood across geographic and temporal scales and the environmental performance of blue foods [30–34]. Moreover, ecological benefits and potential for offshore mariculture are being examined while mapping suitable areas and assessing the feasibility of offshore aquaculture for sustainable seafood production [35–38]. In this framework, government regulations, insurance policies, and incentives aimed at promoting sustainable mariculture development are important while addressing environmental concerns and social justice issues [39–43].

3. Data and Methodology

This paper utilizes data from the ORBIS database to analyze the financial performance of 60 active mariculture firms in Portugal from 2013 to 2022. Various financial indicators, including turnover, net profit, cash reserves, total assets, and others, are assessed to gauge the economic sustainability of these firms. Basic statistics, time trends, and regional analyses are conducted to understand the overall performance and variations across different regions in Portugal. Additionally, the influence of firm age and size on financial outcomes is examined, with findings presented in tables to provide a comprehensive overview of the relationship between firm characteristics and financial performance. Through this data-driven approach, the study offers insights into the factors shaping the financial dynamics of the mariculture sector in Portugal, informing strategic decision-making for policymakers, industry stakeholders, and investors.

The ORBIS database, managed by Bureau Van Dijke, provides financial data for firms in Portugal and Spain, ensuring data integrity. It collects and harmonizes data from mandated firm reports, including those from Informação Empresarial Simplificada (IES) in Portugal. These streamlines reporting obligations and enhances data quality across parameters like accuracy, timeliness, completeness, and consistency. Table 1 explains the variables.

Table 1. Variables' explanation.

Variable	Calculation/Explanation
Age	Age of the company reflects the experience and stability of the company, which can affect performance.
Turn	Total revenue generated by the company. Reflects the company's ability to generate sales and revenue, a key indicator of financial performance.
Net	Net profit. Total profit after deducting expenses from revenue. Reflects the company's profitability, indicating its ability to generate profit from its operations.
Cash	Cash reserves. Total amount of cash and cash equivalents held by the company. Indicates the company's liquidity and ability to meet short-term financial obligations.
Tass	Total value of assets owned by the company. Reflects the size and scale of the company's operations, which can influence its competitiveness and ability to generate returns.
Share	Total value of shareholders' equity in the company. Indicates the portion of the company's assets that belong to shareholders, reflecting their ownership stake and potential returns.
Curr	Current ratio. Ratio of current assets to current liabilities. Measures the company's short-term liquidity and ability to cover its short-term obligations with its current assets.
Profmg	Profit margin. Percentage of revenue that translates into profit. Indicates the efficiency of the company's operations in generating profit from its sales.
Roe	Return on equity. Ratio of net income to shareholders' equity. Measures the company's ability to generate profit from shareholders' equity, reflecting its efficiency in utilizing shareholders' funds to generate returns.
Solv	Solvency ratio. Ratio of total assets to total liabilities. Indicates the company's ability to meet its long-term financial obligations with its assets.
Empl	Total number of employees reflects the company's workforce size, which can impact productivity, operational efficiency, and, ultimately, performance.
Size	The size is measured by the number of employees and takes value 1 for microfirms with less than 10 employees, 2 for firms with 10 to 49 workers, and 3 for more than 50 workers-
Prod	Labour Productivity indicates the efficiency of the company's operations in producing goods or services, which can impact its competitiveness and profitability.

Notes: Nominal values are in Th. USD and ratios are expressed in %.

4. Results

We calculate a set of performance indicators for mariculture firms in 2013–2022. The basic statistics are summarized in Table 2.

Table 2. Basic statistics, 2013–2022.

Variable	Obs	Mean	Std. Dev.	Min	Max
age	600	20.6	16.8	8	111
turn	553	1341.1	8927.2	0	190,546
net	563	38.6	8216.0	−94,277	166,084
cash	563	402.9	7283.6	−11,867	167,166
tass	565	3448.0	17,954.0	1	299,010
share	565	858.1	7882.1	−134,026	93,294
curr	553	7.2	14.7	0	92
profmg	455	1.1	34.4	−100	100
roe	446	−10.8	116.1	−885	912
solv	530	32.0	40.1	−96	100
empl	505	8.8	19.3	1	170
size	505	1.2	.5	1	3
prod	500	84.5	102.4	−2	1656.9

Note: own analysis on Stata 17.0.

Most variables have a considerable range between their minimum and maximum values, indicating significant variability in the dataset. Standard deviations are relatively high for some variables, suggesting a wide dispersion of values around the mean. For certain variables like 'turn', 'net', 'cash', 'tass', and 'share', there are outliers indicated by the large difference between the mean and maximum values. Also, some variables like 'profmg' and 'roe' have negative mean values, suggesting potential issues or losses in profitability for certain companies.

The presence of negative values in 'profmg' and 'roe' could indicate financial difficulties or inefficiencies in some companies. Variables like 'curr' and 'solv' have minimum values of 0 or negative, which might indicate potential financial risks or liquidity problems in certain cases.

Time trends. Table 3 shows the trends in time. Over the period, there is a notable increase in turnover (turn), indicating growing sales revenue for mariculture firms. However, net profit (net) shows fluctuation, with some years experiencing losses and others gaining profitability. Cash flow (cash) show variability, suggesting fluctuations in liquidity over time.

Table 3. Mean values by year.

Year	Age	Turn	Net	Cash	Tass	Share	Curr	Profmg	Roe	Solv	Size	Empl
2013	21	629	−453	−170	6917	2227	8	2	−56	32	1	8
2014	21	706	−478	−242	4647	403	11	4	−14	29	1	8
2015	21	747	−331	−128	3942	135	7	−10	−20	28	1	8
2016	21	1243	−1604	587	1424	−1863	8	−1	−14	30	1	7
2017	21	3717	2788	2856	1927	794	6	0	−10	26	1	8
2018	21	865	9	81	2253	877	7	6	−2	28	1	8
2019	21	1043	51	133	2916	1199	9	3	29	37	1	9
2020	21	1086	−93	−4	3403	1383	7	−1	−17	34	1	10
2021	21	1484	286	428	3817	1748	5	6	11	40	1	11
2022	21	1608	83	266	4025	1967	6	2	−26	38	1	12

Note: Source: own calculations on Stata 17.0.

Total assets (tass) demonstrate a general upward trend, indicating expansion in the scale of operations. Shareholders' equity (share) also displays growth, reflecting increased ownership stake in mariculture firms.

The period analyzed is market by business cycles, as follows:

Pre-Crisis (2013–2014): This period reflects a relatively stable phase before the onset of significant economic challenges. While there was modest growth in turnover, declining net profits and liquidity constraints hinted at potential vulnerabilities.

Crisis (2015–2016): This phase marks the aftermath of the economic crisis, characterized by a decline in net profits and liquidity challenges. The industry faced pressures from reduced consumer spending and economic uncertainty.

Recovery (2017–2019): During this period, the mariculture industry showed signs of recovery with increasing turnover, indicating improving market conditions. Net profits and liquidity also improved gradually, reflecting a rebound from the crisis.

Pandemic Period (2020–2021): The outbreak of the COVID-19 pandemic introduced new challenges, disrupting supply chains and causing fluctuations in demand. Despite these challenges, the industry demonstrated resilience, with total assets and shareholders' equity showing stability.

Post-Pandemic Recovery (2022): The period following the pandemic is marked by efforts to recover and adapt to the new normal. It represents a phase of cautious optimism, with the industry seeking to rebuild and strengthen operations amidst ongoing uncertainties.

Regional Trends. Evaluating the performance of mariculture firms by regions in Portugal is crucial for several reasons:

Regional disparities: Portugal's geographical diversity and varying economic landscapes result in significant regional disparities. Understanding the performance of mari-

culture firms at a regional level helps identify areas of economic strength and weakness. This information is vital for policymakers to formulate targeted interventions and allocate resources effectively to address regional imbalances.

Resource allocation: Different regions may have distinct natural resources, infrastructure, and human capital, which can influence the productivity and competitiveness of mariculture firms. Evaluating performance by region allows policymakers to allocate resources strategically, such as investing in infrastructure development, research and development, or workforce training, to enhance the competitiveness of the mariculture sector in each region.

Policy formulation: Regional performance analysis provides valuable insights for policymakers in designing tailored policies and initiatives to support the growth and sustainability of mariculture firms. By understanding the specific challenges and opportunities faced by firms in different regions, policymakers can develop targeted interventions that address regional needs and promote balanced economic development across the country.

Stakeholder engagement: Evaluating performance by region facilitates stakeholder engagement and collaboration at the local level. It allows industry associations, research institutions, and local communities to participate in the decision-making process, identify shared priorities, and develop collaborative solutions to common challenges faced by mariculture firms in their respective regions.

Sustainable development: Assessing regional performance enables the integration of sustainability considerations into regional development strategies. By evaluating the economic, environmental, and social performance of mariculture firms in each region, policymakers can promote sustainable practices, minimize environmental impacts, and enhance the resilience of local communities dependent on mariculture activities.

In a nutshell, evaluating the performance of mariculture firms by regions in Portugal is essential for informed decision-making, targeted policy interventions, and sustainable development of the mariculture sector.

Table 4 shows the mean values for financial ratios by NUTs II regions. The Centro region stands out with the highest average turnover, reflecting robust sales performance, while also boasting the highest average cash reserves, indicating strong liquidity.

Table 4. Mean values by regions, 2013–2022.

Variable	North	Centro	Lisbon	Alentejo	Algarve	Madeira
age	29	27	14	36	19	17
turn	988.2	3617.2	307.2	113.5	565.0	894.6
net	−32.9	282.3	−119.5	−3.6	−15.4	49.6
cash	25.68	1516.5	−56.2	7.3	52.8	90.2
tass	2030.8	9100.5	1885.9	779.8	1261.7	953.3
share	701.4	1648.8	673.3	771.1	543.5	271.6
curr	1.3	4.1	5.6	39.9	10.8	1.0
profmg	−7.9	−5.0	−2.1	−3.3	10.2	3.1
roe	−25.0	−21.0	−9.0	−0.4	−2.3	0.3
solv	25.7	36.6	21.2	98.9	34.5	24.0
size	2	1	1	1	1	1
empl	15	16	4	1	6	7
prod	79.62	103.68	69.38	116.43	76.22	104.61

Note: there are no data for Azores. Source: own calculations on Stata 17.0.

Algarve emerges as a top performer in terms of net profit, profit margin, and ROE, suggesting efficient operations and effective utilization of shareholders' funds. Alentejo showcases superior financial stability with the highest average solvency ratio and strong ownership stake, as reflected by the highest average shareholders' equity. The Lisbon region's lowest average current ratio highlights potential short-term liquidity issues, suggesting a need for measures to enhance financial stability. In contrast, the Alentejo region's lowest average employee count signals potential challenges related to workforce size and

productivity, warranting strategies to boost employment and enhance operational efficiency. Furthermore, the Lisbon region's lowest average labor productivity underscores the need for initiatives to improve operational effectiveness and optimize resource utilization in the labor market.

Age Trends. Regional insights suggest regions with a long-standing tradition and experience in mariculture may have established practices, knowledge networks, and supportive infrastructures that contribute to the success and financial stability of mariculture firms operating within them. Older firms located in these regions may benefit from the accumulated expertise, established supply chains, and favorable regulatory environments, which can positively impact their financial performance compared to newer entrants or firms operating in regions with less mariculture tradition. Understanding the regional context and its influence on the performance of mariculture firms provides additional depth to the analysis, highlighting the interplay between industry experience, regional dynamics, and corporate performance. Therefore, considering regional insights alongside the age and size of mariculture firms offers a comprehensive understanding of the factors shaping financial outcomes in the mariculture sector.

Indeed, analyzing the age of firms is crucial for understanding corporate performance, especially in industries like mariculture, where profitability may take several years to achieve and various challenges, such as diseases, can impact operations along the way. The age of mariculture firms is important in analyzing corporate performance for several reasons. First, in mariculture, it often takes several years for operations to become profitable. Establishing and maintaining mariculture facilities, developing stock, and achieving optimal production levels require significant time and investment. Analyzing the age of mariculture firms helps in assessing their progress along this profitability timeline and understanding the challenges they face during the initial years of operation; second, mariculture involves complex processes and techniques, and firms typically undergo a learning curve as they gain experience and expertise in managing operations efficiently. Older firms may have overcome initial hurdles, refined their production processes, and developed effective strategies for disease management and risk mitigation. Analyzing the age of mariculture firms provides insights into their level of experience and expertise, which can influence their performance and competitiveness; third, disease outbreaks are significant risks in mariculture, potentially leading to substantial economic losses. Older firms may have encountered and learned to manage various diseases over time, implementing preventive measures and protocols to minimize their impact. Analyzing the age of mariculture firms helps in assessing their resilience to disease outbreaks and their ability to adapt and recover from such challenges; fourth, the age of mariculture firms can also reflect their investment and growth trajectory. Older firms may have had more time to attract investment, expand their operations, and establish market presence compared to newer entrants. Analyzing the age of mariculture firms provides insights into their growth patterns, investment strategies, and long-term viability in the industry; fifth, over time, mariculture firms develop industry knowledge, networks, and relationships that can be valuable assets. Older firms may have established partnerships with suppliers, distributors, research institutions, and regulatory agencies, enabling them to access resources, expertise, and support more effectively. Analyzing the age of mariculture firms helps in understanding their position within the industry ecosystem and their ability to leverage networks for competitive advantage.

Table 5 shows the results of corporate financial performance by age. By and large, older firms tend to exhibit higher turnover, net profits, cash reserves, total assets, and shareholders' equity compared to newer firms. This trend suggests that established firms have built up resources and market presence over time, enabling them to generate more significant revenues and profits. However, older firms may also face challenges such as lower liquidity ratios and profitability margins, potentially due to increased operational costs or inefficiencies. In contrast, newer firms show lower average values across most financial variables but may demonstrate higher growth potential and flexibility. They often

exhibit higher liquidity ratios, indicating better short-term financial health. Additionally, newer firms may prioritize efficiency and innovation, leveraging technology and modern practices to compete effectively in the market. Overall, while older firms benefit from experience and stability, newer firms contribute to industry dynamism and innovation, highlighting the importance of a diverse ecosystem of companies in the mariculture sector.

Table 5. Mean values by age of firms.

Age	Turn	Net	Cash	Tass	Share	Curr	Profmg	Roe	Solv	Size	Empl
8	506	−532	−432	2348	714	2	−14	−68	2	1	5
9	44	11	14	78	47	4	1	12	58	1	1
10	155	36	47	320	228	22	36	37	53	1	4
11	259	−13	16	844	268	3	−1	−12	22	1	4
12	165	−19	−3	290	30	3	1	−17	21	1	3
13	638	−48	20	1716	630	10	−8	−18	26	1	9
14	385	−138	9	1546	418	10	−4	5	18	1	6
15	153	1	7	230	79	8	0	22	26	1	4
16	893	18	115	1891	1427	3	2	−24	40	1	6
17	371	−93	−47	1577	635	1	−14	−20	40	1	6
18	21,879	2428	10,907	53,358	7176	5	3	13	−2	2	69
19	1497	179	273	3567	1144	1	11	17	22	2	11
21	584	−326	115	12,172	3148	14	4	−3	48	1	16
23	21	−6	−5	119	20	4	−28	−15	16	1	1
27	1721	131	196	1901	1137	2	8	14	57	2	13
30	3703	87	165	2754	1237	2	3	8	45	2	16
31	136	66	76	371	343	38	55	29	95	1	1
32	333	−2	40	937	627	15	1	−4	62	1	4
35	1307	−519	−353	4886	2399	3	−16	−58	56	2	16
36	1792	240	404	4407	2154	22	4	6	76	2	11
37	409	7	47	1196	251	1	0	2	22	1	3
40	943	−35	−22	1329	543	2	−7	−29	40	2	10
42	60	−47	−11	1121	254	0	−55	−20	22	1	2
56	1036	−35	−26	1880	626	2	−4	−19	34	2	15
66	87	−67	−64	892	−20	0	−18	−212	−3	1	2
111	360	−170	−91	1587	178	0	−11	−151	6	1	6

Note: Source: own calculations on Stata 17.0.

Size trends. Firm size may be crucial for financial performance in the mariculture sector for several of the following reasons:

Economies of Scale: Larger mariculture firms often benefit from economies of scale, allowing them to spread fixed costs over a larger production volume. This can lead to lower average costs per unit of output, enhancing profitability.

Access to Resources: Larger firms typically have greater access to financial resources, technology, and skilled labor, enabling them to invest in advanced production techniques, research and development, and infrastructure improvements. These investments can lead to higher productivity and efficiency, driving financial performance.

Market Power: Larger mariculture firms may have more bargaining power in the marketplace, allowing them to negotiate better prices for inputs and secure favorable contracts with buyers. This can result in higher revenue and improved profit margins.

Risk Management: Diversification of operations and markets is often more feasible for larger mariculture firms, reducing their exposure to risks such as disease outbreaks, market volatility, and environmental disasters. This enhanced risk management capability can contribute to greater financial stability and resilience.

Regulatory Compliance: Compliance with regulatory requirements and certification standards is often easier for larger firms due to their greater capacity to invest in compliance measures and adapt to changing regulations. This can reduce legal and reputational risks, which are important considerations for financial performance.

Innovation and Adaptation: Larger mariculture firms are better positioned to invest in innovation and adapt to evolving market trends, consumer preferences, and environmental challenges. By staying at the forefront of technological advancements and market developments, larger firms can maintain a competitive edge and sustain financial growth.

Overall, firm size influences various aspects of mariculture operations, from production efficiency and market dynamics to risk management and innovation capabilities, all of which ultimately impact financial performance. Understanding the relationship between firm size and financial outcomes is essential for stakeholders, policymakers, and investors seeking to support the growth and sustainability of the mariculture industry. Table 6 displays the results by firm size (micro, small, and large). Larger firms, represented by size category 3, demonstrate significantly higher turnover, net profits, cash reserves, total assets, and shareholders' equity compared to smaller firms. This indicates that larger firms have established substantial market presence and operational scale, allowing them to generate higher revenues and profits.

Table 6. Mean values by firm size.

Size	Age	Turn	Net	Cash	Tass	Share	Curr	Profmg	Roe	Solv	Empl
1	19	241	−32	1	943	334	6	−2.8	−9	24	3
2	29	1879	−145	58	4426	1755	2	−4.9	−29	40	16
3	18	43,666	4861	21,820	106,612	14,410	6	18.5	13	37	136

Note: own calculations on Stata 17.0.

Moreover, larger firms tend to have higher liquidity ratios and profitability margins, reflecting better financial health and efficiency in resource management. On the other hand, smaller firms, represented by size categories 1 (micro) and 2, exhibit lower average values across most financial variables but may demonstrate agility and innovation. They often have higher return on equity ratios, suggesting efficient utilization of shareholders' funds to generate returns. Smaller firms may face challenges related to limited resources and scalability but can leverage their flexibility to adapt to changing market conditions and pursue niche opportunities. Overall, the analysis underscores the importance of considering firm size as a significant factor in understanding the financial performance and dynamics of the mariculture industry.

From a managerial perspective, these trends underscore the importance of careful financial planning to manage fluctuations in profitability and liquidity, especially in the mariculture sector. Firms should prioritize optimizing cash flow management and maintaining adequate reserves to cover short-term obligations. As the scale of operations increases over time, efficient asset management and investment strategies become essential to ensure sustainable growth and profitability.

Regional policies play a crucial role in supporting the mariculture industry's competitiveness and resilience. To foster growth and innovation, policymakers should focus on facilitating access to finance, promoting investment in infrastructure, and encouraging sustainable practices. Targeted interventions may be necessary to address specific challenges faced by mariculture firms, such as improving market access or enhancing productivity through technological innovation. The analysis also highlights the dynamic nature of the mariculture industry, which requires adaptive management strategies and supportive policies to promote economic sustainability and growth. Evaluating performance by regions in Portugal provides valuable insights into regional disparities, resource allocation, policy formulation, stakeholder engagement, and sustainable development. By considering regional insights alongside firm age and size, stakeholders can develop comprehensive strategies to support the mariculture sector's long-term success and resilience.

5. Discussion

The concept of Blue Growth, aimed at fostering sustainable development and economic expansion in marine and maritime sectors, presents both opportunities and challenges

for mariculture. While it offers a means to meet the growing demand for seafood and address concerns regarding overfishing and environmental degradation, financial decisions within the mariculture sector are heavily influenced by management practices and political frameworks. Government policies play a pivotal role in supporting sustainable mariculture through investment incentives, infrastructure development, and skill enhancement, particularly in regions with lower performance metrics. Strategies such as Portugal's National Strategy for the Sea 2021–2030 (ENM) and the Strategy for Increasing the Competitiveness of the Mainland Commercial Port Network—Horizon 2026 drive the policy aspects of Blue Growth and mariculture in the country. These strategies aim to govern the sea for energy transformation, sustainable economic growth, job creation, and climate change mitigation, setting objectives like combating climate change and promoting the blue economy. However, challenges persist in implementation, including undefined action plans and insufficient funding. Integration of national strategies within the EU's Integrated Maritime Policy allows alignment with common EU objectives, ensuring a comprehensive approach to sustainable resource management. Financial support is crucial for policy implementation, aligning with principles of subsidiarity, competitiveness, and stakeholder involvement. Internationally, Portugal aligns with the UN's 2030 Agenda for Sustainable Development, focusing on SDG 14 (Life Below Water). Mariculture plays a vital role in addressing gaps identified in the 2030 Agenda, such as food security and ocean sustainability, contributing to sustainable development, economic growth, job creation, and marine ecosystem preservation. By providing an alternative source of fish and seafood, mariculture helps reduce pressure on wild fish populations, promoting the sustainable use of ocean resources. However, expanding mariculture faces challenges like geographical limitations and complex regulatory frameworks. Achieving sustainable mariculture growth requires balancing economic viability with environmental protection and social responsibility, emphasizing the integration of financial analysis with sustainability indicators to comprehensively assess mariculture operations. Sustainability assessment tools must accommodate diverse contexts and complexities, considering economic, ecological, and social dimensions.

This study highlights fluctuations in turnover, net profit, and liquidity over a 10-year period, reflecting the industry's vulnerability to economic cycles and external shocks. These findings corroborate existing literature, which emphasizes the dynamic nature of the mariculture sector and the importance of adaptive financial strategies [9,11].

Regional Trends:

The Centro region's superior performance in turnover and liquidity aligns with literature suggesting regional disparities in mariculture development [28]. Tailored policy interventions to address such disparities have been advocated by scholars, emphasizing the need for localized strategies [27].

Age Trends:

The observed differences between older and newer firms echo previous research on the advantages of experience versus innovation and agility [10]. Understanding these dynamics is crucial for informing industry strategies and policies [12].

Size Trends:

The study's findings regarding the financial performance of larger versus smaller firms resonate with the literature on economies of scale versus flexibility [13,44]. Balancing these factors is essential for firms of all sizes to thrive, as emphasized in prior research [16].

Implications for Policy and Practice. The study underscores the importance of tailored policy interventions, echoing calls from the literature for supportive regulatory frameworks and financial incentives [42]. Additionally, the emphasis on financial planning and risk management [45,46] aligns with existing recommendations for enhancing industry resilience [41].

Limitations

While financial analysis provides valuable insights into the economic sustainability of mariculture firms, it may not fully capture the environmental and social dimensions of

sustainability. Future research could employ a more integrated approach that considers multiple sustainability indicators. In addition, the analysis did not account for external factors such as regulatory changes, market conditions, or environmental events, which could influence the financial performance of mariculture firms. Incorporating these factors into future research could provide a more comprehensive understanding of industry dynamics.

6. Conclusions

This study provides a comprehensive analysis of the financial performance of mariculture firms in Portugal from 2013 to 2022. The findings reveal insights into the industry's economic sustainability, regional disparities, age dynamics, and firm size effects, offering valuable implications for policymakers, industry stakeholders, and mariculture firms.

The analysis of financial indicators highlights the industry's resilience in navigating economic challenges and external shocks, such as the COVID-19 pandemic. While mariculture firms experienced fluctuations in turnover, net profit, and liquidity over the 10-year period, they demonstrated overall growth and stability, reflecting the sector's importance in Portugal's economy.

Regional analysis underscores the need for tailored policy interventions to address regional disparities and promote balanced economic development across different regions. Quantitative research findings suggest that policymakers should focus on facilitating access to finance, promoting investment in infrastructure, and encouraging sustainable practices to support the growth and resilience of the mariculture sector.

In addition, age trends reveal the influence of industry experience on financial performance, with older firms demonstrating higher turnover, net profits, and total assets compared to newer firms. However, newer firms exhibit higher liquidity ratios and may prioritize efficiency and innovation, contributing to industry dynamism and competitiveness.

Moreover, size trends highlight the advantages of economies of scale for larger mariculture firms, which demonstrate higher turnover, net profits, and asset values compared to smaller firms. However, smaller firms exhibit agility and innovation, leveraging flexibility to adapt to changing market conditions and pursue niche opportunities.

Overall, the mariculture sector in Portugal holds significant potential for growth and innovation, and by leveraging industry strengths and addressing key challenges, stakeholders can work together to ensure the sector's long-term success and contribution to sustainable economic development.

Future avenues of research could focus on integrating environmental and social sustainability metrics into financial analysis, conducting more detailed regional analyses with granular data and qualitative methods, and employing empirical research methods to provide mechanistic insights into the factors influencing financial outcomes in the mariculture sector.

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