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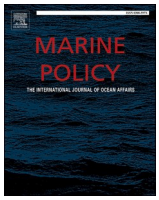

The economic sustainability of Italian aquaculture farms: Who has the potential to start the blue transition?

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ABSTRACT

The European policy objectives, aligned with the Green Deal, focus on strengthening the aquaculture sector's resilience, competitiveness, and sustainability. In this regard, the present work explores whether aquaculture companies are prepared to embrace the blue transition and invest in new practices and technologies. The study examines the case of Italian aquaculture by analyzing the financial performance of various companies through Altman's Z' Score, classifying them based on their balance sheets from 2017 to 2021. This study supports the idea that financially stable companies have the economic potential to invest in a more sustainable future. The findings highlight that 80 % of Italian aquaculture companies are currently under financial stress, limiting their capacity to adopt new practices or technologies. These results open the debate for decision-makers about whether the priority should be the blue transition or the companies' financial stability.

1. Introduction

Millions of people rely on aquatic systems for their livelihood, and it is expected that aquaculture development will have a substantial influence on future global food and nutrition security, encompassing the assurance of a diverse, sustainable, and healthful diet [16,37]. Concerning European aquaculture, in 2020, the production exceeded one million tons and employs around 57,000 people, with Spain, France, Greece, and Italy accounting for over 60 % of it [68]. According to the Eurostat database, in 2022, Italian aquaculture registered a turnover of 554 million euros, producing about 131 thousand tons of products. The primacy is held by Mediterranean mussels, which reached 61 thousand tons, followed by trout (29 thousand tons), clams (21 thousand tons), and seabream and seabass productions (13 thousand tons) [33]. Consequently, there is still considerable potential for growth and diversification when considering the introduction of new practices and technologies to address challenges to the different marine, freshwater and shellfish species [72,77].

The FAO Roadmap for the Blue Transition [35] and recent communications at the European level are prompting the sector to both develop its full potential and increase its commitment to sustainability. In particular, the European Commission recently published the Communication "*Strategic Guidelines for a more sustainable and competitive European aquaculture*" for the period 2020–2030 [29], adopting a New Strategic Vision [30] which identifies aquaculture as a source of low-carbon food. In addition, other initiatives, such as Eu Algae [39] and Energy Transition [32] move towards more restorative sustainability models in a circular economy perspective. Promoting sustainability is also a key priority of the European Maritime, Fisheries, and Aquaculture Fund (EMFAF) across the seven-year planning [30], effective since July 14th, 2021. The EMFAF aims to support the EU Common Fisheries Policy (CFP), the EU maritime policy and the EU agenda for international ocean governance with a total budget of €6.108 billion. Still, one of the main focuses of the fund is to facilitate the development of a sustainable blue economy in the future [31].

Considering the development of the European blue transition, two main aspects can be identified as "delayers" of its progress: the relatively recent establishment of policies dedicated to sustainable aquaculture (1) and the numerous crises faced in recent years (2).

First, blue policies were established later than agricultural ones, so the sustainability challenges related to the sector [73]. Blue policies were initially regulated within the Common Agricultural Policies (CAP), and only later, in 1983, the CFP was established. At that time, the need for a CFP was closely tied to the fishing sector, as it represented a

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strategic economic sector for the new countries (e.g., United Kingdom, Ireland, Denmark, Greece, Portugal, Spain) joining the European Economic Community (EEC) [69]. It was only in 2013, with the publication of the European Commission's Communication "Strategic Guidelines for the Development of Aquaculture in the EU" [27], that the first formal connection between aquaculture and blue policies was established [59], leading to the creation of the European Maritime Affairs and Fisheries Fund [28]. The need for a fund arose not only to support a productive sector capable of generating economic and social value but also to address better the challenges of sustainable intensification, which were gaining increasing relevance and interest during those years [34]. Indeed, aquaculture was accused of being unsustainable for different reasons, most notably due to exploiting natural fish stocks for aquafeed production and the consequent impact on natural ecosystems [57]. This scenario lays the groundwork for rethinking production models and demonstrating the pivotal role of aquaculture in shaping a future grounded in social, economic, and environmental responsibility [25].

The second mentioned aspect refers to the recent years crises, notably the COVID-19 pandemic, which affected most of the agri-food sectors [1,19], including European aquaculture [26,58,76]; and the geopolitical instability in Eastern Europe arising from the Russia-Ukraine conflict, which has considerably slowed down the growth and competitiveness of companies [50]. These crises intensified an already precarious situation, leading to increased operational costs and undermining the fragile economic viability of aquaculture companies [22]. This situation of instability and uncertainty has further cooled the relationship between the world of credit and businesses, leading to an increase in the relational gap between credit institutions and aquaculture companies. This generated severe difficulties for the sector, which was already suffering from a structural and organizational deficit in the context of a full financial crisis [4]. It is therefore not surprising that one of the critical issues for the European aquaculture sector is the lack of adequate financial support from the credit market needed to sustain business development, especially for small and medium-sized enterprises (SMEs) [43,45,78]. A limited access to capital, high investment risks and lack of collateral often hinder entrepreneurial initiatives, such as implementing new practices [54,65]. Therefore, assessing the financial constraints of aquaculture companies plays an essential role in policy planning and regulatory interventions [53].

In an era where aquaculture needs changes, any emphasis on sustainability needs to be grounded in the financial stability of a business [24]. For this reason, there is an increasing need for new studies focusing on "financial readiness" for the blue transition. Readiness has been described as the preparedness of an organization to face future and unpredictable changes [21,56] and Agyapong & Tweneboah [3] revealed that, specifically, financial preparedness strongly influences the adoption of future actions for the sustainability of blue sectors. In this regard, this paper attempts to respond to the following research question:

– Do Italian aquaculture companies have the economic potential to undertake the blue transition?

Specifically, the present study uses company creditworthiness as a proxy of financial preparedness to support the hypothesis that the most stable companies are more able to invest in innovation and embrace the blue transition. To test the hypothesis on the Italian aquaculture sector and classify the companies according to their creditworthiness, a variation of Altman's well-known Z Score, the Z' Score, was utilized.

2. Theoretical background

European aquaculture companies are generally small or medium-sized and are subject to high variability in economic performance [45,53]. For this reason, the farmers' decision to invest in innovations to embark on the blue transition may not always be a straightforward choice [49]. Indeed, how a company finances itself influences its value and growth opportunities [64]. A company's investments can be funded internally with retained earnings. Still, growth opportunities are limited by the size of annual profits. In contrast, with external financing, the company is temporarily obligated to pay interest on the debt and repay the capital according to a predetermined schedule [48]. Therefore, companies need to develop production systems to generate sufficient cash flow to repay investments [46]. Moreover, the presence of a biological cycle further increases the need for capital, in this case, to finance working capital. For companies that prepare financial statements, the International Accounting Standard (IAS) 41 requires fish to be classified as working capital during the farming cycle [23], often leading to an imbalance between profits and cash flows, with the possibility to create situations where companies are profitable but cannot sustain payments during the financial cycle [46]. When the prolonged nature of a downturn takes on the connotation of a structural event rooted in management, the company may be unable to meet its business obligations and thus enter a state of insolvency [10]. Since insolvency is the result of a dynamic deterioration process, where detectable and quantifiable symptoms are assumed to be present, numerous qualitative and quantitative statistical models have been developed to identify early warning signs to predict it [53,55,66]. There is a wealth of research that has highlighted different methodologies, economic variables and performance indicators to identify the financial strengths and weaknesses of agri-food companies using financial statements [44,46,60,62,70,74]. In this regard, several studies have proposed case studies, such as the salmon industry in Norway [12,79], carp farming in Poland [60], Portuguese mariculture [62], mussel farming in Europe [13], Mediterranean seabass and seabream industry [11,52], or the European industry in a comprehensive sense [40,43,44]. Some estimations of the European aquaculture profitability were recently performed by the European Commission's Scientific, Technical and Economic Committee for Fisheries [68], and the key performance indicators utilized, such as gross value added, earnings before interest and taxes, average wages, and labor productivity. In the EROL studies [26], financial statements were examined through ratio analysis, which, in financial analysis, allows for a horizontal and vertical assessment of an organization's profit and loss accounts, and the creation of various correlations between balance sheet items. Other studies employed the capital structure theories [11,66], the multi-period logit model and generalized least squares estimation (EGLS) [51], the multiple regression analysis [46], the classification and regression tree model (CART) [55], and the Altman model [53] which aims to classify European aquaculture companies based on the values of the observed financial variables.

The literature review reveals a gap in the use of these economic and financial analyses as possible contributions to the strategic definition of policies oriented both to support the competitive and sustainable development of the aquaculture sector. In this sense, studies to ascertain the financial readiness of companies to invest in circular economy and sustainability practices is a concept that has been scarcely introduced in research.

3. Method

Assessing the financial health of companies has always been a topic of great interest in the research field [44,5], and a correct interpretation of companies' performance indicators plays a crucial role, regardless of the size, type of business or any other characteristic of the company itself [42,62,70]. The most frequent term to describe the condition of a company is "financial distress" [14]. An example is held by Alaka et al. [5], where both the importance of choosing the best tool to predict financial distress and the relevance of this prediction for stakeholders are emphasized. However, the origin of financial situation theory dates to the 1920s-1930s, while the first proposed model appeared in the literature decades later, around the mid-1960s, in the study of Beaver [14]. Following Beaver's line of research, several studies have tried to

predict the financial distress of companies [17,18,20,9,10]. One of the best-known models for predicting insolvency is the so-called Altman Z Score, which has become popular worldwide among finance, banking and credit risk scholars to assess the creditworthiness of corporate counterparties [8]. Creditworthiness is a judgment that can explain the probability of default of a firm, or rather that the debtor is unable to pay the part of the capital to the creditor on time. The judgment is usually used to schedule the potential borrowers based on their reliability [10]. The variables used in the process typically refer to factors representative of the company's financial condition that can be derived from accounting records, the objectivity and completeness of which are partly determined by the disclosure requirements and regulations to which they are subject. The statistical analysis performed to realize this objective is Altman's predictive model, also known as the Z Score.

This model uses a multivariate discriminant analysis to classify a statistical unit according to its explanatory variables. The model can be expressed as a linear combination of the independent variables using the following formula:

$$Z = \alpha + \beta_1 X_1 + \beta_2 X_2 \ldots + \beta_n X_n$$

The Z value indicates the dependent variable's score (*discriminating value*) to assess the group classification, while the *X* values are the independent variables (*uncorrelated*) with related coefficients.

To measure the company's solvency in each period (*year*) and perform a discriminating statistical analysis, the Z Score method considers groups of companies of equal size and, based on a linear relationship, identifies five variables for each company in the sample. These variables, which are five balance sheet ratios representative of the liquidity, profitability, leverage, and solvency of the companies, are then weighted by coefficients, resulting in a score. The user-friendliness and cost-effectiveness of this method have facilitated numerous revisions, including by the author himself, who has constantly updated the parameters and adapted the coefficients to populations other than companies listed on financial markets [10]. Altman's model, which exists in various adaptations, is among the most widely used models in the world for assessing corporate insolvency [53]. In addition, Altman's model better suits the present research purpose than other models, such as the Ohlson (O-score) or the Springate models. Differently than the O-Score model, which is based on a probabilistic approach, the Altman model allows to obtain more consistent estimations, avoiding overestimating the failure probability of individual firms; moreover, it is particularly suitable for listed and non-listed companies [15]. Furthermore, the Springate model, widely used primarily to assess the failure probability of small and medium-sized firms, is considered less comprehensive compared to the Z-score. Thus, Altman's model seems more consistent than the other two mentioned models [38,63].

The original formulation of the Altman Score [6] was as follows:

$$Zorj = \quad 1.2X_1 \quad + \quad 1..4X_2 \quad + \quad 3.3X_3 \quad + \quad 0.6X_4 \quad + \quad 0.999X_5;$$

typically employed for analyzing manufacturing and listed companies, and more recently (e.g., [80]; [53]) utilized also for the aquaculture sector. Then, over time, it underwent various reformulations, each evolving its characteristics based on the specific analyzed sample.

Among the various reformulations of the model, the present study applied a Z Score variation, the Z' Score, which is typically utilized for the industry sector. The scientific literature, especially for the innovation transfer, treated the aquaculture sector as industrial [2,47] due to its structure since it represents a business with high capitalization and investment in the facilities. The lack of an appropriate aquaculture regulatory framework may represent a significant obstacle to future sustainable developments in numerous European and non-European countries. This may complexify the classification of different aquaculture activities, which are already characterized by high heterogeneity in production systems and reared species, and which exhibit different entrepreneurial behaviors based on the size and level of organization of operations [47]. The FAO [36] "*Legal frameworks for sustainable aquaculture*" also underscores the dual nature of this sector due to the companies' possibilities to be established as agricultural farms, using biological materials, or as industrial firms, depending on the complexity of their capital structure. The twofold opportunity is meant to provide a tax advantage to those companies that do not need high capitalization but benefit from the possibility of joining simplified regimes such as the agricultural ones. An example is held by Italy, where farmers are not necessarily required to declare balance sheets if their aquaculture company falls under the regulation of an "agricultural entrepreneur" [61].

On these bases, the present study assumes that those who report financial statements are more structured companies with more entrepreneurial behavior.

The samples used to calculate Z' Score included all the available companies registered on Italian Chambers of Commerce database belonging to the Italian aquaculture sector (ATECO 0.3). Therefore, in this work, the choice of Z Score goes towards Z', which suits the extracted data since Italian aquaculture companies are not listed on the financial markets and can be considered as industries and "not full-agricultural-nature" companies.

The main variables utilized in the Z' Score are listed in Table 1.

The relationship identified to give rise to the score was:

$$Z' = 0.717X_1 + 0.847X_2 + 3.107X_3 + 0.420X_4 + 0.998X_5;$$

Where:

X_1 = *Working capital/Total assets*

X_2 = *Retained Earnings (Legal reserve + Extraordinary reserves) /Total assets*

X_3= *Earnings before interest and taxes/Total assets*

X_4 = *Book value of equity/Book value of total liabilities*

X_5 = *Sales/Total assets*

Z' = *Overall Index*

To rank Italian aquaculture companies according to their creditworthiness, the Altman Z' Score model identifies three different threshold values intending to determine the "distress zone", "moderate risk zone", and "safe zone" based on the risk of insolvency. Moreover, the *cut-off* value, corresponding to 2.675, sets the boundary between those companies characterized by low and moderate-high risk of insolvency (Fig. 1).

The threshold values are consistent with the literature on the topic and the proposed model. Altman's Z score identified risk areas with values between 1.81 and 2.67, a narrower range having more data and treating listed and less heterogeneous companies; in the later version, the values changed between 1.10 and 2.60 [7].

The Z-Score analysis was conducted for the years 2017–2021 in order to compare how the companies' solvency changed during the considered

Table 1
Variables and definitions.

Variable	*Definition*
Working Capital	It indicates the difference between current assets and current liabilities represented in the balance sheet
Total Asset	It represents the sum of all assets owned or controlled by a company, reflecting its financial strength and resources.
Retained Earnings	It is the fraction of the profits not distributed to the shareholders in the form of dividends but that remains reinvested in social assets (such as legal and extraordinary reserves)
Earnings before interest and taxes (EBIT)	It is an intermediate result that assesses the company's profitability, not considering the financial structure.
Equity	It is the measurement of the size of assets resulting from the difference between assets and liabilities.
Total Liabilities	It indicates the sum of the company's liabilities
Sales	It represents the volume of business generated through the sale of goods.

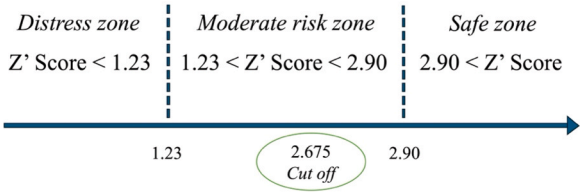

Fig. 1. Representation of classification areas.

period. Table 2 provides the sample's geographical aggregated distribution by Italian region, while a more detailed dataset, referred to the provincial distribution, is reported in **Appendix I.**

4. Results

A total of 392 companies were observed in 2017, 405 in 2018, 434 in 2019, 457 in 2020 and 487 in 2021. The reason for this observation floatation can be due to several possible factors, such as (as pointed out by [53]) a change of core business, a merger with another company or the disappearance of the company itself and the lack of communication of the balance sheet information.

What emerged from a first analysis is that in terms of short-term liquidity, the average working capital recorded in the analyzed sample accounted for €170,409.2, with a relatively low average dispersion. The 34.6 % of the total of companies reported a negative working capital value. The average value of total assets owned or controlled by a company was €1512,906, displaying a high variability in total assets. The retained earnings also showed a high variability, referring to €1189,651. Moreover, these companies showed a positive *EBIT* (Earnings before interest and taxes) on average, while the negative value of the minimum underscores a sufferance from very high operating losses. The maximum value of liabilities, amounting to €36,151,802, reveals a high debt situation for some companies (Table 3).

As previously mentioned, according to the three different threshold values identified by the Altman model, Italian aquaculture companies can be classified as:

- high risk of insolvency (*distress*) (Z' Score< 1.23)
- moderate risk of insolvency (*grey*) (1.23 < Z' Score < 2.90)
- low insolvency risk (*safe*) (2.90 < Z' Score)

Companies with a Z' Score above the upper limit (2.90) were classified as "*safe*" and considered trustworthy. Companies showing a Z' Score between the upper and lower Z' Score threshold values (1.23 < Z' Score < 2.90) were those for which the model was unable to predict the future state reliably and classified as *"moderate risk" (grey)*, so requiring further analysis. Lastly, companies with a score below the lower value (1.23) were categorized as *"financially distressed"* (*distress*) and considered excessively risky. The results of this classification are displayed in Table 4.

Table 2
Geographical sample distribution over the years.

	Years				
Region	**2017**	**2018**	**2019**	**2020**	**2021**
Abruzzo	6	6	6	6	7
Basilicata	2	2	2	2	2
Calabria	6	6	6	6	6
Campania	28	30	32	33	35
Emilia-Romagna	107	111	115	121	130
Friuli-Venezia Giulia	15	14	16	16	16
Lazio	20	20	24	24	25
Liguria	3	3	3	3	4
Lombardy	9	9	10	12	13
Marche	10	10	11	11	11
Molise	3	4	4	4	4
Piedmont	2	2	2	2	4
Apulia	54	55	59	67	70
Sardinia	28	28	29	30	31
Sicily	14	20	25	27	29
Tuscany	12	13	15	15	16
Trentino-South Tyrol	5	4	5	4	5
Umbria	1	1	1	1	1
Veneto	67	67	69	73	78
Total	**392**	**405**	**434**	**457**	**487**

Table 3
Descriptive statistics for each variable observed over the period 2017–2021 (average).

Variable	***Mean***	***Standard Deviation***	***Minimum***	***Maximum***
Working Capital	170,409,2	1117.376	−6785,227	14,886,476
Total Asset	1512,906	3938,637	125	36,151,802
Retained Earnings	272,066.5	1189,651	−151,116	19,672,536
Earnings before interest and taxes (EBIT)	8246.929	370,970.3	−8686,919	6010,730
Equity	480,009	1923,342	−6029,364	23,919,520
Total Liabilities	1512,906	393,863,7	125	36,151,802
Sales	1013,603	3532,900	0	57,678,371

The annual percentage changes in the number of companies were examined to understand how companies modulated their financial position. Companies with high insolvency risk and those with zero risk increased in 2018 compared to 2017 by 7.07 % and 9.23 %, respectively, while moderate risk ones decreased by 4.2 %. In 2019, the number of enterprises in every zone increased compared to 2018: businesses with a moderate risk of insolvency and those with a high risk of insolvency increased by 7.3 % and 5.58 %, respectively, while those with zero risk slightly increased.

The changes in the last analyzed year showed an increase of 65.31 % in zero-risk companies, while the number of companies with a high risk of insolvency increased slightly (2.51 %), and the medium risk decreased by 4.73 %.

Overall, based on current observations, it is possible to say that high-risk companies gradually increased from 2017 to 2021 (33 %). As far as moderate risk is concerned, the trend in absolute terms appears more variable. The lowest number of companies in the safe zone was recorded in 2020 (49 companies).

The sub-sample of companies common to the two years was extracted to compare the actual change in the financial situation over the 2017–2021 period. Therefore, a total of 365 companies were analyzed. Fig. 2 provides a graphical representation of the Altman Z' Score over the national territory (at a province level) for the year 2017 of the sub-sample. The three clusters, according to the level of insolvency risk, are displayed in different colors to show the overall situation of the aquaculture companies among Italy. The results shed light on the high risk of insolvency situation in Southern Italian provinces. Only Vibo Valentia province is characterized by the majority of *"safe zone"* firms. Considering the Northern Regions, it appears to be a similar situation, with some exceptions for the provinces of Ferrara and Florence.

Fig. 3 shows the same graphical representation of the Altman Z' Score of the country for the year 2021. From this analysis, the companies located in the Southern regions, more precisely in the provinces of

Table 4
Share of active companies that belong to different levels of risk insolvency by year.

	Year				
Zone	***2017***	***2018***	***2019***	***2020***	***2021***
Distress	184	197	208	239	245
Moderate risk (Grey)	143	137	147	169	161
Safe	65	71	79	49	81
Total companies	***392***	***405***	***434***	***457***	***487***

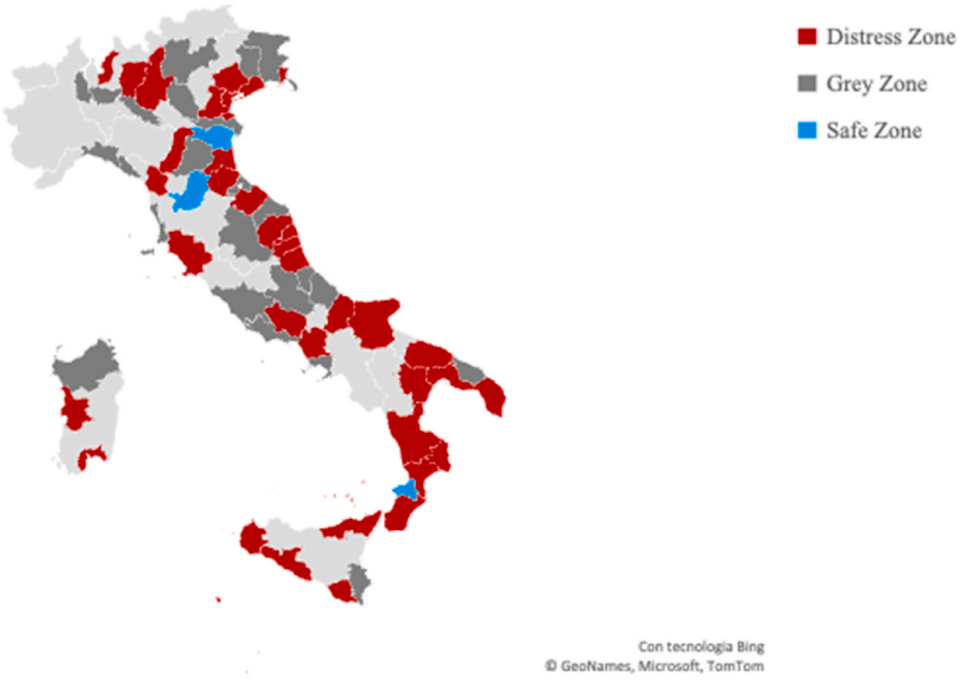

Fig. 2. Altman Z' Score of Italian aquaculture companies for the year 2017.

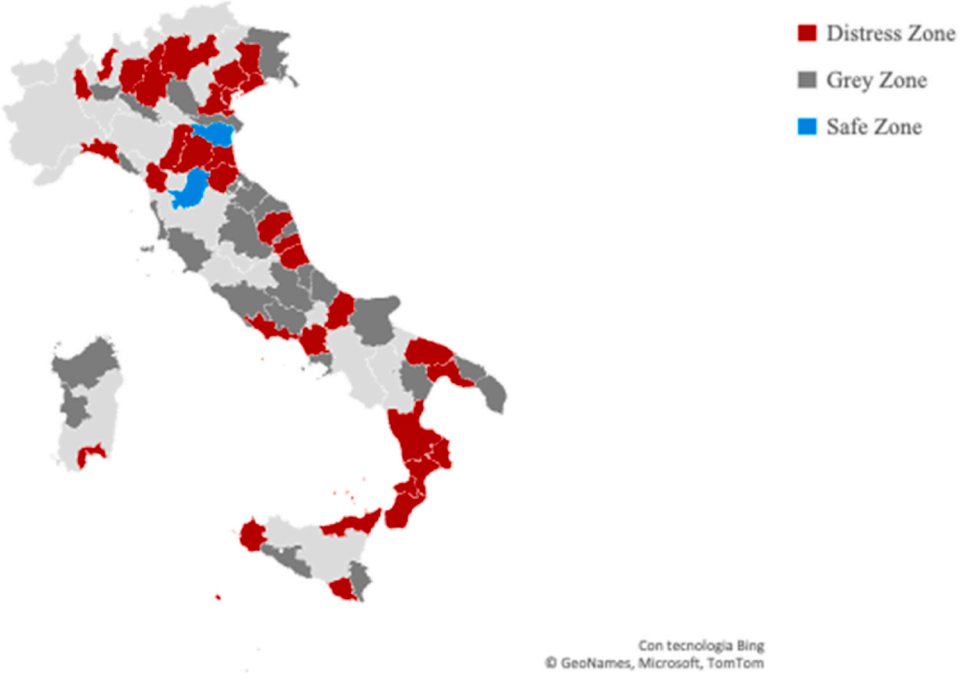

Fig. 3. Altman Z' Score of Italian aquaculture companies for the year 2021.

Trapani, Messina, Ragusa, Reggio Calabria, Vibo Valentia, Catanzaro, Crotone, Cosenza, Bari and Taranto, belong to the *"distress zone"*. Furthermore, the companies located in the province of Cagliari are also at high risk of insolvency. Lastly, those companies in the *"safe zone"* are mainly located in the provinces of Firenze and Ferrara.

5. Discussion

The results showed that the financial status of Italian aquaculture companies has not improved over time but rather the opposite. In the considered period, annually, more than 80 per cent of the analyzes 365 companies are considered in a critical situation.

The year 2020 reports the most significant change in the number of companies at high risk of insolvency (14.9 %) compared to 2019, a trend that could be attributed to the concurrent crisis caused by the COVID-19 pandemic, which began in late March 2020, and disrupted potential investment decisions, international trade, and the functioning of the labor market [22,4].

The comparison of the resulting classification through the Z' Score for 2017 and 2021 across the geographical distribution shows that firms

in the Southern area continue to experience significant financial difficulties five years later. For example, the province of Vibo Valentia, characterized by enterprises in the *"safe zone"* in 2017, shifted to the trouble zone in 2021. Some companies in the Northern area have worsened their situation by moving from the *"grey zone"* to the *"distress zone"*, such as in the provinces of Bologna, Novara, Genova, Pordenone and Trento. Differently, companies in the Central area moved from the *"distress zone"* to the *"grey zone"*, such as those in Fermo, Frosinone, Grosseto and Pesaro provinces. Other companies in the Southern area, such as Lecce, Matera, Foggia, and Oristano, moved from the *"distress zone"* to the *"grey zone"*. The case of the aquaculture farms in the Province of Ferrara, which are always located within the "safe zone", is peculiar. This area is known for the vital presence of the shellfish farming sector, mainly concentrated in the "Sacca di Goro" lagoon. Aquaculture in the area generates an estimated annual turnover between 60 and 70 million euros, employing around 1700 people, corresponding to about 60 % of the active population, in addition to employment in the fishing industry, commercial and collateral activities, such as shipbuilding and tourism [71].

6. Conclusion

Financial creditworthiness is essential for a sector like aquaculture, which requires significant initial and continuous investments to maintain sustainable operations [46] and comply with environmental strategies. Therefore, the lack of access to credit capital may be particularly disadvantageous and hinder a potential transition to more sustainable aquaculture production models.

Aside from the latest study by Lososová and Zdeněk [53], the present research represents one of the preliminary enquiries in the field. Nonetheless, the current study considered for the first time the dual nature of aquaculture entrepreneurs and adopted Altman's Z' score to emphasize the industrial behavior of aquaculture companies.

The analyzed companies declare balance sheets, which suggests they are more structured. Therefore, companies that do not declare financial statements may be less structured and have even more financially complex situations, especially in the relationship with credit, as they're forced to reconstruct their creditworthiness without official documentation.

This poses a dilemma: "How can these companies cope with the need to invest in sustainability when their financial stability is already precarious?". This opens a debate on the priority of EMFAF interventions. Is it right to focus exclusively on sustainable transition, or should priority be given to stabilizing and revitalizing businesses? Without financial stabilization, any attempt at transition could fail. The transition to sustainable aquaculture is necessary, as demonstrated by the recent literature [25,37,54,65,73] but neglecting the financial status of companies' risks to trigger a process of concentration of market power in the hands of few large groups. Indeed, there is the risk that larger companies, having access to more significant financial resources, will make a technical transition since they are able to invest. These companies could incorporate smaller ones and cause the latter to cease territorial control and lose their crucial role in promoting social and economic sustainability in the local community. It is precisely the SMEs that are at the root of the development of certified quality production, such as PDOs and PGIs, which hardly emerge in the aquaculture sector. It might be more effective to prioritize the solvency assurance of companies, which would allow them to stabilize and effectively adopt sustainable practices [24] or, eventually, quality schemes [75].

A balanced approach is essential, providing financial support to stabilize aquaculture businesses and then offering incentives for a sustainable transition [45]. A policy framework offering stabilization, based on a realistic understanding of the financial constraints of aquaculture businesses, followed by incentives, could facilitate a more inclusive and socially responsible transition. The aid provided by the European Union in 2020 to compensate for losses resulting from the pandemic crisis enabled aquaculture businesses to access the financial means necessary to meet their immediate needs for working capital and investments and to continue their activities. By supporting investments in aquaculture, fisheries, transformation and marketing with a budget of €180 million, the new challenge of the EMFAF 2021–2027 is to reduce the criticality of companies' access to credit capital and to encourage investments aimed at the blue transition. And to ensure that SMEs are not left behind in this process. Furthermore, using financial instruments, such as mutual funds or micro-credits, could make a decisive contribution to supporting SMEs in achieving the EMFAF objectives [75]. Although they have not yet been employed in the European fisheries and aquaculture sector, financial instruments are not new if the new programming period is considered. The underutilization of these instruments has been attributed to several factors [41], such as information asymmetry due to imperfect knowledge of financial instruments, excessive management complexity and lack of expertise on the part of Member States.

However, this research presents some limitations. First, the Italian legal status places the farmer in a simplified regime, where legal presumptions determine taxable income. Therefore, it is not possible to find indicative elements of the patrimonial and financial condition that ordinarily would derive from keeping compulsory accounting records. Secondly, the presence of cooperatives, with their typical legal structure and annual costs, does not allow an easy comparison with those of corporations. Finally, it is important to keep in mind the inherent limitations of Altman's model: (i) the variables considered are exclusively accounting and do not include macroeconomic information; (ii) the predictive power of the model is only high one year before bankruptcy, but decreases as the time interval before bankruptcy increases; (iii) the model does not take into account variables related to managerial inadequacies that could be linked to the firm's economic-financial difficulties; (iv) the analysis includes the years 2020 and 2021, which were characterized by the COVID-19 pandemic period that on the one hand negatively impacted the industry [67], and on the other hand saw exceptional financial supports that may have affected the balance sheet results.

As the blue transition is a complex challenge for the aquaculture sector, future research could focus on a more detailed and specific analysis of the sector's financial challenges and opportunities. Such studies could provide key information for developing targeted and differentiated policies to support the blue transition, responding not only to the specific needs of international and national sectors but also to those of the territorial context in which they operate.

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Appendix I

Table 1
Sample distribution by Provinces.

Province	Years 2017	2018	2019	2020	2021
Agrigento	2	2	2	2	2
Ancona	3	3	4	4	4
Ascoli Piceno	2	2	2	2	2
Bari	2	2	2	2	2
Benevento	0	1	1	1	1
Bergamo	1	1	1	1	1
Bologna	2	2	2	2	3
Brescia	2	2	2	2	2
Brindisi	3	3	2	3	3
Cagliari	3	3	3	3	3
Caltanissetta	0	1	1	1	1
Campobasso	3	4	4	4	4
Caserta	2	2	2	2	2
Catania	1	3	4	5	6
Catanzaro	2	2	2	2	2
Chieti	2	2	2	2	2
Como	1	1	1	2	2
Cosenza	1	1	1	1	1
Cremona	1	1	1	1	2
Crotone	1	1	1	1	1
Fermo	2	2	2	2	2
Ferrara	87	89	93	97	105
Firenze	1	1	1	1	1
Foggia	30	30	32	37	38
Forlì-Cesena	3	4	4	4	4
Frosinone	1	1	1	1	1
Genova	1	1	1	1	1
Gorizia	4	3	5	5	5
Grosseto	5	6	8	8	8
L'Aquila	1	1	1	1	1
La Spezia	2	2	2	2	3
Latina	9	9	9	9	9
Lecce	2	2	2	2	2
Livorno	4	4	4	4	4
Lucca	2	2	2	2	3
Macerata	2	2	2	2	2
Matera	2	2	2	2	2
Messina	1	1	1	1	2
Milano	4	4	4	5	5
Modena	1	1	1	1	1
Monza -Brianza	0	0	1	1	1
Napoli	26	27	29	30	32
Novara	2	2	2	2	2
Oristano	4	4	4	4	5
Padova	3	3	3	3	3
Perugia	1	1	1	1	1
Pesaro Urbino	1	1	1	1	1
Pescara	1	1	1	1	2
Pordenone	3	3	3	3	3
Ragusa	1	3	6	6	6
Ravenna	8	8	8	10	10
Reggio Calabria	1	1	1	1	1
Rimini	6	7	7	7	7
Roma	10	10	14	14	15
Rovigo	34	34	35	36	39
Sardegna	2	2	2	2	2
Sassari	19	19	20	21	21
Siracusa	5	5	5	6	6
Taranto	17	18	21	23	25
Teramo	2	2	2	2	2
Torino	0	0	0	0	2
Trapani	4	5	6	6	6
Trento	5	4	5	4	5
Treviso	4	4	4	4	4
Trieste	2	2	2	2	2
Udine	6	6	6	6	6
Venezia	23	23	23	26	28
Verona	3	3	4	4	4
Vibo Valentia	1	1	1	1	1
Total	**392**	**405**	**434**	**457**	**487**

Data availability

The authors do not have permission to share data.

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