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SWOT-AHP HYBRID METHOD FOR RANKING THE STRATEGIES IN THE SHIPBUILDING SECTOR

Gabriel POPESCU, Carmen GASPAROTTI*

Department of Naval Architecture, Naval Architecture Faculty, Dunarea de Jos University, Galati, Romania

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Abstract. The paper outlines the most important shipbuilding strategies in Romania that would allow this industry to increase its performance to be competitive. The research is mainly based on the collection of information from experts in the field from ANCONAV (Romanian Shipbuilders Association), specialists in design and production, and shipyard managers in Romania. The SWOT analysis was based on this information and was the starting point in formulating the strategies. The quantitative determination of the importance of each factor and sub-factor from the SWOT matrix in view of ranking the strategies, but also the verification of the points of view of the experts in the field were performed using the Analytical Hierarchy Process Method (AHP), using Excel applications. The obtained results consisted in identifying the internal and external environmental factors and formulating the main strategies with positive effects on the Romanian naval sector (the development of a Romanian cluster, the consolidation of the position on the global ship market through aggressive marketing, investments regarding the construction of ecological ships, the development of centers of excellence for exploiting the research-development-innovation capacity, the limitation of highly-skilled labor migration, expanding the digitalization, and developing a marketing policy to promote the national shipbuilding companies globally).

Keywords: SWOT matrix, AHP, pairwise comparisons, local priorities of the factors, ranking the strategies, shipbuilding sector.

JEL Classification: C02, C88, L10.

Introduction

The shipbuilding industry has specific characteristics and operates in a complex business environment. It is a strategic, open, and competitive industry on the global market (Mascaraque-Ramírez et al., 2018). In the shipbuilding industry, maintaining the market and competitiveness are achieved by winning and executing orders for ships in open competition. The competitive advantage in the shipbuilding sector is achieved through high-quality products and services, the emphasis being on product and process quality, as well as on

*Corresponding author. E-mail: *carmen.gasparotti@ugal.ro*

production efficiency. Emphasis is placed on product quality due to the risky environment in which the ship operates in order to ensure its safe operation (Juran & Defeo, 2016). The quality of the process is an important factor in achieving a profitable production, all this in the conditions in which the quality standards are very strict and have an international character. The complexity of the process of increasing the performance of the naval sector requires a systematic approach by carrying out a detailed analysis regarding the internal and external environmental factors and formulation of the strategies to be implemented. The most commonly used method for identifying these factors, being also a decision-making tool, is the SWOT analysis. It incorporates strengths and weaknesses (internal factors) and opportunities and threats (external factors), providing the basis for strategic planning (Killen et al., 2005). In many situations, there may be dependencies between the effects of the external and internal factors, which must be taken into account during strategic planning (Yuksel & Dagdeviren, 2007).

A successful strategic plan requires companies to focus on maintaining and developing strengths, capitalizing on opportunities, reducing weaknesses, and avoiding threats (Abdel-Basset et al., 2018), in order to later identify the strategies to put into practice. The next step is the TOWS matrix, developed by Weihrich (1982), with the help of which the strategies are formulated. In most industries, the companies are free to choose the strategies, with the goal of sustainable success that can support growth and secure the company's long-term future.

As stated by Jooste and Fourie, (2009), the implementation of these strategies is much more important than their formulation, but effective implementation faces many obstacles, one of which is the lack of high-level strategic management.

The SWOT method, although considered very general by many researchers (Kajanus et al., 2012; Madsen, 2016; David et al., 2019; Namugenyi et al., 2019; Benzaghta et al., 2021), in the case of shipyards, which have complex and specific characteristics and activate at globally (Syahtaria et al., 2019), it can be used for a comprehensive analysis of the environment in which they operate.

However, the use of the SWOT matrix does not allow a comprehensive assessment of the strategic situation because it does not include means for the analytical determination of the importance of the factors or the evaluation of the strategies in relation to the identified factors (Kajanus et al., 2012). By using the SWOT method, a qualitative analysis of the strategic planning process is obtained, depending on the capacities and expertise of those who participate in this process. To eliminate this shortcoming, the SWOT method can be combined with a quantitative method, such as the AHP.

The AHP proposed by Saaty (1980) is an effective tool in decision making. The method treats both qualitative and quantitative criteria and uses the judgment of experts, allowing verification of the inconsistency of these judgments in order to improve them, for better coherence of the evaluations made by decision-makers (Saaty, 1994). This method involves pairwise comparisons to set priorities for each criterion, as well as priorities for decision alternatives and ultimately determines the overall priority for making the best decision (Alho & Kangas, 1997).

Starting from the fact that there are very few studies (Ma'ruf, 2009; Lumaksono, 2014; Hossain et al., 2017; Syahtaria et al., 2019; Baso et al., 2020) on defining and prioritizing

strategies aimed at improving the situation of the shipbuilding sector, the paper aims a study in this regard. Thus, the purpose of this study is to determine the current situation of the Romanian naval sector, using the SWOT matrix, and the formulation and classification of the strategies that would increase the performance of this industry, using as criteria the sub-factors in the SWOT matrix. The originality consists in the fact that such a study is carried out for the first time in this industrial sector in our country which contributes to the identification of the strategic perspectives for development. The study can be useful both for the business environment, by highlighting the possibilities of defining and classifying the development strategies based on the identification of the environmental factors, but also for researchers seeking to improve the results obtained by the SWOT method by combining with AHP. The entries in AHP are obtained following the collection of information from experts in the field, using Saaty's measurement scale.

This research is organized into several sections: Literature review – in Section 1; research methodology – in Section 2; the case study conducted on the Romanian naval sector is presented to validate the application of the SWOT-AHP hybrid method – in Section 3. Finally, conclusions and future directions are presented.

1. Literature review

The use of SWOT and AHP methods in scientific research facilitates the formulation and selection of the strategies that, following implementation, can support the long-term success of the companies (Learned et al., 1969). The research is based on the literature review to provide a basis for the application of the hybrid SWOT-AHP method in the real case of the Romanian naval industry. This section provides a brief research review on achieving competitiveness by adopting appropriate strategies, several models for the business environment or to support decisions, and the benefits of implementing cutting-edge technologies in the industry.

Competitiveness is the condition of survival for many companies. Porter (2008), referring to the competitiveness of the companies, shows that they must take into account both the internal economic environment, which ensures the conditions of operation and success in the market, and the evolution of the external economic environment. For a shipyard operating in a constantly changing global market, competitiveness can be achieved by adopting strategies capable of maximizing the order book and ensuring the construction of ships at the quality and at the time they are demanded on the market (Panagiotou, 2003). Thus, Hossain et al. (2017) conducted a study on the Chinese shipbuilding industry to highlight starting from the SWOT method, that the factors that determined this industry to become competitive and efficient are government policy, national maritime strategy, and other supportive measures of the local shipyards. Lumaksono (2014) used SWOT analysis to identify some alternative strategies that can be used in the development of a traditional shipyard in the Sumenep region, using FAHP for ranking the strategies, based on the analysis of the environmental factors, in order to capture the perceptions of the specialists in the field. Şenol et al. (2017) proposed a detailed autonomous transport strategy based on the SWOT-AHP analysis, as a management and planning tool for global transport. The strategic actions established through online and face-to-face consultations of the experts are aimed at transforming threats into

opportunities and weaknesses into strengths. Putu et al. (2017) determined significant strategic factors for naval base relocation by combining SWOT methods with AHP, in order to develop this naval base, taking into account the main internal and external factors (availability of logistics region, topography, oceanography state). Strategic planning was carried out in order to develop this naval base and make it work optimally. In an attempt to explain the competition between China and Korea in shipbuilding, Lee (2019) examined the competitiveness by comparing the attributive factors of competitiveness, using AHP. He has concluded that the competitive factors are: technology and quality, shipbuilding price, and export credit. A more recent study carried out by Anwar et al. (2020) analyzed the strategies used by several shipping companies and shipyards in Indonesia, to survive in severe conditions and compete in a sustainable way, using the SWOT method, strategies that were then ranked by AHP. The conclusion was that for the Indonesian shipyards the best-rated strategy is to reduce the weaknesses (low productivity and capacity) by avoiding the threats (weakening of the global economy). Hozairi et al. (2020) conducted a study that aimed to determine the best strategy for improving maritime security in Indonesia, using the combination of SWOT and AHP methods. The results have shown that the strategy with the highest share is the one that aims to improve strengths (maritime country, very high government support, application of MCS technology (Monitoring, Controlling, Surveillance) by taking advantage of the opportunities (very high potential of natural resources in the sea, reform of Indonesia's marine security governance).

Taking into account the commercial environment in which it operates, and the internal and external environmental factors, a series of researches are focused on making models for the business environment or for supporting decisions. So, a business environment model was developed by Ma'ruf et al. (2006), which included five internal factors and five external factors, specific to medium-sized shipyards. The study used multivariate factor analysis to identify strategic factors, and the results obtained were used to develop business submodels for shipyards. Applying these models in the case of the shipyards could provide strategic options that lead to sustainable competitive advantage. Celik (2010) used in his study the SWOT-AHP combination to model the selection process of the marine suppliers. In this regard, he proposed a decision model, combining the environmental factors with AHP to obtain a methodology that can be integrated into technical ship management procedures. Akyuz and Celik (2017) investigated the possibility of improving the planned maintenance system (PMS) onboard the ship using the SWOT-AHP hybrid method. The authors have developed an enhanced maintenance concept (e-PMS) to ensure reliable, safe, and efficient shipboard operations that are integrated into the safety management system.

In recent decades, the industry has made remarkable progress in promoting high-performance techniques and technology. An important place in the top technologies was occupied by Concurrent Engineering, widely used in the shipbuilding industry. It has penetrated many industries for the benefits it presents, mainly shortening the execution time, decreasing production costs, and increasing product quality. So, Kim and Whang (1993) suggested a methodology for measuring and forecasting technological capabilities in the industry, using AHP combined with growth curve patterns. Tummala et al. (1997) formulated an AHP model for evaluating the success factors, benefits, and costs at the strategic and operational

level for the development of the strategies for implementing the Concurrent Engineering. They have noted that the benefits of implementing competing technology are increased quality and reduced costs. Yasseri (2012) proposed a method for selecting the most appropriate technologies or components for underwater production systems, in which he used several decision variables, from which: technology availability, reliability, maintainability, operability, and costs, using the AHP method. Sahin et al. (2015) have used the AHP method for the selection of the technologies in maritime logistics having as criteria the lifetime, brand value, maintenance, and costs. Bucak et al. (2019) conducted an assessment of the effects of Industry 4.0 on the maritime sector, using for this purpose SWOT analysis and ranking of the SWOT elements by the AHP method.

SWOT-AHP analysis has been successfully applied in a number of recent studies (Jain et al., 2021; Stefan et al., 2021; Veličkovska, 2022; Shiwakoti & Regmi, 2022).

2. Research methodology

The research methodology first involves reviewing the literature to obtain information on the use of the SWOT-AHP hybrid method in formulating and selecting strategies. In order to

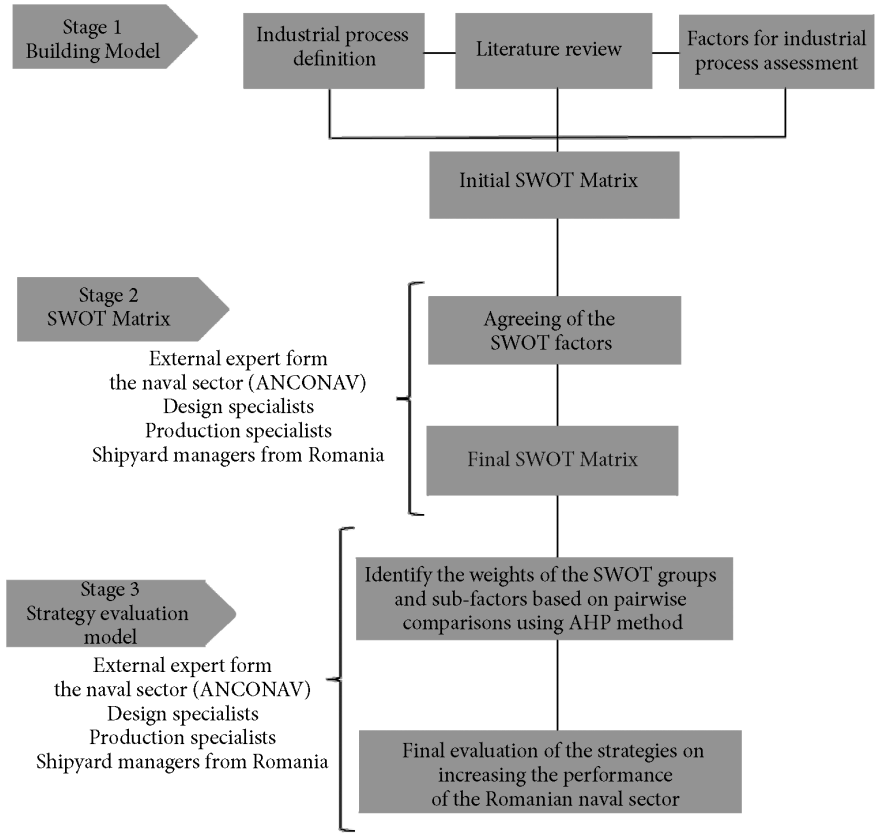

Figure 1. Main stages of the working methodology

identify the internal and external environmental factors and to define the best strategies for increasing the performance of the Romanian naval sector, a questionnaire was sent online, to a number of twenty-five experts belonging to this sector. Based on the judgment of these experts, pair-wise comparisons were made between SWOT groups and between sub-factors in each group to determine their weights. A quantitative measure of their importance was obtained. Then, alternative strategies were developed using the TOWS matrix. Verifying the consistency of the expert evaluations was performed by calculating the consistency ratio (CR) defined in step 3 of this section. The proposed methodology for evaluating and prioritizing strategies for increasing the performance of the Romanian naval sector, based on SWOT-AHP is presented in Figure 1. Starting from the main stages of the methodology presented in this figure, the five steps by which AHP has been integrated into SWOT are presented in detail (Wickramasinghe & Takano, 2010) below.

Step 1. Identify the factors in the SWOT matrix

The factors identified in the SWOT matrix characterize the internal and external environment of the Romanian shipbuilding sector. Their identification was made using the expertise and professionalism of the experts from the Association of Shipbuilders in Romania (ANCONAV), the specialists in design and production, and the managers of the shipyards in Romania. Seven strengths, five weaknesses, five opportunities, and six threats were identified, based on which seven strategies were formulated (Table 1).

Table 1. Factors identified in the SWOT matrix

STRENGTHS (S) – diversified order book all intended for export (S1); – competitive labor costs (S2); – the image of a reliable partner with traditional knowledge in shipbuilding (S3); – highly qualified, internationally recognized workforce (S4); – skills for the construction of specialized ships, for repair and conversion (S5); – large production capacities (S6); – integrated information system of design-production-management (CAD/CAE /CAM) (S7).	**WEAKNESSES (W)** – lack of an aggressive market strategy, as a result of the lack of marketing specialists (W1); – incomplete use of existing production capacities (W2); – poor development of the environmental protection management (W3); – low degree of automation in technological processes (W4); – lack of manufacturers of equipment for the naval field in the region (W5).
OPPORTUNITIES (O) – favorable geographical location (exit to the Black Sea and over 1000 km from the Danube) (O1); – technological transition regarding the propulsion systems (O2); – partnership relations with shipowners and/or shipyards in the world (O3); – improving technological exchanges and the tendency to build ecological ships (O4); – collaboration relations between shipyards and profile faculties (O5).	**THREATS (T)** – low level of growth of the world economy (Q1); – the tendency of Asian countries to include in their portfolio existing ships in the portfolio of Romanian shipyards with competitive prices (T2); – reduced level of the international trade (T3); – migration of skilled labor in shipyards in Europe (T4); – lack of an internal market for ships (T5); – overcapacity in the tonnage of the world fleet (T6).

Step 2. Formulation of the strategies using the TOWS matrix

Defined strategies aim to improve the current situation in the Romanian naval sector in order to increase its performance taking into account the internal and external environmental factors. From the strategies proposed by the experts in the field, those strategies were selected, which in the current conditions regarding the existing resources and the environmental factors, can be viable. In order to put them into practice, it is necessary ranking them, using the AHP method. The formulation of the strategies takes into account logical combinations that can be achieved between internal and external environmental factors using the TOWS matrix (Table 2), which includes four types of strategies: SO, WO, ST, and WT. In this way, the internal and external factors of the naval sector are incorporated into the defined strategies. For the seven selected strategies, rational combinations were made (for example, the strategy WO2, combines the weak point W1 with the opportunity O3). However, these strategies may be influenced by factors other than those taken into account in formulating the strategy (eg. the strategy WT can be supported by opportunities and strengths to a lesser extent than weaknesses and threats).

Table 2. TOWS matrix

		INTERNAL FACTORS	
EXTERNAL FACTORS		STRENGTHS (S)	WEAKNESSES (W)
	OPPORTUNITIES (O)	**Maxi-Maxi SO strategies** • developing the centers of excellence for the exploitation of the research-development-innovation capacity and the involvement of these centers in projects in the field in order to increase the quality of ships and reduce costs (SO1); • investments for the construction of ecological ships: ships with low emissions and ships that incorporate energy-efficient technological solutions (SO2); • extension of the ship digitization process (SO3).	**Mini-Maxi WO strategies** • developing of the Romanian maritime cluster – collaboration platform between producers, research-development-innovation centers, and shipowners (WO1); • developing a marketing policy for the promotion of national shipbuilding companies globally (WO2).
	THREATS (T)	**Maxi-Mini ST strategies** • limiting the migration of highly qualified labor force by attracting it to motivating activities according to specialization (ST).	**Mini-Mini WT strategies** • consolidating the position on the global ship market through aggressive marketing for maintaining and even developing the existing market niche (WT).

Step 3. Hierarchical structure regarding the evaluation of the strategies

The hierarchical structure regarding the evaluation of the strategies that aim at increasing the performance of the Romanian naval sector (Figure 2), presents on the four levels, from top to bottom, the purpose, the SWOT matrix with the internal and external environmental factors, and the strategies defined at step 2, which will be compared.

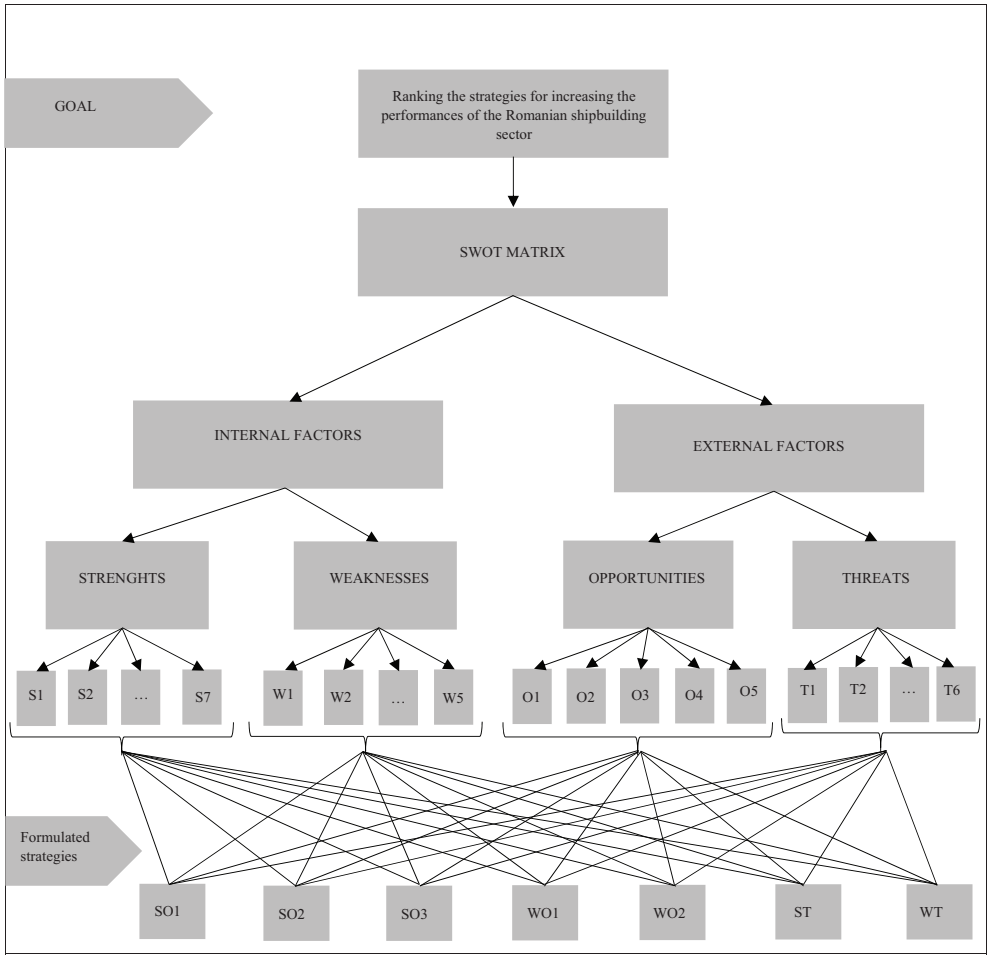

Figure 2. Hierarchical structure regarding the evaluation of the strategies aimed at increasing the performance of the Romanian naval sector

Step 4. Pair-wise comparisons to determine the relative importance of the factors and sub-factors in the SWOT matrix

The pair-wise comparisons performed at this step allow the calculation of the relative importance of the factors and sub-factors in the SWOT matrix. Considering the comparisons made, first between the SWOT factors (groups) and then between the sub-factors, their relative local priorities were obtained using Saaty's scale. Table 3 shows the numerical scale of Saaty used for pair-wise comparisons.

To make the pair-wise comparisons we proceeded as follows: the pair-wise comparisons between the SWOT groups/sub-factors were made after it was previously established which group/sub-factor is more important and how important it is in relation to the others. Thus, the relative local priorities of each group/sub-factor were obtained. $N\ (n - 1)/2$ pairs of factors have been compared, n being the number of factors. For this, we created a real matrix

Table 3. Saaty's scale for pairwise comparisons (source: Saaty, 1980)

Intensity of importance	Interpretation judgment
1	criteria i and j that are compared are equally as the importance
3	criterion i is slightly more important than j
5	criterion i is much more important than j
7	criterion i is strongly more important than j
9	criterion i is absolutely more important than j
2, 4, 6, 8	intermediate judgments

$n \times n$ denoted by A. Each entry of this matrix, a_{ij}, represents how important the criterion i is in relation to j, so that $a_{ij} = 1/a_{ji}$.

Matrix A is of the form:

$$A = (a_{ij}) = \begin{bmatrix} 1 & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ 1/a_{1n} & \cdots & 1 \end{bmatrix}. \quad (1)$$

From matrix A the normalized matrix was obtained. The n-dimensional column vector, denoted by W, represents the weight vector for the compared factors and is obtained by calculating the average of the entries on each row in the normalized matrix:

$$W_j = \frac{\sum_{l=1}^{n} \hat{a}lk}{n}, \quad (2)$$

where: $\bar{a}lk$ – entries of the normalized matrix.

In order to establish the consistency of the evaluations of the decision factors, the CR was calculated. It is given by the ratio between the consistency index (CI) of the matrix containing the judgments of the decision-makers and the consistency index (RI) of a matrix, which contains judgments that have been entered randomly. The values calculated for RI are those provided by Saaty (1980).

The consistency indices for the randomly generated matrix are presented in Table 4, n being the number of elements that are compared. To continue the AHP analysis the value obtained from the calculation for CR must be less or equal to 0.1.

Table 4. Consistency indices for the randomly generated matrix (source: Saaty, 1980)

n	3	4	5	6	7	8
RI	0.58	0.9	1.12	1.24	1.32	1.41

The calculation of the CR index is performed starting from the matrix that includes the judgments of the decisional factors regarding the comparisons for factors, multiplying each element from the columns of this matrix with the weight of the criterion-related to the respective column. The weighted sums are obtained in this way, by summing the values on each row of the matrix. The elements of the weighted sum vector, thus obtained, are divided

by the weight corresponding to each criterion, then averaging the values obtained. The average of the obtained values represents the value λmax (the largest eigenvalue), used for the calculation of the index CI:

$$CI = (\lambda max - n)/(n - 1). \quad (3)$$

Having the value of the CI determined and of the RI, obtained from Table 2, CR can be determined.

Finally, the global priorities of the sub-factors are calculated as a product between the priority of the corresponding group and that of each sub-factor. The vector obtained is called the vector of the global priorities of the sub-factors (W_{opsf}).

Step 5. Hierarchy of the strategies to increase the performance of the Romanian naval sector

The hierarchy of the strategies involves determining the relative importance of each strategy compared to the others. For this, pair-wise comparisons of the defined strategies are made, in relation to each sub-factor from the SWOT matrix, using Saaty's scale.

If we denote by m the number of the alternative strategies and by n the number of subfactors, we can construct a real matrix (mxm), denoted by $Y^{(i)}$, $i = 1, ..., n$. Each entry in the matrix $Y^{(i)}$ represents the evaluation of a strategy compared to the others, in relation to each subfactor i. Then, we make $n(n - 1)/2$ pair-wise comparisons to obtain the weight vector for the defined strategies ($W_{ws/sf}$). Finally, the ranking of the strategies is achieved by calculating the vector of the global priorities of strategies ($W_{gpStrategies} = W_{opsf} \times W_{ws/sf}$).

3. Case study carried out on the naval sector in Romania

The model proposed in Section 2 aims to solve the real situation of the Romanian naval industry, presented in the case study in this section.

3.1. Data collection

In order to collect the data, in order to carry out this study, a questionnaire was sent online to twenty-five experts from the Romanian naval sector (design and production specialists and managers from Romanian shipyards) to determine internal and external environmental factors and define the strategies. Data were collected from experts in May 2021. The experts identified the main environmental factors, in the first stage, after which the most relevant ones were selected, in the second stage, in the perspective of formulating the strategies. In order to define in detail, the most effective strategies for the Romanian naval sector, individual interviews were conducted with the experts included in the study. Based on the discussions, they agreed on a number of seven strategies, which were then prioritized. The relative importance of the strategies formulated in the opinion of the naval experts is presented in Table 5.

Table 5, based on the weighted arithmetic mean of the answers given by the twenty-five experts in the naval sector, shows that the most important strategies are WO1 and WT. The average value of the relative importance given by the experts to the seven strategies is 3.79, which shows that the chosen method of ranking in this study is adequate.

Table 5. The relative importance of the strategies formulated in the opinion of the experts

No.	Strategies	Weighted arithmetic mean of the experts' answers in the field*
1	developing of the Romanian maritime cluster – collaboration platform between producers, research-development-innovation centers, and shipowners (WO1)	4.28
2	consolidating the position on the global ship market through aggressive marketing for maintaining and even developing the existing market niche (WT)	4.28
3	investments for the construction of ecological ships: ships with low emissions and ships that incorporate energy-efficient technological solutions (SO2)	4.04
4	developing the centers of excellence for the exploitation of the research-development-innovation capacity and the involvement of these centers in projects in the field in order to increase the quality of ships and reduce costs (SO1)	3.92
5	limiting the migration of highly qualified labor force by attracting it to motivating activities according to specialization (ST)	3.76
6	extension of the ship digitization process (SO3)	3.32
7	developing a marketing policy for the promotion of national shipbuilding companies globally (WO2)	2.96

Note: * All calculations were obtained using the Likert scale from 1 to 5, where 5 – is extremely important; 1 – is extremely unimportant.

3.2. Case study

For the pair-wise comparisons of the SWOT groups and sub-factors but also of the strategies in relation to each sub-factor, face-to-face interviews were conducted with the experts within the group.

The case study begins with the pair-wise comparisons of the SWOT groups and the calculation of the CR consistency index values (Table 6). The values obtained reveal that the strengths have the highest weight (0.539), followed by opportunities (0.282), threats (0.093), and weaknesses (0.086). The CR consistency index (0.043) demonstrates the consistency of the decision-making process.

Table 6. Priorities of the SWOT groups and consistency ratio

SWOT groups	S	W	O	T	Priority of SWOT groups
Strengths	1	5	3	5	0.539
Weaknesses	0.2	1	0.2	1	0.086
Opportunities	0.333	5	1	3	0.282
Threats	0.2	1	0.333	1	0.093
CR = 0.043					

Based on the pair-wise comparisons of the sub-factors (strengths: S1…S7; weaknesses: W1…W5; opportunities: O1…O5; threats: T1…T6), made similar to the SWOT groups in Table 6, the CR coefficients corresponding to these sub-factors (Table 7) and their local priorities (Table 8), in column (4), were obtained.

Table 7. Consistency ratio for sub-factors in SWOT groups

Sub-factors from SWOT groups	S1……S7	W1……W5	O1……O5	T1…….T6
CR	0.042	0.06	0.094	0.069

From the data presented in Table 8, it can be seen that the sub-factors with the highest local/global priorities from the internal environmental factors are: integrated informatic design-production-management system (CAD/CAE/CAM) (S7-0.250) and incomplete use of the existing production capacities (W2-0.338), and from the external environmental factors are: partnership relations with shipowners and/or shipyards in the world (O3-0.413) and migration of skilled labor in shipyards from Europe (T4-0.388).

Overall priority of the sub-factors in column (5) from Table 8 was obtained by making the product between the priority of each group (column (2)) (calculated in Table 6) and the priority of each sub-factor from the corresponding SWOT group (priorities being obtained by making matrices similar to those from Table 6, but making pair-wise comparisons between sub-factors from each group).

The vector of the global sub-factors priorities is W_{opsf} (according to step 4 from the methodology) and it is obtained based on the values in Table 8.

Table 8. Overall priorities

SWOT group (1)	Group Priority (2)	SWOT Sub-factors (3)	Sub-factors Priority (4)	Overall Priority of the sub-factors (5) = (2) × (4)
Strengths	0.539	S1	0.197	0.106
		S2	0.151	0.081
		S3	0.086	0.047
		S4	0.205	0.110
		S5	0.083	0.045
		S6	0.027	0.015
		S7	0.250	0.135
Weaknesses	0.086	W1	0.095	0.008
		W2	0.338	0.029
		W3	0.049	0.004
		W4	0.220	0.019
		W5	0.298	0.026

End of Table 8

SWOT group (1)	Group Priority (2)	SWOT Sub-factors (3)	Sub-factors Priority (4)	Overall Priority of the sub-factors (5) = (2) × (4)
Opportunities	0.282	O1	0.049	0.014
		O2	0.121	0.034
		O3	0.413	0.116
		O4	0.228	0.064
		O5	0.190	0.053
Threats	0.093	T1	0.114	0.011
		T2	0.248	0.023
		T3	0.074	0.007
		T4	0.388	0.036
		T5	0.105	0.010
		T6	0.071	0.007

$$W_{opsf} = \begin{bmatrix} S1 \\ S2 \\ S3 \\ S4 \\ S5 \\ S6 \\ S7 \\ W1 \\ W2 \\ W3 \\ W4 \\ W5 \\ O1 \\ O2 \\ O3 \\ O4 \\ O5 \\ T1 \\ T2 \\ T3 \\ T4 \\ T5 \\ T6 \end{bmatrix} = \begin{bmatrix} 0.106 \\ 0.081 \\ 0.047 \\ 0.110 \\ 0.045 \\ 0.015 \\ 0.135 \\ 0.008 \\ 0.029 \\ 0.004 \\ 0.019 \\ 0.026 \\ 0.014 \\ 0.034 \\ 0.116 \\ 0.064 \\ 0.053 \\ 0.011 \\ 0.023 \\ 0.007 \\ 0.036 \\ 0.010 \\ 0.007 \end{bmatrix}.$$

The evaluation of the strategies regarding the increase of the performance of the Romanian naval sector was made considering the hierarchy from Figure 2. Based on the pair-wise comparisons of the strategies in relation to each sub-factor of the SWOT matrix, the weights of the strategies (Tables 9–12) were determined, and then their weight vector ($W_{ws/sf}$) was obtained, a vector with 23 columns (the number of the sub-factors) and 7 rows (the number of the strategies). The final ranking of the strategies was based on the global priorities vector of the strategies ($W_{gpStrategies}$) (according to the calculation method from step 5 of the methodology).

Table 9. Pair-wise comparisons of the strategies in relation to the strengths

Concerning S1	Inconsistency ratio	Priorities of the strategies concerning S1
SO1	0.072	0.105
SO2		0.180
SO3		0.121
WO1		0.061
WO2		0.060
ST		0.237
WT		0.237
Concerning S2	Inconsistency ratio	Priorities of the strategies concerning S2
SO1	0.03	0.244
SO2		0.053
SO3		0.169
WO1		0.147
WO2		0.147
ST		0.184
WT		0.056
Concerning S3	Inconsistency ratio	Priorities of the strategies concerning S3
SO1	0.045	0.082
SO2		0.168
SO3		0.067
WO1		0.240
WO2		0.059
ST		0.089
WT		0.295
Concerning S4	Inconsistency ratio	Priorities of the strategies concerning S4
SO1	0.06	0.216
SO2		0.144
SO3		0.127
WO1		0.176
WO2		0.070
ST		0.042
WT		0.225

End of Table 9

Concerning S5	Inconsistency ratio	Priorities of the strategies concerning S5
SO1	0.09	0.132
SO2		0.333
SO3		0.090
WO1		0.132
WO2		0.053
ST		0.044
WT		0.215
Concerning S6	Inconsistency ratio	Priorities of the strategies concerning S6
SO1	0.09	0.156
SO2		0.193
SO3		0.077
WO1		0.208
WO2		0.064
ST		0.064
WT		0.238
Concerning S7	Inconsistency ratio	Priorities of the strategies concerning S7
SO1	0.08	0.264
SO2		0.208
SO3		0.101
WO1		0.133
WO2		0.036
ST		0.036
WT		0.222

In the case of pair-wise comparisons of the strategies in relation to the seven strengths of the Romanian naval sector established (Table 9), the highest shares were obtained by the strategies WT, SO1 si ST.

Table 10. Pair-wise comparisons of the strategies in relation to the weaknesses

Concerning W1	Inconsistency ratio	Priorities of the strategies concerning W1
SO1	0.01	0.080
SO2		0.080
SO3		0.074
WO1		0.086
WO2		0.276
ST		0.086
WT		0.320

End of Table 10

Concerning W2	Inconsistency ratio	Priorities of the strategies concerning W2
SO1	0.05	0.109
SO2		0.288
SO3		0.064
WO1		0.171
WO2		0.093
ST		0.077
WT		0.198
Concerning W3	Inconsistency ratio	Priorities of the strategies concerning W3
SO1	0.02	0.139
SO2		0.297
SO3		0.113
WO1		0.113
WO2		0.113
ST		0.113
WT		0.113
Concerning W4	Inconsistency ratio	Priorities of the strategies concerning W4
SO1	0.045	0.192
SO2		0.256
SO3		0.118
WO1		0.113
WO2		0.096
ST		0.113
WT		0.113
Concerning W5	Inconsistency ratio	Priorities of the strategies concerning W5
SO1	0.044	0.148
SO2		0.077
SO3		0.075
WO1		0.437
WO2		0.087
ST		0.087
WT		0.087

From the pair-wise comparisons of the strategies in relation to the five established weaknesses (Table 10), the highest weights were obtained by the strategies WT, SO2, and WO1.

Table 11. Pair-wise comparisons of the strategies in relation to the opportunities

Concerning O1	Inconsistency ratio	Priorities of the strategies concerning O1
SO1	0.05	0.169
SO2		0.144
SO3		0.051
WO1		0.134
WO2		0.058
ST		0.049
WT		0.395
Concerning O2	Inconsistency ratio	Priorities of the strategies concerning O2
SO1	0.08	0.240
SO2		0.135
SO3		0.063
WO1		0.202
WO2		0.081
ST		0.084
WT		0.194
Concerning O3	Inconsistency ratio	Priorities of the strategies concerning O3
SO1	0.07	0.050
SO2		0.166
SO3		0.072
WO1		0.361
WO2		0.061
ST		0.077
WT		0.212
Concerning O4	Inconsistency ratio	Priorities of the strategies concerning O4
SO1	0.03	0.125
SO2		0.424
SO3		0.063
WO1		0.156
WO2		0.066
ST		0.076
WT		0.090
Concerning O5	Inconsistency ratio	Priorities of the strategies concerning O5
SO1	0.07	0.286
SO2		0.058
SO3		0.057
WO1		0.301
WO2		0.059
ST		0.133
WT		0.106

In the case of pair-wise comparisons of the strategies in relation to the five established opportunities (Table 11), the highest weights were obtained by the following strategies: WT, WO1, SO1 si SO2.

Table 12. Pair-wise comparisons of the strategies in relation to the threats

Concerning T1	Inconsistency ratio	Priorities of the strategies concerning T1
SO1	0.026	0.164
SO2		0.112
SO3		0.097
WO1		0.291
WO2		0.112
ST		0.112
WT		0.112
Concerning T2	Inconsistency ratio	Priorities of the strategies concerning T2
SO1	0.076	0.105
SO2		0.168
SO3		0.091
WO1		0.192
WO2		0.079
ST		0.091
WT		0.274
Concerning T3	Inconsistency ratio	Priorities of the strategies concerning T3
SO1	0.00	0.111
SO2		0.111
SO3		0.111
WO1		0.333
WO2		0.111
ST		0.111
WT		0.111
Concerning T4	Inconsistency ratio	Priorities of the strategies concerning T4
SO1	0.03	0.154
SO2		0.077
SO3		0.077
WO1		0.088
WO2		0.077
ST		0.439
WT		0.088

End of Table 12

Concerning T5	Inconsistency ratio	Priorities of the strategies concerning T5
SO1	0.05	0.167
SO2		0.136
SO3		0.121
WO1		0.167
WO2		0.121
ST		0.121
WT		0.167
Concerning T6	Inconsistency ratio	Priorities of the strategies concerning T6
SO1	0.07	0.094
SO2		0.317
SO3		0.131
WO1		0.066
WO2		0.121
ST		0.136
WT		0.136

Table 12 presents the strategies with the highest weights obtained from their pair-wise comparisons in relation to the six established threats, which are WO1, SO1, WT, ST si SO2.

With the help of the values obtained for the priorities of the strategies in relation to each sub-factor from the SWOT matrix, given in Tables 9–12, the vector of the weights of these strategies was obtained, denoted with $W_{ws/sf.}$ The vector of the global priorities of the strategies ($W_{gpStrategies} = W_{opsf} \times W_{ws/sf}$) regarding the increase of the performance of the Romanian naval sector is:

$$W_{gpStrategies} = \begin{bmatrix} SO1 \\ SO2 \\ SO3 \\ WO1 \\ WO2 \\ ST \\ WT \end{bmatrix} = \begin{bmatrix} 0.167 \\ 0.178 \\ 0.097 \\ 0.187 \\ 0.074 \\ 0.111 \\ 0.187 \end{bmatrix}.$$

The results obtained based on the methodology presented in section 2, using the SWOT-AHP hybrid method, to rank the strategies for increasing the performance of the Romanian naval sector, have led to the following order: the first two strategies WO1 and WT have the same global weight, followed, in decreasing sense by SO2; SO1; ST; SO3, WO2.

3.3. Results and discussion

In order to increase the performance of the Romanian naval sector, the strategy regarding the development of the Romanian maritime cluster (WO1) and the strategy of consolidating the position on the global ship market through aggressive marketing to maintain and even develop the existing market niche (WT) are priority.

The strategy WO1 brings together organizations from different sectors of the activity (companies in the naval field: shipyards, design companies, professional association ANCONAV, the union of the Romanian ports, universities as research-development-innovation centers, local public authorities, industrial park, shipowners, port operators), which logically have common interests. Based on the collaboration platform between the partner organizations, the cluster helps to find the best solutions for the integration of the value chain in the naval industry, cooperates to achieve the common interests of the partner organizations, and, as stated by Monteiro et al. (2013), favors a suitable environment for promoting networks of RDI of excellence, but also interdependent relationships with other sectors of economic activity and other international maritime clusters. The strategy will lead to an increase in the level of technological innovation and the performance of the naval industry, which determines the increase in its competitiveness, thus ensuring the long-term development of the naval sector.

The introduction of the strategy WT aims to use a more active, even aggressive behavior of the Romanian shipyards that allow maintaining and development of the niche market won. In addition to the internal and external environment of the shipyard, this market strategy will take into account the worldwide manifestations aimed at increasing competitiveness (Baso et al., 2020).

Adopting the strategy of investments for the construction of green ships (SO2) will contribute to reducing air and marine environment pollution. This will be achieved through the use of advanced technologies in shipbuilding, such as the use of liquefied natural gas or electric batteries for ship propulsion, the use of modern systems to reduce pollutant emissions, and energy-saving systems by improving energy efficiency, decarbonization technologies, including fuel cells. Investments in such ships represent a challenge and an opportunity for Romanian shipyards.

The introduction of the strategy regarding with development of the centers of excellence for exploiting the research-development-innovation capacity and involvement of these centers in projects in the field in order to increase the quality of ships and reduce costs (SO1) pursues the superior capitalization of the highly qualified labor force in the sector. The development of the research-development-innovation activity is imposed by the need to face the competition, obtain the lowest possible costs, and accelerate the process of product renewal. In order to stimulate innovation, it is necessary to intensify the research-development activity and support it with important investments. Research-development-innovation activities will focus on products and services that incorporate advanced technologies, and practical and efficient solutions in terms of the prices and quality of the ships.

The strategy of limiting the migration of highly skilled labor by engaging in motivating activities according to specialization (ST) will lead to an increase in the performance in im-

portant activities in the naval field, quality, and productivity of labor, with positive effects on production cost and market competitiveness.

The strategy of expanding the ship digitization process (SO3) is very important. Digitization in the shipbuilding sector is a new concept of Connected Industry 4.0, as shown by Sánchez-Sotano et al. (2020), which highlights the potential of new technologies based on product and service innovation, operational excellence, etc. This concept includes integrated processes and products to operate environmentally, efficiently, and flexibly, which are based on: the Internet of Things (IoT), artificial intelligence (AI), innovation, remote sensing networks, collaborative robotics, additive manufacturing, connectivity, security cybernetics, and diversification, virtual and augmented reality (VAR). The implementation of this strategy in the shipyards in our country would lead to improving shipyard performance in terms of productivity, costs, marketing policies, innovation, and well-paid jobs, which will consolidate the competitiveness of the Romanian shipbuilding industry on the market.

The strategy of developing a marketing policy for the promotion of the national shipbuilding companies globally (WO2) facilitates the promotion of shipyards' ability to build, repair, and convert a wide range of ships in high quality and safe conditions, to increase the orders for new ships and the number of ships calling at Romanian ports to be repaired. In this way, the production capacities and the labor force of the shipyards will be better used.

Conclusions

The research in this paper presents a systematic approach and analytical means for strategic planning in order to increase the performance of the Romanian naval sector. The SWOT-AHP hybrid method has been applied to improve the information base of the strategic planning processes at the level of shipyards. The methodology proposed by the authors can be used by any shipyard with relatively similar business environment characteristics, with the aim of adopting effective development strategies. The first step was to perform the SWOT analysis of this sector based on information collected from experts in the field. The next step was to create the TOWS matrix with the help of which the strategies to be put into practice were defined by logical combinations between the SWOT factors. AHP was used to determine the relative importance of SWOT factors and sub-factors and the overall priorities of the strategies formulated by experts in the field. The seven defined strategies were ranked as follows: firstly, with the same weight, were the strategies of consolidating the position on the global ship market through an aggressive marketing to maintain and even develop the existing market niche (WT) and developing of the Romanian maritime cluster-collaboration platform to intensify the collaboration between producers, research-development-innovation centers and shipowners (WO1), followed by the strategy aimed at investments for the construction of ecological ships (SO2), with the benefits arising from the construction of these types of ships, development of the centers of excellence for exploiting research- development-innovation capacity and involvement of these centers in projects in the field in order to increase the quality of ships and reduce costs (SO1), limiting the migration of highly qualified labor force by attracting it in motivating activities according to specialization (ST), expanding the process of digitization of ships (SO3), with

positive effects on performance in terms of productivity, costs and innovation, lastly, the strategy of developing a marketing policy for the promotion of national shipbuilding companies globally (WO2). The results show that the proposed approach has the advantages of the SWOT-AHP hybrid method to select the most effective strategies to increase the performance of the Romanian naval sector while being a relatively simple and appropriate tool for this type of strategic problem. In this context, in the future, additional studies can be carried out using the decision-making model with several criteria for the classification of the shipyards in Romania.

The limitations of this study refer to our focus only on the shipbuilding industry in Romania. However, the model can be applied to any shipyard, taking into account the business characteristics of each.

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Author contributions

The two authors conceived the study, realized the questionnaire, collected the data, and interpreted the results.

Disclosure statement

The authors declare that they do have not to compete for financial, professional, or personal interests from other parties.

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