

Supplier Selection of Combat Vessels Under Geopolitical Uncertainty: The Case of the Hellenic Navy

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Structured Abstract

Article Type: Research Article

Purpose—The purpose of this paper is to develop a comprehensive decision-making framework for military procurement that integrates both technical evaluation and geopolitical uncertainty. The study aims to demonstrate how strategic considerations, such as alliances and defense industrial cooperation, may alter supplier preferences in the selection of major combat systems.

Design/Methodology/Approach—The analysis applies the Analytic Hierarchy Process (AHP) as a deterministic stage to evaluate alternative vessel designs according to operational and economic criteria. A second, stochastic stage incorporates geopolitical uncertainty through a modified Magrabe¹ approach using the Geopolitical Risk Index as a volatility proxy. The model is empirically applied to the 2021 frigate procurement of the Hellenic Navy.

Findings—Results show that the inclusion of geopolitical uncertainty may significantly affect the ranking of suppliers. Strategic benefits—such as alliance formation and technology transfer—can alter optimal choices derived from purely technical or economic criteria

Practical Implications—Defense procurement agencies should incorporate geopolitical risk and strategic benefits into quantitative evaluation frameworks to ensure more realistic and resilient acquisition decisions.

Originality/Value—This study introduces geopolitical uncertainty into AHP-based military supplier selection, offering a novel link between defense economics and international security analysis.

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I. Introduction

In response to the challenges faced in a volatile geopolitical and geostrategic environment, Greece has recently embarked on a number of decisive moves aimed at upgrading the Hellenic arsenal. One of these moves regards the purchase of three (with an option of a fourth) frigates for the Hellenic Navy. The decision to purchase the specific type of frigates finally chosen was preceded by keen competition among leading naval manufacturers both in Europe and the US. This paper does not aim to assess the selection procedure that the Hellenic government and the General Staff followed. It aims, however, to highlight the margins offered in such major weapon systems selection procedures when uncertainty accompanies the operational, economic and financial criteria employed. To do so, we shall first present a brief literature review on the subject, followed by a description of the decision-making method used. The empirical section of the paper shows how this method is then applied to choose between the various candidate vessels under purely deterministic criteria. Such choices, however, may be affected by various uncertain factors outlining the geostrategic and geopolitical environment in the areas of interest. The extent to which uncertainty affects, and even distorts, the reasoning of such major choices is then introduced in the paper followed by the concluding remarks.

Our scope is to present an updated methodology of the supplier selection process that considers the technical aspects of the evaluation together with the uncertainty of the international environment. This research comes to fill the relevant gap in the literature by focusing on the case study of the Hellenic Navy's combat vessels supplier selection. We make two main contributions to the existing literature. First, we expand the AHP to include geopolitical uncertainty and second, we update the extremely limited literature focusing on the supplier selection process in the military sector (combat vessels). The findings of our research show that geopolitical uncertainty may affect the ranking of preferred suppliers in the case of combat vessels. Specifically, when uncertainty and strategic benefits are introduced in the analysis, we observe that the initial supplier selection order based on the deterministic AHP is affected to a considerable extent. Consequently, when it comes to the policy implications, the paper underlines the necessity to consider not only the technical, operational and economic benefits related to the purchase of defense equipment, naval vessels in our case, but also possible relevant geopolitical benefits during the selection process, following strategic alliances.

The rest of the paper is organized as follows: Section II presents a review of previous studies. Section III discusses the methodology employed. We present and discuss our results and the data in section IV, while section V reports a sensitivity analysis, under two alternative scenarios. Section VI summarizes the results and presents our conclusions.

II. Literature Review

As early as the beginning of the nineties, Insua and French² perform a sensitivity analysis within a Bayesian context in a multi-objective decision-making framework. According to the authors, this analysis traces the leading inputs in determining equipment selection, which can thus be revised more carefully. The paper points to a number of solution-concepts and shows how to identify possible competitors in the case of each such solution. Finally, it concludes by offering examples and suggesting ways of conveying the information to the decision-maker. Later, Hartley³ analyzed the demand and supply sides of the defense market with an application to the UK case. Using a non-technical, however highly descriptive approach, the paper deals with the usefulness or otherwise of retaining a sound domestic industrial base rather than “shopping around.”

In the years to follow, the relevant literature assumes the tendency to become more technical, focusing mainly on the supply side, with Sarkis and Talluri⁴ using a model for evaluation and selection of suppliers considering strategic, operational, tangible, and intangible measures. Chan,⁵ on the other hand, proposed a method called Chain of Interaction aiming at facing the difficulties linked to the dynamic nature of supply chain management. He suggested an AHP that systemizes all initial steps, like the formation of selection criteria that lead to the implementation of the AHP. The proposed Interactive Selection Model can be applied to supplier selection through the identification of buyer–supplier interactions and the valid data-collection methods. An interesting paper by Bui et al.,⁶ pointed to a risk-based framework for military capability planning, within which evolutionary algorithms are used to tackle problems with two or even more conflicting objectives. The framework allows the addition of a risk-based objective to the problem to support risk assessment during the planning process. The paper thus suggests a risk-assessment mechanism analyzing the performance of any proposed framework in a risk-pro or risk-averse environment.

Turning to examining selection processes in a fuzzy environment, Lee⁷ applies a fuzzy analytical hierarchy processing model, which incorporates the benefits, opportunities, costs and risks. This evaluates suppliers using a variety of factors that formulate the buyer-to-supplier relationship aiming at obtaining a performance ranking of the suppliers. The paper includes a case study of backlight unit supplier selection for a TFT-LCD manufacturer, with the proposed model facilitating the decision process. Being a general form model, it can be applied by a wide variety of firms that make decisions on supplier selection. Always in the fuzzy logic context, Lin⁸ uses the fuzzy analytic network process approach to consider the effects of interdependence among selection criteria and to handle inconsistent and uncertain judgments. At a next phase, the paper resorts to fuzzy multi-objective linear programming to select the best suppliers for achieving optimal order allocation in a fuzzy environment. In another interesting paper, Li and Zabinski⁹ present Pareto-optimal solutions to demonstrate the contribution of stochastic programming as well as chance-constrained programming models in the case of a robust supplier selection. The authors underline the tradeoff between costs and risks using multi-parametric programming techniques to analyze the alternative Pareto-optimal supplier selection solutions as it concerns the chance-constrained programming models thus providing insights into the robustness of the solutions with respect to the number of suppliers and the costs. By contrast, New et al.¹⁰ are much more specific, defining the policy for Reliability Centered Maintenance in the Royal Navy and the Royal Fleet

Auxiliaries. The paper focuses on how employment of Reliability Centered Maintenance is integrated into the Safety Case regime and evaluates and discusses its potential benefits. A very useful contribution has been made by Pal et al.,¹¹ who present a critical evaluation of the relevant literature on supplier selection methods. The issue of supplier selection applied to an automobile company in India is also addressed by Luthra et al.¹² The authors propose a framework to evaluate sustainable supplier selection by using an integrated AHP approach that identifies 22 sustainable supplier selection criteria and three dimensions of criteria (economic, environmental, and social) through literature and experts' opinions. The paper aims at contributing to the process of distinguishing the important supplier selection criteria but also at evaluating the most efficient supplier for sustainable supply chains while remaining competitive in the market. In the same context, Taherdoost and Brard¹³ provide an assessment of the research on the issues of supply chain management, the supplier selection criteria and an evaluation of the supplier selection methods. The paper concludes that the application of a structured decision-making technique is vital, especially when considering both qualitative and quantitative criteria. In the same context, in a case study on international plastic raw material suppliers for a US based manufacturer, Hosseini and Khaled¹⁴ distinguish between three categories of resilience capacities (selection absorptive, adaptive and restorative capacity) in a paper that examines the various relevant criteria for the choice of a supplier. The authors use predictive analytics models to describe the resilience value of each supplier, while improving predictive performance by combining binomial logistics regression and neural networks. Alikhani et al.¹⁵ focus on a simultaneous consideration of factors like sustainability and risk to propose a multi-method approach based on quantitative empirical investigations, and analytical modeling. Their approach incorporates both sustainability and suppliers' risk factors into the supplier selection problem and regards both risk-neutral and risk-averse decision-makers. The AHP approach is again used in an application to health-care supply chain issues by Bhosale and Umap.¹⁶ The paper evaluates suppliers using fuzzy stochastic data. The authors argue that the method is applicable to cases in which supplier selection must take place in a short time period. Finally, a useful paper in more ways than one is Ocampo et al.,¹⁷ which presents a revision of different methods of supplier selection from 2006 to 2016. The authors distinguish between individual, integrated and emerging supplier selection approaches, with the latter involving novel methodologies addressing specific supplier selection issues that include uncertain environment, risks, and sustainability.

Turning again to defense equipment issues, Qin et al.¹⁸ provide reference for the enhancement of naval equipment capability by studying the structure and main contents of task-oriented naval equipment support system. The study is based on hierarchical thinking, proposing relevant evaluation indices and aggregation methods. Finally, in a recent contribution, Dos Santos et al.¹⁹ focus on the specific case of choosing a medium-size warship to be built for the Brazilian Navy through the application of the AHP method. The paper considers a number of ship projects with regard to several operational and economic criteria. The evaluations of BN officers with recognized experience and knowledge in military operations has been used as an important input to this selection procedure. The evaluation is accompanied by a sensitivity analysis based on the relationship between standard deviation and mean scores to verify and increase the reliability of the ranking.

The literature review analysis revealed the usefulness of the AHP methodology in evaluating different options, among them in the selection process of the military sector.

When it comes to military applications, it is evident that the selection process in real life is affected by geopolitical factors, and therefore it would be interesting and useful to introduce geopolitical uncertainty in the AHP selection method. Our research comes to fill that gap by focusing on the case study of the supplier selection for combat vessels of the Hellenic Navy.

III. Materials and Methods

The comparison of the various vessels proposed to the Hellenic Navy requires the application of a method that will quantify the characteristics of each of the designs and will determine the standards considered for the selection process.

3.1 AHP Methodology

The method applied in this paper belongs to the Multi-Criteria Decision-Making methods (MCDM)²⁰ family and is known as the Analytic Hierarchy Process.²¹ This method is based on developing matrices by comparing pairs of design choices, in our case vessel types. The score assigned to each vessel choice is produced by setting “how many times more preferred (better)” is one vessel choice over the other for a specific criterion, following Saaty’s²² scale of relative importance (Table 1).

Table 1: Saaty’s (2005) scale of relative importance

Scale	Numerical rating ($v_{i,j}$)	Explanation according to Saaty (2008)	Reciprocal ($\frac{1}{v_{i,j}}$)
Extremely preferred	9	The evidence favoring vessel i over vessel j for the selected criterion of the system is of the highest possible order	1/9
Very strong to extremely	8	Intermediate stages of relative contribution of vessels (i, j) to the selected criterion of the system	1/8
Very strongly preferred	7		1/7
Strongly to very strongly	6		1/6
Strongly preferred	5		1/5
Moderately to strongly	4		1/4
Moderately preferred	3		1/3
Equally to moderately	2		1/2
Equally preferred	1	Two vessels (i, j) contribute equally to the selected criterion of the system	1

According to Saaty, the scale indicates how many times more important or dominant one element is over another, with respect to the criterion used. The scores assigned

vary between 1 and 9 for each specific criterion of a system, with 1 attributed to vessel choices which are equal between them and whereas 9 identifies a vessel choice which the panel of experts considers nine times more preferred than the other for a specific criterion of a system. The scale described in Table 1 is used to evaluate the relative importance of each pair of vessels, as reported in Table 2.

Table 2: Saaty's (2005) matrix of relative assessments ($x_{i,m}$) for each criterion of the design-vessel ($v_{i,j}$) and their ranking vector

Type of Vessel	Vessel 1 ($j = 1$)	Vessel 2 ($j = 2$) ($j = \dots$)	Vessel N ($j = N$)	Vessel's ranking vector ($x_{i,m}$)
Vessel 1 ($i = 1$)	1	$\left(\frac{1}{v_{1,2}}\right)$	$\left(\frac{1}{v_{1,\dots}}\right)$	$\left(\frac{1}{v_{1,N}}\right)$	$\frac{1}{N} \sum_{j=1}^N \left(\frac{v_{1,j}}{\sum_{i=1}^N v_{i,j}}\right)$
Vessel 2 ($i = 2$)	$(v_{2,1})$	1	$\left(\frac{1}{v_{2,\dots}}\right)$	$\left(\frac{1}{v_{2,N}}\right)$	$\frac{1}{N} \sum_{j=1}^N \left(\frac{v_{2,j}}{\sum_{i=1}^N v_{i,j}}\right)$
..... ($i = \dots$)	$(v_{\dots,1})$	$(v_{\dots,2})$	1	$\left(\frac{1}{v_{\dots,N}}\right)$	$\frac{1}{N} \sum_{j=1}^N \left(\frac{v_{\dots,j}}{\sum_{i=1}^N v_{i,j}}\right)$
Vessel N ($i = N$)	$(v_{N,1})$	$(v_{N,2})$	$(v_{N,\dots})$	1	$\frac{1}{N} \sum_{j=1}^N \left(\frac{v_{N,j}}{\sum_{i=1}^N v_{i,j}}\right)$

The last column of Table 2 denotes the formula for calculating the ranking vector of each vessel. This calculation is carried out by taking the average of the scores attributed to one choice over the sum of the scores that the rest of the choices received when compared to that one, as follows:

$$\frac{1}{N} \sum_{j=1}^N \left(\frac{v_{1,j}}{\sum_{i=1}^N v_{i,j}}\right), \text{ for vessel } i = 1 \text{ (1)}$$

$$\frac{1}{N} \sum_{j=1}^N \left(\frac{v_{2,j}}{\sum_{i=1}^N v_{i,j}}\right), \text{ for vessel } i = 2 \text{ (2)}$$

.....

$$\frac{1}{N} \sum_{j=1}^N \left(\frac{v_{N,j}}{\sum_{i=1}^N v_{i,j}}\right), \text{ for vessel } i = N \text{ (3)}$$

Where $v_{i,j}$ is the relative importance between two alternative designs i, j of each design (vessel). We repeat the same process for each criterion of the same system.

Thereafter, following the same method, we construct the matrix of the relative importance for the each of the selected criteria (reliability, effectiveness, flexibility, redundancy) and their ranking vector (Table 3), as follows:

$$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{1,j}}{\sum_{i=1}^4 m_{i,j}} \right), \text{ for criterion reliability (4)}$$

$$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{2,j}}{\sum_{i=1}^4 m_{i,j}} \right), \text{ for criterion effectiveness (5)}$$

$$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{3,j}}{\sum_{i=1}^4 m_{i,j}} \right), \text{ for criterion flexibility (6)}$$

$$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{4,j}}{\sum_{i=1}^4 m_{i,j}} \right), \text{ for criterion redundancy (7)}$$

Where $m_{i,j}$ is the relative importance for the selected criteria ($m_{i,j}$)

Table 3: Matrix of relative importance for the selected criteria (m_i) and their ranking vector

critereon	Reliability ($j = 1$)	Effectiveness ($j = 2$)	Flexibility ($j = 3$)	Redundancy ($j = 4$)	Criterion ranking vector (m_i)
Reliability ($i = 1$)	1	$\left(\frac{1}{m_{1,2}} \right)$	$\left(\frac{1}{m_{1,3}} \right)$	$\left(\frac{1}{m_{1,4}} \right)$	$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{1,j}}{\sum_{i=1}^4 m_{i,j}} \right)$
Effectiveness ($i = 2$)	$(m_{2,1})$	1	$\left(\frac{1}{m_{2,3}} \right)$	$\left(\frac{1}{m_{2,4}} \right)$	$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{2,j}}{\sum_{i=1}^4 m_{i,j}} \right)$
Flexibility ($i = 3$)	$(m_{3,1})$	$(m_{3,2})$	1	$\left(\frac{1}{m_{3,4}} \right)$	$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{3,j}}{\sum_{i=1}^4 m_{i,j}} \right)$
Redundancy ($i = 4$)	$(m_{4,1})$	$(m_{4,2})$	$(m_{4,3})$	1	$\frac{1}{4} \sum_{j=1}^4 \left(\frac{m_{4,j}}{\sum_{i=1}^4 m_{i,j}} \right)$

The final evaluation of each of the design-vessels for each of the systems (propulsion and power generation, armament and electronics) is calculated as the weighted average, where the weight is the relative importance of each criterion of all of the ranking vectors of the vessels. Therefore, the final evaluation of the w vessel (v_w) for all the criteria, of each system, is calculated as follows:

$$m_1 v_w + m_2 v_w + m_3 v_w + m_4 v_w = \sum_{i=1}^4 m_i u_w \quad (8)$$

We repeat the above process for each of the three systems (propulsion and power generation, armament, electronics). The total assessment of a design choice is calculated by summing the scores over each criterion multiplied by the weight factor of the same criterion.

A fourth group of performance determinants, namely the main particulars, is also included using conventional grade scales, depending on the performance of each vessel applying the four criteria (complement, service speed, range and endurance, autonomy). Having evaluated the four systems we get the total weighted evaluation of each vessel (design), which expresses an operational benefit for the buyer, namely the Total Benefit Index. Thereafter, we calculate the Total Cost Index considering the weight of each vessel's price in the average price of the vessels. The net benefit index for each vessel is the difference between the Total Benefit and the Total Cost indices, which shows the ordering of the vessels according to the deterministic methodology.

3.2 Selection Methodology Under Uncertainty

The results obtained under the AHP methodology consider different criteria and systems, thus allowing an in-depth analysis of the possible benefits and costs of each design. However, a supplier selection process that deals with military equipment should also consider factors that aim at diminishing the impact of uncertainty, such as conventional or hybrid threats. Therefore, the candidate suppliers of military equipment are usually in the position, in close cooperation with their governments, to offer to the possible buyer extra benefits—which we call strategic benefits—in the form of alliances, technology transfer or even by strengthening the domestic Defense Industrial Base, to reduce uncertainty. To incorporate uncertainty in our evaluation, we apply Magrabe's²³ formula. Specifically, we develop the following formula, in line with Wu²⁴:

$$NBI_u = TBI N(d_1) - TCI N(d_2) \quad (9)$$

where NBI_u is the Net Benefit Index under uncertainty, TBI is the Total Benefit Index and TCI is the Total Cost Index. $N(\cdot)$ denotes the cumulative normal distribution function. It also holds that:

$$d_1 = \frac{\ln\left(\frac{TBI}{TCI}\right) + \sigma^2 \frac{T}{2}}{\sigma\sqrt{T}} \quad (10)$$

and

$$d_1 = d_2 - \sigma\sqrt{T} \quad (11)$$

Further, it holds that:

$$\sigma^2 = \sigma_{TBI}^2 + \sigma_{TCI}^2 - 2\rho\sigma_{TBI}\sigma_{TCI} \quad (12)$$

where σ^2 is the combined volatility, ρ is the correlation between TBI and TCI and T is the duration of the contract.

It should be noted that several researchers use different approaches to determine volatility. For example, Taudes²⁵ and Kumar²⁶ argued that volatility can be estimated by the experience of the parties included in the process or even by conducting operational research. Bardhan et al.²⁷ calculate the volatility by developing alternative scenarios.

In estimating the volatility of our supplier selection process, we frame our analysis in two steps. In the first step, aiming at comparing the evolution of two indices (NBI , NBI_u) depending on various values of volatility, we conduct numerical simulations (volatility scenarios) with volatility ranging from 0 to 1 (0.1, 0.2, 0.3, ... 0.9). At a second step, we introduce in our model the current volatility using as proxy the Geopolitical Risk Index (GPR) by Caldara and Iacoviello²⁸ and specifically three different versions of it: (a) Geopolitical Threats Index, (b) Geopolitical Acts Index and (c) Geopolitical Risk Index, which is the average of the previous two indices. In doing so, we can compare the NBI , NBI_u indices, assuming an objective measure of the current volatility.

IV. Empirical Results

We frame our empirical analysis in two stages. First, we apply the AHP to quantify the characteristics of each of the designs (Table A.1 of the Appendix) and calculate the $NBIs$. Second, we apply the selection methodology under geopolitical uncertainty to calculate the NBI_u s and compare the results, namely the vessels' ordering under deterministic and stochastic environment, respectively.

4.1. Criteria Selection and Their Ranking Vector

The first step to comparing the six frigate designs is selecting criteria according to which the optimization will take place. Analyzing the operational requirements prevailing in the Greek maritime environment, together with the integrated defense doctrine to which the Hellenic Navy is required to abide, the selected criteria are reliability, effectiveness, flexibility and redundancy.

More specifically, reliability measures the extent to which the systems of a vessel perform as designed, which implies that the higher the reliability the lower the degree of unplanned repairs. Effectiveness measures the degree to which the vessel can execute the mission required by the buyer, while flexibility measures the ability to undertake different types of operations or missions. Finally, redundancy measures the extent to which the vessel's critical systems are backed up and therefore the vessel's ability to remain operational following sustained damage. Table 4 depicts the values of the relative importance assigned to each of the criteria. Table 5 presents the corresponding ranking vector for each

of the criteria, in which reliability appears to be the most important one, as it measures the extent to which the systems of a vessel perform as designed. Given the friction prevailing in the Aegean and the Eastern Mediterranean Sea, which requires pronounced military power, reliability ensures not only attainment of the operational targets but also a low degree of unplanned repairs. Concerning effectiveness, this describes the degree to which the vessel can execute the mission required by the buyer, at the lowest possible cost. This is a paramount constraint, given the tight fiscal restrictions imposed on the Greek economy. Turning to redundancy, the high-friction environment under which the vessel is expected to perform entails considerable damage possibilities, which should not deprive the vessel from accomplishing its mission. Finally, flexibility measures the ability to undertake different types of operations or missions. This has not been rated as being a top priority for the Hellenic Navy because the environment in which its units are expected to operate requires more specialization than flexibility.

Table 4: AHP Matrix for selected criteria.

Criteria	Reliability	Effectiveness	Flexibility	Redundancy
Reliability	1.000	3.000	6.000	1.000
Effectiveness	0.333	1.000	8.000	3.000
Flexibility	0.167	0.125	1.000	0.200
Redundancy	1.000	0.333	5.000	1.000

Table 5: Ranking vectors for the selected criteria using AHP.

Ranking Vector	
Reliability	0.3913
Effectiveness	0.3336
Flexibility	0.0458
Redundancy	0.2293

4.2. Evaluation of the Systems

At the next step, we focus on four systems comprising the design of each vessel, namely, propulsion and power generation, armament, electronics and main particulars. Our study takes for granted that all sellers offer a more or less similar full-support logistic package.

4.2.1 Propulsion. The role of the propulsion and power generation systems of each vessel is decisive.²⁹ Given that the Hellenic Navy has shown preference for diesel or gas engines (mainly for their “or” propulsion variants like CODOG and COGOG), we need to observe that diesel engines provide a cost efficient and very reliable option while gas turbines offer greater power density (acceleration and top speed), suffering, however, from higher consumption and being a more fragile arrangement. Indeed, diesel engines grant considerable fuel economy, as well as extreme reliability and toughness, while their wide commercial

use means there are many ports where they can be repaired. For a balanced evaluation, one must consider the diesel engine's disadvantages too, which sum up to their weight and size, as well as their noise and vibration.³⁰

Turning to the alternative engine options, gas engines are compact with excellent acceleration and power. Electric motors are silent and efficient at low RPMs, while IEP is more damage resistant with more design freedom.

Each frigate proposed to the Hellenic Navy may be equipped with several propulsion and power generation choices; however, our paper will focus on the arrangements considered during the evaluation by the Hellenic Navy. The attribution of the scores in this case has required the consultation of a panel of experts whose extensive experience and knowledge in naval warship design or naval operations satisfies the requirement described in AHP literature. The final evaluation depicted in Table 6, after considering the ranking vector of the criteria themselves (weight factors) shows that MMSC scores highest due to its redundant and effective arrangement, followed closely by the MEKO class vessel, whereas FREMM and SIGMA frigates obtain similar scores for their propulsion and power generation design choices.

Table 6: Evaluation of Propulsion and Power Generation system, each vessel and criteria, using AHP.

Reliability							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking Vector
MMSC HF2	1	0.125	0.125	0.125	0.2	0.5	0.028
FDI	8.000	1	1	1	0.333	1	0.168
SIGMA 11515 HN	8.000	1.000	1	1	1	4	0.211
MEKO A300	8.000	1.000	1.000	1	4	7	0.313
FREMM-IT	5.000	3.000	1.000	0.25	1	5	0.216
TYPE 31 HN	2.000	1.000	0.250	0.142	0.2	1	0.064
Effectiveness							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking Vector
MMSC HF2	1	8	5	3	4	4	0.373
FDI	0.125	1	4	0.25	1	4	0.121
SIGMA 11515 HN	0.200	0.250	1	3	6	8	0.200
MEKO A300	0.333	4.000	0.333	1	6	8	0.198
FREMM-IT	0.250	1.000	0.167	0.166	1	5	0.074
TYPE 31 HN	0.250	0.250	0.125	0.125	0.2	1	0.034
Flexibility							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking Vector
MMSC HF2	1	0.5	0.333	0.5	1	0.5	0.090
FDI	2.000	1	3	0.5	3	2	0.224
SIGMA 11515 HN	3.000	0.333	1	0.333	2	3	0.162

	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking Vector
MEKO A300	2.000	2.000	3.000	1	4	5	0.339
FREMM-IT	1.000	0.333	0.500	0.25	1	3	0.101
TYPE 31 HN	2.000	0.500	0.333	0.2	0.333	1	0.083
Redundancy							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking Vector
MMSC HF2	1	6	5	7	3	5	0.418
FDI	0.167	1	0.25	0.333	0.142	0.2	0.034
SIGMA 11515 HN	0.200	4.000	1	1	0.25	0.333	0.076
MEKO A300	0.143	3.000	1.000	1	0.166	0.2	0.060
FREMM-IT	0.333	7.000	4.000	6	1	4	0.265
TYPE 31 HN	0.200	5.000	3.000	5	0.25	1	0.149
Final Evaluation							
	0.235	0.124	0.174	0.218	0.175	0.074	

4.2.2 Armament. Armament choices are crucial, by definition, for the operational ability of each naval unit. Again, every class may be equipped with a wide variety of different systems, and thus the evaluation must be based on the relevant arrangements proposed during the selection process. The defense equipment arrangement borne by the vessel will determine, to a large extent, the missions and roles that the ships will be able to undertake. The results (Table A.2 of the Appendix) show that MEKO, FREMM and FDI are in rather equal terms. The vessels are equipped with anti-air (e.g., Aster-30, ESSM) missiles, anti-surface (e.g., Exocet, Harpoon) missiles and anti-submarine (e.g., CAPTAS-4) systems that ensure hit-to-kill capabilities and a high possibility to defeat suturing attacks. MMSC performs poorly in this case mainly because of two reasons: first, the lack of hull mounted sonar, and second, the fact that its initial design referred to a littoral combat vessel, meaning that the addition of extra armament may come at a cost concerning its stability during open-sea operations in the eastern Mediterranean.

Most types of vessels are well-equipped in terms of point- and area-defense systems. In terms of anti-submarine systems, the MMSC and possibly the Type 31 seem to be lagging behind. In the case of the former, even if a towed sonar is installed, this may present compatibility problems due to the waterjets' noise.

Regarding aircraft carried, all types are equipped with a reliable helicopter (Seahawk, NH90 or Wildcat) and the MMSC and the FDI use, in addition, UAVs (Firescouts for the former and Schiebel Camcopters for the latter).

4.2.3 Electronics. In all cases, the sensors and processing systems of all types of vessels are state of the art in terms of technology. An exception may be the Lockheed Martin COMBATSS-21 combat management system, a modified version of Aegis, the technology of which dates to the '80s.

The electronics on board, in several cases coordinated with the armament of the vessel, cover a wide range of systems, such as target identification, navigational equipment,

electronic countermeasures and integrated communication systems. However, unlike the armaments case, we assume that all vessels are equipped with cutting-edge technology tailored to fulfill the requirements of modern sea warfare, and therefore we rate them as being of equivalent performance (Table A.3 of the Appendix).

4.2.4 Main Particulars. We finally evaluate a fourth group of performance determinants, namely Main Particulars, which is composed of four criteria (complement, service speed, range and endurance/autonomy) that may be crucial for the performance of the vessels but have not been included in the evaluation thus far. To rate each of the main particulars we develop grade scales, depending on the performance of all vessel types regarding each of the four criteria as this is considered by the Hellenic Navy. In fact, the Hellenic Navy requirements call for a high number of endurance days and a range as long as possible, compatible with the Integrated Defense Doctrine demands. There is also a preference for a rather low complement figure given the country’s declining birth rate. Table 7 shows the grade scales and Table 8 the corresponding evaluation for each vessel. The weight of each of the criteria in the final average of the Main Particulars system is 25%. We observe that FDI scores highest mainly due to its autonomy (45 days), a performance which, however, is close to that of almost all competitors, with the exception of the MMSC, which is a littoral combat vessel. On the issue of the limited range of MMSC, we should add that the shallow draft of the vessel, despite its advantage in the Aegean Sea, may become a serious disadvantage for operations in the eastern Mediterranean Sea as it affects the ship’s stability, especially in bad weather conditions. On the other hand, one cannot overlook the MMSC’s speed performance along with the limited complement needs.

Table 7: Grade scales of Main Particulars.

Complement		Range		Service Speed		Endurance/autonomy	
<i>personnel</i>	<i>grade scale</i>	<i>nautical miles</i>	<i>Grade scale</i>	<i>Knots</i>	<i>Grade scale</i>	<i>days</i>	<i>Grade scale</i>
80–100	0.25	3000–3500	0.05	25–30	0.05	15–24	0.05
100–120	0.20	3500–4500	0.10	30–35	0.10	25–34	0.10
120–140	0.15	4500–6000	0.15	35–40	0.15	35–44	0.15
140–160	0.10	6000–7500	0.20	40–45	0.20	45–54	0.20
160–180	0.05	7500–9000	0.25	45–50	0.25	55–60	0.25

Table 8: Evaluation of Main Particulars.

Criteria	MMS C HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN
Complement (25%)	0.222	0.222	0.222	0.111	0.111	0.111
Speed (25%)	0.250	0.250	0.125	0.125	0.125	0.125
Range (25%)	0.053	0.158	0.158	0.211	0.211	0.211
Endurance/Autonomy (25%)	0.118	0.235	0.118	0.118	0.235	0.176
Average	0.161	0.216	0.156	0.141	0.170	0.156

4.3 Total Benefit, Total Cost and Net Benefit Indices

Having evaluated the four systems of each vessel, we thereafter get the total weighted evaluation of each vessel. Each of the vessel's four systems offers an operational benefit and therefore the total weighted evaluation shows the total benefits for each vessel (Table 9). Note that propulsion and power generation and armament bear equal weights (25% each), while electronics bear a slightly lower weight (20%) contrary to the main particulars (30%), because of their relative importance as indicated by the Hellenic Navy requirements. We observe that, according to our methodology, the order of the vessels, concerning the operational benefits, is as follows: FDI (0.186), MEKO (0.186), FREMM (0.175), SIGMA (0.169), MMSC (0.146) and TYPE 31 (0.138).

Table 9: Total Benefit Index

Total criteria (main + particulars)	MMSC		SIGMA	MEKO		TYPE 31
	HF2	FDI	11515 HN	A300	FREMM-IT	HN
Propulsion and Power Generation (25%)	0.235	0.124	0.174	0.218	0.175	0.074
Armament (25%)	0.047	0.214	0.168	0.213	0.213	0.145
Electronics (20%)	0.135	0.183	0.183	0.183	0.135	0.183
Main Particulars (30%)	0.161	0.216	0.156	0.141	0.170	0.156
Total Benefit Index	0.146	0.186	0.169	0.186	0.175	0.138

Note: The sum of all the TBI indices equals 1.

At the next step, we calculate the total cost of purchasing each vessel. Due to the lack of relevant data, we ignore the cost of maintenance of the vessels, thus focusing on the purchasing cost. Row 2 of Table 10 depicts the purchasing cost for each vessel and row 3 the average price of the vessels. The fourth row shows the ratio of each vessel's price over the average price while the Total Cost Index (row 5) is given by the ratio of percentage average price over the sum of the percentage average prices. Therefore, the sum of the Total Cost Index yields the ordering of the vessels in a form comparable to the Total Benefit Index.

Table 10: Total Cost Index

	MMSC		SIGMA	MEKO		TYPE 31
	HF2	FDI	11515 HN	A300	FREMM-IT	HN
Cost of Purchase (in mil. Euros)	510	765	600	575	750	500
Average price	616.67					
% Average Price	0.827	1.241	0.973	0.932	1.216	0.811
Total Cost Index	0.138	0.207	0.162	0.155	0.203	0.135

Notes: The sum of all the TCI indices equals 1.

Finally, Table 11 shows the net benefit index for each vessel, which is the difference between the Total Benefit Index and the Total Cost Index. In order to have a clearer picture of the differences among the indices of the vessels, we multiply the net benefit index by 1,000.

Table 11: Net Benefit Index

	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN
Net Benefit Index	0.051	0.055	0.058	0.072	0.049	0.047
Net Benefit Index × 1,000	51.244	55.051	58.424	72.496	49.061	47.057

4.4 Vessel Selection Under Geopolitical Uncertainty

Introducing a stochastic element in the selection process, in the sense of geopolitical uncertainty, presupposes a theoretical framework and a set of assumptions in our model. In fact, our theoretical approach builds on the realist assumption that the international system consists of states seeking relative power advantages over competitors within an anarchic international order, as described by Hobbes³¹ and Morgenthau.³² In that sense, power is a tool for a state to serve its national interests, and such a strategy demands primarily the formation of a political or military alliance, technology transfer and strengthening of the national Defense Industrial Base. Such power determinants contribute to overcoming the consequences of the security dilemma,³³ as this is rooted in the anarchy of the state system.³⁴

The problem according to the political realism approach is that the target of international peace is a non-realistic one and that states are bound to face, sooner or later, the threat of war as a means of influence of rival states.³⁵ It is straightforward that those threats increase geopolitical uncertainty faced by the states, which then seek to increase their power as a reaction to the threat of the adversary state, thus contributing to uncertainty reduction. Suppliers of military equipment are not only positioned to consider such threats faced by states but to offer extra benefits to potential buyers to counterbalance the uncertainty caused by the threat. It goes without saying that such a contribution is expected to be over and above all conventional operational benefits that the state receives from the purchase of new military equipment per se. We consider those extra benefits as being of strategic nature as they include, among others, a formation of a political or military alliance, technology transfer and strengthening of the national Defense Industrial Base of the buyer. Strategic benefits can be interpreted as an extra cost (benefit) paid (received) by the seller (buyer) to increase its ability to face uncertainty caused by threats of its adversaries. Therefore, the higher the uncertainty, the higher the threat that the seller undertakes to counterbalance and therefore, the higher the expected net benefit for the buyer country. Equivalently, the higher the uncertainty, the higher the strategic benefits offered by the seller. In both interpretations, we expect a positive relationship between the value of the NBI_u and the volatility as this is described by Eq.12 and proxied, according to our theoretical approach, by different types of geopolitical uncertainty.

In the light of the analysis developed in this section, the main advantages of introducing uncertainty are the following: First, the military selection process accounts for the impact of geopolitical uncertainty and second, the selection process considers the extra benefits that a country receives from a potential supplier of military equipment to counterbalance uncertainty.

Focusing on our case, the sellers that offered strategic benefits to the Hellenic Navy were Naval Group (French–Greek Military Partnership) and Lockheed Martin (because of the leading role of the US in NATO and the strengthened cooperation between Greece and US in the last decades). Thus, figure 1 presents the evolution of the NBI_u under various values (scenarios) of volatility for each type of vessel. It should be noted that with the exception of Lockheed Martin (MMSC HF2) and Naval Group (FDI), the other sellers did not offer any strategic benefit in the sense defined above, and consequently, no matter what the level of volatility is, the net benefits received by each vessel remain unchanged and equal the net benefits shown in Table 8.

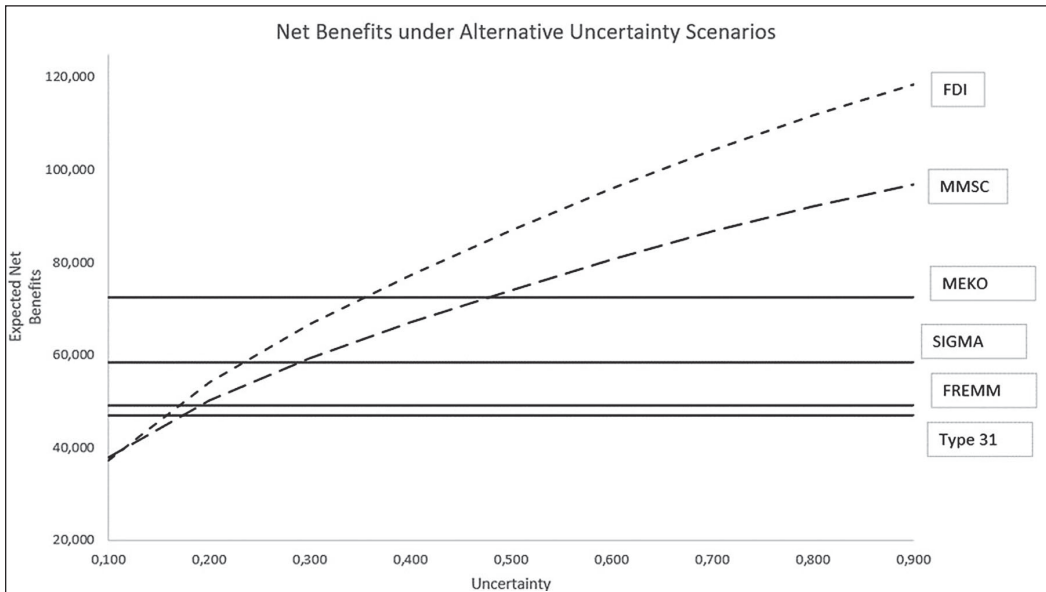


Figure 1: Evolution of NBI_u under alternative volatility scenarios

Figure 1 depicts the importance of incorporating possible strategic benefits in the selection process of military equipment based on different volatility (uncertainty) scenarios. Thus, based on the net benefits under uncertainty index, NBI_u for the FDI and MMSC HF2 frigates exceed those of other competitors that did not offer any specific strategic benefit. Therefore, the selection ordering changes depending on the existence of such strategic offers and the level of volatility.

A final important issue that remains to be examined is a robustness check of these findings that favor the selection of FDI and MMSC HF2 not under scenarios, but in the context of an application of our model as described in section 3.2. To do so, we use as a proxy the Geopolitical Risk Index (GPR), specifically three different versions of it: (a) Geopolitical Threats Index, (b) Geopolitical Acts Index and (c) Geopolitical Risk Index, which is the average of the previous two indices. Table 12 depicts the NBI_u values for FDI and MMSC HF2 under the above three indices. For comparison reasons we add the corresponding NBI for the other frigates, that remains unaffected by the geopolitical environment due to the lack of strategic benefits.

Table 12: Net Benefit Index under alternative geopolitical threats

	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN
Geopolitical Threats ($\sigma^2=0.459$)	71.188	83.028	58.424	72.496	49.061	47.057
Geopolitical Acts ($\sigma^2=0.471$)	72.023	84.174	58.424	72.496	49.061	47.057
Geopolitical Risk ($\sigma^2=0.463$)	71.467	83.411	58.424	72.496	49.061	47.057

According to our results FDI has by far the highest NBI_u value, with MEKO being in the second place with minimal difference from MMSC HF2. We conclude, therefore, that any suppliers' selection procedure concerning defense equipment must necessarily include considering the benefits that arise from possible strategic offers and their importance in strengthening a country's position in the global or regional hierarchy, depending on the prevailing geopolitical environment.

V. Sensitivity Analysis

In this section, we present two alternative scenarios concerning the evaluation of the vessels under uncertainty. If we accept that the weights assigned to the different systems and main particulars can be regarded as the standard ones, we shall move to examining the ordering of the vessels under two extreme scenarios. In these scenarios, we assume criteria regarding the propulsion and power generation, armament, and electronics as well as the main particulars. In our initial scenario, we have assumed that the weights of the main designs and the particulars were 25% for the propulsion and power generation, 25% for the armament, 20% for the electronics and 30% for the main particulars. This distribution ensures that the frigates can serve multiple roles in a balanced way.

However, to check the sensitivity of our results, we now assume that the requirements of the Hellenic Navy are such that the operational capabilities of the frigates focus more on the Aegean Sea, which means that distances are very short and therefore speed and autonomy do not play a primary role. In fact, there may be higher requirements for multiple-role missions with stronger armaments and electronics rather than patrol missions far from the naval base of the frigates. Of course, each navy would prefer a vessel that covers all different types of missions, but due to scarcity there are always tradeoffs and opportunity costs. The new distribution of the weights becomes 20% for the main particulars, 30% for electronics, 30% for armaments and 20% for propulsion-power generation. Table 13 shows the net benefit index under alternative geopolitical threats for the above "Aegean Sea" system weight distribution scenario. The evolution of the corresponding NBI_u is shown in Figure 2. We observe that there is no substantial change in the ordering of the vessels. However, we find that the net benefit under uncertainty of the MMSC exceeds that of the MEKO for lower level of uncertainty ($\sigma^2 \geq 0.300$), namely even when the strategic benefits are of lower importance. This evidence is in line with the fact that the MMSC vessel was initially designed as a

littoral vessel and therefore it performs more efficiently in close seas as the Aegean Sea of this scenario.

**Table 13: Total Benefit Index
(Aegean Sea scenario)**

	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN
Geopolitical Threats ($\sigma^2=0.459$)	74.332	89.266	55.998	63.698	47.932	50.760
Geopolitical Acts ($\sigma^2=0.471$)	75.178	90.443	55.998	63.698	47.932	50.760
Geopolitical Risk ($\sigma^2=0.463$)	74.615	89.689	55.998	63.698	47.932	50.760

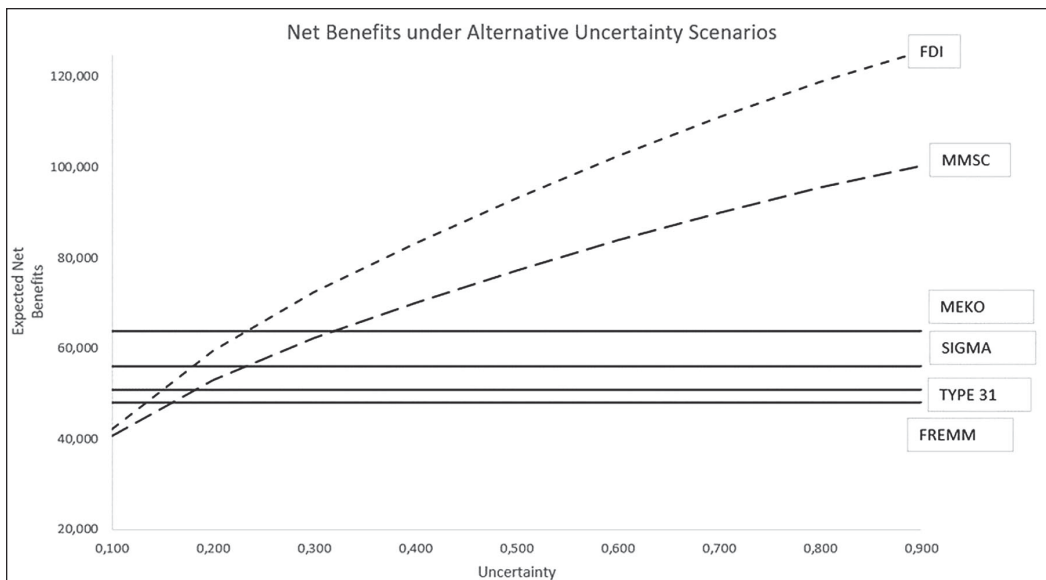


Figure 2: Evolution of NBI_u under alternative volatility scenarios and Aegean Sea scenario for systems weight distribution.

In the second sensitivity scenario, the operational requirements of the vessels change in an attempt to focus more on operations far from the Aegean Sea reaching as far as the Red Sea, considering the recent geopolitical events. In such case the distribution of the weights becomes 50% for the main particulars, 15% for electronics and 17.50% for propulsion-power generation and 17.50% for armament. Table 14 shows the net benefit index under alternative geopolitical threats for the above “Red Sea” system weight distribution scenario. The evolution of the corresponding NBI_u is shown in Figure 3. We now observe that the net benefit under uncertainty of the MMSC vessel exceeds that of MEKO only for very high levels of uncertainty ($\sigma^2 \geq 0.700$), namely when the strategic benefits play a major role. These findings are in line with the fact that the MMSC vessel was initially developed as a littoral vessel, which means that it has less capabilities for operations far from the naval base, as the “Red Sea” scenario requires.

Table 14: Total Benefit Index (Red Sea scenario)

	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN
Geopolitical Threats ($\sigma^2=0.459$)	62.380	83.826	60.010	75.095	47.961	51.204
Geopolitical Acts ($\sigma^2=0.471$)	63.178	84.976	60.010	75.095	47.961	51.204
Geopolitical Risk ($\sigma^2=0.463$)	62.647	84.210	60.010	75.095	47.961	51.204

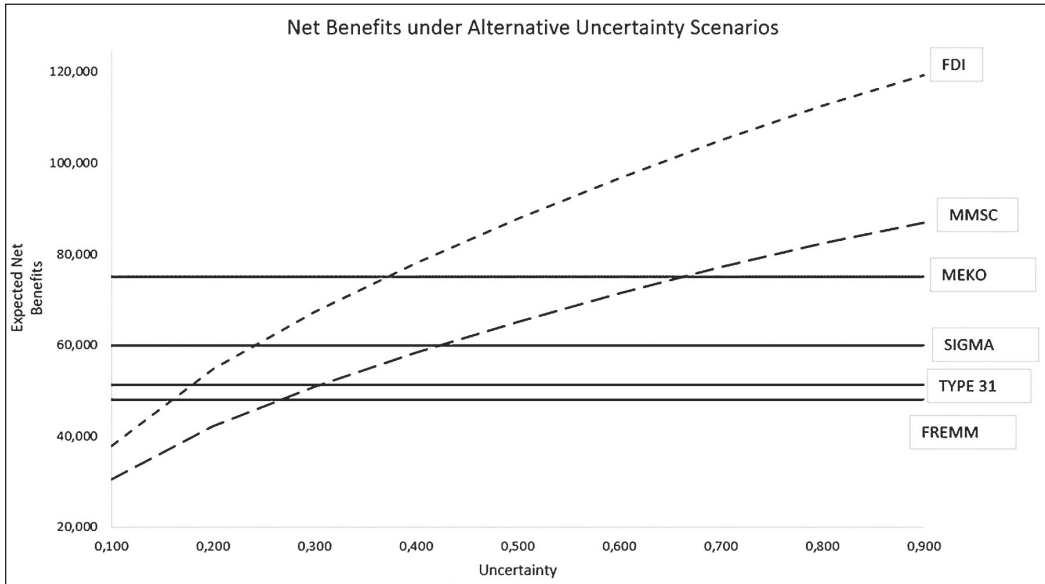


Figure 3: Evolution of NBI_u under alternative volatility scenarios and Red Sea scenario for systems weight distribution.

VI. Conclusions— Policy Implications

This paper provides empirical evidence on the issue of supplier selection as regards combat vessels, applied to the case of the order placed by the Hellenic Navy in 2021. Our scope is to present a new methodology for the supplier selection process that considers the technical aspects of the evaluation together with the uncertainty of the international environment. This methodology is developed in two stages. We first apply the AHP method to quantify the characteristics of each of the vessels and calculate the net benefits for each vessel following a deterministic selection process. At a second step, to account for possible geopolitical threats we introduce a stochastic element in our model's selection process in the sense of geopolitical uncertainty. On this basis, we consider the extent to which the initial hierarchy ordering of the vessels is altered when introducing the geopolitical threats variable and possible strategic benefits from military alliances. To the best of our knowledge, geopolitical uncertainty has not been examined before in a military supply selection model.

Our empirical results point to the conclusion that geopolitical uncertainty may affect the preferential ordering of a supplier selection in the case of combat vessels. When uncertainty and strategic benefits are introduced in the analysis, we observe that the initial supplier selection order based on the deterministic AHP is affected to a considerable extent. Therefore, the paper underlines the necessity to consider not only the technical, operational and economic benefits related to the purchase of defense equipment, naval vessels in our case, but also possible relevant geopolitical benefits during the selection process, following strategic alliances.

Appendix to “Supplier Selection of Combat Vessels Under Geopolitical Uncertainty: The Case of the Hellenic Navy”

Table A1: Designs

Design	Website
MMSC HF2	https://www.lockheedmartin.com/en-us/products/multi-mission-surface-combatant.html
FDI	https://www.naval-group.com/en/greece-launches-its-program-three-defense-and-intervention-frigates-fdi-hn-naval-group
SIGMA 11515 HN	https://www.damen.com/vessels/defense-and-security/sigma-frigates/sigma-multi-mission-frigate-11515
MEKO A300	https://www.thyssenkrupp-marinesystems.com/en/products-services/surface-vessels/frigates
FREMM-IT	https://www.fincantieri.com/en/products-and-services/naval-vessels/bergamini-class/
TYPE 31HN	https://www.babcockinternational.com/what-we-do/marine/defense/type-31/

Table A2: Evaluation of Armament system, each vessel and criteria, using AHP.

Reliability							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	0.2	0.2	0.2	0.2	0.2	0.038
FDI	5.000	1	1	0.5	0.5	1	0.147
SIGMA 11515 HN	5.000	1.000	1	0.5	0.5	1	0.147
MEKO A300	5.000	2.000	2.000	1	1	2	0.261
FREMM-IT	5.000	2.000	2.000	1	1	2	0.261
TYPE 31 HN	5.000	1.000	1.000	0.5	0.5	1	0.147

Effectiveness							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	0.250	0.333	0.333	0.333	0.333	0.057
FDI	4.000	1	2	2	2	3	0.313
SIGMA 11515 HN	3.000	0.500	1	1	1	2	0.174
MEKO A300	3.000	0.500	1.000	1	1	2	0.174
FREMM-IT	3.000	0.500	1.000	1	1	2	0.174
TYPE 31 HN	3.000	0.333	0.500	0.5	0.5	1	0.106
Flexibility							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	0.25	0.25	0.25	0.25	0.25	0.048
FDI	4.000	1	1	1	1	1	0.190
SIGMA 11515 HN	4.000	1.000	1	1	1	1	0.190
MEKO A300	4.000	1.000	1.000	1	1	1	0.190
FREMM-IT	4.000	1.000	1.000	1	1	1	0.190
TYPE 31 HN	4.000	1.000	1.000	1	1	1	0.190
Redundancy							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	0.25	0.25	0.25	0.25	0.25	0.048
FDI	4.000	1	1	1	1	1	0.190
SIGMA 11515 HN	4.000	1.000	1	1	1	1	0.190
MEKO A300	4.000	1.000	1.000	1	1	1	0.190
FREMM-IT	4.000	1.000	1.000	1	1	1	0.190
TYPE 31 HN	4.000	1.000	1.000	1	1	1	0.190
Final evaluation							
	0.047	0.214	0.168	0.213	0.213	0.145	

Table A3: Evaluation of electronics system, each vessel and criteria, using AHP.

Reliability							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	1	1	1	1	1	0.167
FDI	1.000	1	1	1	1	1	0.167
SIGMA 11515 HN	1.000	1.000	1	1	1	1	0.167
MEKO A300	1.000	1.000	1.000	1	1	1	0.167

	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
FREMM-IT	1.000	1.000	1.000	1	1	1	0.167
TYPE 31 HN	1.000	1.000	1.000	1	1	1	0.167
Effectiveness							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	0.333	0.333	0.333	1	0.333	0.071
FDI	3.000	1	1	1	3	1	0.214
SIGMA 11515 HN	3.000	1.000	1	1	3	1	0.214
MEKO A300	3.000	1.000	1.000	1	3	1	0.214
FREMM-IT	1.000	0.333	0.333	0.333	1	0.333	0.071
TYPE 31 HN	3.000	1.000	1.000	1	3	1	0.214
Flexibility							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	1	1	1	1	1	0.167
FDI	1.000	1	1	1	1	1	0.167
SIGMA 11515 HN	1.000	1.000	1	1	1	1	0.167
MEKO A300	1.000	1.000	1.000	1	1	1	0.167
FREMM-IT	1.000	1.000	1.000	1	1	1	0.167
TYPE 31 HN	1.000	1.000	1.000	1	1	1	0.167
Redundancy							
	MMSC HF2	FDI	SIGMA 11515 HN	MEKO A300	FREMM-IT	TYPE 31 HN	Ranking vector
MMSC HF2	1	1	1	1	1	1	0.167
FDI	1.000	1	1	1	1	1	0.167
SIGMA 11515 HN	1.000	1.000	1	1	1	1	0.167
MEKO A300	1.000	1.000	1.000	1	1	1	0.167
FREMM-IT	1.000	1.000	1.000	1	1	1	0.167
TYPE 31 HN	1.000	1.000	1.000	1	1	1	0.167
Final evaluation							
	0.135	0.183	0.183	0.183	0.135	0.183	

Notes

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Author Contributions

The authors have equally contributed to all parts of this paper. All the authors have read and approved the final manuscript.

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The data employed in this research paper and the codes to replicate the results are available upon request.

Consent for Publication

This study presents original material that has not been published elsewhere.

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