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A COST-BASED DEFENSE DECISION APPROACH IN VOLATILE ENVIRONMENT

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Abstract:

The paper captures the effect of uncertainties from the security environment on the investment decision in equipment purchase or modernization. Partial irreversibility and limited flexibility specific to military decisions create the context for the introduction of opportunity cost into the analysis. The problem of defense resource allocation is analyzed based on the principles of complex system engineering. The design of allocation strategies is analyzed by integrating dynamic defense capabilities through the paradigm of real option analysis. Based on obtained results, the strategic decision maker can better understand the spectrum of possible solutions and how to act in case of major shocks.

Keywords: volatile environment, real option analysis, decision making, crisis cycle, stochastic life cycle cost

1. Introduction

The decision-making process is usually based on the backward approach (Keeney, 2012), solving a possible problem with an identified solution before understanding what one hopes to achieve by solving that problem: developing the best military capabilities.
Military decisions aimed at achieving small and visible benefits, with potentially negative and invisible side effects, lead to visible disruptions in the military system in the form of unintended consequences, which are repeated with increasing intensity in order to correct side effects (Taleb, 2012). This situation that leads to loss of sight of available resources. Dynamic resource allocation models provide a quick intuitive picture of the timing and investment solution to follow.

Militarization, in terms of the proposed purpose, is defined as a complex phenomenon directly influenced by developments in national, regional and international security environments, expressed as a set of indicators of a state's military capability (IEP, 2015).
In this context, when the potential return on investment is difficult to demonstrate, it is needed an approach in which the strategic decision maker can better understand the spectrum of possible decisions and how to act in case of shocks based on cost analyzes.

If during the armed conflict (which is the culmination of the politico-military crisis) the assessment of operational military capabilities is based on the success/ failure of military intervention, in the pre-crisis stage this approach is much more difficult to achieve, given the possibility of real testing.

The strategic decision in the military field is an increasingly challenging activity. Awareness of the need to optimize resource allocation strategies from the pre-crisis stage and providing decision-makers with tools to allow them some flexibility on possible changes in the external environment is imperative.

The research is based on the results obtained by Balos and Cioaca (2017) that improve the military decision-making process in the pre-conflict stage based on the analysis of the influence of uncertainty on the allocation of resources. The novelty element consists in the stochastic approach of the value of costs instead of the deterministic one, which allows the incorporation of "strategic shocks" in the support analyzes for the defense decision process.

2. Considerations regarding the evolutions in the security environment

Any theoretical or applied-operational approach in the military field starts from the analysis of the security environment. When we find out that its main characteristics are complexity and volatility the predetermined objectives are more difficult to achieve.

To capture the evolutions in the security environment, we designed the analysis in three main directions: the transition to multipolarity, the crisis curve and the militarization index (Figure 1).

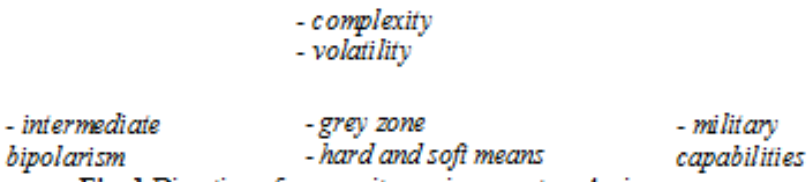

Fig. 1 Directions for security environment analysis

The reconfigurations in the global power relations generated by the trajectories of the new power centers confirm the existence of an anti-fragile satellite intermediate bipolarism that ensures the transit towards multi-polarity (Cioaca, 2020).

On a small scale, the Black Sea region imports from the general characteristics of the global security environment: instability and unpredictability; interdependence and conflict; instability and adaptability; multidimensionality and asymmetry.

The geographical proximity of the states in the Black Sea region was not a sufficient condition for building a regional identity even 30 years after the collapse of the USSR. The existence of distinct, sometimes conflicting, interests at the national level, as well as the intersection of the competitive interests of Russia and the West, transforms the Black Sea region into an area characterized by multiple dynamics. Currently, the main vector of instability in the area is the use of hard tools - military forces (several times in the last 12 years) and soft tools (information, energy, economic, diplomatic, cultural, etc.) by Russia in order to restore influence and control in the vicinity of the borders, to which is added the Western strategy to counteract this "malignant influence" (RAND, 2019). A coherent strategy must meet challenges such as:
- different perception of threats;

- the existence of the gap of military capabilities;
- the decrease of credibility (against the background of the proliferation of nationalism and the limited reaction after the actions in Georgia and Ukraine);
- the argument of proportionality in the use of advanced defense systems as a means of deterrence;
- the multitude and diversity of vulnerabilities at national level;
- the lack of elements of strategic culture, which should compensate for the absence of detailed rules of operation at supra-national level.

All these challenges become potentiating factors that hinder the process of designing a generally accepted strategy to ensure stability and security in the area.

Another particularly important aspect that completes the analysis of the security environment is the capture of pressure to reshape the crisis curve. The classical approach to conflict shows that peace is a stage of stability that involves the absence of contradiction generating confrontation (Orzeata, 2019). On the strategic time axis escalation, actual confrontation (which can take the form of demonstration of force or armed conflict), de-escalation and return to new normalcy are successively lined up.

Characterizing the current security environment, it can be seen that not only military activities, but also political, economic or information have the characteristics of a real war (Gorbachev, 2019). The West's vision also recognizes the existence of several global actors acting on the brink of military conflict (DoD, 2018). At a theoretical level, the concept of "gray area" was developed. This area is positioned in terms of the intensity of actions on the border between peace and armed conflict. It can be characterized by: the presence of hard and soft tools that threaten the interests of one or more state or non-state actors; the difficulty of identifying the initiators; an adequate response to effective deterrence does not justify the use of military force (Degeratu, 2020).

All these arguments lead to the development of a new approach to crises based not so much on the cyclicality of disruptive actions, but especially on the recognition of a new typology: the persistent unconventional crisis. Thus, a seemingly flattened curve of the crisis is outlined, in relation to the intensity of the actions and the dimensions of manifestation (Figure 2).

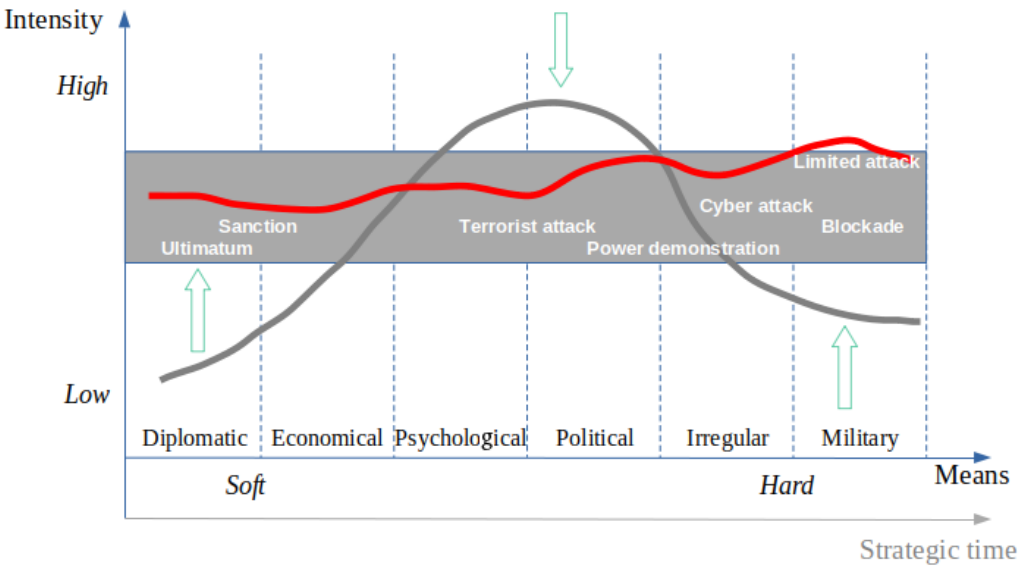

Fig. 2 Persistent unconventional crisis curve

The crossing of the border of intensity towards the war zone happens quite rarely. Harari (2018) exposes in a specific prophetic manner at least three arguments: the disappearance of physical limits (time and space) which opens a new register of threats; wars in the 21st century that are unprofitable business; recent confrontations which show that the great powers seem to have lost the recipe for success.

The role of the military in the gray area is not to challenge the instruments of influence in the same way, but to design a desired long-term final state that can be achieved through the use of non-violent means (e.g. social media operations, CIMIC activities) in line with political and economic objectives (Carment and Belo, 2018).

The new approach to the crisis curve becomes a particularly important element for shaping the decision-making model, from several perspectives: capability requirements, resource constraints; level of uncertainty.

Militarization is the phenomenon introduced in the analysis to capture developments in the regional and international security environment, expressed as a set of indicators of a state's military capability in relation to the perception of threats. Thus, the general militarization index highlights the trend of armament at national level, based on the following weighted indicators: military expenditures (percentage of GDP); army personnel (reported per 100,000 inhabitants); volume of arms exports and imports; financial contribution to peacekeeping missions; nuclear and heavy weapons capabilities; access to small arms (IEP, 2015).

The analysis of the evolution of this indicator highlighted a general trend towards rearmament, even in Europe, an area characterized for a long time by a decline in defense budgets. The year 2015, amid the conflict in Ukraine, led to a significant increase in militarization in the Black Sea countries to a peak, so that in 2016-2020 we can see a slight downward trend that tends to stabilize around high average value of 2.03 (Figure 3).

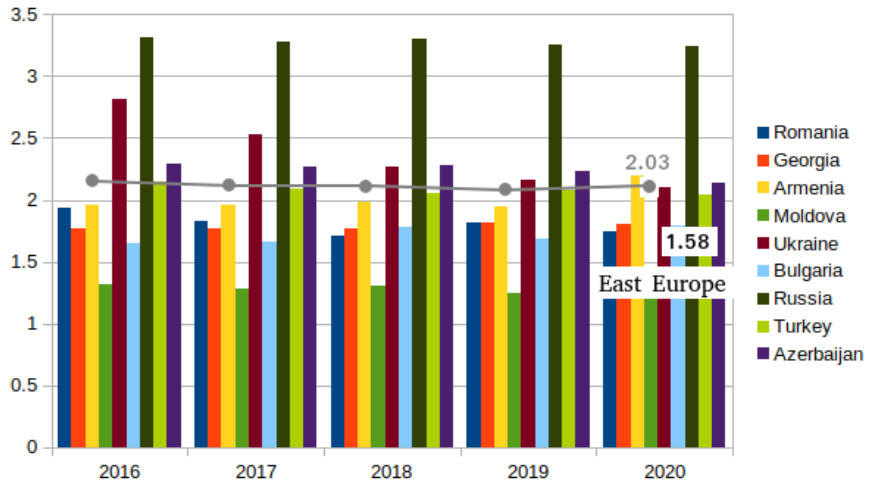

Fig. 3 The evolution of the Militarization Index

The value of the index for 2020 was determined without taking into account the impact of the "heated" conflict in September in Nagorno-Karabakh, but it captures the effect generated by the economic decline caused by the COVID-19 pandemic crisis.

The evolution of the general index of militarization is related to the different perceptions of the states regarding the threats, which determines new configurations in the field of military capability requirements. At both NATO and EU level, the biggest security threat is Russia's growing aggression. However, at the level of the Member States, the perception of this threat decreases as we move away from the "epicenter". For example, the militarization index increased compared to 2018 for Romania by 2.4%, for Italy and Germany by 0.4%, and for Portugal decreased by 3.2%.

The Black Sea region has become a strategic frontier (power consolidation - enlargement policy, peace - frozen or hot conflicts, stable states - fragile states) subject to constant militarization manifested by investments in technological innovation or military acquisitions (SBSR, 2018).

The high levels of military spending are justified by the existence of threats from the security environment, the continuous increase in the prices of military equipment or the desire to play an important role at the international level. The counterbalance of these pressure factors on the national defense budgets is achieved by the limitation and prioritization of visible resources in the context of the economic decline generated by the COVID-19 pandemic. This leads to an accepted annual budget level that also captures the competition between endowment programs for future funding. The great challenge for decision makers is to maximize the benefits obtained in terms of capabilities with available resources.

3. A cost-based decision model

The development of a decision-making model aims to improve defense decisions in the context of a permanent unconventional crisis by exploiting uncertainties with an impact on the efficient use of limited resources and improving security at national and regional levels.

Decisive moments in the process of allocating resources for the development of military capabilities can take the form of: approvals (continuation/ stopping the process) or elections (from several alternatives). The consequences of decisions are characterized by uncertainty: either they are evaluated in terms of increasing the deterrent/ response capacity, or in terms of reducing the risks in the operational environment.

The problems that require strategic decisions derive from the lack or gap of capacity in relation to the identified needs (Kokotti, 2019). The options portfolio theory solves the decisional dilemma related to the choice of military capabilities to maximize the chances of fulfilling the established performance objectives.

For the development of a decision model based on the determination of a stochastic life cycle cost and the theory of real options (ROA), the following hypotheses are considered:

Hypothesis 1: The level of uncertainty decreases as the state of tension escalates. Among the characteristics of the "gray area" are: average level of uncertainty, high level of prices for military equipment/ services, budgetary commitments.

Hypothesis 2: two options are considered: expand (E), corresponding to the continuation of investments, which allows the development of capabilities necessary to obtain advantages at the level of future opportunities; and the defer (A), valuable in the medium term and high uncertainties, which allows option E to remain open.

By applying the contract of options for investments in defense, the holder is given the right, but not the obligation, to acquire a capability at a given time, at a predetermined price. The analysis of real options offers a way of protection against investment risk, through the possibility

of not investing at a given time and waiting for new opportunities, but also maximizing performance with available resources.

Factors such as the duration and relatively high costs of acquisition and implementation, funding volatility, irreversibility or project risks, lead to representation in the form of a composite option associated with a succession of decisions.

Hypothesis 3: the value of a military capability is given by the maximum cost that the decision maker is willing to pay (Ryan et al., 2013) in the context of the most likely financing scenario (compliance with financial commitment).

Hypothesis 4: the estimation of the life cycle cost associated with the investment project follows an evolution described by a Markov chain (future evolution depends only on the current state of the process, but also on the one existing in the previous moments) and uses the modeling with the Poisson distribution of "strategic shocks" (adequate for the distribution of rare events in the time interval corresponding to the investment).

Positive or negative jumps, the source of which is rare events, may represent uncertainties about the timing and consequences of new information on technological progress, legislative changes, economic and financial crises, military conflicts etc.

The analysis of real options, by capturing the investment phenomenon in dynamics, leads to the improvement of the possibility of solving the existing uncertainties in the security environment regarding the optimal use of resources (Moreno-Hines, 2007). Thus, based on the available information, a substantiated support is offered in order to be able to answer the questions: "What would it cost if ...?" (specific for Planning phase) and "What will it cost and when?" (specific for Programming phase).

Approaching the Planning, Programming, Budgeting and Evaluation System (PPBES) as a decision support tool (from the perspective of allocating resources to meet defense objectives, but also estimating the medium-term decision impact) (Constantinescu, 2016]), the results obtained from environmental analysis security and the hypotheses considered lead, in terms of compound real options, to the configuration of the following favorable scenarios:

1. The defer option (Tab. 1) offers the possibility to save from the costs associated with a top capacity, which under normal conditions is not feasible due to exceeding the maximum cost that the decision maker is willing to pay.

<table>
<tr><td colspan="2">Defer</td><td rowspan="2">Exercise Option</td><td>The value of capability opportunities</td></tr>
<tr><td>High Volatility</td><td>Call Option</td><td>Saved Costs</td></tr>
</table>

Tab. 1 Defer option

2. The expand option (Tab. 2) offers the possibility to continue the investments if the conditions are favorable, which means that the activation of the option represents an opportunity cost of the investment for the development of additional capabilities. The inclusion of managerial flexibility from the perspective of exploiting the uncertainty in the security environment and the response to market changes provide added value to the investment project.

In this decision-making model, the role of the analysis of real options is to change the traditional way of approaching the process of identifying and exploiting strategic options in the field of defense. In an area where there is a permanent capacity gap in relation to identified needs, the investment result is difficult to quantify, and the market is characterized by excessive bureaucracy, limited number of suppliers/ buyers and high technology (Kokotti, 2019), decision makers they are forced to exploit uncertainty in terms of new opportunities.

<table>
<tr><td colspan="2">Expand</td><td rowspan="2">Activate option</td><td>Reengineer the program</td></tr>
<tr><td>Project</td><td>Call Option</td><td>Additional capabilities</td></tr>
</table>

Tab. 2 Expand Option

The decision-making model is completed with the analytical element for evaluating investment projects in the field of defense: stochastic life cycle cost (SLCC). This makes the connection with the budgeting phase, in which the answer to the question: "How much will it cost?" must be provided.

Cost estimating is the process of applying cost analysis to forecast the nature and magnitude of the likely future economic costs of a program under uncertainty conditions. The result of this process is materialized in the form of Life Cycle Cost (LCC) estimation, which is the interconnection element between Planning and Budgeting.

The budgeting decision of a program is based on the LCC estimate as a sum of all recurring and one-time costs over the full life of a program. The limitations of this tool are highlighted by statistical results: cost and timing overruns are a constant in military endowment programs (Ryan et al., 2013). The causes are both exogenous and endogenous: the difficulty of including the sources of fluctuations in the evolution of costs, by neglecting the risk of jumping generated by rare events; inability to capture changing capacity requirements throughout the life cycle of the developed system.

SLCC, by approaching LCC as a random variable with a Poisson distribution probability, is a decision support tool capable of providing more accurate estimates. Capturing the evolution of these costs over the life cycle is highlighted in equation 1, where: α represents the growth rate per unit time, σ is the volatility of the process, θ is a random number generated by using the standard normal distribution N (0,1), and q is the frequency of "strategic shocks".

$$LCC_{t+1} = LCC_t(1+\alpha) + \sigma \cdot LCC_t \cdot \vartheta \cdot \left[1 + \sum_{q=0}^{i}\left(e^{-\lambda} \cdot \frac{\lambda^q}{q!}\right)\right] \quad (1)$$

Based on above cost assumptions and the inputs, the result of the analysis were simulated in Mathcad (Figure 4).

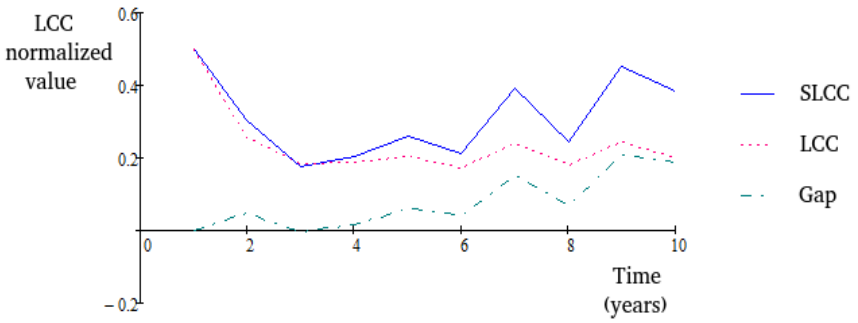

Fig. 4 SLCC simulation

The model allows the simulation for different values of the LCC, both the result of the investment project (the difference between the SLCC and the estimated LCC), and the optimal time to change the strategy. The difference between the estimated LCC and the SLCC highlights the difference between the static approach and the dynamic cost approach, with direct implications on the program's performance indicators.

The utility of the cost model can be improved with the availability of volatility data (risk associated with the LCC variable) and the probability of shocks from similar programs. Also, successive runs allow the sensitivity to be assessed so that the impact of shocks on the program is reduced.

Completing the analysis of real options with the stochastic approach to life cycle cost is an integrated solution for the analysis and comparison of investment projects in the field of defense.

3. Conclusions

The decision-making process that aims to develop new military capabilities through the acquisition of technology or services is a complex, long-term, bureaucratic process supported by specific tools and techniques. The investment decision in the field of defense is a decision in conditions of uncertainty.

The analysis of the security environment in the first part of the paper provides sufficient elements for the design of new decision support tools in order to solve problems related to capability requirements, limited resources or uncertainty levels.

The development of a decision-making model based on the determination of a stochastic cost of the life cycle and the theory of real options substantiate the objective of maximizing the benefits obtained in terms of capabilities with available resources.

The research results allow outlining a framework for planning medium-term defense investments so that uncertainties for potential gains in terms of capability can be exploited, as well as substantiating forecasts of program performance.

The limits of the approach derive from the lack of analysis of the effects of competitive dynamics on the creation and exercise of real options, taking into account the specifics of the defense market, but also from the availability of data on planning and achieving the objectives established by the program.

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