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THE USE OF PRODUCTION ANALYSIS MODELS IN OPTIMIZING THE DEVELOPMENT OF MILITARY CAPABILITIES

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Abstract:
CPB intends to provide a better response to more dynamic and various risks and threats that address the economic, political, social and military stability of the contemporary world. In view of the aforementioned aspects, this paper intends to present an analysis of different ways in which the CPB process and the process of developing military capabilities may be modeled, taking into consideration the economical aspect of maximizing the required benefits while minimizing costs

Key words: capabilities based planning, production analysis, models, outputs, inputs

1.Introduction

Capability Based Planning (CPB) is considered for a while to be a big challenge for the modern states regarding the defense resources management. This concept is an integrated part of continuous process of the military structures transformation, during peace time and/or military operations.

CPB intends to provide a better response to more dynamic and various risks and threats that address the economic, political, social and military stability of the contemporary world. As any of other defense activity, CPB requires certain resources for the purpose of analysis, identification, design and implementation of both planning concept and production and utilization of the military capability. The aforementioned resources are human, financial, material and informational.

We are now facing a difficult period, full of economical and financial crises and increased uncertainty. All these issues challenge the nations in different degrees, according to their preparedness and level of development. Due to the intensity of the crisis, the effects may be observed not only in the economic and financial fields, but also in other areas of activity, like the military. This is the reason for the need of all the specialists involved in defense planning to figure out the necessity of implementing a more effective resource management for all the activities associated to the military. It is hard to believe that the allocation systems which were used before the onset of the crisis are still reliable and can be further used in order to guarantee the success of the military activities.

According with the aforementioned aspects, this paper intend to present an analysis of a potential way to optimize the CPB process itself and the associated military capabilities, using models applicable in the economic field of production analysis, related to the economical aspect of maximizing the required benefits while minimizing the costs.

2. Production analysis models and the military capabilities development

In view of the aforementioned aspects, this paper intends to present an analysis of different ways in which the CPB process and the process of developing military capabilities may be modeled, taking into consideration the economical aspect of maximizing the required benefits while minimizing costs.

The Capability Based Planning process has been defined as a “method which involves a functional analysis of operational requirements. Capabilities are identified based on the tasks required… Once the required capability inventory is defined, the most cost effective and efficient options to satisfy the requirements are sought.”[1]. A more comprehensive approach defines CBP as “planning, under uncertainty, to provide capabilities suitable for a wide range of modern-day challenges and circumstances while working within an economic framework that necessitates choice.”[2]

The process is based on the concept of military capability (defined as “the ability to provide an operational effect required by the operational standards specific to an environment, in a specified time and to sustain that effect for a specified period of time; it is provided by a system consisting of Doctrine, Organization, Training, Materiel, Leadership development, Personnel, Facilities, Interoperability (DOTMLPFI) readiness, deployability”)[3] and starts with the setting of goals of objectives for the military at the political/strategic level, followed by the identification of shortfalls and capability needs. These result from mission area assessments and identification of scenarios, followed by the identification and analyses of potential ways of action, including the analysis of risk.

The concept of planning on capabilities has been adopted not only by individual countries, but also by NATO; thus, the “NATO Defense Planning Process consists of five steps: establishing the Political Guidance, determining the Minimum Capabilities Requirements, Apportion the requirements and set targets, Facilitate the implementation and review the results in the form of Capability Review”[4].

The optimization of the military capability production process is considered analogue with the production of goods and services, the basis of the market economy. Each military capability can be considered as a mix of resources which will be used to perform a certain mission. This mix of resources must consider first of all the purpose of its existence and generate the maximum benefit. At the same time, because of the resource scarcity, the use of this mix must be considered in the economic context. These two aspects have opposing effects, but defense experts have enough room to develop a multitude of accurate scenarios based on different resource envelopes which are available. The decision-makers may also benefit from this multitude of scenarios and better integrate their decisions, both at the horizontal level and at vertical levels.

If we consider the production of a military capability represents a transformation of inputs into outputs, we can state that this process follows the general model of the Cobb-Douglas production function. This model assumes the transformation of two inputs, labor and capital, in a single output, in this case the required military capability. Of course, each element of the military capability (human, material, financial, informational) will be part of one of these inputs.

The mathematical expression of Cobb-Douglas production function for a military capability is represented bellow

$$MC = A \cdot K^{\tilde{}} \cdot L$$

where: MC = the monetary value of the required military capability
A = total value of the productivity
K = the monetary value of the capital (materials, financial resources, information)
L = the monetary value of labor
α = the elasticity of capital
β = the elasticity of labor

The economic theory in general covers a wide range of the production process of goods and services. All this aspects consider mostly profit and cost to be relevant factors in taking a decision. In the case of military, the concept of benefits is more appropriate than that of profit. In this respect it is very important to design with accuracy the production function needed for the specific military capability. The military capability design should be based on phenomenological research, such as statistical determination of most stable correlation among military capability production indicators (mean, marginal, substitution, elasticity). After this research is done the next step should be the designing process of the production function in two steps:

1. Establish the stable correlation among indicators, by using a differential equation with labor productivity as unique variable;
2. Integrate the equation to obtain the production function with the analysis of the effects of technological change.

In the case we ignore the technological change, situation that should not be taken in consideration, a range of induced production functions will be obtained, such as: elasticity, marginal efficiency, marginal rate of substitution, elasticity of substitution.

Induced production functions such as elasticity are based on statistic data which highlight a stable statistic link between elasticity and labor:

EL = h(kt)

where: h: R → R is an elementary function, which may be linear, parabolic, hyperbolic, logarithmic, exponential, and other types, according to the statistical methodology of specifying, estimating, and parametric and consistency testing. This specific situation occurs when defense experts who are involved in the development of the military capability production function model put more emphasis on human factor. The production function in this case should be:

$$MC(K,L) = A \cdot K \cdot e^{-H(\frac{K}{l})}$$

where: MC(K,L) = the monetary value of the required military capability
A = total value of the productivity
K = the monetary value of the capital

Induced production functions such as marginal efficiency are based on statistic data which show that marginal productivity is dependent on average productivity

ηL= h(wL(k))

where h : R+ → R+. This dependency is based on achievement of optimal condition to produce the desired military capability with maximum benefits at the minimum costs.

The production function in this situation is:

$$MC(K,L) = L \cdot G^{-1} \cdot (\ln \frac{K}{L} + \ln c)$$

where: L = the monetary value of labor
K = the monetary value of the capital
c = constant

$$G(f(k)) = \int \frac{f'(k)}{f(k) - h(f(k))} dk$$

The induced production functions, such as marginal rate of substitution, are based upon statistical analysis of the marginal rate of technical substitution which emphasizes the military capability production dependency to the technical level. If marginal rate of substitution is constant, reflecting the perfect alignment of input costs with inflation rate, we are obtaining the following formula:

$$MC(K,L) = A \cdot [K + \quad L]^{\circ}$$

ρ = function’s homogenous degree
β = marginal rate of substitution

The induced production functions such as elasticity of substitution are based upon correlation between coefficient of substitution elasticity and technical level per capita. The production functions can be designed in different ways according to the situations but relevant forms are the following:

Sato’s production function:

$$MC(K,L) = A \cdot \frac{K^2 L^2}{\sim K^3 + \quad L^3}$$

, for α, β >0
where: A = total value of the productivity
L = the monetary value of labor
K = the monetary value of the capital
α = the elasticity of capital
β = the elasticity of labor

Allen’s production function:

$$MC(K,L) = \sqrt{2¥KL - \sim L^2 - \quad K^2}$$, for α, β >0 and γ2 > αβ

where: L = the monetary value of labor
K = the monetary value of the capital
α = the elasticity of capital
β = the elasticity of labor
γ = the variable elasticity of substitution

As I have mentioned before, the process of obtaining military capabilities can not be separated of technical change. This progress is never ending and its speed is increasing. In the same time the defense experts involved in the process of producing military capabilities are challenged by the economical aspect. The technical change is a powerful factor which generates the increase of the output even the volume of the inputs remains the same on the short term. In this respect is important to introduce in all mathematical representations of the production functions another factor – time.

$$MC_t = f(K_t, L_t, t)$$

This new factor will review all the indicators that defense experts may take into consideration while developing the model of military capability production function in order to obtain the optimum output. The use of time like another powerful factor inside of military capability production functions with technical change will allow a more precisely quantification of the output increase, and the level of the military capability respectively.

According to the economic literature, the technical change can be expressed as:

- neutral (Hicks – 1932),
- unbiased (Harrod's or Solow's type),
- biased (Solow's or Weiszacker' type),
- induced (by the factor's quality – Nelson's or Denison's type; by the experience – Arrow's type).

The production functions with neutral technical change (Hicks) for a military capability may be the following:

$$MC(K_t, L_t, t) = A \cdot e^{Tt} \cdot G(K_t, L_t)$$

where:

A = the capital productivity coefficient of progress change
G = the labor productivity coefficient of progress change
Lt = the monetary value of labor at time t
Kt = the monetary value of the capital at time t

This function form allows the experts to take into consideration the same influence of the progress change on output through capital and labor.

The production functions with unbiased progress change, Solow type, are based on the fact that marginal efficiency of labor is not modify over time, but is dependent on average productivity. In the case of military capabilities is a little bit harder but not impossible to analyze the impact of the personnel's wages according with their productivity, no matter of time. In this respect, the defense experts have to determine the adequate performance indicators of the military activity and to pursue the acceptance of them by the system. I consider that this might be one of the ways to increase the performance of the military system, by implementing a real philosophy about economy of military inputs. Mathematical expression of the production function with unbiased progress change, Solow type, for a military capability may be the follow:

$$MC(K_t, L_t, t) = L_t \cdot G^{-1}[A(t) \cdot \frac{K_t}{L_t}]$$

where:

Lt = the monetary value of labor at time t
Kt = the monetary value of the capital at time t
A = the capital productivity coefficient of progress change
G = the labor productivity coefficient of progress change

This formula shows us that the progress change is acting mostly through the capital but this is also a powerful generator of human labor.

Nevertheless, the complexity of military capability production process assumes that progress change is acting differently from generation to generation of production factors. The new generations are incorporating the scientific and technical progress due to the last discoveries in various fields of science and technology. I have to reaffirm that a military capability comprise a wide range of resources, each of them affected by deep transformations due to military or civilian research. The new production factors contribute more to the production than the oldest, at the same quantity of use. This is the case both for capital and for labor. The new generations of the defense personnel are more specialized and adapted to use the latest information technologies. This aspect will determine a much better blend between the users and future military systems to be used.

In the case of the Solow model with biased progress change in specific generation of capital, it can be shown that the investments play a crucial role, as a key vector of progress change, even if the depreciation of the fix assets has to be assumed and monitored. In the case of military capabilities, the high initial investment sometimes transcends the efficiency and effectiveness from the economic point of view. In this respect, the defense experts have to establish an accurate aim of the military capability and the optimum ways to obtain it. They have to formulate viable solutions to decelerate the military capabilities depreciation, because of the difficulties to evaluate the benefits after using the military capability or just its existence as a discouraging factor. To make things a little bit more complicated, the defense experts have to figure out that in parallel with the main stream of the progress change, another small stream will be present, an unbiased progress change generated by the entire process management of the military system, at the specific moment when the picture is being interpreted.

If the human factor is biased by progress change, it can be assumed that each new generation of input (labor) will contribute more to output increase than the previous one. A very used model in the market economy is Weiszacker model which introduce relevant performance indicators in order to enrich the production functions typology as follows:

- Nτt number of employees at current time t, being employed for τ years, considered after finishing desired adequate studies;
- efficiency of an employee of Nτt category;
- the duration of supplementary studies to increase professionalism;
- the depreciation rate of knowledge due to time passing;
- accumulated experience thru work and continuous learning.

Following this arguments, a formula of the military capability production functions with three trends can be expressed as follows:

$$MC_t = B \cdot [(1+\text{«})(1+\text{¥})]^t \cdot [\sum_{\text{²}=t-\bar{\ }_K}^{t} (1+\text{ª})^{\frac{\text{²}}{\text{˜}}} \cdot (1-\text{¢})^{t-\text{²}} \cdot I_{\text{²}}]^{\text{˜}} \cdot [\sum_{\text{²}=t-\bar{\ }_L} N_{\text{²}t} \cdot g(n_{\text{²}t})]$$

where:

B = constant

μ = constant pace of biased progress change

γ = the variable elasticity of substitution

θK = the age of oldest generation of capital

θL = the age of the oldest generation of labor

λ = the pace of the progress change of each capital generations

More complicated models for production functions with biased progress change can be represented, such Denison-Nelson model. This model may offer to defense experts the possibility to identify carefully the potential volumes of capital and labor regardless to relevant factors of the core process. Some of these factors related to capital should be: the pace of capital increase, the pace of biased progress change and impact over capital change and mean service life. Some quantitative and qualitative factors related to potential volume of labor should be: the pace of physical labor increase (quantitative), the pace of biased progress change to human factor due to higher specialization, work experience and use of IT in all activities. Even in this case, the defense experts have to take into consideration the aspect of residual stream of autonomous biased progress change due to overall management of the defense system.

3. Conclusion

The production of a military capability is a complex, challenging and resource consuming process. The optimization of this process must be a high priority for the defense experts and for decision-makers because of time and resources available.

In my opinion, various economy-proofed models may be implemented in the production of the desired military capabilities after a careful selection and implementation. Putting more economic science to work in this field, it should drive to a better formulation of military capability model which can offer a better simulator before to start to build it.

The use of production functions may be the source of a better resource allocation and link among relevant risk and threats that address national security and the aims and objectives of the defense sector.

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