*The 12th International Scientific Conference*
*"DEFENSE RESOURCES MANAGEMENT IN THE 21st CENTURY"*
**Braşov, November 9th-10th 2017**

# MEASURING PRODUCTIVITY IN THE MILITARY SECTOR

**Filip Călin**

Ministry of National Defense / Romania

**Abstract:**

Approximately 80% of world trade currently travels by sea, representing around 93,000 merchant vessels, 1.25 million seafarers, and almost six billion tons of cargo. When appear some disturbing factors, that affect the transfer of goods and the free transit on sea routes for civilian ships involved in trading, disorders of all specific processes are inevitable, starting from the delays to financial losses, lack of confidence and not the least occurrence of critical conditions that can culminate in life lost. About maritime piracy it was written very much, there have been made statistics, but it has not managed so far to put all these documents in a white book of piracy. The data presented in this paper are the results of corroborating statements transmitted by NATO, EU and the organizations involved in analyzing this phenomenon.

*Key words: productivity, labour, efficiency, performance, measurements*

## 1. Introduction

"Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker."[1]

Productivity in the stone age was extremely low and the standard of living was the same, but over time, increasing productivity, we managed to increase our level of material comfort.

Military productivity can not be seen apart from the national productivity, they will grow together.

Keeping this in mind, we will discuss various ways to measure productivity in the military sector, in order to be able to increase it and also we will reveal the resulted benefits.

## 2. Understanding productivity

This part could be considered an introductive one, but as long as it seems that productivity doesn't play a major role in the military sector, I considered necessarily to deepen the concept.

### 2.1. Productivity definition

We hear the word "productivity" almost every day and increasing it, it seems to be an individual and collective goal. Even we are accustomed with the term, let's review its meaning. There are various ways of defining productivity:

2.1.1. Productivity is commonly defined as a ratio of a volume measure of output to a volume measure of input use.[2]

2.1.2. Productivity measures the efficiency of a company's production process. It is calculated by dividing the outputs produced by a company by the inputs used in its production process.[3]

2.1.3. Productivity measures how certain resources are managed to accomplish timely objectives. It can also be defined as an index that measures output (goods and services) relative to input (labor, materials, energy).[4]

2.1.4. Productivity is the rate at which goods are produced or work is completed.[5]

So, on short: Productivity = units of outputs / units of inputs [6] (1)

### 2.2. Examples

Some examples will further clarify the term:

2.2.1. GDP per capita for a country, that is a measure of living standard, can be seen as productivity as long as GDP is the output and number the people is the input. Below are few countries, along with their GDP per capita, ranked by International Monetary Fund in 2016:

| Rank | Country | Int$ | Rank | Country | Int$ | Rank | Country | Int$ |
|---|---|---|---|---|---|---|---|---|
| 1 | Qatar | 127,660 | 18 | Germany | 48,111 | 58 | Romania | 22,348 |
| 2 | Luxembourg | 104,003 | 24 | United Kingdom | 42,481 | 78 | China | 15,399 |
| 3 | Singapore | 87,855 | 25 | France | 42,314 | 123 | India | 6,616 |
| 6 | Norway | 69,249 | 36 | Czech Republic | 33,232 | 132 | Moldova | 5,328 |
| 7 | Ireland | 69,231 | 45 | Hungary | 27,482 | 172 | Sierra Leone | 1,672 |
| 11 | United States | 57,436 | 48 | Russia | 26,49 | 186 | Central African Republic | 652 |

**Table 1**

2.2.2. In a small factory manufacturing shoes, productivity can be measured as a ratio of number of produced shoes pairs to number of employees;

| Average no. of employees in 2016 | No. of produced shoes pairs in 2016 | Productivity in 2016 |
|---|---|---|
| 65 | 2453 | =2453/65=37,74 |

**Table 2**

2.2.3. In the same factory from the previous example, another way of measuring productivity is dividing the number of produced shoes by the number of work hours of all employees in a certain period of time.

| No. of work hours of all employees in 2016 | No. of produced shoes pairs in 2016 | Productivity in 2016 |
|---|---|---|
| 14866 | 2453 | =2453/14866=0,165 |

**Table 3**

### 2.3. Why we should measure productivity?

The scopes of measuring productivity are:

2.3.1. Increasing efficiency – one main goal of any manager is to rise and if is possible to maximize the efficiency of the organization what means to get the maximum amount of outputs using the total inputs at its disposal.

2.3.2. Cost savings – the managers also try to minimize the resources that ultimately are reduced to money and calculating productivity gives you important clues to cut the cost of a process.

2.3.3. Performance monitoring – measuring productivity helps the manager to asses and to quantify the progress to an established target and provide feedback useful also to stakeholders.

2.3.4. Problems diagnosing – productivity analysis provides the manager indications to correct malfunctions and to prevent crises.

2.3.5. Improving the planning process – measuring productivity gives many indications that support the manager to identify the week link, to improve decision making in order to get the best results.

2.3.6. Identifying technological improvements – productivity assessment helps manager to identify the opportunity to introduce innovations, a new technology, as a way to adjust the benefits.

All these so called purposes of measuring productivity are also means to alter the productivity.

2.3.7. Augmenting the profit is the ultimate goal of the stakeholders and it is achievable by manipulating productivity. Subtracting inputs from outputs after they are translated in terms of money gives you the profit;

2.3.8. For other activities which don't produce countable outputs, the purpose is winning the competition and can be reached by optimizing productivity.

2.3.9. Another reason for measuring productivity is that the productivity is a complex indicator, it comprises both the information delivered by the effectiveness and efficiency.

### 2.4. Productivity measure classification

As it can be traceable from previous ideas, measuring productivity is kind of a tricky business. Still there are these main types of productivity measure, based on the number of inputs:

2.4.1. Single factor productivity (SFP) measure (outputs are divided by a single type of inputs);

2.4.2. Multi factor productivity (MFP) measure (outputs are divided by a packet of inputs).

2.4.2. Total factor productivity (TFP) measure (outputs are divided by all of the inputs). [8]

### 2.5. Terms related to productivity

As it can be seen from definition, productivity measure the relationship between outputs and inputs and is mainly related to economical sectors, where some goods or services are provided, outputs and inputs being easily measurable. So, in order to be able to measure the productivity, first we are forced to identify and measure the inputs and the outputs. This is both a science and an art.

2.5.1. Outputs

2.5.1.1. Gross output – represent the services or the goods produced by an organization, which are available and usable.

2.5.1.2. Value added – it is useful when in a process use an intermediary input, this intermediary input is subtracted from the gross output, resulting value added; productivity is measured using value added in respect to primary input; this way, productivity is mainly related with the income.

2.5.2. Inputs

2.5.2.1. Labor input - as an input for labor productivity measurement, it is most widely used the total hours of work, an obsolete one is the number of employees;

2.5.2.2. Capital input - comprises the raw materials, stocks, machinery, equipments, tools, infrastructure, technology, other production costs.

# 3. Productivity in noncommercial sectors

Since the military sector is part of the public sector, this short chapter will provide a bridge between the consecrated domain of productivity and the military activity.

## 3.1. Distinctive conditions

While in a commercial sectors, and I included here production, industrial, agricultural, sales, services, the outputs are visible and easily measurable, in other sectors like public, there are not so readily quantifiable outputs, and even if it is measurable, they are not valid indicators for measuring productivity

Of course, we can find a lot of outputs, such as the number of certificates emitted by an office or the number of fines issued by a police department, but it is disputable that these are suitable outputs to measure productivity and the results are really meaningfully and usefully. These outputs are related somehow to efficiency, telling nothing about effectiveness since the outcomes are not taking into account.

Here is another issue there, a lot of services or institutions outcomes are hardly, even no measurable, for instance how we quantify the outcomes of a city hall, or of a police station? It is troublesome to measure fire protection or security provided by state. Another difficulty derives from the fact that we don't have a measure unit for quality and even it seems not to be accounted when we talking about productivity, it is. In the case of clearly measurable outputs, only the final products that exceed an establish standard are taken into account. On the other hand, when we talking about not so swimmingly accountable outputs, like security provided, quality would be an appropriate quantifying element, but, unfortunately, it doesn't exist a measurement unit for it.

## 3.2. Possible solutions

Because of this, the US Bureau of Economic Analysis (BEA) proposed and adopted a convention of pricing public sectors outputs in terms of inputs, namely, employee compensation (benefits). This productivity reflects the living standard of employees, yet, unrevealing any information about the results of the activity.

Another approach in calculating productivity in the public sector could be using as outputs consequences of activities or outcomes, the infractions rate modification instead of fines issued number. This method is related to efficiency and effectiveness, but has a shortcoming too, the consequences could be influenced by external factors thus the result would be distorted.

The challenge in measuring productivity is to choose the proper output related to existing inputs.

# 4. Applying productivity related terms in the military sector

## 4.1. Overview

Measuring productivity in the military sector is facing the same difficulties like public sector and some commercial ones: it's a hard job to pick the right output.

Another hardship derives from the very large spectrum of activities executed in the military, from the administrative ones to combat or from cleaning to engineering.

On top of these is the continuing transformation, evolution of the military, always in the search of the newest technologies, running the race for the more deployable, multirole and higher readiness forces.

### 4.2. Outputs for the military sector

In the following sections I would evaluate few possible outputs to take into account as factors in measuring productivity in the military sector.

4.2.1. Visible outputs

I would consider as visible outputs any countable result of military personnel activity, like documents elaborated, exercises completed, equipments repaired or maintained, usually duties enumerated in the job description and/or parts in approved plans.

These outputs being easily countable offer a pretty exact value of productivity, but don't reveal the real result of military missions.

4.2.2. Consequence outputs

I ventured to say that these outputs are the real and the truly outcomes we expect from the military sector, such are maintaining a peaceful climate by deterring or defeating any aggressor. These consequences are of course difficult to quantify and on the other hand are not only a result of military activity but also of the internal affairs, external policy, intelligence structures and so on.

One possible approach is to assimilate "the peace level" with the terrorist alert state and to allocate a value to, like this:

| Alert state | Low | Cautious | Moderate | High | Critical |
|---|---|---|---|---|---|
| Peace level | High | Moderate | Cautious | Low | Critical |
| Value | 5 | 4 | 3 | 2 | 1 |

**Table 4**

4.2.3. Outputs in terms of inputs (employee benefits)

Using this kind of outputs, measured productivity won't offer any indication about the work done in the system or about the fulfillment of the tasks, so it is not valuable by itself. It is however useful as a comparison term with other sectors even public or private.

Also, it could be an indicator of the personnel quality, a higher productivity would evidence a more educated or skilled employee, being a consequence of natural tendency of people to choose a better paid job. Forward, this would act as a turbine, boosting the productivity since motivated employees tend to be more productive.

4.2.4. Evaluation outputs

As long as in the military sector is implemented a standardized evaluation method, these evaluations could be used as outputs for measuring productivity. Supposing that the evaluation process is design and implemented in respect with goals and missions accomplishment, it will provide adequate information to obtain accurate productivity values.

Shortfalls in this approach is the human intervention in the evaluation process that could lead to subjective evaluations thus to misleading measured productivity.

4.2.5. Tests outputs

Considering that testing procedures are in place for any stages of standardized training process, the tests results are valuable outputs for evaluating productivity. Even the tests are not covering entire spectrum of military activities, their results offer a fair perspective of the personnel potential and give pretty good outputs for measuring productivity.

The tests also can include the exercises and even real combat outcomes.

### 4.3. Inputs for the military sector

Unlike the outputs which are different from sector to sector and they could be a hard job to choose, the inputs are the same no matter the domain we want to evaluate productivity for.

4.3.1. Labor input

Even the total hours of work is widely used as labor input, I would prefer the number of employees as an input because military are supposed to be always in certain states of alert, and willingly to overcome the normal working hours if necessary. This approach does not take into account the efficiency which is supposed to be considered as part of the outputs, but it will give the employee contribution to the outcome. As long as the labor code and the implied amount of work time per week or per month is applied in the military sector it is accepted a standard value of efficiency.

Anyway, the total labor hours can replace the employees number as an input for productivity and it helps to obtain a more accurate perspective about efficiency. It has a bigger relevance when the total working hours is different than the standard. The ratio between the standard and the amount of time spent at work, in a certain period of time, will provide a value for efficiency.

4.3.1. Capital input

Given the definition from the subsection 2.5.2.2., the military budget is a credible candidate for the capital input, comprising all the expenditures in the sector.

## 5. Calculating productivity in the military sector

### 5.1. Single factor productivity

Each pair of an output and an input lead to a valid single factor productivity value. Consequently, we will have ten possible productivity measurements:

5.1.1. Labor visible productivity ($P_{LV}$)

It represents the ratio of the visible outputs (VO) to the labor input (LI):

$P_{LV}$ = VO / LI = VO / MoND Employees No. (2)

As we mentioned before, it is easily calculated, but overlook the real expectations from the military. Anyway, it is a valuable tool in designing a structure, a job description and to equitable distribute the workload per employee.

5.1.2. Capital visible productivity ($P_{CV}$)

It is calculated as the ratio of the visible outputs (VO) to the capital input (CI):

$P_{CV}$ = VO / CI = VO / MoND Budget (3)

It has the same shortfalls like the previous one.

5.1.3. Labor consequence productivity ($P_{LC}$)

It expresses the ratio between the consequences (CO) and the labor input (LI).

$P_{LC}$ = CO / LI = CO / MoND Employees No. (4)

The deficiences of this method are described in the subsection 4.2.2.

5.1.4. Capital consequence productivity ($P_{CC}$)

It represent the the ratio of the consequence outputs (CO) to the capital input (CI):

$P_{CC}$ = CO / CI = CO / MoND Budget (5)

It could be a strong evidence of the money spending efficiency, the burden consist of the consequences quantifying difficulty and of the proper contribution allotment to the military sector.

5.1.5. Labor benefit productivity ($P_{LB}$)

It is obtained by dividing the benefits of military personnel (BO) by the total employees number (LI):

$P_{LB}$ = BO / LI = BO / MoND Employees No. (6)

It is a comparison tool between different economical and social brances and is also util to indicate the military sector capability in attracting quality employees.

5.1.6. Capital benefit productivity ($P_{CB}$)

It is calculated as the ratio of the benefits of military employees (BO) to the capital input (CI):

$P_{CB}$ = BO / CI = BO / MoND Budget (7)

It represent the personnel cost percentage in the total military cost and is a helpful instrument in analizing the other courses of improving armed forces capabilities like investments, operating, research and development or renewing.

5.1.7. Labor evaluation productivity ($P_{LE}$)

It represent the the ratio of the evaluation outputs (EO) to the labor input (LI):

$P_{LE}$ = EO / LI = LO / MoND Employees No. (8)

The result is valuable as long as the evaluation method is comprehensive and the evaluation itself is objective.

5.1.8. Capital evaluation productivity ($P_{CE}$)

It is obtained by dividing the evaluation results of the military personnel (EO) by the capital input (CI):

$P_{CE}$ = EO / CI = EO / MoND Budget (9)

The possible shortages are the same as at the labor evaluation productivity.

5.1.9. Labor test productivity ($P_{LT}$)

It is obtained by dividing the military personnel test outcomes (TO) by the total employees number (LI):

$P_{LT}$ = TO / LI = TO / MoND Employees No. (10)

The advantages and the disadvantages are described in the subsection 4.2.5.

5.1.10. Capital test productivity ($P_{CT}$)

The name doen't reflect very precise the measuring methode:

$P_{CT}$ = TO / CI = TO / MoND Budget

Again, there are no much to supplement as long as the tests are extensive.

### 5.2. Multifactor productivity (MFP)

Combining the effect of both the labor and the capital inputs to the desired output will offer an aggregate efficiency of the process and a measure of the labor or capital influence to the outcomes [7]. These values alteration provides a valuable instrument in the management or transformations assesment and furthermore offer improving solutions. A formula for calculating MFP is the Cobb-Douglas equation:

$MFP = O/ (C^{\alpha} * L^{(1-\alpha)})$, or $O = MFP * C^{\alpha} * L^{(1-\alpha)}$ [9] (11), where

O = outputs;

C = capital input;

L = labor input;

$\alpha$, $(1 - \alpha)$ = elasticity of outputs in respect with inputs (capital, respective labor), is usually between 0,25 and 0,4.

To deepen furthermore, we can split the labor input into employees number and total working hours:

$O = MFP * C^{\alpha} * L_e^{(1-\alpha)} * L_{wh}^{(1-\alpha)}$ (z), (12), where

$L_{em}$ = labor input in respect with the employees number;

$L_{wh}$ = labor input in respect with the total working hours.

Of course, following the same procedure someone can also divide the capital input into budgetary chapters or upon other criteria, analize deeper the impact on the outcomes and provide ways to improvements.

Because these are all the inputs we use, the total factor productivity is the same as the multifactor productivity and overall, it represent a magnitude of techological improvements, the employees and management quality.

As a result, as long as we have five evidenced outputs we will have five measured productivity, each with corespondent convenience inherited from the single fator productivity they are consisted of:

5.2.1. Visible productivity $P_V = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (13)

5.2.2. Consequence productivity $P_C = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (14)

5.2.3. Benefit productivity $P_B = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (15)

5.2.4. Evaluation productivity $P_E = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (16)

5.2.5. Test productivity $P_T = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (17)

5.2.6. Significance

Our goal is to increase the outputs/outcomes. Analizing formula (12) anyone can see that in order to achieve our goal we have to increase any or all of the terms. The last three, coresponding with capital and labor inputs are practically limited (human, materiale or financial resources and working hours), but the first one, the productivity is theoretically unlimited, being restricted only by our creativity. That's the reason we struggle to raise the productivity.

### 5.3. Composite productivity

Each of the productivity measuring methods presented above is valuable for a specific aim and each of them has conveniences and/or inconveniences. To surmont this and to obtain an instrumental measured productivity, I suggest a composite method of calculating productivity, namely, the weighted average of the all enumerated specific productivities. The challenge is to provide the most appropriate quotient for each of the distinctive productivity[10]. Another drawback is that we can not compare apples and oranges. We have to translate first all the outputs into the same measure units: percentage. To do this, we compare the outputs obtained (O) with the desired ones ($O_D$), leading to outputs rate (OR):

$OR=(O/ O_D)*100$ (18)

| Output (O) | VO | CO | BO | EO | TO |
|---|---|---|---|---|---|
| Desired Output ($O_D$) | $VO_D$ | $CO_D$ | $BO_D$ | $EO_D$ | $TO_D$ |
| Output rate (OR) | $VOR=(VO/ VO_D)*100$ | $COR=(CO/ CO_D)*100$ | $BOR=(BO/ BO_D)*100$ | $EOR=(EO/ EO_D)*100$ | $TOR=(TO/ TO_D)*100$ |

**Table 5**

Consequently, we attain the productivity rate (PR), replacing the output with the output rate:

$PR=OR/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (19)

And the total factor productivity rate for all the five outputs are:

Visible productivity rate $PR_V = VOR/( C^{\alpha} * L_{en}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (20)

Consequence productivity rate $PR_C = COR/( C^{\alpha} * L_{en}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (21)

Benefit productivity rate $PR_B = BOR/( C^{\alpha} * L_{en}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (22)

Evaluation productivityrate $PR_E = EOR/( C^{\alpha} * L_{en}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (23)

Test productivity rate $PR_T = TOR/( C^{\alpha} * L_{en}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$ (24)

As long as here are no available studies and researches in this domain, I propose the following values for coefficients:

| Productivity rate | $PR_V$ | $PR_C$ | $PR_B$ | $PR_E$ | $PR_T$ | Total |
|---|---|---|---|---|---|---|
| Quotient | $Q_V$ | $Q_C$ | $Q_B$ | $Q_E$ | $Q_T$ | |

| abreviation | | | | | | |
|---|---|---|---|---|---|---|
| Quotient value | 0,1 | 0,4 | 0,1 | 0,2 | 0,2 | 1 |

**Table 6**

Consequently, the formula for the comprehensive productivity rate is:

$PR = Q_V * PR_V + Q_C * PR_C + Q_B * PR_B + Q_E * PR_E + Q_T * PR_T$ (25)

## 6. Raising productivity in the military sector

Is it there any gain in raising the productivity of the military? Is it worthing the effort? All the goals mentioned in section 1.3 fit in the armed forces. Let's see just some of the benefits for the military:

- higher readiness status;
- more deployable forces;
- more interoperable forces;
- more reliable forces;
- quiqer response to any threat;
- better equipments;
- better training;
- more chances to win.

### 6.1. Productivity growth

Measuring productivity and having some metrics does not represent by itself any value. Our ultimate objective is gaining a competitive advantage over any adversary and we accepted that the optimum method is raising the productivity. Benchmarking it would be precious, but where we find the comparison amount?

As long as such a database does not exist it's up to us to create one, month by month and year by year, keep track of productivity growth and provide ways to continually raise it.

PG = (Pay - Pry) / Pry (26), where

PG = productivity growth,

Pay = productivity in the analyzed year

Pry = productivity in the reference year

### 6.2. Ways to increase productivity

Starting from the productivity definitions and formulas, I identified these methods of rising productivity metrics:

6.2. 1. Decreasing the capital used to obtain a unit of outputs:

- using the newest and suitable technology and software products;
- implementing enterprise architecture, eliminating unnecessarily expenditure;
- smart resource management (doing more with less);
- clear vision, strategic plan and willingness to achieve it;
- implementing enterprise architecture.

6.2. 2. Decreasing the employees or the man-hours used to obtain a unit of outputs:

- employees education;
- employees training;
- employees motivation;
- employee development and career management;
- fair employee workload and working conditions;
- fair employee benefit;

- smart human resource management (smart recruiting, right man in right place, smart retention policy);
- clear vision, strategic plan and willingness to achieve it;
- implementing enterprise architecture.

### 6.3. Other aspects related to productivity

6.3,1. Employees quality

In the equation (12) we used, we didn't evidence the employees quality contribution to the outcome, this is hidden in the labor input. It is obvious that an educated, trained, motivated and eager employee would do a better job than one who has these qualities less developed. Having two employees with the same" virtues" but with different experience grade, the more experienced will do the job much faster and better than the less experienced one. Studies shows that a 10 percent decrease in all experience variables they took into accounts leads to a decrease of 4.8 percent in the probability that the soldier will kill the enemy, and an increase of 9.2 percent that the soldier will be killed. [11]

6.3.2. Employees retention

Related with the previous subsection, derived from it, emerge the necessity of employee retention, the experienced and valuable ones. A smart retention policy, based on a strategic view, with a balanced numbers of cadets and senior employees, would assure a high productivity value.

## 7. Case study: Measuring productivity for a radiolocation subunit from Romanian Air Forces

### 7.1. Challenge

Efficiency indicators are not very intensively used in the Romanian military sector. There are some kind of indicators hidden in so called ready reckoners or time standards and performance indicators. Having emphasized the importance of productivity in achieving the proposed goals, I will deliver a method of calculating it in the military sector.

### 7.2. Solution

The difficulty consists of choosing the right outputs and inputs. Where are we starting from? From the objectives of the unit:

- aerial space surveillance, in the established area;
- maintaining personnel level of training according with the actual standards.

I will calculate productivity for two years, in order to compare it, for 2016 and for 2002.

#### 7.2.1. Productivity in 2016

7.2.1. 1. Inputs data

Labor input:

- personnel: 40
- worked hours per year: 78.720

Capital input: 3,122,773 lei = 767454 $

$\alpha = 0,3$, where $\alpha$ elasticity of outputs in respect with inputs (capital, respective labor)

7.2. 1.2. Visible productivity

Visible Outputs:

| Visible Outputs | Documents elaborated | Exercise completed | Maintenance duties | Total O (VO) |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Importance coefficient | 0.2 | 0.4 | 0.4 | 1 |
| Done | 121 | 11 | 32 | 41.4 |
| Foreseen to be done | 130 | 11 | 33 | 43.6 |

**Table 7**

7.2.1.2.1 Labor visible productivity

$P_{LV}$ = VO / LI = VO / Employees No.=41.4/40=1.035 or

$P_{LV}$ = VO / LI = VO / No.WH=41.4/78.720 k=0.526

7.2.1.2.2. Capital visible productivity

$P_{CV}$ = VO / CI = VO / Budget = 41.4/ 3.12 mil. =13.269

VOR = (41.4/43.6)*100 = 94.95

$P_V = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}104725$

$PR_V = VOR/( C^{\alpha} * L_{en}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}24019$

7.2.1.3. Consequence productivity

The main mission of the small unit is to survey the aerial space in concordance with the technical possibilities. This can be translated in a radars responsibility coefficient, meaning the ratio of the period of time when the radars are in proper technical state from the total period of analyzed time (1 year).

COR = 91, where COR – consequence output rate

7.2.1.3.1. Labor consequence productivity

$P_{LC}$ = COR / LI = CO / Employees No. =91/40 =2.275, or

$P_{LC}$ = COR / LI = CO / No.WH=91/78.720 = 1.156

7.2.3.2 Capital consequence productivity

$P_{CC}$ = COR / CI = CO / Budget = 91/ 3.12 = 29.167

$P_C = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}23019$

$PR_C = COR/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}23019$

7.2.1.4. Benefit productivity

7.2.1.4.1. Labor benefit productivity

$P_{LB}$ = BO / LI = BO / Employees No. = 1.44/40 = 0.036, or

$P_{LB}$ = BO / LI = BO / No.WH = 1,44/ 78.720 = 0.018

BOR = 100

7.2.1.4.2. Capital benefit productivity

$P_{CB}$ = BO / CI = BO / Budget = 1.44/3.12 = 0.461

$P_B = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}00364$

$PR_B = BOR/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}25296$

7.2.1.5. Evaluation productivity

A clear established method of personnel evaluating is in place. There are 10 competencies, attitudes and skills evaluated and marked from 1 to 5, 5 being the best, so one can obtain a maximum 50 points.

Summing the individual mark, we get 1537 points from 2000 possible.

EO=1689

EOR=(1537/2000)*100=76.85

7.2.1.5.1. Labor evaluation productivity

$P_{LE}$ = EO / LI = LO / Employees No. = 1537/40 = 38.425, or

$P_{LE}$ = EO / LI = LO / No.WH = 1537/78.72 = 19.525

7.2.1.5.2. Capital evaluation productivity

$P_{CE}$ = EO/ CI = EO / Budget = 1537/3.12 = 492.628

$P_E = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)})$

7.2.1.6. Test productivity

This domain is also well regulated and every employee had to sustain a series of tests during the year. The possible results of the tests are shown below and we appointed a mark for each of them:

| Result | Exceptional | Very well | Well | Satisfactory | Mediocre | Unsatisfactory |
|---|---|---|---|---|---|---|
| Mark | 10 | 9 | 8 | 7 | 5 | 4 |

**Table 8**

TO= 352

TOR= (352/400)*100 = 88

7.1.6.1. Labor test productivity

$P_{LT}$ = TO / LI = TO / Employees No. = 352/40 = 8.8, or

$P_{LT}$ = TO / LI = TO / No.WH = 352/78.72 = 4.471

7.2.1.6.2. Capital test productivity

$P_{CT}$ = TO / CI = TO / Budget = 352/3.12 = 112.82

$P_T = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0,89042$

$PR_T = TOR/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0,2226$

**7.2.2. Productivity in 2002**

7.2.2. 1. Inputs data

Labor input

- personnel: 72
- worked hours per year: 141725

Capital input (actualized): 995783 * 2.137 = 2127988 lei

Inflation rate was 213.7%

$\alpha = 0,3$,

7.2. 2.2. Visible productivity

Visible Outputs:

| Visible Outputs | Documents elaborated | Exercise completed | Maintenance duties | Total O (VO) |
|---|---|---|---|---|
| Importance coefficient | 0.2 | 0.4 | 0.4 | 1 |
| Done | 86 | 2 | 23 | 27.2 |
| Foreseen to be done | 90 | 2 | 23 | 28 |

**Table 9**

7.2.2.2.1 Labor visible productivity

$P_{LV}$ = VO / LI = VO / Employees No.=27.2/72=0.378 or

$P_{LV}$ = VO / LI = VO / No.WH=27.2/141.725 =0.192

7.2.2.2.2. Capital visible productivity

$P_{CV}$ = VO / CI = VO / Budget = 27.2/ 2.128 mil. =12.735

$P_V = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0,03389$

VOR = 97,14

$PR_V = VOR/( C^{\alpha} * L_{en}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0,12102$

7.2.2.3. Consequence productivity

COR = 88, were COR – consequence output rate

7.2.2.3.1. Labor consequence productivity

$P_{LC}$ = COR / LI = CO / Employees No. =88/72 =1.222 or

$P_{LC}$ = COR / LI = CO / No.WH=88/141.725 = 0.621

7.2.2.3.2 Capital consequence productivity

$P_{CC}$ = COR / CI = COR / Budget = 88/ 2.128 = 41.353

$P_C = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}10963$

$PR_C = COR/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}10963$

7.2.2.4. Benefit productivity

7.2.2.4.1. Labor benefit productivity

$P_{LB}$ = BO / LI = BO / Employees No. = 0.950/72 = 0.0132, or

$P_{LB}$ = BO / LI = BO / No.WH = 0.950/ 141.725 = 0.0067

7.2.2.4.2. Capital benefit productivity

$P_{CB}$ = BO / CI = BO / Budget = 0.950/2.128 = 0.496

$P_B = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}00118$

BOR = 97,22, as long and some benefits are remaining to be paid

$PR_B = BOR/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}12112$

7.2.2.5. Evaluation productivity

Because in 2002 was in place a different method of personnel evaluated, it is not possible to make a fair comparison, so I didn't calculate evaluation productivity.

7.2.2.6. Test productivity

TO= 584

TOR= (584/720)*100 = 81,11

7.2.2.6.1. Labor test productivity

$P_{LT}$ = TO/ LI = TO / Employees No. = 584/72 = 8.111, or

$P_{LT}$ = TOR / LI = TO / No.WH = 584/141.725 = 4.121

7.2.2.6.2. Capital test productivity

$P_{CT}$ = TO / CI = TO / Budget = 584/2.128 = 274.436

$P_T = O/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}72757$

$PR_T = TOR/( C^{\alpha} * L_{em}^{(1-\alpha)} * L_{wh}^{(1-\alpha)}) = 0{,}10105$

### 7.2.3. Productivity comparison

7.2.3.1. Single factor productivity comparison

| P/Y | $P_{LV}$ | $P_{CV}$ | $P_{LC}$ | $P_{CC}$ | $P_{LB}$ | $P_{CB}$ | $P_{LT}$ | $P_{CT}$ |
|---|---|---|---|---|---|---|---|---|
| 2002 | 0.378 | 12.735 | 1.222 | 41.353 | 0.0132 | 0.496 | 8.111 | 274.436 |
| 2016 | 1.035 | 13.269 | 2.275 | 29.167 | 0.036 | 0.461 | 8.8 | 112.82 |

**Table 10**

To be able to represent it on the same graph, I transformed the data:

| P/Y | $P_{LV}$ | $P_{CV}$/10 | $P_{LC}$ | $P_{CC}$/10 | $P_{LB}$*10 | $P_{CB}$ | $P_{LT}$/10 | $P_{CT}$/100 |
|---|---|---|---|---|---|---|---|---|
| 2002 | 0,378 | 1,2735 | 1,222 | 4,1353 | 0,132 | 0,496 | 0,8111 | 2,74436 |
| 2016 | 1,035 | 1,3269 | 2,275 | 2,9167 | 0,36 | 0,461 | 0,88 | 1,1282 |

**Table 11**

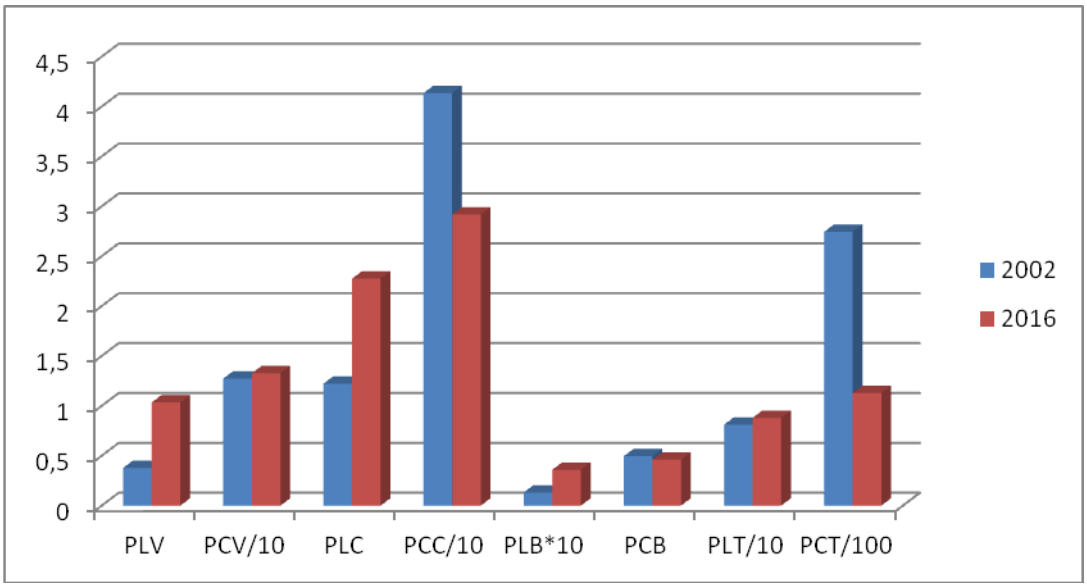


Fig.1

7.2.3.2. Multi factor productivity comparison

| Productivity/Year | $P_V$ | $P_C$ | $P_B$ | $P_T$ |
|---|---|---|---|---|
| 2002 | 0,03389 | 0,10963 | 0,00118 | 0,72757 |
| 2016 | 0,10473 | 0,23019 | 0,00364 | 0,89042 |

**Table 12**

To be able to represent it on the same graph, I transformed the data:

| Productivity/Year | $P_V$*10 | $P_C$*10 | $P_B$*1000 | $P_T$ |
|---|---|---|---|---|
| 2002 | 0,3389 | 1,0963 | 1,18 | 0,72757 |
| 2016 | 1,0473 | 2,3019 | 3,64 | 0,89042 |

**Table 13**

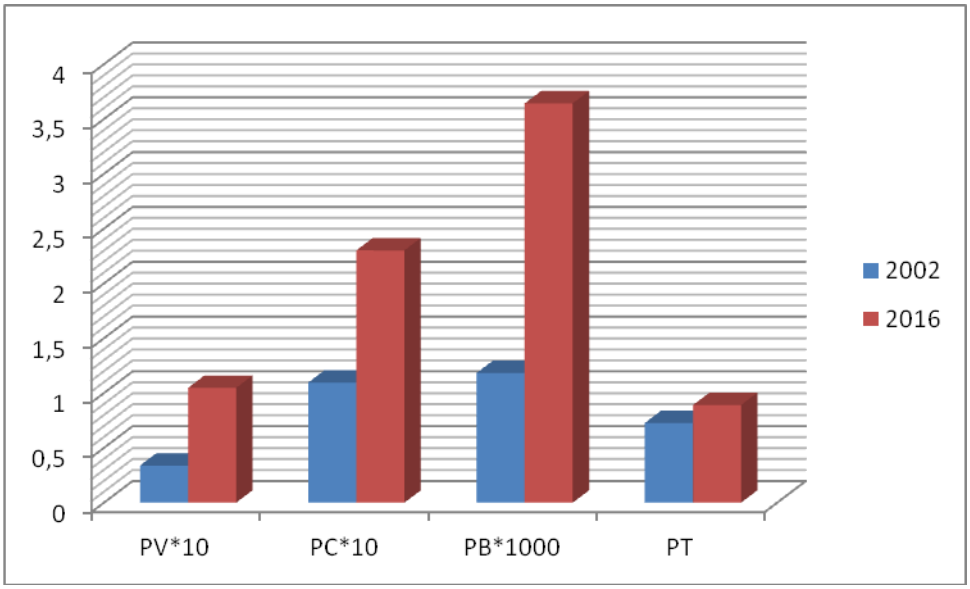


Fig. 2

7.2.3.3. Multi factor productivity rate comparison

| Productivity rate | $PR_V$ | $PR_C$ | $PR_B$ | $PR_T$ |
|---|---|---|---|---|
| 2002 | 0,12102 | 0,10963 | 0,12112 | 0,10105 |
| 2016 | 0,24019 | 0,23019 | 0,25296 | 0,2226 |

**Table 14**

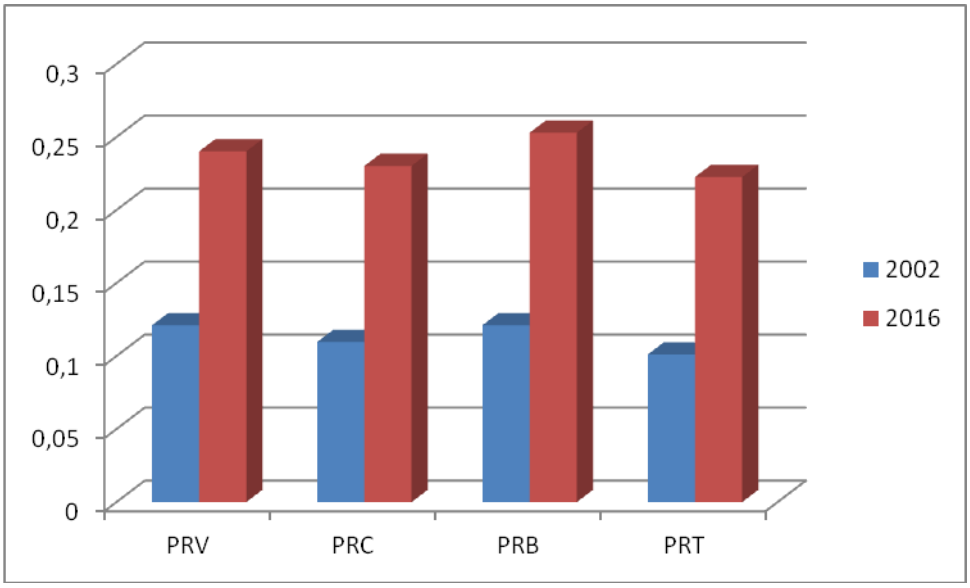


Fig. 3

7.2.3.4. Composite productivity comparison

| Productivity rate | $PR_V$ | $PR_C$ | $PR_B$ | $PR_T$ |
|---|---|---|---|---|
| 2002 | 0,12102 | 0,10963 | 0,12112 | 0,10105 |
| 2016 | 0,24019 | 0,23019 | 0,25296 | 0,2226 |
| Importance coefficient | 0,1 | 0,5 | 0,2 | 0,2 |

**Table 15**

| Composite productivity | P |
|---|---|
| 2002 | 0,11135 |
| 2016 | 0,23423 |

**Table 16**

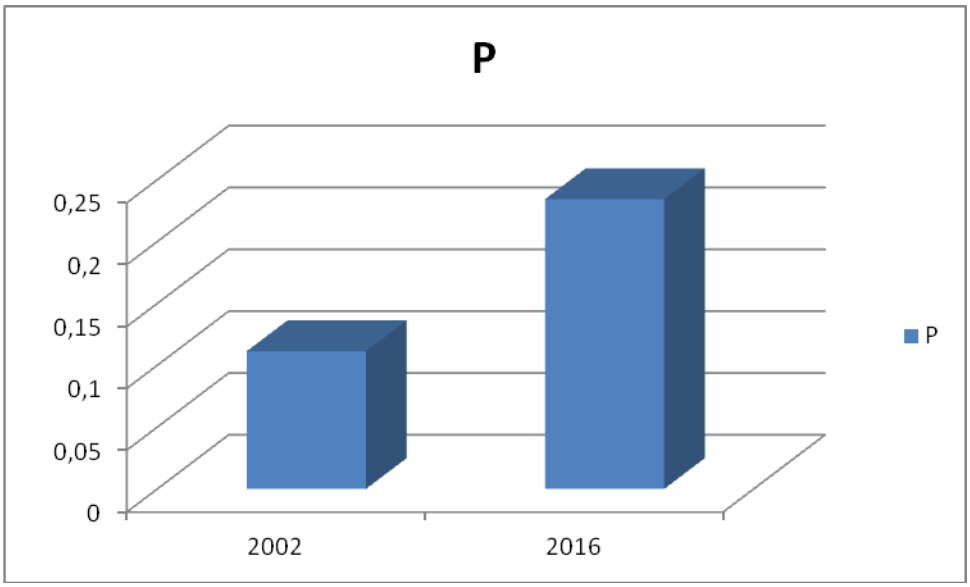


Fig. 4

**7.3. Benefits. Results.**

Labour visible productivity (PLV)

It grew almost three times since 2002. The reasons are the personnel reduction on one hand and on the other hand, the massive computers utilization.

7.3.1. Capital visible productivity (PCV)

There are no big difference here, but a slightly increase over time exists. The output rising is paid by the costs.

7.3.2. Visible productivity ($P_V$)

In 2016 productivity is more than three times higher then in 2002, as a combined action of labor and capital inputs.

7.3.3. Labour consequence productivity (PLC)

Again, here we have an augmentation over time, near two times. It seems that fewer people do a better job, but what can't be seen is that now are functioning a number of modern radars. As was predicted, improving the technologies will raise the productivity.

7.3.4. Capital consequence productivity (PCC)

This time, the productivity in 2016 is smaller than in 2002. Even we have better results in 2016, these outcomes comes with a charge.

7.3.5. Consequence productivity ($P_C$)

Although capital consequence productivity in 2002 is bigger than in 2016, due to the contribution of the labor productivity, the consequence productivity in 2016 is approximately two times higher.

7.3.6. Labour benefit productivity (PLB)

Employees salaries got up more than three times since 2002, in average, but this doesn't reflect reality. A large number of employees in 2002 were in fact executing a compulsory military service and their wages were very low.

7.3.7. Capital benefit productivity (PCB)

Again here is no significant difference. In 2002 almost a half of the military budget went on employee salaries, in 2016 a little less.

7.3.8. Benefit productivity ($P_B$)

The 2016 productivity is about two times higher than 2002 productivity and this reflect a better employee quality and a better living standard for personnel.

7.3.9. Labor test productivity (PLT)

The difference between 2002 and 2016 is not significant, but a personnel quality improvement is noticeable.

7.3.10. Capital test productivity (PCT)

Here is a decrease in productivity, in 2016 is less than a half of 2002. The test results are better, but again with a high price.

7.3.11. Test productivity ($P_T$)

The overall test productivity is better in 2016, under a combined influence of personnel and capital.

7.3.12. Productivity rate (PR)

All productivity rate, visible, consequence, benefit and test have almost the same growth, 100%.

7.3.13. Composite productivity (P)

As a logically result, having all the terms of a weighted average two times higher in 2016 than in 2004, the composite productivity is 100% bigger.

7.3.14. Benefits

Calculating productivity and analyzing the results can optimize the labor and the costs in order to get maximum output.

## 8. Conclusions

Measuring productivity and increasing it is a must-use top management tool and should be an important part in the strategic vision of the military system.

This paper is by far not exhaustive, it is just an introductive one, it emphasizes the huge potential of increasing the productivity in the military sector, and suggests a way to accomplish it. Further, in depth analyses, using the unanimous accepted language, the math, it will uncover more detailed and concrete ways of measuring and raising the productivity and implicitly we will assure the accomplishment of established goals.

Continually monitoring productivity and its components provides rapid feedback to see if you are on the right track and/or offers guidance to improve or correct the activities and processes in order to reach as soon as possible the assumed level of ambition.

## References:

[1] Paul Krugman, *The Age of Diminishing Expectations*, 1994

[2] OECD Manual, Mesuring productivity, 2001, https://www.oecd.org/std/ productivity-stats/2352458.pdf

[3]http://www.investopedia.com/ask/answers/040615/why-productivity-important-concept-economics.asp

[4]https://www.smartsheet.com/blog/how-calculate-productivity-all-levels-organization-employee-and-software

[5] https://www.merriam-webster.com/dictionary/productivity

[6] https://hbr.org/1988/01/no-nonsense-guide-to-measuring-productivity

[7] Paul Schreyer, *Measuring Productivity*, Conference on next steps for the Japanese SNA Tokyo, 25 March 2005;

[8] John W. Kendrick and Beatrice N. Vaccara - *New Developments in Productivity Measurement*, University of Chicago Press, 1980;

[9] Nicholas Crafts - What creates multi-factor productivity ?, University of Warwick, 2008;

[10] David T. Owyong, *Productivity Growth: Theory and Measurement*, http://www.apo-tokyo.org/productivity/016_prod.pdf

[11] Jennifer Kavanagh, *Determinants of Productivity for Military Personnel*, RAND Corporation, www.rand.org., 2005.