Economic Aspects of the Military Robotics Introduction and Development in the War Theatre

ALEŠ OLEJNÍČEK
Department of Economics
University of Defence
Kounicova 156/65, 662 10 Brno
CZECH REPUBLIC
ales.olejnicek@unob.cz

Abstract: This essay concerns with the problem of the economic aspects of the military robotics. The main aim of the essay is description and explanation of increasing importance of the military robots introduction into military operations with an accent on the economic side this phenomenon. The essay topic has connection with capital-labour substitution, barriers of introduction and next development of military robotics and limits of development military robots market and industry. This essay has primarily methodological and introductory purpose and character.

Key-Words: Military robotics, military robots, influence principle of military robotics development, capital-labour substitution, military robotics industry

1 Introduction

The **military robotics** surprisingly does not fall into „Science Fiction“ or future category. There are people that are aware of military usage of robots today. During last decade we are witnesses of the steep surge of the **military robots** on the battlefield. Thousands are deployed in Iraq and Afghanistan, supporting troops on land, at sea, and in the air [1].

The question is why we are witnesses of the massive military robotics usage only during the last decade. Which factors determine this development? Is this development the common trend across all armies or only in some ones?

2 Principles Influencing Development of Military Robotics Area

The economic theory can be very useful for understanding of development and nowadays state of military robotics. The economic theory shows that economic dimension have played appreciable part in the key military issues. The decision-making process under military conditions was often influenced by some fundamental economic principles. The shape of final decision in military affairs was determined by the effect intensity of these principles. These principles include: a) principle of the marginal opportunity costs, b) principle of expected marginal costs and benefits, c) principle of substitution, d) principle of economies of scale, e) principle of diminishing returns, f) principle of the incentives role and g) principle of the customer and supplier relationship [2].

The evaluation of the influence rate of the principles mentioned above enables us to understand and explain the radical changes in the military robotics area.

It is possible to assume that the most influential on **military robots introduction** in the theatre from the principles above are: principle of the **marginal opportunity costs**, principle of the **economies of scale** and principle of the **capital-labour substitution**.

2.1 Marginal Opportunity Costs Principle

This principle can be linked with increasing costs of the professional soldier training and with the possible loss of this soldier in a combat. The army loses trained productive power and society loses citizen that can play the role of the labour force, parent or voter.

For that reason, we can think about growing pressure on research, development and introduction of the military robots into armed forces. The higher marginal opportunity cost will be the higher pressure on the military robotics we can expect.

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2.2 Economies of scale principle

Generally the economies of scale are linked with decreasing of unit costs due to production increasing. This surge of the production is reached by force of the business operation efficiency. We can see the economies of scale in connection with military robotics development in decreasing indirect costs (i.e. fuel, spare parts, and services) by way of the growth in quantity of consumed commodities.

2.3 Capital-labour substitution principle

It is supposable, that this principle will be the most powerful in connection with military robotics widening. We can speak in this context that military manpower can be to some extent substituted by capital. In this case, the soldiers can be superseded by military robots. Substitution of capital for labour is encouraged by two fundamental rational motives. The first is **protection incentive**; the second is **increasing productivity incentive**.

The **protection incentive**, which is fulfilled by replacement of soldier performance by technology (in our case by military robots), makes protection of the specialized military manpower from death, health loss, or decreasing possibility of their injuries possible. A consequence of this substitution can be two phenomenons, on the one hand it is diminishing of labour requirements and consequently personnel saving, on the other hand it is transfer of manpower to other area of the line of duty. In to reverse, **soldier equipping by capital leads to increase of its productivity**. This type of substitution between capital and labour decreases the dependence of armed forces on the labour market or on the demography population development, possibly on development its pacifistic moods. Replacement labour by capital and simultaneous surge in overall value of the capital on labour unit is described as **capital deepening.** Capital deepening of armed forces strengthens its technology level.

A contemporary military robots introduction into equipment of armed forces is led by both mentioned incentives. All three showed principles of the stronger influence will dynamize the development of military robotics.

3 Microeconomic analysis of substitution between labour and capital – case of military robotics

If we want to describe problem of capital-labour substitution with connection military robots theatre introduction, we can use tools of microeconomic analysis. Firstly we have to describe military production function by two-factor model. The general two-factor production function may be given algebraically as

$$Q = f(K, L) \tag{1}$$

where Q = amount of output produce, K = amount of capital input, and L = amount of labour input.

The production function expressed by equation above is described in Fig. 1. Each of described curves in the figure is an isoquant. These isoquants represents the various combinations of the two inputs (in our case labour of military professionals and capital in form of military robots) capable of producing the given output. The slope of the isoquant measures the rate at which capital and labour can be substituted reciprocally.

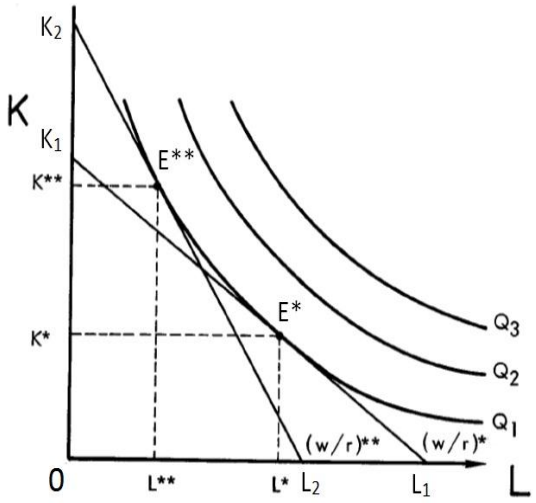

Figure1: Production function of the defence – two-factor model

The production function, by itself, described on Figure 1 does not provide guideline for optimal allocation two inputs – capital and labour. The instruction for the optimal allocation of resources we gain if we put this function into a cost framework.

For a given budget constraint, the optimal allocation is the combination of capital (military robots) and labour (military professionals) that maximizes output (in our case output is "Defence").

In the two-input model the total costs of using any combination of inputs can be written as

$$TC = rK + wL \tag{2}$$

where TC = total costs, w = unit cost of labour, r = unit cost of capital services (military robots).

For given budget constraint and given prices (costs) of capital and labour on the relevant markets, the armed forces can afford to hire a labour at value $0L_1$, $0L_2$, or can buy a capital at value $0K_1$,$0K_2$. Because soldiers have to have some equipment and weapons and we are not able fully replace soldiers by military robots, armed forces are on its budget line at the value E*, E**. In connection to this point, it can afford the labour at value 0L*, 0L**, which is equipped by capital at value 0K*, 0K**. The slope of the isocosts is given by mutual price rate of each separate inputs (w/r)*, (w/r)**. Figure 1 shows the change when capital costs are decreasing, optimal relation between capital and labour is changing and (K*/L*) is moving toward (K**/L**). The optimum capital-labour ratio increases. Described event is case of capital for labour substitution [3].

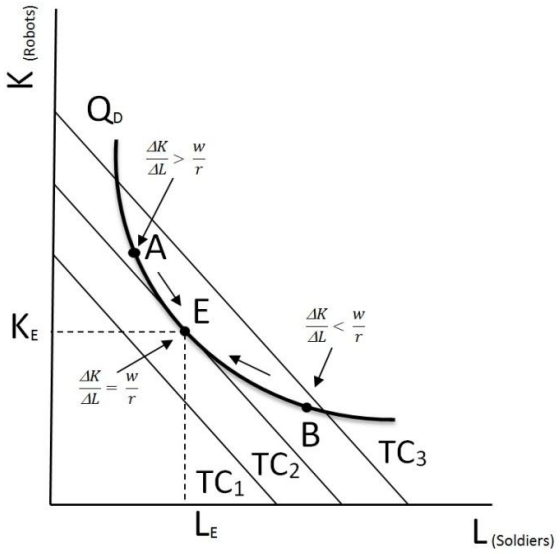

Figure 2: Optimal production of defense and costs minimization

The Figure 2 describe situation when we try to minimalize costs of defense production by finding the optimal ratio between capital (military robots) and labour (military professionals). This situation is nearly able to describe the behaviour national states across Europe.

On the Figure 2 point B describe situation, when marginal rate of technical substitution military robots (capital) for military professionals (labour) is lower than ratio between costs of labour and costs of military robots usage. **In this case it is more suitable replace labour by capital.** The situation in point A is inverse. So there is more suitable to replace capital by labour. Optimal ratio between military robots and military professionals is at the point E.

Now is required to judge an impact of the change in relative prices of the inputs on the optimal production level (see Figure 3).

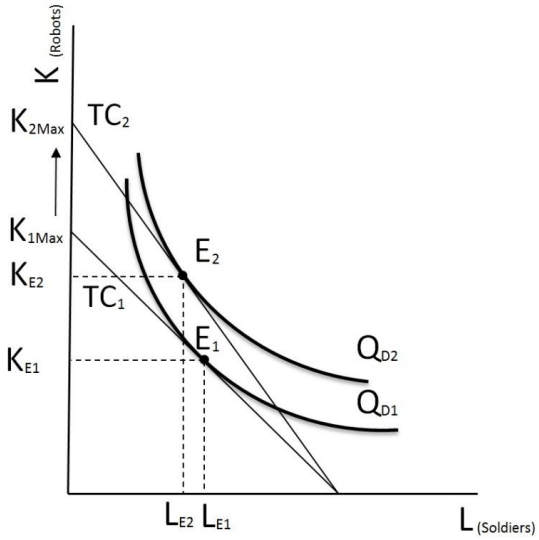

Figure 3: Decreasing price of capital (military robots)

In the case of price decreasing of some inputs, we can expect increasing of its usage for two reasons: firstly these inputs are cheaper than other inputs, so it is possible other inputs to substitute by this cheaper input. This phenomenon we name as **substitution effect**. Secondly, input price reduction decreases costs and enables the growth of production (in our case "defense"). It means that we can joint more inputs. This phenomenon we name as production effect (see Figure 4). **Reduction of military robots price will probably lead to its massive usage in armed forces** [4].

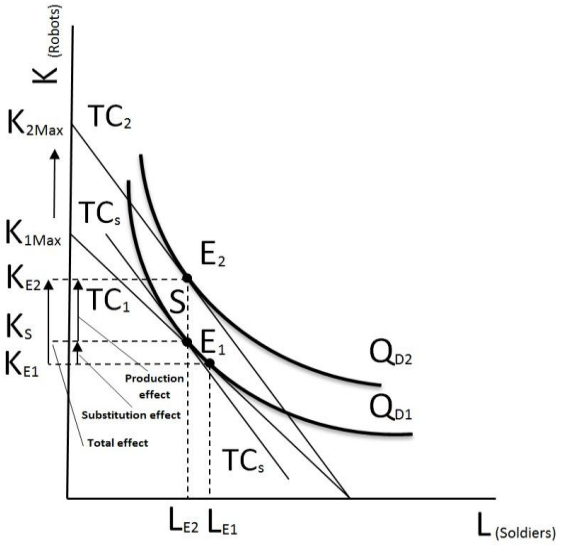

Figure 4: Lessening price effect on the capital growth and decomposition overall effect on substitution and production effect

Thanks to simplified microeconomic analysis is visible, that whole range of factors impact on introduction and development of the military robotics under defence condition. These factors influence in the given concrete state under its economy framework. We can assume that variety military robotic usage will differ from country to country due to above mentioned factors. From microeconomic point of view is evident, that military robotics and its development is dependent on following factors: a) **price of capital (military robots)**, b) **marginal rate of technical substitution of inputs** MTRS (Marginal Rate of Technical substitution), c) **capital-labour price ratio** (w/r).

From theoretical point of view, future surge of military robots can be caused by decline its price, abilities of military robots reduce requirements of the live human power and favourable development of the military robots and military professionals price ratio.

4 Economic aspect of military robots introduction in practice

Over 40 countries have military-robotics programs today. The U.S. and much of the rest of the world is betting big on the role of aerial drones: Even Hezbollah, the Iranian-backed Shiite guerrilla force in Lebanon, flew four Iranian-made drones against Israel during the 2006 Lebanon War. The age when unmanned robots will replace soldiers on the battlefield is not really far off.

Try to find relationship between the theoretical preconditions of military robotic development and present situation and prospective development in this area. In connection with research of introduction and future development of military robotics is required to find answer on following two questions. **The first question:** Is technology (military robots) ready for fully usage in the armed forces from the technical point of view? This question is connected with the problem of the **military robots autonomy and reliability.** The autonomy of military robots is crucial for the substitution of capital for labour; this ability limits real replacement soldiers by military robots in the battle field. The autonomy of military robots includes two levels – the decision level autonomy and the energy level autonomy. **The second question:** Is technology (military robots) acceptable for producers, armed forces, departments of defense and national governments from an economic point of view? There are some problems: firstly problem of economies of scale, secondly problem of unit price level of military robots, thirdly problem of relationship between military robots unit costs and costs of soldier military training.

4.1 Economic aspects of military robotics theatre introduction on the side of the industry

Future of **military robotics market** and **industry** is dependent on next preconditions: a) successful military tests of developed military robots; b) requirements to reach a competition advantage or competition threats; c) ability in short time to reach economies of scale, d) solvency of future potential customers (mainly national government).

Tangible evidence of the ability of military robotics industry to perform reliable military robots is its explosion in Iraq and Afghan war theatre. When U.S. force went into Iraq, the original invasion had zero military robots on the ground. By the end of 2004, the number was up to 150. By the end of 2005, it was up to 2400. By end of 2006, it had reached the 5000 mark [5]. Under statement of **The International Federation of Robotics** (IFR) issued in 2009 it was predicted that at about 42 000 military robots will be in operation [6]. The rapid growth of the military robotics markets has announced **the Winter Green Research 2010 study**. This study predicted that military robotics markets at $831 million in 2009 are anticipated to reach $9.7 billion by 2016 and military ground robot markets at $3.4 billion in 2011 are anticipated to reach $12.3 billion by 2018 [7], [8]. The U.S. government has declared the preparedness to fund the military robotics research in 2009 and 2011. **The 2011-2015 President's budget** for unmanned systems reaches overall value $32,705 billion [9]. **The previous 2009-2013 President´s budget** for unmanned systems was planned to reach overall value $18,900 billion. The surge of spending is evident [10].

4.2 Economic Aspects of Military Robotics Theatre Introduction on the Side of the Armed Forces and Government

Main reasons for military robots introduction to the theatre are following: a) protection of human (soldier) life; b) higher level of efficiency and effectiveness of robotic systems; c) armed forces attractiveness increasing with connection on the recruitment goals; d) modernization of armed forces [11].

The public opposition to the war losses is

growing recently but this phenomenon is not new. Society is not willing to bear the costs of "**the black bag**" effect. We can compare the price of military robots production and development with price of human life. Value of human life varies between $2 and $11 million. The price of military robots varies between $10 000 (IROBOT 110 FIRSTLOOK) and $104 000 000 (RQ-4 GLOBAL HAWK). The comparison is not simple and results are not unambiguous. On the basis of military robotics systems price range we shall predict the heavy expenses in connection of armed forces modernization. The rapid acquisition modernisation strategy, particularly for military robots, can lead to an oversupply of systems accomplishing similar tasks but without the inter-system compatibility. While this strategy encouraged market competition, it also **created training and support challenges** (costs problems).

5 Economic aspect of military robotics development

In connection of further development of the military robotics, it is crucial to recognize the factors which strongly influence this development. The knowledge of these factors enables us to make optimal predictions about this phenomenon.

We may conclude from literature research evidence, that further military robotics development and progress is influenced by following agents and factors [12].

5.1 The main agents influencing military robotics development

The **main agents** are: a) Governments (the size of military expenditure); b) Military (the strategy of real capabilities of military robots utilization); c) Military robotics industry (the ability to develop applicable technology).

5.2 The main factors influencing military robotics development

The **main factors** are: a) value of human life; b) costs of military professionals training; c) future development and achievable size of the military robotics market; d) state and future development of public finance and budgets.

6 Conclusion

Appeal for military organizations is fact that robotic devices are able to change the essence of armed combat. **Decreasing of military budgets is worldwide spread trend.** This direction is from human point of view acceptable; however it is very danger from military point of view. This direction decreases the ability to react on unforeseeable events.

The attention is devoted to human as living being, as a part society which does not accept the losses including the members of armed forces. These trends are visible and cause qualitative changes in the armed forces, resulting in modernization, professionalization and reorganization. The main result should be required ability of prompt reaction on an invisible risk and danger.

New technologies, unfortunately, **are very expensive.** For that reason, the usage and introduction new technologies in the armed forces have to be **cost-effective**.

In connection to military robotics, it is visible that we will able to take advantage of **capital-labour substitution** in the foreseeable future. The mass production of military robotic enables military robots producers to take advantage of economies of scale and to decrease unit price of military robotics systems. Higher autonomy of the military robots will develop the substitution of labour by military robots. And consequently, **capital deepening will lend to support increasing technological forwardness** of the armed forces.

For next advancement in military robotics economics area it could be beneficial to **create the theoretical model which enables us to understand and to predict future development of military robots usage**.

As the **basic variable** usable in this model we can consider following: a) factors increasing **usefulness of military robots** for armed forces; b) factors influencing **evaluation of human life value**; c) factors which shape **governments willingness to pay money for military purpose**; d) factors which shape a **stability and development of military robotics market**; e) factors influencing **formation, size and competitiveness of firms** that produce military robots (military robotics industry).

Investigation of these factors, searching their interrelationship, judging their importance and their usage in the model **will flow into better receptiveness** of military robotics development.

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