DEFENCE RESOURCES

ECONOMICS OF MILITARY ROBOTICS

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Contents

LEARNING OUTPUTS

Students will know:

- basic concepts from military robotics economics area
- basic and economic classification of military robots

Students will be able to:

- demarcate the basic economic principles usefulness within economic analysis of military robots war theatre usage,
- explain the microeconomic analysis of substitution between capital and labour under condition armed forces.

Students will capable of:

- discussion factors and agents influencing future development and introducing military robots into armed forces.

THE ECONOMICS OF MILITARY ROBOTICS

KEY TERMS

Military robots, military robotics, economics of military robotics, Capital-labour substitution, military robots history, military robots typology, benefits and costs of military robots.

INTRODUCTION

Military robotics is revolutionizing warfare today through the use of advanced technologies that help the military on the battlefield and create a better, more flexible and cost efficient military. Military Robotics can be used to help in the diffusing of bombs for example, or unmanned aerial vehicles can provide a "birds-eye-view" of territories for military troops.

In the future, military robotics will include such things as medical robots to help carry wounded soldiers off the battlefield and will be used as prosthetics for injured troops who have had limbs amputated. Recent research from WinterGreen Research predicts the market for military robotics will hit $9.7 billion by 2016. The robotics units used in public spaces and on the battlefield.

1 BASIC CONCEPTS

Robots, robotics, military robotics, military robots, military robots history, military robots typology, expenditure on military robots research and development, military robots market, military robots market share, future of military robots market, economics aspects, price of military robots, pros and cons of military robots theatre introduction, RMA and military robotics

2 HISTORY OF MILITARY ROBOTICS

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. For the last few decades, robots are becoming very popular and common in military organizations. There are many military robots used by military organizations for taking many risky jobs that cannot be done by human. And Andrew Elwell in his articles informs that "UAE firm opens biggest manufacturing space in the world". [1]

Over 40 countries have military-robotics programs today.[2] 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.[3] The age when unmanned robots will replace soldiers on the battlefield is not far off.

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. When the U.S. invaded Iraq in 2003, it had just a handful of drones. Today, U.S. forces have around 7,000 unmanned vehicles in the air and an additional 12,000 on the ground.

2.1 From ancient Greece to the age of "Star wars"

The ancient roots of robotics are connected with the brilliant Greek mathematician, Archytas of Tarentum. He built a mechanical bird dubbed "the Pigeon" that is propelled by steam. It serves as one of history's earliest studies of flight, not to mention probably the first model airplane.

But as the first attempt to create military robots we could consider the invention of Leonardo DaVinci. Leonardo DaVinci designs a **mechanical device that looks like an armoured knight.** The mechanisms inside "Leonardo's robot" are designed to make the knight move as if there was a real person inside. Inventors in medieval times often built machines like "Leonardo's robot" to amuse royalty.

Austria sent about 200 **pilotless balloons** to help quell the Venetian rebellion in 1849. The balloons were reportedly loaded with bombs armed by timed fuses.

Everything started at the end of the 19th century, precisely in 1898. That year the famous inventor **Nicola Tesla** demonstrated one of his inventions. This invention was a radio controlled boat intended for military use (see Figure XX).

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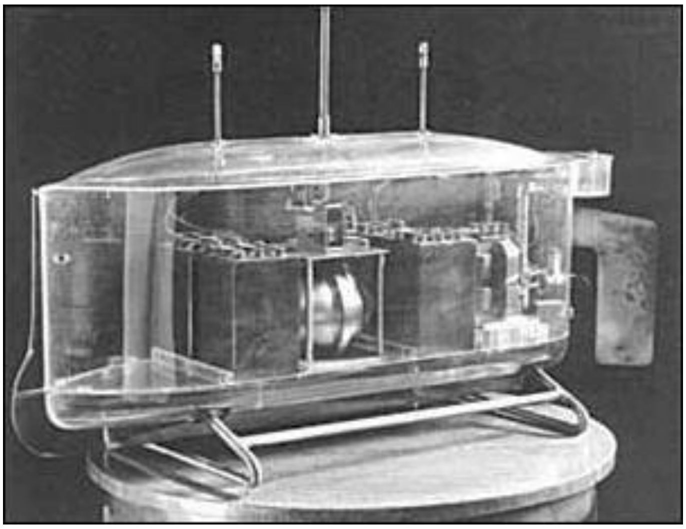
[1] Very famous and „luminary" of military robotics thoughts P. W. Singer stated that „I robot" firm have made for robotics the same good what Microsoft for computers.

[2] Around the world combat robots that mimic a wide range of organisms including humans, dogs, scorpions, centipedes, lizards, fish and even grasshoppers are being developed. China, France, Japan, Switzerland, the U.K. and the U.S. are developing robots that resemble fish which can function as unmanned submarines. The Massachusetts Institute of Technology already tested the "Robotuna," while research is under way for China's "Dongle," France's "Jessiko," Japan's "Robotic Koi" and Switzerland's "Boxybot." Research is also under way for snake-like amphibious robots.

[3] LEVISON, Charles., Israeli Robots Remake Battlefield. Accesible on: http://online.wsj.com/article/SB126325146524725387.html

Figure 1 Radio controlled boat by Nicola Tesla



Sources: TURI, Jon. Tesla's toy boat: A drone before its time. Accessible on: http://www.engadget.com/2014/01/19/nikola-teslas-remote-control-boat/; http://www.kerryr.net/pioneers/gallery/ns_tesla16.htm

Mr. Tesla offered his invention to US navy in order to produce radio controlled torpedoes. When the navy refused, he offered his invention to the United Kingdom. However, it seems that his invention was just too much to handle for people of that time.
Mechanization and mass production made possible early automatic weapons in the nineteenth century. Military experimentation with machines that were also mobile and unmanned **began during World War I**—including even radio-controlled airplanes, the very first unmanned aerial vehicles (UAVs). [4]

When the war devolved into a trench-warfare stalemate, **remote-controlled vehicles gained appeal as a means to break the deadlock**: Land-based devices included **the electric dog**, a three-wheeled supply cart designed to follow the lamp of its controller; more deadly was the **land torpedo**, an **armoured tractor** meant to trundle 1,000 pounds of explosives into enemy trenches. In the air the first of what we now call cruise missiles was **the Kettering Bug**, a tiny airplane that used a barometer/altimeter, a mechanical counter and a pre-set gyroscope to fly on course and then crash into a target. The war ended before it could be used in combat.
The **only system operationally deployed during World War I** was Germany's FL-7 wire-guided motorboat. Designed to be rammed into enemy ships, it carried 300 pounds of explosives. FL-7 drivers initially sat ashore atop 50-foot towers, later aboard seaplanes. Both methods proved unwieldy, however, so in 1916 the Germans put Tesla's wireless radio-control system into service. In October 1917, off the coast of German-occupied Belgium, an

[4] **World War I British flyer Reginald Denny** became a postwar stunt pilot and then moved to Hollywood to work as an actor. Denny appeared in more than 100 movies, and while horsing around on various film sets, he became a hobbyist of radio-controlled model airplanes. In 1934 he opened the Reginald Denny Hobby Shops on Hollywood Boulevard. As World War II loomed, Denny thought his radio-controlled planes would make perfect target drones for anti-aircraft gunners. In the late 1930s he pitched the U.S. Army on his RP-4 Radioplane, the "Dennymite," powered by a 6-hp engine with a 12-foot, 3-inch wingspan. In 1940 the Army ordered 53 of the RP-4, redesignating it the OQ-1. A few months later the attack on Pearl Harbor and America's entry into the war created an urgent need for anti-aircraft gunners—and target drones. During the war the U.S. military bought nearly 15,000 Dennymites**, making the type the first mass-produced unmanned plane in history**.

FL-7 struck and damaged HMS *Erebus*, a British monitor that had been bombarding German naval bases at Ostend and Zeebrugge.[5]

The next prominent step in this field was achieved in 1930-ties in the Soviet Union. The soviets made **a remotely controlled tank** so called - **teletank** (телетанк). The tank's control system was modified and pneumatics, electric relays and radio signals were used to control the tank.

Figure 2 Teletank

Sources: SOFGE, Erik. Tale of The Teletank: The Brief Rise and Long Fall of Russia's Military Robots. Accessible on: http://www.popsci.com/blog-network/zero-moment/tale-teletank-brief-rise-and-long-fall-russia%E2%80%99s-military-robots

The teletank could be controlled from 500-1500m away depending on weather and other conditions. The idea was following - two tanks formed a combat pair. One tank, codenamed TT, was a radio controlled tank the other was a command centre codenamed ТУ.

The crew was located at the ТУ and could remotely control the TT. The teletanks were equipped with DT machine guns, flamethrowers and smoke canisters to provide a smokescreen. An armoured bomb that could be dropped to destroy enemy fortifications could be attached too.

The T-18, T-26, T-27 and TT-БТ-7 were developed as teletanks. Only T-26 teletank was used in combat in Winter War though.

World War II saw the operational use of several unmanned weapons by both the Allied and Axis forces, including remote-controlled bombs; it was also a period of rapid advancement in analog and electronic computing.

Germany again proved more inclined than its enemies to develop and use unmanned systems. The vehicle that saw most use was the **Goliath tracked mine** (see Figure XX), which carried 100 pounds of explosives. Designed to be steered into enemy tanks and bunkers, it was about the size of a small go-cart, powered at first by electric motors and later by 12.5-hp gasoline engines. The Germans built some 7,000 Goliaths, using them on the Eastern Front, at Normandy and during the Warsaw Uprising. Its effectiveness was limited, however, by its low speed, poor ground clearance and vulnerability to small-arms fire.

[5] Accessible on: http://www.historynet.com/drones-dont-die-a-history-of-military-robotics.htm

Figure 3 Goliath tracked mine

Sources: GUTTMAN, Jon. Goliath Tracked Mine: The Beetle That Started the ROV Craze Accesible on: http://www.historynet.com/goliath-tracked-mine-the-beetle-that-started-the-rov-craze.htm#sthash.ESGocM0F.dpuf

The Germans were equally **revolutionary in the air,** deploying the first workable cruise missile (the V-1) and ballistic missile (V-2). **They were also the first to deploy remotely piloted**— as opposed to preprogrammed —**aerial drones**. **The FX 1400 "Fritz"** was a 3,000-pound (1,400-kg) glide bomb with a 700-pound warhead, four small wings, controllable tail surfaces and a rocket motor. The Germans would drop the device at high altitude from a Dornier Do 217 bomber. A bombardier would then steer the Fritz via radio link using a joystick. [6] Germany built about 2,000 of these remote-controlled bombs, though by that stage of the war Allied air superiority generally negated the threat.

In 1944 the United States' focus on **aerial weapons** led the U.S. Army Air Forces and U.S. Navy to launch **Operations Aphrodite and Anvil**, respectively. The idea was to strip heavy bombers of all unnecessary equipment, then pack them with 10 tons of Torpex, an explosive more powerful than TNT. A crew would get the plane in the air, arm the explosives and then bail out. A nearby mother ship would then take radio remote control and, using television cameras mounted in the drone's cockpit, steers the plane into targets too well protected for manned bombers to risk approaching.[7]

Military interest in robotics was spotty during the Cold War; with inventors repeatedly finding that what was technically possible mattered less than what was bureaucratically

[6] In September 1943 a fleet of Fritz-carrying Do 217s attacked an Italian naval fleet defecting to the Allies near Sardinia. One bomb damaged the battleship Italia. Two others hit the battleship Roma, which broke in two and sank in minutes, taking more than 1,200 crewmen to their deaths.

[7] On Aug. 12, 1944, the Navy sent a converted B-24 Liberator from England to take out a suspected German supergun in northern France that supposedly could hit London, more than 100 miles away. But the volatile Torpex detonated prematurely, vaporizing the Liberator and killing its crew, pilot Lieutenant Wilford J. Willy and co-pilot Lieutenant Joseph P. Kennedy Jr. Kennedy's younger brother, John, would inherit the family's hopes, while the Army and Navy terminated the operations.

feasible. Robotic systems were getting better, but the interest, energy, and proven success stories necessary for them to take off just weren't there.

The **only substantial contract during this long dry spell** was one that the **Ryan aeronautical firm** received in 1962 for **$1.1 million** to make an unmanned reconnaissance aircraft. The drone that came out of it, the Fire Fly, flew 3,435 missions in Southeast Asia. Overall, though, the Vietnam experience was as bad for robotics as it was for the broader U.S. military.

Most of the uses of unmanned systems were classified and thus there was little public knowledge of their relative successes, as well as no field tests or data collection to solve the problems they incurred (16 percent of the Fire Flys crashed). As veteran robotics scientist Robert Finkelstein has pointed out, "It took decades for UAVs to recover from Vietnam misperceptions."

The next big U.S. military spending on unmanned planes didn't come until 1979, with the Army's Aquila program. The Aquila was to be a small propeller-powered drone that could circle over the front lines and send back information on the enemy's numbers and intentions. Soon, though, the Army began to load up the plane with all sorts of new requirements. It now had to carry night vision and laser designators, spot artillery fire, survive against enemy ground fire, and so on. Each new requirement came at a cost. The more you loaded up the drone, the bigger it had to be, meaning it was both heavier than planned and an easier target to shoot down. The more secure you wanted the communications, the lower the quality of the images it beamed back. The program originally planned to spend $560 million for 780 Aquila drones. By 1987, it had spent over $1 billion for just a few prototypes. **The program was cancelled** and the cause of unmanned vehicles was set further back, again more by policy decisions than the technology itself.

Work continued, but mainly on testing various drones and ground vehicles, which were usually regular vehicles jury-rigged with remote controls. During this period, most of the ground systems were designed to be tele-operated—that is, using long fiber-optic wires to link the robot to the controller. Any enemy with a pair of scissors could take them out. One of the few to be built from the ground up to drive on its own was Martin Marietta's eight-wheeled "Autonomous Land Vehicle." Unfortunately, the weapon had a major image problem: It was shaped like an RV, what retirees would use to drive cross-country to see the Grand Canyon. This killed any chance of convincing the generals of its use for warfighting.
Another significant **program that didn't take off in this period** was a 1980 Army plan for a **robotic antitank vehicle.** The idea was to take a commercial all-terrain vehicle, rig it for remote control, and load it with missiles. Congress thought that ATVs, while certainly fun for country kids to ride around behind trailer parks, were a bit too small to be taking on Soviet tanks. So the program was cancelled. But the military mistakenly came to believe that Congress's real objection was to the weaponization of unmanned systems. "So," as Finkelstein says, "misinterpretation kept weapons off for almost a decade."

Despite these setbacks, the American military robotics community didn't waver in its belief in the usefulness of its work. **It could point to other nations beginning to successfully deploy unmanned systems,** like **Israel's successful experience with drones** in the 1980s.

2.2 New era of Military Robotics

By the time of the 1991 Persian Gulf War, unmanned systems were gradually making their way into the U.S. military, but in very small numbers. The Army had a handful of **M-60 tanks converted into unmanned land-mine clearers,** but they were left behind in the famous "left-hook" invasion force that drove across the desert into Iraq.

The Air Force flew just one UAV drone. The only notable success story was the Navy's use of the Pioneer drone, an unmanned plane (almost exactly like the planned Aquila) that the Navy had bought secondhand from the Israelis. It flew off of World War II-era U.S. battleships that had been taken out of mothballs in the 1980s and updated for use in pounding ground targets with their massive sixteen-inch guns. The guns fired shells that weighed 2,000 pounds and could leave a crater the size of a football field. The little drones, which the Iraqis took to calling "vultures," would fly over targets and spot where the shells were landing. "The Iraqis came to learn that when they heard the buzz of a Pioneer overhead, all heck would break loose shortly thereafter because these sixteen-inch rounds would start landing all around them," said Steve Reid, an executive at the Pioneer's maker, AAI. In one case, a group of Iraqi soldiers saw a Pioneer flying overhead and, rather than wait to be blown up, waved white bed sheets and undershirts at the drone—the first time in history that human soldiers surrendered to an unmanned system.

Of course, the real stars of the Gulf War were not unmanned systems in the way we think of them now, but new "smart bombs"—that is, cruise missiles and laser-guided bombs. A massive PR campaign was built around the guided weapons as the "heroes" of the hundred-hour war. The only problem was that they weren't. **Only 7 percent of all the bombs dropped were guided; the rest were "dumb."** The most influential technology in the Gulf War was not the sexy smart bombs, but the humble desktop computer. By 1990, the U.S. military had bought into the idea of digitizing its forces and was spending some $30 billion a year on applying computers to all its various tasks**. The Gulf War was the first war in history to involve widespread computers, used for everything from organizing the movement of hundreds of thousands of troops** to sorting through reams of satellite photos looking for targets for missiles to hit. Calling it a "technology war," the victorious commanding general, "Stormin'" Norman Schwarzkopf, said, "I couldn't have done it all without the computers."[8]

The programs also began to pass some key hurdles of acceptability. The various military services had long resisted buying any unmanned systems, but slowly they began to accept their use. In 1997, for example, the Air Force Chief of Staff, General Ronald R. Fogleman, instructed his planners that his service could "no longer...spend money the way we have

[8] Over the rest of the 1990s, as sensors and computer processors improved, unmanned systems became ever more capable. But the "magic moment," as retired Air Force Colonel Tom Erhard put it, occurred in 1995, when unmanned systems were integrated with the Global Positioning System (GPS). "That's when it really came together." Now widely accessible by devices in automobiles, the GPS is a constellation of military satellites that can provide the location, speed, and direction of a receiver, anywhere on the globe. It allowed unmanned systems (and their human operators) to automatically know where they were at any time. With GPS, as well as the advance of the video game industry (which the controllers began to mimic), the interfaces became accessible to a wider set of users. Drones began to be far more intuitive to fly, while the information they passed on to the generals and troops in the field became ever more detailed.

been," and mandated that they consider investing in new technologies such as UAVs. The military advantages of unmanned systems became increasingly clear to observers in the Pentagon. In many situations, robots have faster reaction times and better aim than human beings. They are often ideal for filling roles that people in the field call the "Three Ds": dull, dirty, or dangerous. Unlike humans, who get tired and hungry and lose concentration and effectiveness, robots can perform boring tasks with unstinting accuracy for long periods of time. (As one advertisement for an unmanned plane put it, "Can you keep your eyes open for thirty hours without blinking?") They can operate in dirty environments, such as battle zones filled with biological or chemical weapons, or under other dangerous conditions, such as in space, in rough seas, or in flights with very high gravitational pressures.

The rising interest in robots in the late 1990s coincided with changing political winds—a shrinking U.S. military as part of the post-Cold War so-called "peace dividend," and an **increasing belief that public tolerance for military risk and casualties** had dropped dramatically after the relatively costless victory in the Gulf War.

In 2000, this was the main factor that led Senator John Warner (R.-Va.), then chairman of the Armed Services Committee, to mandate in the Pentagon's budget that by 2010, **one-third of all the aircraft designed to attack behind enemy lines be unmanned**, and that **by 2015, one-third of all ground combat vehicles be driverless.** And then came September 11, 2001. The annual national defense budget since 9/11 has risen to $515 billion (an increase of 74 percent between 2002 and 2008), not counting the cost of operations in Afghanistan and Iraq. There has been a massive increase in spending on research and development and on procurement, with a particular focus on anything unmanned. "Make 'em as fast as you can" is what one robotics executive recounts being told by his Pentagon buyers after 9/11. Enthusiasm has only grown thanks to successes on the battlefield.

With this change in military mentality, money, and use, the groundwork was finally laid for a real military robotics industry. As the Washington Post put it, "The undertaking has attracted not only the country's top weapons makers but also dozens of small businesses...all pitching a science-fiction gallery of possible solutions." Robert Finkelstein recalled a time when he personally knew most of the engineers working on military robotics. Today, the Association for Unmanned Vehicle Systems International has fourteen hundred member companies. Almost four thousand people showed up at its last annual meeting.

3 TYPOLOGY OF MILITARY ROBOTICS

For **classification of military robots** we can use two criterion, the first is connected with the **type of capabilities** which each robots are able perform, the second one has connection with the **area** where military robots perform their tasks.

3.1 Military robots - Type of capabilities

Under the first typology, we can separate following types of military robots:

- Cargo Carriers
- Search and Rescue
- Mine Clearance
- Fire-fighting
- Surveillance and Reconnaissance
- Armed Robots

3.2 Military robots – Type of performance area (environment)

Unmanned Aerial Vehicle

These are flying robots. Usually used for surveillance missions. However, it seems that it's possible that there will be unmanned fighters and bombers one day as well.

Unmanned Ground Vehicles

Most of the military robots in sections above are actually UGV's. This means that they move on the ground.

Unmanned Underwater Vehicle

These are robots that can swim underwater.

UAV's, UGV's and UUV's are more like a division by the environment and should not be viewed separately of all the other chapters. Any of these can be in the same time a surveillance robot or maybe a mine clearance military robot, for example.

4 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.

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.**

FOR BETTER UNDRSTANDING PROBLEM

More deeper insight into problem of basic economic principles usage within military robotics you can reach by study following study materials:

VAN TUYLL, Hubert., BRAUER, Jurgen. Colonizing Military History: A Millennial View on the Economics of War. Accessible on: http://www.stonegardeneconomics.com/pubs/2003_vanTuyll_Brauer_DPE_v14n3.pdf

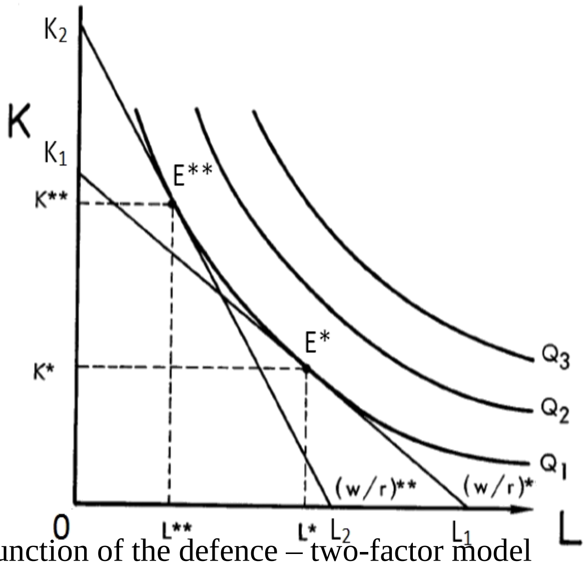
5 MICROECONOMIC ANALYSIS – SUBSTITUTION BETWEEN LABOUR AND CAPITAL

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 Figure 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.



(1)

(1)

Figure 1: 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 cost 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 0L1, 0L2, or can buy a capital at value 0K1,0K2. 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.

6 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 future development of military robotics is required to find answer on following two questions: **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. **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. **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.

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

Future of military robotics market 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).

6.2 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.

7 ECONOMIC ASPECTS 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

7.1 The Main Agents Influencing Military Robotics Development

The **main agents** influencing military robotics development are following:

1) **Governments** (the size of military expenditure); this agent is influenced by character of decision-making process (public choice). Further, decision about defence and security include three levels – military, financial and political. Under these conditions decision making process sometimes lacks the economic rationality.
2) **Military** (the strategy of real capabilities of military robots utilization); Military is not homogenous system. It consists from army, navy and air forces, each part of armed forces has own establishment. Misunderstanding and lack of communication among them could result in inappropriate strategy of military robots use within separate forces.
3) Military **robotics industry** (the ability to develop applicable technology); The degree of military robotics industry maturity is fundamental for future development of this part of defense industry [19]. We can assume its rapid growth. Bill Gates, for instance, describes robotics today as being where the computer industry was around 1980. Peter Singer noted that in 2004, the number of personal robots in the world was estimated at 2 million. By the end of 2007, a United Nations report found that there were 4,1 million robots around the world in people´s homes. By end of 2008, there was expected total number at about 11 million. The trajectory of the growth is astonishing [20]. Such development is possible to trace in military robots industry too.

7.2 The Main Factors Influencing Military Robotics Development

The **main factors** influencing military robotics development are following:

1) **Value of human life** (The higher value of human life is accepted, the quick pace of growth could be reached);
2) **Costs of military** professionals **training** (If we take an account all direct and indirect cost of military professionals training, in some cases It is possible to claim that are comparable with procurement and maintenance costs of some selected military robots);
3) **Future** development and achievable **size** of the military robotics **market** (This factor is mainly influenced by degree of competition, level of monopoly and rate of state intervention.);

4) State and **future development of public finance** and budgets (This factor is crucial at present. Indebtedness ties a capacity of action of the national governments to fulfill their mission – security, economic development and social agreement.).

A change in these agents and factors directly influences military robotics development. Fact of high importance is economic character of nearly all above mentioned agents and factors.

CONCLUSION

Appeal for military organizations is fact that robotic devices are able to change the essence of armed combat. Decreasing of military budget is worldwide spreaded 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 robotic, 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 support to decreasing technological forwardness** of armed forces.

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