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# Armenia Towards a "New Economy": Defense Industry

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**Abstract.** In fact, a new arms race could start in the world as a side effect of the so-called “4th Industrial Revolution” – the main innovative trend of which is the widespread use of technologies such as artificial intelligence, machine learning, quantum computing, additive manufacturing, robotics, Internet of things, cloud technologies etc., and the countries involved in military conflicts cannot neglect this circumstance. As a small country, Armenia needs an economy-army coalesced “intelligent” system that will respond adequately to any, even the slightest threat to the country's security. This approach requires the development of indigenous defense industry. It is obvious that the development of Armenian defense industry is in the inevitable point of intersection of the new wave of economic transformations and the breakthrough of the “4th Industrial Revolution”, as the initiator of positive changes in the economy, from which positive externalities must be spread throughout the economy by a chain reaction. The article discusses the issues of defense industry development in Armenia in accordance with new challenges of Industry 4.0.

**Key words:** Industry 4.0; defense industry; additive manufacturing; 3D printing; artificial intelligence; robotics; Internet of things; cloud technologies

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# Армения на пути к «новой экономике»: оборонная промышленность

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**Аннотация.** Побочным эффектом так называемой «4-й промышленной революции», основной инновационной тенденцией которой является широкое применение таких технологий, как искусственный интеллект, машинное обучение, квантовые вычисления, аддитивное производство, робототехника, интернет вещей, облачные технологии и т.д., может стать по сути новая гонка вооружений, и страны, вовлеченные в военные конфликты, не могут пренебрегать этим обстоятельством. Как небольшая страна, вовлечённая в локальный конфликт, Армении нужна такая синергетическая (с взаимоусиляющими компонентами) «интеллектуальная» система «армия-экономика», которая сможет адекватно реагировать на любую угрозу безопасности страны. Очевидно, что в неизбежной точке пересечения новой волны экономических преобразований в Армении и нового прорыва «4-ой промышленной революции» находится оборонная промышленность, в качестве инициатора позитивных изменений в экономике, откуда положительные экстерналии цепной реакцией должны распространяться по всей экономике. В статье рассматриваются вопросы развития оборонной промышленности Армении в контексте новых вызовов Индустрии 4.0.

**Ключевые слова:** экономическая революция, индустрия 4.0, оборонная промышленность, аддитивное производство, 3D печать, искусственный интеллект, робототехника, интернет вещей, облачные технологии

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**Introduction.** Presenting the new Government program on February 12, 2019, Armenian Prime Minister Nikol Pashinyan, referring to the desideratum of economic revolution, formulated virtually the national agenda of economic development: "Overcoming extreme poverty, a significant reduction of poverty and unemployment, continuous growth of salaries and pensions, and increasing export growth rates. The combination of all these indicators we consider as economic revolution" [1]. Of course, the goals of the new Government are consonant with the imperative of urgent problems facing the country, but as Socrates notes: "The success of change is to focus all of your energy not on fighting the old, but on building the new". Therefore, the construction of the "New economy" of Armenia should be based on new criteria of development that is already appointed for Armenia by the "4th Industrial Revolution".

The fact of the "4th Industrial Revolution" was acknowledged by the world community in January 2016 at the framework of the World Economic Forum in Davos. Earlier in 2015, Founder and Executive Chairman of the World Economic forum, Klaus Schwab, announced some new technologies as main driving forces of this revolution: Artificial Intelligence, Big Data Technology, Internet of Things, Robotics, Self-driving Cars, 3D Printing, Biotechnology, Quantum Calculations etc. [2].

All these technological changes, at first glance, are diametrically opposed to the targeting goals of "unemployment reduction and poverty eradication", since one of the most dangerous trends in the "4th Industrial Revolution" is the growth of technological unemployment around the world. The scale of this threat is best described in a study conducted by Oxford University researchers [3], according to which 47% of the US able-bodied population are at risk of unemployment as a result of automation and robotization. McKinsey estimates the same number at 45%, while, according to World Bank estimates, 57% of OECD jobs can be automated over the next two decades [4].

However, the consequences of this revolution may vary depending on country's level of development, resource endowment, as well as the peculiarities of human capital. For Armenia, the concept of "Industry 4.0" can turn from the challenge into an important platform for leap-frogging development of economy. The point is that artificial intelligence will replace the workforce in areas that do not require creative and innovative approaches to work, and are mainly dominant in the service sector. The latter is a low value-added economic area and, their replacement by real sector industries creating more value-added in perspective, can only indicate positive changes. The challenge ahead is to create new jobs in the new manufacturing industries faster than the robotization of the service sector will take place.

**2. New technological solutions of "4th Industrial Revolution" for defense industry.** The issue of which manufacturing industries are more flexible and capable of adopting the "new technology agenda" was the subject of intensive discussions between analysts. Ebner and Bechtold, for example, find that from this point of view, the automotive industry is the most flexible industry [5]. However, it should be noted that the defense industry is traditionally in the forefront of new technologies. In the second half of the 20th century, the revolutionary technological innovations such as satellite communications, jet engines, semiconductors, nuclear energy, space industry, Internet have been achieved as a result of military purposes R&D [6]. Let's consider how new technological solutions are translated into action in defense industry.

**3D printing or additive manufacturing.** This is an industrial technology that allows to manufacture a wide range of products, objects, parts, spare parts, by gradual (layer-by-layer) addition of materials (such as plastic, metal, ceramic powder) on a three-dimensional digital model. The achieved progress allows producing metallic and non-metallic prototypes of objects as well as functional products that do not require mechanical post-processing for a while now [7]. As of September 2018, the global market of additive production is $1.3 billion, with the US, Japan, Germany and China leading. The advantages of 3D printing are intensively used in medicine, mechanical engineering, aerospace and military industry.

Exclusive capabilities of additive manufacturing allow not only to significantly increasing the efficiency of materials use and to achieve the utmost precision of product specifications and technical features without any mechanical intervention, but also have the following advantages:

– transition from mass production to mass customization allowing to satisfy as many individual customers as possible;

– the ability to create products with a complex shape or even with a configuration impossible in the routine production;

– reduction of production costs including costs of small batches which was impossible without scale effect under usual production conditions;

– significant reduction in the duration of the production cycle, significant increase in production flexibility, since there is no need to the equipment modification and readjustment for a new product [8].

These technologies are indispensable, especially in the production of unmanned aerial vehicles. For example, this is best illustrated through UAV's models manufactured by one of the Russian companies ("Luch" OJSC), that additive manufacturing technology has made it possible to noticeably save time and financial resources, in addition, UAVs produced by this technology can be repaired and manufactured directly on the zone of military operations.

**Cloud technologies.** The cloud manufacturing can be described as a smart networked manufacturing model that provides higher product individualization, broader global cooperation, knowledge-intensive innovation and increased market-response agility [9]. Such a production model works through cyber-physical production lines, which provide free access to a wide variety of production and information resources. The cloud allows organizations to virtually keep and process information on its production resources within a central location and provide collaborating companies with access to shared cloud platform in real-time, saving operational and other costs [10]. This always-accessible and operative interaction between suppliers and consumers is crucial to creating electronic value chains. The latter will allow companies to significantly reduce production costs and order performance time, as well as warehousing expenses, improve customer service, and optimize work between partners, turning all the information necessary to create electronic value chains into accessible in real time for all stakeholders [11].

Although the use of cloud technologies in the defense industry is associated with certain risks due to high probability of information leakage and other reasons, they still had a "revolutionary" effect and continue to influence the aerospace and defense industries. In particular, the cloud could be brought into field of military operations using mobile devices, enabling the extensive information about operational military activities and to take more effective countermeasures. Furthermore, their use is also appropriate for automated defense economy management and for research in the field of cybersecurity. Note that cloud technologies are interconnected with Big Data and Internet of Things.

**Internet of Things.** The Internet of Things (IoT) refers to the networking of physical objects through the use of embedded sensors, actuators, and other devices that can collect and transmit information about objects [12]. The IoT provides an opportunity to analyze the environment of items based on information obtained from them, and accordingly to manage remote (online) increasing the efficiency and accuracy of actions.

The Internet of Things includes a wide range of technologies: identification technologies (such as optical identifiers: barcodes, Data matrix, QR-codes and real-time locating systems), data measurement technologies (from ordinary sensors to up-to-date smart meters), data transmission/exchange technologies and data processing facilities. One of the main problems here is that the system could provide functional capabilities so that the computer could receive all the information independently and without human intervention. It is also necessary to eliminate as much as possible the influence of the human factor when collecting information, which will ensure the reliability and accuracy of the information received.

The analysts of prestigious American research and consulting company Gartner forecast 20 billion internet-connected things by 2020, in turn, Intel provides an even more impressive figure – 200 billion [13].

Internet of Things is extensively used in defense industry, especially for intelligence purposes, but the possibilities of its use will expand in the future. Here are some examples. In military situation, the so-called "attacking swarms" of UAV (or other unmanned underwater and subsurface vehicles) can have greater efficiency. "Attacking swarm" can successfully perform the tasks assigned to it according to unified plan and design thanks to installed sensitive devices (sensors) that collect operatively the necessary information to process it in real-time and to guide operations. Innovative approaches to armor the military equipment are also based on the logic of the Internet of Things, which reckon for transfer of data about the direction of attack and other details to other military equipment on the battlefield, soldiers and the control center, if the equipment damaged.

**Robotics.** Analysts consider the development of robotics as a precondition for predicting successes, expected efficiency, and increasing productivity in the framework of Industry 4.0 concept. Indeed, the most advanced robots of new technological world, capable to collaborating with each other and humans (also called "cobots"), are really the driving force of the "4th Industrial Revolution" [14], as their

production and exploitation requires a combination of all the breakthrough technologies: artificial intelligence, automated management, cloud technology, Internet of things etc. The application of robots in the production process noticeably increases productivity because robots often work faster, more accurate and more efficient than people. It is known that the company Philips has completely robotic productions, for example, in the Netherlands. Philips produces electric razors in a "dark factory" with 128 robots and just nine workers, who provide quality assurance [15].

In the light of current tendency of robotics and artificial intelligence development we can presume that they are widely used in the military as well. Actually, a diverse array of robotic systems is used in the military sphere – from scout and sapper robots to the most ordinary robotic infantry units. The use of robots with the aforementioned exemplifications is no longer an innovation in the military sphere, for example, sapper robots have more than 40 years of history, and the armored vehicles with remote control are even older. In current trends ensuring the multifunctionality of military robots, accuracy of operations and abilities to navigate in complex locations are dominated.

One of the most interesting design is the robot-snake, able to glide silently even in an extremely difficult terrain, equipped with a thermal imager, camera, microphone, introduced by Israel in 2009. Some time later, the USA also presented similar development: the “American snake” could climb trees, entwine objects and thus shoot from more than secluded places.

**Artificial intelligence.** Robotics is closely connected with another modern technology, artificial intelligence, which is predicted to lead to the largest revolution in human history but, unfortunately, will also lead to the collapse of humanity [16]. Nevertheless, with all these risks, the development and application of artificial intelligence has already become a reality in the modern world. The matter in question is the existence of intelligent systems that can perform creative functions hitherto considered exclusively human abilities. Robots with artificial intelligence have a certain degree of independence in decision-making and actions, as well as the ability to repeat and improvise actions. Artificial intelligence is now widely used in trade organization, financial services markets, inasmuch it allows to quickly research the market and to perform data mining. Another important area of artificial intelligence application is medicine - medical diagnostics, interpretation of medical images, development of individual treatment plans, activities of robots taking care of the elderly and disabled persons. In addition, artificial intelligence is also capable of creating artworks. For example, piece of music created by artificial intelligence Emily Howell (algorithmic music) are registered as US patents. According to a study by Marketsandmarkets (global market research consulting company), the World market for artificial intelligence technologies intended for military use in 2017 was estimated at $6.26 billion, which is forecasted to reach $18.8 billion in 2025 increasing by 14.7% annually [17]. This is perhaps the fastest growing market, and technological innovations in this area are the most advanced. Let’s present the most modern of them.

The project was launched in United States in early 2019 envisaging to develop virtual assistants for military personnel to help increase the effectiveness of personnel during military operations. The system that has been called ATLAS (Advanced Targeting & Lethality Automated System) has advanced targeting and high lethality capabilities due to minimizing the negative impact of stressful situations on personnel actions during military operations. In particular, the system takes over the functions of detecting potential targeting, determining if they are hostile and aiming, leaving the final decision to fire to the commander.

The use of artificial intelligence is also effective in the control systems of military fighters. In 2016, it was proved that the artificial intelligence ALPHA, designed to control military fighters, won a landslide victory over the former flying-ace of the United States army in a virtual dogfight [18]. Technologies of identification (recognition) of objects, people and items provide automation and high efficiency of data analysis obtained from satellite images and devices. Artificial intelligence can also improve radar station performance in terms of predicting and countering a missile attack.

With all that, the most urgent and dangerous of the global problems of the human society is the excessive militarization of artificial intelligence. In August 2017, 116 experts and founders of artificial intelligence and robotics companies from 26 countries around the world sent an open letter to the UN to ban the production of autonomous weapons (through the use of artificial intelligence), substantiating that “they will permit armed conflict to be fought at a scale greater than ever, and at timescales faster than humans can comprehend” [19]. However, no international treaty, having legal

force in this matter, has been signed, and the use of artificial intelligence in the military industry is already an irreversible process.

There are many examples of new technology solutions used in defense industry. We did not touch on the use of block-chain technology, nanotechnology, quantum and many other technologies in the defense industry, which are also trends in Industry 4.0. We considered important to emphasize that the main goal of this revolution is to combine the capabilities of presented new technologies for creating and optimizing new production chains (including electronic ones). For example, by combining the Internet of Things, Cloud technologies, Big Data and additive manufacturing, the companies can respond in real time to the demand for specific product and, to meet this demand, produce products corresponding to all individual needs, as well as armaments and military equipment adapted to the strategic requirements of each country.

**3. The new agenda of defense industry development in Armenia.** Per se, the new race for innovative weapons has begun in the world, and the states involved in military conflict cannot neglect this fact. The reality, that the defense industry development in Armenia has no alternative anymore, we are already substantiated in early 2016 [20], even then noting that the only way to effectively solving the interconnected issues of economic development and ensuring security of Armenia is to develop the indigenous defense industry. Obviously, the defense industry is in the inevitable point of intersection of the new wave of economic transformations and the breakthrough of the “4th Industrial Revolution” as the initiator of positive changes in the economy, from which positive externalities must be spread throughout the economy by a chain reaction.

As a small country, surrounded by real and potential enemies, Armenia needs an economy-army coalesced "intelligent" system that will respond adequately to any, even the slightest threat to the country's security. In practice, the main guarantee of the country's security is the army, which requires, first of all, significant human resources involved in the military sphere, and then - financial resources. In the case of Armenia, the lack of human resources is caused not only by a small number of populations, but also by the adverse socio-economic situation, which continues to be the main cause of emigration. On the other hand, the continual involvement of human resources in Armed Forces poses another threat to the state - the depletion of human capital. Meanwhile, for many years Armenia has been considered a country of high-quality human capital and characterized by its ability to rapidly absorbing the achievements of scientific and technological progress and initiate high-tech products manufacturing. The analysis of the Human Capital Development Index, published by the World Economic Forum in 2017, shows that in the near future Armenia may lose the advantage of a high-quality workforce, the restoration of which will require more than one decade [21]. Regarding financial resources, it should be noted that military spending, despite considerable amount – about 4% of GDP over the past 10 years – did not have a stimulating effect on economic growth when economic patterns suggest an obvious impact. The point is that military spending can have a stimulating effect on the economy only when a significant part of them is channeled to the real economy through government procurement on defense. In the case when a significant part of military spending channels to the import of weapons and other military products, not a stimulating effect on the economy is multiplied, but a negative one, especially if we take into account that the source of financing large military expenses is an increase in public debt.

The Industry 4.0 platform provides all solutions to the optimization problem conditioned by imperatives of limited human and financial resources to ensure the security of Armenia – and not only this one. It also provides an opportunity to prevent the militarization of the economy. In the social-welfare function, security is an important component but, nevertheless, it is welfare function. Therefore, to develop an army without economic development, per se, is unlikely. In an effort to transform the economy in a way as to ensure the integrated development of innovative technologies and defense industry, the concept of "nation-army" actually grows into the concept of "nation-economy-security", in which the emphasis is shifted from "whole society for the army" to "whole society for their own well-being and security". Not much seems to change. But it is the establishment of this agenda into the everyday livelihood of society can create an institutional environment that will dictate long-term trends in the development of society. In this context, Industry 4.0 "offers" not to turn a nation into an army, but to turn a nation into a huge "army" of intellectuals capable of designing such a "smart" military-industrial complex that can with minimal human resources, but with significant knowledge-intensity and technological effectiveness, to solve maximum successfully any security problems facing the country. As a result, we can have a military-

industrial complex with the following features:

– full front line robotization, significantly reducing the number of casualties during sabotage attacks;

– widespread use of ground and air robotic intelligence system in peacetime and wartime;

– use of multifunctional unmanned aerial vehicles (including armed drones) during military operations;

– availability of modernized weapons and military technology equipped with remote control systems;

– ability to carrying out high-efficiency network-centric warfare based on new advanced information exchange and analysis systems (by using cloud technologies);

– effective management of military situation and ensuring accuracy of the countermeasure maintaining a high level of situation awareness due to the technological capabilities of the Internet of Things;

– high-tech army uniforms equipped with elements of assessment of the soldier's moral and psychological state and adequately response;

– defense industry enterprises appointed with additive manufacturing technologies, which are flexible in timely order execution with high accuracy - almost individually;

– improved logistic system of military-industrial complex conditioned by simplification of transactions and costs reduction due to the shortening and elimination of intermediate links in management process.

At the same time, it is obvious that such a development of defense industry cannot be separated from the development of other manufacturing sectors, since Industry 4.0 technologies can also be more successfully used in civilian production, and in some cases they can be transferred to the military sphere from there. On the other hand, the defense industry development can also contribute to the development of related and supporting industries (alternative energy, radio electronics, electro technical manufacturing, etc.), becoming a key manufacturing sector that can set entire economy in motion.

**4. Concluding observations.** Based on this research, we present a number of observations and recommendations for bringing the economic revolution in Armenia into compliance with global innovation trends and developing the defense industry.

1. Innovative technologies are created and implemented in the production process by human capital, therefore, the preventing of permanent human capital degradation in Armenia and creating favorable conditions for development are of paramount importance. This could be accomplished by:

– to establish strict quality standards for education from primary education to university and post-graduate levels, preventing a large number of "semi-literate" graduates and scientists who demonstrate "mental disabilities" in solving practical problems;

– to make more stricter the approaches to teaching mathematics, physics and informatics in school curricula;

– to make robotics a compulsory subject in schools and institutions providing secondary technical education;

– to increase the number of State-requisitioned places at universities for engineering, physics and mathematics professions, while at the same time imposing strict requirements on the possession of basic skills intended for comprehension under the curriculum;

– to create favorable conditions for close collaboration between universities and employers in terms of structuring higher education programs in accordance with real needs of labor market;

– considering that in the "new economy" the manufacturing processes are significantly complicated from both technological and organizational points of view, to increase perceptibly the funding of interdisciplinary research, as well as contribute to development of interdisciplinary competencies for different professions.

2. Considering the lack of effective links between different sectors of economy - public and private, financial and industrial, scientific and educational, as well as the weak relationship between different production sectors as the main obstacles to whole economy development (and especially of defense industry), we suggest:

– to partially liberalize the dissemination of information on defense industry (keeping secret the technologies of new weapons production), enabling private investors (including those from Armenian Diaspora and foreigners) to properly evaluate investment efficiency and take greater initiative;

– to perform periodic analysis (through surveys) of the human resource demand of high-tech companies, "inventory" of required skills and abilities, in order to coordinate them with educational processes;

– to diversify the platforms for interaction between Government, private companies and research institutes in the high-tech field, from joint

research and development to commercialization of their results and to exposure to external markets;

3. To provide access to new source of high-tech project financing and opportunities for using contemporary money attraction mechanisms - crowdfunding, crowdlending, crowdinvesting, ICO (initial coin offering), particularly by:

– including the subject "Alternative financing" as an compulsory course in economic universities;

– providing advanced telecommunication infrastructures (as the main ecosystem for Industry 4.0) with appropriate availability of software and cybersecurity guarantees allowing unlimited access for all participants in economic activity;

– creating favorable conditions for use of block-chain technologies and raising public awareness in this regard;

– establishment and enhancing of appropriate legal framework for operations on crowd platforms;

– issuing state-guaranteed private debt instruments, which can also stimulate the development of the local stock market;

– considering the possibility of investing funds of compulsory accumulations of pensions in low-risk high-tech projects.

4. To develop in a short time the architecture of the "smart" military-industrial complex and its model of digital control in order to plainly assessment of demand for new technological solutions in this area and economy's ability to respond it.

5. As a pilot production project in defense industry, we suggest to establish a joint venture (for example, Armenian-Russian or Armenian-Belarusian) for Aircraft production, modernization and maintenance services in Gyumri on the basis of aircraft repair military unit. The enterprises will specialize in high-quality maintenance, repair and modernization of military and civil aircraft, as well as in manufacturing of aircraft parts and components and in helicopters and aircrafts assembling activities, will have a laboratory for designing new specimens of aircraft and developing new technologies for aviation equipment modernization. Such a proposal is justified by several factors: the availability of high-quality workforce (graduates of Military Aviation University Named after Marshal Khanperiants); neighborhood of Gyumri Technology Center; capability of dual-use products manufacturing (provision of services); availability of adequate transport infrastructure, including airport in operation.

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