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Artificial Intelligence, Smart Robots and a New Economic Order

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In the process of transition from agricultural society to industrial society, which started with the Industrial Revolution in England, the mechanization process experienced five different stages and in the last stage, with the development of computers, automation in production was achieved. While developments in a certain region or country of the world spread to other parts of the world with technological spread, technological revolutions also spread and paradigm changes occurred. With the development of information processing technologies, productivity has started to increase with the use of automation and robot technology in production. This process, which continued until the 2010s, is thought to lead to the formation of smart factories that can produce under the dominance of robots, after the new point reached in artificial intelligence and robot technology, and this development will further increase productivity in production. Intelligent robots working in the internet of things system will be able to work with greater power and longer periods than humans, and smart factories that are almost never shut down will emerge. In the transformation in this process, which is also called robonomics, changes in the theory of economy may occur and a new economic order may emerge. The question of why behind-the-scenes countries, such as Turkey, could not catch up with the leading ones, is another matter of discussion. However, in such periods of technological paradigm change, an opportunity arises for lagging countries for their economic development. On the other hand, we can say that Turkey will either be able to catch up with the technological level of developed countries by taking advantage of the opportunity, by means of a step-by-step technological development, or it will continue to stay among the countries that lag behind by missing the opportunity.

Keywords: technological development, incremental technological development, radical technological development, smart robots, robonomics, smart factories, technological unemployment, universal basic income

Introduction

Everyone agrees that it is necessary to have a basis for assessing and estimating the impact of technical change on society in general or on any particular aspect of human activity. New technologies, on the other hand, are raining down on us or surprising us like an earthquake, and there is little we can do as a society to dominate them or guide them for the common good. What we will discuss here is that, despite the undeniable diversity of

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technologies, the unpredictable nature of invention, and the uncertain and risky nature of business innovation, there is an identifiable logic behind major trends in technical change (Perez, 2004, p. 2; Dolanay, 2022ı).

The invention of a new product or process takes place in what might be termed techno-scientific, and can stay there forever. In contrast, an innovation is an economic fact. The first commercial introduction of an innovation transfers it from the techno-economic field to the future market as an isolated event that is decided to open up if successful. In case of failure, it can disappear for a long time or forever. In the event of success, it may still remain an isolated fact or become economically important, depending on its degree of relevance, its impact on competitors, or its impact in other areas (Perez, 2004, p. 3; Dolanay, 2022ı). Yet it is the process of mass adoption that has the most far-reaching social consequences. Widespread diffusion is what turns what was once an invention into a truly socio-economic phenomenon. Therefore, inventions can occur at any time, of different importance, and in varying rhythms. Not all of these turn into innovations, and not all innovations are widely disseminated. In fact, the world of the technically possible is always much larger than the world of the economically profitable, which is socially acceptable. Therefore, our focus should be on innovation diffusion (Perez, 2004, p. 3; Dolanay, 2022ı).

Incremental and Radical Innovations

Incremental innovations are successive improvements over existing products and processes. From an economic point of view, such change is collectively behind the overall rate of productivity growth. Frequent increases in technical efficiency, productivity, and precision in processes, regular changes in products to achieve better quality, reduce costs, or expand their range of uses are characteristic features of the evolutionary dynamics of each technology. Called the “natural trajectory” by Nelson and Winter (1977) and the “technological paradigm” by Dosi, the logic guiding this evolution is analyzable and makes the course of gradual change relatively predictable. According to the fundamental and fundamental economic principles given technologically, for example, those microprocessors will be smaller, more powerful, work faster, etc. It is possible to predict with reasonable certainty. It is natural to expect technological evolution to lead to successive developments towards petroleum derivatives. In process industries, it was easy to expect a trend towards achieving these economies of scale across all industries after the discovery of Chilton’s Law, which said that doubling plant capacity only increases the cost of investment by two-thirds. Therefore, the vast majority of innovations occur in a continuous stream of incremental changes along expected directions (Perez, 2004, p. 3; Dolanay, 2022ı).

A radical innovation, on the contrary, is the introduction of a truly new product or process (Freeman et al., 1982). Because of the independent nature of incremental change trajectories, it is practically impossible for a radical innovation to emerge from efforts to improve an existing technology. Nylon cannot result from successive improvements made in rayon plants, and nuclear power cannot be developed through a series of innovations in fossil fuel power plants. A radical innovation, by definition, is an outlet that can start a new technological route. While radical innovations are more willingly adopted when the predetermined trajectory approaches extinction, they can be introduced at any time, shortening the life cycle of the products or processes they replace. There are some radical innovations that gave birth to a whole new industry. Television, for example, brought not only a manufacturing industry, but also programming and broadcasting services, which expanded the advertising industry. In this sense, important radical innovations are at the center of the forces behind economic growth and structural change (Perez, 2004, p. 4; Dolanay, 2022ı).

The Birth, Development, and Recession Phase of a Technology

When we consider the evolution of a technology from market entry to maturity, in the product and its production process in its incipient, relatively primitive stage, there is a lot of trial purchase on the market and among the first users. Gradually the product consolidates a position in the market and the main trends of its trajectory are determined. From then on, there is a kind of departure for a period of incremental improvements in quality, efficiency, cost-effectiveness, and other variables that eventually meet limits. At this point, the technology reaches maturity. When it reaches maturity, it has lost its dynamism and strength. Profitability begins to decline as costs rise. Depending on the product type, this cycle can take months, years, or decades; It can cover a single firm, tens of firms, or thousands of firms. As technology approaches maturity, a jolt often leaves only a few manufacturers behind. There is also a high probability that the product will be replaced at maturity or that the technology will be sold to weaker manufacturers with lower factors (as in the spread of mature industries to the Third World in the late 1960s and late 1970s) (Perez, 2004, p. 4; Dolanay, 2022ı).

Radical Innovations Create Paths for Technological Systems

Freeman et al. (1982) defined technological systems as constellations of innovations that are technically and economically interrelated and that affect various branches of production. Rosenberg (1975) has described how some innovations trigger the appearance of others. For example, breakthroughs in increasing the speed of operation of machine tools have spurred innovative efforts in cutting alloys. Relying on higher temperatures and speeds and, in general, increasing trajectories in a product, process, or industry branch tends to encounter bottlenecks that become incentives for innovations—even radical ones—in other industries. Nelson and Winter (1977) described generic technologies encompassing a natural evolutionary trajectory, a series of interconnected radical innovations (Perez, 2004, p. 5; Dolanay, 2022ı).

In petrochemical technology, for example, several different but interrelated systems can be identified: synthetic fibers transforming the textile and apparel industries. Creating brand new lines of equipment for extrusion, molding and cutting with versatility and transforming the packaging industry as well, it is plastics that open up a wide universe of innovation in the packaging industry (Perez, 2004, p. 6).

From the point of view of a technological system, then, there is a logic that unites successive radical innovations on a common natural trajectory. Once this logic is established, it is possible to reveal features in the system, each of which appears to be a radical innovation when considered separately, but which, when included in the system, suggests that there will be an incremental succession of new products and processes (Perez, 2004, p. 6; Dolanay, 2022ı).

Starting with the vacuum cleaner and washing machine, the line of consumer durables made of metal or plastic with electric motors passes through food processors and freezers, then approaches extinction with the electric can opener and electric carving knife and is considered a gradual change. In the field of products, this is an ordinary example of an exemplary logic. The succession of plastic materials with the most diverse properties, based on the same principles of organic chemistry, is an example in the field of intermediates, which has tremendous impact in generating innovations in user industries. With the introduction of growing petroleum-based agricultural implements, combined with multiple petrochemical innovations in fertilizers, herbicides, and pesticides, machines are an example of the consistent evolution in the logic of a productive system. The pervasive impact of a new technological system derives from the multiple characters and broad adaptability of contributing innovations. Each technology system brings together technical innovations in inputs, products, and processes, organizational and managerial innovations. Moreover, they can cause significant social, institutional, and even political changes. The technological constellation of the "Green Revolution" gave rise to single-crop agriculture in large lands and caused changes in the organization of production and distribution as well as in the ownership structure. The automobile assembly line, the internal combustion engine, networks of parts suppliers, distributors and service stations, suburban living and commercial centers have been just a few of the elements of the technical, economic, and social cluster that is gradually built around the inner periphery (Perez, 2004, p. 6; Dolanay, 2022ı).

Yet technology systems, similar to individual technologies, eventually exhaust their potential for further growth and development. Over a long period of time, a technological system offers numerous and growing opportunities for innovation and investment in complementary products, services, or materials. But when the system reaches maturity, where it loses its technological and market dynamism, it threatens the growth and profits of most of the firms involved and therefore encourages the search for radical new products that will serve as the core of other new technology systems (Perez, 2004, pp. 6-7; Dolanay, 2022ı).

After a radical technological innovation has emerged, new business areas are opened in the economic boom period, which is followed by a recession and adaptation in the first place, and we can say that this is due to the high performance of the innovation, that is, the technological transformation also transforms the economy. Just like the transition from propeller aircraft technology to jet engine aircraft technology. In this case, as shown in the graphs consisting of performance and time axes, as the radical innovation gets old, if incremental innovations are made, the performance of the innovation enters a stagnation period and the rising curve becomes horizontal. This curve, also called the S curve, can be drawn for all radical innovations. However, many successive S-curves can be drawn for innovations in information technology (Ford, 2018, pp. 85-96; Dolanay, 2022ı).

Technological Transformations the World Has Experienced

Perez (2002; 2011) divides the technological transformations of the world into five phases. According to Perez, each phase was formed by the emergence of one or more radical technological innovations. The first phase started with the mechanization of the cotton textile industry with the steam engine during the First Industrial Revolution in England. At this stage, transportation was done through the development of water channels and shipping. In the second phase, railway transportation started to develop from 1829, and the development of iron and coal use played a strategic role in the development of railways. In the third phase, the use of steel has increased since 1875, the use of steel in steam engines has developed, the use of steel in ships has begun, and there have been developments in the fields of chemistry, civil engineering, and electronics. In the fourth phase, starting from 1908 in the USA, the use of oil in automobiles began to develop, the mass production system emerged and spread to Europe. In the fifth phase, the information revolution has emerged since 1971, and the telecommunication field has developed by means of computer hardware and software based on cheap microelectronics (Dolanay, 2022ı).

Fourth Industrial Revolution (Industry 4.0)

Jeremy Rifkin (2021) was the first to use the name of the Third Industrial Revolution, which started with the emergence of automation in production as a result of the development in computer technology in the 1970s. Industry or Industry 4.0 refers to a process we are in today. Therefore, it is not a completed period yet and theories about its future are emphasized. Industry 4.0 in general: robots take over production, production with 3D printers, the development of artificial intelligence, big data studies, and many other innovations (https://www.muhendisbeyinler.net/4-sanayi-devrimi-nedir/; Yüksekbilgili & Çevik, n.d., p. 424; Dolanay, 2022ı).

For the theoretical beginning of Industry 4.0, studies were carried out on the concept that Kagermann et al. (2011) put forward in his study in 2011, and the principles of the Industry 4.0 process were established based on the concept. He states that the industrial revolution includes not only the development in automation, but also intelligent observation and decision-making processes (Alçın, 2016, p. 21; Yüksekbilgili & Çevik, n.d., p. 424; Nuroğlu and Nuroğlu, 2018, p. 527; Koç & Teker, 2019; ACATECH, 2013; Soylu, 2018, p. 45; Dolanay, 2022ı).

The characteristics of these changes, also known as "Internet of Things", "Internet of Everything", or "Industrial Internet", which will help to distinguish them from the first three industrial revolutions, and can be listed as follows (Yüksekbilgili & Çevik, n.d., p. 424; Dolanay, 2022ı).

Cyber-Physical Systems (CPSs)

Cyber-physical systems (CPSs) connect the physical world with the virtual computing world with the help of sensors and actuators. CPSs, which consist of different constituent components, create global behaviors in cooperation. These components include software systems, communication technologies, sensors/actuators, often including embedded technologies, to interact with the real world. Cyber-Physical Systems that unite these two worlds consist of two important elements: Network formed by objects and systems that communicate with each other over the internet and with a designated internet address. It is a virtual environment that emerges by simulating real-world objects and behaviors in a computer environment. Cyber-Physical Systems, which create a very wide communication network together with the "Internet of Things" and thus tend to remove the border between real and virtual worlds, constitute one of the underlying forces of Industry 4.0 (http://www.endustri40.com/siber-fiziksel-sistemler/; Dolanay, 2022ı).

Industry 4.0-based production processes are based on systems connecting to different networks through various interfaces and communicating with different services. Industry 4.0 reflects the communication between the Cyber-Physical Worlds to machines, just as we access various contents with the internet connection on smart phones and communicate with other smart phones around us via different platforms. The most obvious example of this is "Smart Factories". Automation processes in Smart Factories mean that devices and machines communicate with each other and determine and regulate production processes within themselves. For example, in case of a resource shortage at any stage of production, the necessary resource order is automatically placed, faults can be detected and fixed instantly and on-site, so that the system can be operated at full capacity and without any problems (http://www.endustri40.com/siber-fiziksel-sistemler/; Dolanay, 2022ı).

These systems connect the real physical world with the virtual computing world through sensors. Systems that create a wide communication network and thus eliminate the boundaries between the real and virtual worlds are also one of the most fundamental driving forces of Industry 4.0 (http://www.endustri40.com/siber-fiziksel-sistemler/; Yüksekbilgili & Çevik, n.d., p. 424; Dolanay, 2022ı).

Thanks to cyber-physical systems, future facilities will have newly created conditions and interfaces, and it will be possible to be more flexible in controlling these interfaces simultaneously and updating the hardware in production processes with the latest innovations. In this way, it will take less time to adapt all relevant changes to the production processes, and it will be possible to minimize potential problems and disruptions. All of these will naturally increase the level of productivity (Yüksekbilgili & Çevik, n.d., p. 424; Dolanay, 2022ı).

Cyber-Physical Systems play an essential role not only in production but also in many places related to the production process. Some of them can be listed as (http://www.endustri40.com/siber-fiziksel-sistemler/; Dolanay, 2022ı):

(a) Physical and organizational business processes are controlled by a monitor,

(b) It involves significant user-participation and interaction,

(c) Provides adaptation and development to reactive changes in the environment with real-time structuring, distribution, or assignment,

(d) Controlling and optimizing its own performance with a constant monitor,

(e) Requires a high degree of reliability,

(f) It requires the integration of different technical disciplines and different application areas,

(g) Local, regional, national, and global autonomy requires hierarchical decision systems with a high degree of autonomy (http://www.endustri40.com/siber-fiziksel-sistemler/; Dolanay, 2022ı).

It can also make significant differences in R&D, design, and marketing processes. For example, before a factory is physically established, it can be established through simulation and all necessary feasibility studies can be done through this simulation. In short, Cyber-Physical Systems, and thus Industry 4.0, promise a future in terms of producing solutions that we cannot even imagine today, improving resource use, and increasing efficiency (http://www.endustri40.com/siber-fiziksel-sistemler/; Dolanay, 2022ı).

Big Data

Today, it is possible to see the elements of the information society in all areas of life. Most people now have a smartphone in their pocket, most people have a computer at home, and all companies have information technology management units in their back offices. But the information itself is not so visible. However, only half a century after computers entered human life, the amount of information has begun to be collected in a way that acquires a meaningful and special quality. Today, not only the amount of information has increased, but also the speed of access to information has increased. Quantitative change brought with it qualitative change. The collection of data to form a meaningful whole first took place in the fields of astronomy and genetics. The concept of big data was first used in these fields, and then this concept started to be used for every field. Big data has started to show itself in all areas of our lives. For example, in the internet search engine Google, we encounter big data in every field, from the diagnosis and treatment of diseases to the field of shopping over the Internet. Big data is the form of all data collected from different sources such as social media shares, blogs, blogs, photos, videos, log files, converted into a meaningful and workable form. As usual, it is the unstructured data stack, which is not used much until recently, except for the structured data kept in relational databases. According to the widespread IT belief that has now been demolished, unstructured data were worthless, but big data showed us something, which is that enormously important, usable, useful information emerged from the phenomenon called information dump today, that is, the only system that caused treasure to come out of the garbage dump. Big data consists of a large amount of information such as web server logs, Internet statistics, social media posts, blogs, microblogs, information from climate sensors and similar sensors, call logs obtained from GSM operators. Big data, when interpreted with the right analysis methods, can enable companies to take their strategic decisions correctly, manage their risks better, and make innovations. Most of the companies still continue to make decisions based on the data they have obtained through conventional data warehouse and data mining methods. However, dynamically predicting consumer trends requires analyzing big data and acting according to these analyses (https://tr.wikipedia.org/wiki/B%C3%BCy%C3%BCk_veri; Dolanay, 2022ı).

It is a term that includes many subjects such as the creation, storage, flow, and analysis of this big data, which is difficult to process with traditional database tools and algorithms. As the data are too large for classical databases to handle, the growth rate of data exceeds a computer or a data storage unit. With 2012 figures, 2.5 quintillion bytes of data are produced daily in the world. All works such as processing and transferring big data of this scale are called Big Data. Today's databases are not enough to keep the data growing on this scale. While relational databases can hold data at gigabyte level, they can store data at petabyte level with big data. However, big data are only suitable for batch processing. Advanced databases like Transactions lack critical features. Since databases can perform operations such as reading, writing, updating, etc., these transactions are considered atomic and with various locking mechanisms, the data are prevented from becoming inconsistent by changing it by more than one transaction. It should be used in cases where big data are written once and read many times. Because data are processed in parallel in more than one place, data of this size are produced in many areas from RFID sensors to social media and hospitals. Big Data emerges as a need in many areas where data processing is carried out, especially the analysis of DNA sequences, data from weather sensors (https://tr.wikipedia.org/wiki/B%C3%BCy%C3%BCk_veri; Dolanay, 2022ı).

It is important to use innovative data systems, as there will be much more data movement that needs to be processed and recorded in the production facilities of the future shaped by Industry 4.0. All data flowing from different sources such as posts, blogs, photos and videos on the internet, on various social media sites, is transformed into a meaningful and workable form. Big Data consists of a huge amount of data such as internet statistics, social media posts, blogs and information from similar sensors (https://tr.wikipedia.org/wiki/B%C3%BCy%C3%BCk_veri; Yüksekbilgili & Çevik, n.d., p. 424; Dolanay, 2022ı).

If these data can be analyzed and interpreted correctly by businesses; it enables them to make important strategic decisions in the right way, to keep the risk at a minimum level and to manage them better, and thus to work with high efficiency (http://www.mckinsey.com/businessfunctions/operations/our-insights/how-big-data-can-improve-manufacturing; Yüksekbilgili & Çevik, n.d., p. 424).

Digital Information Exchange

One of the fundamental philosophies of Industry 4.0 is to connect the virtual and real worlds. Thanks to the uninterrupted exchange of information between contents, equipment, components, systems, and people via the internet, final products, machines, contents, and every step in production will have digital footprints. In this way, it is thought that production can be made faster, more flexible, with low risk, and with high efficiency. Accordingly, smart factories will automatically adapt to current conditions and even organize their production planning according to order demands (Taghizadeh & Keser, 2015; Yüksekbilgili & Çevik, n.d., p. 424-425; Dolanay, 2022ı).

Artificial Intelligence (AI)

The term Artificial Intelligence was coined by John McCarthy in 1958. He defined it as "the science and engineering of making intelligent machines" (McCarty, 1958, pp. 75-91). Artificial Intelligence is the branch of computer science that deals with the study and design of intelligent agents that sense their environment and take actions that maximize its environment. The way AI succeeds can be described as: "The ability to keep two different ideas in mind at the same time and still function". But AI must include learning from past experience, reasoning for decision making, inference, and swiftness. In addition, they should be able to make decisions by making inferences according to priorities and cope with complexity and uncertainty. Machines programmed to perform tasks that require intelligence when performed by humans are said to have artificial intelligence. The scientific purpose of AI is to create an intelligence that can infer or reason within the machine by creating computer programs that exhibit intelligent behavior using symbols. AI will not be time-independent when defined. Considering the time, he can form his judgment about any system (Singh et al., 2013; Russel & Norvig, 2010; Dolanay, 2022ı).

Artificial intelligence is accomplished by examining how the human brain thinks and how people learn, make decisions, and work while trying to solve a problem, and then using the results of that work as the basis for developing intelligent software and systems (www.tutorialspoint.com; Dolanay, 2022ı).

Intelligent Robots

Robots that are expected to eliminate human-induced errors are widely used in production. Therefore, robot technologies are promising in terms of increasing the impact of the Fourth Industrial Revolution, namely Industry 4.0. For example, in the future, smart robots in smart factories will be able to manage production by communicating with each other, by division of labor, analyzing, and reacting to changes. These robots distinguish the materials moving on the conventional production line, thanks to sensor technologies, and know which processes they need to be subjected to at which stage. In this way, it is possible to process each different product in a single production line without any errors (Yüksekbilgili & Çevik, n.d., p. 425; Ford, 2018; Dolanay, 2022ı).

Digital Industrialization

With Industry 4.0, all of the production processes will be planned in the first place before mass production and will be provided through a virtual production program plan. All steps will first be verified virtually, then physical production will be completed (Yüksekbilgili & Çevik, n.d., p. 425; Dolanay, 2022ı).

Industry 4.0 reveals the smart production economy that will have a say in the future with digital change factors. For businesses aiming to have a say in international competition, intelligent robots will play an indispensable role in this new order, artificial intelligence systems that can be used in marketing and management stages, R&D (Research and Development) units, and internet-based systems that will carry out the information flow between all these and the physical world, these systems will ensure that these systems work in harmony. They need to support and develop their bodies with working teams. Advances in technology have been the main driving force of industrial revolutions since their inception. In the 18th century, steam-powered machines started to be included in the production processes, at the beginning of the 20th century, mass production with electrical energy was born and productivity increased. After the 1970s, automation systems began to spread with the use of information technologies in the industry. With the Fourth Industrial Revolution, four main currents led to great changes in business life and laid the foundation of this revolution. These currents can be explained as follows (http://www.otomasyondergisi.com.tr/arsiv/yazi/97-turkiyenin-kuresel-rekabetciligi-icin-birgereklilik-olarak-sanayi-40; Yüksekbilgili & Çevik, n.d., p. 425; Dolanay, 2022ı):

- Regional flows: Increase in social interaction and trade between countries
- Economic flows: Rising new strong economies and increasing globalization with financial resource flows
- Technological trends: Increasing connectivity and development of platform technologies
- Metastreams: Increasing concerns about scarce resources, environment and safety (http://www.otomasyondergisi.com.tr/arsiv/yazi/97-turkiyenin-kuresel-rekabetciligi-icin-birgereklilik-olarak-sanayi-40; Yüksekbilgili & Çevik, n.d., p. 425; Dolanay, 2022ı).

These 4 entities have created new value chains by forming the basis of processes where sensors, information technologies, and production equipment are increasingly interconnected. These systems, known as cyber-physical systems, provide information and data exchange between each other thanks to internet integration, and analyze data in order to predict possible errors, and quickly adapt to updated conditions (http://www.gazeteekonomi.com/ekonomi/sanayi-40-konferansinda-engelse-gonderme-h153237.html; Yüksekbilgili & Çevik, n.d., p. 425; Dolanay, 2022ı).

Although there are still many organizations using unconnected systems today, connectivity is increasing day by day and it has started to take an important place in the industry. Today, it is no longer possible to think of the physical world and the virtual world separately from each other. While the virtual world is built on the real world, the boundaries of physical life are expanded by the virtual world. Cyber-physical systems that provide the connection and information exchange between these two worlds constitute one of the most fundamental forces of Industry 4.0. Today, advanced technology information systems are located at the center of production processes. Machines equipped with cyber physical systems and technologies will have new interfaces. In order to be faster and more flexible in controlling them simultaneously and making necessary updates, the equipment in the value chain needs to be supported with new innovations and adapted to cyber-physical systems (Yüksekbilgili & Çevik, n.d., p. 426; Dolanay, 2022ı).

The basis of Industry 4.0 is to enable production processes and systems to connect with various networks through different interfaces and communicate with various services. An example of this is that we can access the content we want with the internet connection on our smart phones, and we can communicate with other smart phones around us over various networks. When examined in the context of industry, it can be seen that Industry 4.0 carries the connections between cyber-physical worlds to machines. From this point of view, “Smart Factories” can be given as an example. Automation in Smart Factories means that equipments communicate with each other and determine their functions among themselves and plan them. For example, if there is a shortage of raw materials during production, the necessary order can be placed automatically, and in case of any malfunction, it can be detected immediately and quickly fixed. Cyber physical systems can also make effective differences in R&D and marketing departments. Before any new department is physically established, it is simulated and feasibility studies can be carried out thanks to these systems. In summary, Industry 4.0 and cyber-physical systems create a future where faster and more innovative solutions are produced and more efficient (Yüksekbilgili & Çevik, n.d., p. 426; Dolanay, 2022ı).

Technology with rapid developments has changed its understanding of production, design, and service within the framework of the innovations it brings. Although a significant number of manufacturers have started to use automation systems and radio frequency systems (RFID), many of their processes have been transformed into “intelligent” processes, but the technology has not yet reached the level that fully meets the expectations. The main goal of cyber physical systems is to use “intelligent monitoring” and “intelligent control” processes (Yüksekbilgili & Çevik, n.d., p. 426; Dolanay, 2022ı).

Artificial Intelligence, Intelligent Robots, and Robonomics

Since the invention of computers or machines, their ability to perform various tasks has continued to increase exponentially. Humans have developed the power of computer systems in terms of expanding various fields of work, increasing their speed, and decreasing their size with time. A branch of Computer Science called

Artificial Intelligence seeks to create computers or machines as intelligent as humans (www.tutorialspoint.com; Dolanay, 2022ı).

Artificial Intelligence is a way of making a computer, computer-controlled robot, or software think intelligently the way intelligent people think. AI is accomplished by examining how the human brain thinks and how people learn, decide, and work while trying to solve a problem, and then using the results of that work as a basis for developing intelligent software and systems. While harnessing the power of computer systems, human curiosity asks, "Can a machine think and act like humans?" it makes you wonder (www.tutorialspoint.com; Dolanay, 2022ı).

Thus, the development of artificial intelligence began with the intention of creating intelligence in machines similar to what we find high and value in humans. It is about creating expert systems that exhibit intelligent behaviors, learn, show, and explain what they have learned, and give advice to their users (www.tutorialspoint.com; Dolanay, 2022ı).

The Fourth Industrial Revolution is changing the global economic landscape. Following the advancement in robotics, artificial intelligence, and automation technologies (RAIA), companies from various economic sectors are starting to adopt RAIA to reduce costs, generate additional revenues, ensure consistent product quality, streamline operations, expand production/service capacity, and increase company competitiveness. This applies not only to manufacturing companies where industrial robots have been used for decades, but also to warehousing and logistics, agriculture, education, financial trade, transportation, journalism, tourism and hospitality, and other industries. Search results in search engines (e.g. Google), social media website (e.g. Facebook) news feed or product recommendations from online retailers (e.g. Amazon) are based on artificial intelligence. Companies have started using chatbots to communicate with their online customers (Ivanov, 2017, pp. 1-2; Dolanay, 2022ı).

The trend to use RAIA in the production of goods and services will continue to accelerate in the future until society reaches a point where all (or an overwhelming part) of goods and services are produced by RAIA with limited human participation. Such an economic system, robots, artificial intelligence, and (service) automation, is called "robonomics" (Crews, 2016; Ivanov, 2017, p. 2; Dolanay, 2022ı).

In the mass introduction of RAIA, its most prominent aspect is that the disappearance of most of the jobs currently available will lead to profound economic, social, and political changes. For example, Frey and Osborne (2013) evaluated the possibility of computerization for 702 detailed occupations in the USA and concluded that 47% of the total jobs in the country are at risk of being replaced by artificial intelligence. Researchers' attitudes towards RAIA are to save people from manual labor and the aim was to identify that new job opportunities would be created to protect people from becoming impoverished and outdated in a fully robotized society. While the economic, social, and political changes caused by robotic technology are relatively well explained in the academic literature, the economic principles of robotomy seem to be neglected (Ivanov, 2017, p. 2; Dolanay, 2022ı).

Origins of Robonomics

Robonomics is an economic system that uses robots, artificial intelligence, and automation technologies in the (service) sector instead of human labor as production factors. For simplicity, they use the term "robot" as an umbrella term for all RAIA technologies. These relate to the number of hours a robot can work, which human workers can work many more hours than the normal 40-hour work week, and the possibility of implementing various tasks and expanding the scope of robots with appropriate software and hardware upgrades, and are intended to be able to work 24/7. In addition, robots can perform the same routine, boring, and/or dangerous tasks over and over again, accurately and on time, without any complaints, strikes, or negative emotions. In the future, RAIA technologies may be more easily purchased or rented than hiring human workers. At the same time, contracts between RAIA manufacturers and their commercial customers can be terminated more easily and less hastily than business contracts with RAIA. It is thought that the new system will bring great convenience, especially in developed countries where there are well-established trade unions, they want high wages for human workers and where there is a long history of employment-related lawsuits. On the other hand, robot technology will not be independent of human control anytime soon. This means that human workers may not be completely replaced by robots in the foreseeable future, but a significant reduction in the number of human workers in current jobs can be expected. Also, robots lack creativity and personal approach to service delivery (partly overcoming the possibility of multilingual human-robot communication) and need structured (predictable) situations to function properly, at least at the moment. However, rapid advances in robotics and artificial intelligence suggest that in the future robots will be able to perform a wider variety of tasks currently only performed by humans. This means that this development will fuel the anti-robot technophobic and Neo-Luddism movement, where companies will begin to actively consider employing robots instead of human workers (Ivanov, 2017, p. 2-3; Dolanay, 2022ı).

In any case, when we compare the situation of robots and human workers, the future does not look bright for human workers and many will see their current jobs disappear and be taken over by robots (Frey & Osborne, 2013); especially for those who work in repetitive, tedious, and/or dangerous tasks, and human workers whose jobs are subject to strict algorithms, the adoption of RAIA will put downward pressure on wages (DeCanio, 2016). Of course, new technologies will create new jobs for people with new skills, but they may create few jobs too late. This provides grounds for many authors to argue that robots will have a profoundly negative impact on society because hundreds of millions of people will be unemployed and lack the skills needed to work in a robotized economy (Barrat, 2013; Crews, 2016; Leonhard, 2016). Metaphorically, we can say that “silicon will replace carbon” in robonomics (Ivanov, 2017, p. 3; Dolanay, 2022ı).

Principles of Robonomics

The emergence of the science of robonomics will have a major impact on economic theory and practice. While many of the basic economic principles will still be applied, other principles and their implications for real-life business practice will need to be reformulated. In particular, the following principles of robotonomy can be determined (Ivanov, 2017, p. 3; Dolanay, 2022ı):

(1) High level of automation of production—This is the fundamental principle of robotomy: all or most of the products (goods and services) are produced/provided by robots/artificial intelligence/self-service/automation technologies. Human labor is often used to control the production process without much involvement in the actual production of goods or the provision of services.

(2) Fewer but more knowledge-intensive jobs—Most people do not work and those who do work predominantly hold highly paid knowledge-intensive RAIA-supported creative jobs.

(3) Disconnecting employment and income—This is one of the most fundamental features of robotonomies. Due to the low number of people employed in economic activities, employment is not the main source of income for households. Governments provide citizens with a universal basic income.

(4) Active use of various single and multi-purpose industrial, service, and social robots—Robots are not limited to manufacturing, warehousing, or transportation, but provide services and act as companions to humans, including sexual partners.

(5) High-cost efficiency of production—New technologies allow the production of (many) goods on demand of single/several units(s) in an economically efficient manner. Society will be able to reach the stage of "radical abundance" (to use the terminology of Drexler, 2013) or "economy of abundance" (Swan, 2017).

(6) Small and dispersed factories close to consumers—This is a direct result of the high-cost efficiency of automated production processes that allow smaller manufacturers to take advantage of economies of scale, be closer to consumers, and save on product lead time and costs.

(7) High standardization of services—Due to the use of RAIA, there is a strict algorithm of service delivery.

(8) Sources of competitive advantage are not abundance of labor and capital, but knowledge and creativity (Ivanov, 2017, p. 4; Dolanay, 2022ı).

The principles of Robonomics will have enormous economic, social, and political consequences. Robonomics will not happen overnight—after the initial excitement and frustration that usually accompanies the introduction of any technology (Gartner, 2016), we will observe the gradual spread of RAIA across industries and countries. Small automated factories will be set up near the cities where customers live, resulting in lower labor costs and outsourcing to attract foreign investors as a competitive advantage. For example, a US-based company that manufactures its products in Southeast Asia, Latin America, or Eastern Europe and imports those products from the US may not be required to continue this practice. RAIA can offset lower labor costs in these region countries and it can become more economically efficient for the company to build smaller automated factories. Thus, smart production facilities that can be established in big cities/big cities in developed countries will be able to save on logistics costs and delivery time. Similarly, chatbots may replace most of the employees in customer call centers in these countries. Therefore, when a transnational company introduces RAIA, it affects not only its home country workforce, but also those abroad. Therefore, we can say that in the future we will observe the spillover effects of RAIA from developed economies to developing economies as the process of replacing low-cost workforce in developing countries with automated factories and robots in developed economies (Ivanov, 2017, p. 4; Dolanay, 2022ı).

Benefits and Challenges of Robonomics

The most obvious benefit is improved long-term quality of life as people are freed from difficult, repetitive, intellectually unchallenging work. People will experience a significant increase in their leisure time, which will enable them to pursue more creative, healthy living, pleasure, and self-actualization activities, and thus people will have more time for travel. We can expect that the increase in leisure time coupled with advances in medicine, the absence of work-related stress, will lead to improved people's standard of health and increased life expectancy (Ivanov, 2017, p. 5; Dolanay, 2022ı).

While the benefits of Robonomics for society may not seem lucrative, society will enjoy them in the long run. However, it may have to pay a high social cost in the short and medium term. Because of increased technological productivity, many job losses from RAIA may not be compensated for by newly created jobs, while the unemployed may not be so easily requalified to face the skills requirements of the robotized economy. Therefore, in the short and medium term (e.g. 10-15 years) society will face significant technological unemployment and human resource surplus. In the long run, companies and governments that can continue to demand increased labor and technology will create social unrest by causing significant psychological problems for the millions of unemployed who have too much free time and cannot find a job to fill them. This may result in the emergence of populist robophobic parties and political instability. Increasing internal and external migration can be expected to further fuel social tension. After all, if social processes are not properly controlled, the fabric of society can be damaged in places by changes in human values: when RAIA can meet their needs, people may begin to consider whether they need to communicate with other people and maintain (family) relationships (Ivanov, 2017, p. 5; Dolanay, 2022ı).

Suggested Solutions for Social Problems That Robonomics Can Bring

Previous studies of literature have focused on mandating employment, government job creation, job sharing, employment impact statements, tax policies, and financial incentives for job creation, etc. focused on some solution proposals for technological unemployment, such as: Stevens and Marchant (2017). These solutions assume that given the right incentives, the economy will create enough jobs to maintain full employment. However, they can work at intermediate stops on the way to robtoonomy as tools to mitigate risks (Ivanov, 2017, pp. 5-6; Dolanay, 2022ı).

The effects of technological unemployment will only be in question during full robotonomy, where the society has reached the full robotization of the economy and people do not need to work. Some specific solutions to the problems that robotonomy can cause may include (Ivanov, 2017, p. 6; Dolanay, 2022ı):

(1) Continuous and fluent (lifelong) free education: It is the most obvious solution to technological unemployment. People will have to accept that education does not end with finishing university, it is a lifelong process. In fact, in order to remain employable in the labor market, they will sometimes need to take regular (online) courses in their professional field every five-seven years to enroll in graduate programs completely unrelated to their previous education (Ivanov, 2017, p. 6).

(2) Entertainment, tourism, leisure activities, volunteering: Having too much free time can be psychologically challenging for many people. A robotonomy society may need activities such as leisure, tourism, volunteer activities in leisure time to occupy people's minds and fill the void left by the lack of employment activities (Ivanov, 2017, p. 6; Dolanay, 2022ı).

Universal basic income (UBI); it is widely discussed as a solution to technological unemployment (Sheahen, 2012; Santens, 2017). Basic Income Studies are discussable approach to improve at AI studies. Under the UBI program, every citizen of a country receives a fixed amount of money each month, regardless of employment status. All other social payments are stopped and replaced with UBI. The main advantage of UBI is that it will provide income and serve as a social safety net to all people in a society—even if people fail in their entrepreneurial activities, UBI will provide them with resources to sustain their families. Also, the UBI system will be easy to manage. The same amount of money will be transferred to everyone once and every month, no one will need to prove anything. Therefore, fewer government employees will be needed. There will be no need for existing heavy bureaucratic social welfare systems. UBI, on the other hand, would need a lot of resources to finance payments for every person in a country (Ivanov, 2017, p. 6; Dolanay, 2022ı).

With limited income tax revenues (due to the low number of employed people), the system can be difficult to finance. In addition, UBI can suppress many people's requests for funding to work and develop themselves. Their lack of skills thus renders them permanently unemployed. Also, if UBI is implemented in only one or a few countries without strict immigration control, there will certainly be a large influx of immigrants who will apply for citizenship to take advantage of UBI. Thus, in order to be successful without causing social pressure through migration, UBI probably needs to be introduced on a global scale, which raises the issue of ensuring a global presence (Ivanov, 2017, p. 6; Dolanay, 2022ı).

Robot-based taxation is recognized as one of the ways to finance UBI. In essence, under the robot tax scheme, every company using robots must pay taxes, and the proceeds are used to support the UBI of displaced human workers. Although robot-based taxation sounds very appealing, its impracticality makes its implementation impossible. It would be practically impossible to provide a comprehensive list of definitions and types of taxable robots. Robot manufacturers will be able to make minor changes to robots to go beyond legal definitions. People may disagree about where the line between an ordinary machine and a robot lies. Also, will an automated factory be treated as a single robot or as each piece of machinery/equipment in it? Difficulties in determining the tax base (value of the robot) and the taxable unit (robot, online bot or automated factory) make robot tax impossible in the near future (Ivanov, 2017, pp. 6-7; Dolanay, 2022ı).

Birth control/maternity patents; taking the stress out of work, having a lot of free time and getting a guaranteed UBI will encourage many families to have more children and lead to a demographic explosion. This will create additional social pressure. Because of the quaranted income, the population can grow so, new people stay out of work, new people qualifying for UBI and more financial resources are required each year to maintain the standard of living of the growing population. This may motivate some politicians to adopt a neo-Malthusian approach. The perceived "overpopulation" approach can be avoided by introducing strict birth control. The practice of requiring a family to obtain a birthright patent before having children, otherwise the fetus will suffer an abortion, may deter many families from having more than a few children. Modern society is already familiar with similar contraceptive practices (for example, China's one-child policy), and birth rates are falling significantly in many developed countries (Castles, 2003). Therefore, such policy proposals are not alien to the populations of developed countries (Ivanov, 2017, p. 7; Dolanay, 2022ı).

Advances in robotics, artificial intelligence, and (service) automation make us see that robonomics is an inevitable economic system. Therefore, economists, politicians, companies, financial institutions, education, and welfare systems, all citizens must be prepared for his arrival. The next question is: when will society reach the robotonomic stage of economic development? Only a crystal ball viewer can definitively answer this question (although not strictly correct). Robonomics will not happen overnight, but gradually, it may take place first in developed countries and then spread to the rest of the world. We can say that exciting years lie ahead (Ivanov, 2017, p. 8; Dolanay, 2022ı).

Conclusion

The studies and researches that have been done give us an idea about the social life that the production based on smart robots and made in smart factories can create in the future and the developments that may occur in the economic literature. However, the fact that national borders may disappear when every country starts production with smart factories, and even that productivity may increase as they disappear, seems to be able to provide a greater increase in welfare than the social problems that technological unemployment may cause.

For developing countries like Turkey, we can say that a window of opportunity has been opened in the implementation of radical innovation. We can say that countries that make good use of it will benefit from the increase in welfare.

References

ACATECH. (2013). *Recommendations for implementing the strategic initiative INDUSTRIE 4.0: Securing the future of German manufacturing industry; final report of the Industrie 4.0 Working Group.* H. Kagermann, J. Helbig, A. Hellinger, & W. Wahlster, (Eds.). Forschungsunion, Munchen: ACATECH (National Academy of Science and Engineering). Retrieved August 25, 2022 from https://www.din.de›resource›blob›recommen..., https://ia801901.us.archive.org›items›FinalRe...

Alçın, S. (2016). A new path for production: Industry 4.0. *Journal of Life Economics, 3*(2), 19-30. doi:10.15637/jlecon.129. Retrieved August 25, 2022 from https://wwww.researchgate.net/publication/301740147

Castles, F. G. (2003). The world turned upside down: Below replacement fertility, changing preferences and family-friendly public policy in 21 OECD countries. *Journal of European Social Policy, 13*(3), 209-227. Retrieved August 25, 2022 from https://journals.sagepub.com›doi›pdf, https://www.researchga

Crews, J. (2016). *Robonomics: Prepare today for the jobless economy of tomorrow.* USA: CreateSpace Independent Publishing Platform.

DeCanio, S. J. (2016). Robots and humans-complements or substitutes? *Journal of Macroeconomics, 49*, 280-291. Retrieved August 26, 2022 from www.elsevier.com/locate/jmacro, https://www.sciencedirect.com

Dolanay, S. S. (2022ı). Yapay Zeka, Akıllı Robotlar ve Yeni Bir Ekonomik Düzen. Presented at *The VIth international "Başkent" congress on physical, social and health sciences proceedings book*, August 27-28, 2022, pp. 245-260. Retrieved September 7, 2022 from https://drive.google.com/file/d/1-euA-zw1SfS9FFH4kvtudmi9Nno2VKCB/view?usp=sharing

Dosı, G. (1982). Technological paradigms and technological trajectories. *Research Policy, 11*(3), 147-162. Retrieved August 16, 2022 from http://citeseerx.ist.psu.edu›viewdoc›download

Drexler, K. E. (2013). *Radical abundance: How a revolution in nanotechnology will change civilization.* New York: Public Affairs. Retrieved August 25, 2022 from https://archive.org›details›i...

Ford, M. (2018). *Robotların Yükselişi: Yapay Zeka ve İşsiz Bir Gelecek Tehlikesi* (1st ed.). İstanbul: Kronik Kitap.

Freeman, C., Clark, C., & Soete, L. (1982). *Unemployment and technical innovation: A study of long waves in economic development.* London: Frances Pinter.

Frey, C. B., & Osborne, M. A. (2013). The future of employment: How susceptible are jobs to computerisation? Oxford Martin programme on technology and employment working paper. Retrieved August 25, 2022 from https://www.oxfordmartin.ox.ac.uk›academic, http://www.oxfordmartin.ox.ac.uk/downloads/academic/The-Future-of-Employment.pdf

Gartner. (2016). Gartner's 2016 hype cycle for emerging technologies identifies three key trends that organizations must track to gain competitive advantage. Retrieved May 30, 2022 from http://www.gartner.com/newsroom/id/3412017

Ivanov, S. (2017). *Robonomics—Principles, benefits, challenges, solutions.* Retrieved August 19, 2022 from https://www.researchgate.net/publication/318034992, https://academia.edu>R...

Kagermann, H., Lukas, W., & Wahister, W. (2011). Industrie 4.0-Mit dem Internet der Dinge auf der Weg zur 4.Industriallen Revolution. Inhalte der Ausgabe Nr. 13/2011, VDI Nachcrichten, Berlin.

Koç, T. Ç., & Teker, S. (2019). Industrial revolutions and its effects on quality of life. *PressAcademia Procedia, 9*(1), 304-311.

Leonhard, G. (2016). *Technology vs. humanity: The coming clash between man and machine.* London: Fast Future Publishing. Retrieved August 25, 2022 from https://dokumen.pub›techno...

McCarthy, J. (1958). Programs with common sense. In *Proceedings of the Teddington conference on the mechanization of thought processes* (pp. 75-91). Richmond, England: Her Majesty's Stationary Office. Retrieved August 25, 2022 from https://stacks.stanford.edu›file

Mensch, G. (1975). *Das technologische patt: Innovationen überwinden die Depression*. Frankfurt: Umschau Verlag.

Nelson, R., & Winter, S. (1977). In search of a useful theory of innovation. *Research Policy, 6*(1), 36-76. Retrieved August 16, 2022 from https://econpapers.repec.org

Nuroğlu, H. H., & Nuroğlu, E. (2018). Digital Transformation of Turkish Industry: Lessons From Germany's. 14th International Conference on Knowledge, Economy & Management Proceedings, 527-538, Retrieved from https://www.researchgate.net/publication/324746827

Perez, C. (2002). *Technological revolutions and financial capital: The dynamics of bubbles and golden ages*. Cheltenham: Edward Elgar Publishing.

Perez, C. (2004). Technological revolutions: Paradigm shifts and socio-institutional change. In Reinert, E. S. (Ed.), *Globalization, economic development and inequality: An alternative perspective* (pp. 217-242). Cheltenham, England: Edward Elgar Publishing. Retrieved August 16, 2022 from https://carlotaperez.org›organizational-change

Perez, C. (2011). Finance and technical change: Long term view. *African Journal of Science, Technology, Innovation and Development, 3*(1), 10-35. Retrieved August 14, 2022 from https://citeseerx.ist.psu.edu›viewdoc›download

Rifkin, J. (2021). *Third industrial revolution: How lateral power is transforming energy, the economy, and the world.* New York: St. Martin’s Griffin.

Rosenberg, N. (1975). *Perspectives on technology*. Cambridge & London: Cambridge University Press.

Russel, S. J., & Norvig, P. (2010). *Artificial intelligence: A modern approach* (3rd ed.). London & Munich: Prentice Hall. Retrieved August 26, 2022 from https://zoo.cs.yale.edu›materials›aima2010

Santens, S. (2017). Unconditional basic income as a solution to technological unemployment. In LaGrandeur, K., and Hughes, J. J. (Eds.), *Surviving the machine age: Intelligent technology and the transformation of human work* (pp. 107-116). London: Palgrave Macmillan.

Schumpeter, J. (1939). *Business cycles.* New York: McGraw-Hill.

Sheahen, A. (2012). *Basic income guarantee: Your right to economic security.* New York: Palgrave Macmillan.

Singh, G., Ajitanshu, M., & Dheeraj, S. (2013). An overview of artificial intelligence. *SBIT Journal of Sciences and Technology, 2*(1), 1-4. Retrieved August 1, 2022 from https://www.researchgate.net›

Soylu, A. (2018). Industry 4.0 and New Approaches in Entrepreneurship. *Pamukkale University Journal of Social Sciences Institute*, 32, 43-57. https://dergipark.org.tr›download›article-file

Stevens, Y. A., & Marchant, G. E. (2017). Policy solutions to technological unemployment. In LaGrandeur, K., & Hughes, J. J. (Eds.), *Surviving the machine age: Intelligent technology and the transformation of human work* (pp. 117-130). London: Palgrave Macmillan.

Swan, M. (2017). Is technological unemployment real? An assessment and a plea for abundance economics. In LaGrandeur, K., and Hughes, J. J. (Eds.), *Surviving the machine age: Intelligent technology and the transformation of human work* (pp. 19-33). London: Palgrave Macmillan.

Tutorialspoint. (2022). Simply easy learning at your fingertips. Retrieved August 26, 2022 from www.tutorialspoint.com, https://www.dcpehvpm.org›BCA›BCA-III›art...

Yüksekbilgili, Z., & Çevik, G. Z. (n.d.). A current and future-based analysis of Turkey’s place in the context of Industry 4.0. Retrieved August 6, 2022 from https://dergipark.org.tr›pub›fesa›issue