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INDUSTRY 4.0 REVOLUTION AND ITS IMPACTS ON LABOR MARKETS

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ABSTRACT
All the Industrial Revolutions in the historical process affected the labor markets and changed the qualifications sought in human capital. However, the possible impacts of the new mode of production, which was put forward in Germany in 2011 and named as the Industrial 4.0 Revolution, especially in the labor markets would be much larger than previous industrial revolutions. This study aims to determine the impacts of the Industry 4.0 Revolution on labor markets on a theoretical basis. The main finding of the study is that the Industrial 4.0 Revolution would lead to major changes in the qualifications required for employment. As a result of the rapid change in the Internet of Things, artificial intelligence, robotics technologies, and algorithms; the future workforce would have to be individuals with multidisciplinary education. These changes would affect not only unqualified employees but also skilled employees such as designers, engineers, and lawyers.
Keywords: Industry 4.0, Labor Market, Industrial Revolutions

ENDÜSTRİ 4.0 DEVRİMİ VE EMEK PİYASALARINA ETKİSİ

ÖZ
Tarihsel süreçte yaşanan tüm Sanayi Devrimleri emek piyasalarına etki ederek, beşeri sermayede aranan niteliklerin değişmesine sebep olmuştur ancak 2011 yılında Almanya'da ortaya atılan ve Endüstri 4.0 Devrimi olarak isimlendirilen, yeni üretim tarzının ekonomik hayatta ve özellikle de emek piyasalarında yaratacağı olası etkiler ilk üç devrimden çok daha büyük olacaktır. Bu çalışma Endüstri 4.0 Devrimin emek piyasalarına etkilerini teorik temelde tespit etmeyi amaçlamaktadır. Çalışma sonucunda elde edilen temel bulgu Endüstri 4.0 devriminin istihdam için aranan niteliklerde büyük değişimlere sebep olacağıdır. Nesnelerin interneti, yapay zeka, robotik teknolojiler ve algoritmalardaki hızlı değişim sonucunda gelecekteki işgücünün multidisipliner eğitim almış bireyler olması gerekecektir. Bu değişimler sadece vasıfsız çalışanları değil, tasarımcı, mühendis, avukat gibi vasıflı çalışanları da etkileyecektir.
Anahtar Kelimeler: Endüstri 4.0, Emek Piyasası, Endüstriyel Devrimler

Introduction
The first substantial change in mankind's lifestyle took place throughout its transition from hunting and gathering to agriculture approximately 10,000 years ago. The agricultural revolution was followed by the First Industrial Revolution that began in the second half of the 18th century. The First Industrial Revolution lasted during the period from 1760 to 1840 which was marked by the invention of the steam engine and the construction of railroads. Along with the Second Industrial Revolution that began at the beginning of the 20th century, the mass production style was formed by the implementation of electricity and assembly lines. The Third Industrial Revolution began

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in the 1960s and brought about the development of semiconductors, personal computers and the Internet towards the end of the century. The Fourth Industrial Revolution was first coined at the 2011 Hannover Fair and is rising over digitalization, but it would indeed have a much wider scope and impact. Breakthroughs in that intertwined physical, biological and digital fields ranging from gene sequencing to renewable energy, from nanotechnology to quantum computing technologies tend to occur simultaneously.

The question of how to shape and steer the new technology revolution; namely, Industry 4.0, poses the most intense and important of the many diverse and surprising challenges faced as of today. The speed and breadth of this new revolution are still not fully understood. The interconnectedness of technological improvements such as billions of mobile devices, computers with increased processing and storage capabilities, easier access to information, artificial intelligence, the Internet of things, autonomous carriers, three-dimensional printers, nanotechnology, and quantum computers in many areas, especially production processes, has changed our lifestyle. We are witnessing deep changes that affect all sectors in economical aspects. New business models are emerging, local institutions are collapsing or undergoing major changes, whereas production, consumption, transportation systems are being reshaped (Schwab, 2016).

The Industry 4.0 revolution differs from the other previous revolutions since it requires harmonization in many disciplines and discoveries in many different fields. Nowadays, digital manufacturing technologies and the biological world can interact with each other. Our personal computers would soon become an integral part of our personal ecosystem. Three physical, digital and biological trends would emerge along with the Fourth Industrial Revolution. Physical trends include autonomous vehicles, three-dimensional printers, advanced robotic applications, and new materials. The most important of digital trends is the Internet of things that would bridge the gap between physical and digital applications. The Internet of things stands for a technology within which connected technologies and various platforms are made possible between objects and people. In the biological field, especially genetic innovations would come to the fore.

In the following sections of the study, firstly the economic outlook before the Industrial Revolution is explained briefly, then the impacts of the first, the second, the third, and the fourth Industrial Revolutions on labor markets are determined and the study is completed with the conclusion section.

Economic Life During Pre-Industrial Revolution Era

Prior to the 1800s, per capita income varied from society to society and from period to period. Nonetheless, it was not possible to speak of an upward trend in any of the societies. For instance, lucky members of relatively wealthy societies, such as 18th-century England or the Netherlands, had material lifestyles equivalent of the Stone Age. But the large masses of people in East and South Asia, especially in China and Japan, were probably living under considerably poorer conditions than the Stone Age conditions. There was no improvement in the quality of life in other observable dimensions. The average life expectancy in the year 1800 was not any longer in comparison to hunter-gatherer societies, it was ranging merely between 30-35 years. Furthermore, hunter-gatherer societies were egalitarian. Material consumption did not change much among society members. Nevertheless, inequality in agricultural economies that dominated the

world as of 1800 was widespread. While only a few people had tremendous wealth, millions could barely feed themselves. In short, even according to the most basic criteria of material life, the average welfare level plunged drastically since the Stone Age until the year 1800 (Clark, 2007).

The Neolithic Revolution stands for the great economic transformation of the pre-industrial period. The transition from hunter-gatherer societies to economies based on human-grown plants and domesticated animals is still disputable as to the extent to which such transition affected living standards. Diamond (1987) even claimed that people were forced to choose between limiting the population and increasing food production and that societies chose to increase food production, which pushed mankind into war and hunger.

The slow pace of technological progress accounts for the material life conditions which have not improved for hundreds of years. As long as technology advances slowly, there is no possibility of permanent improvement of material conditions. It is certain that the economy of human societies before the year 1800 was nothing but an organic (natural) economy. The factors that determine the living conditions of animals and humans are of the same type. This is called *the Malthusian Trap* (Malthus, 1798).

In the Malthusian economy before the year 1800, economic policy was turned on its head. The vice of today were the virtues of that time; whereas today's virtues were the vice of that time. War, violence, disorder, bad harvest, the collapse of public service infrastructures, poor sanitation, which are indicative of failed modern states, were the friends of human beings before 1800 according to the Malthusian economy. They reduced population pressures and promoted material living conditions. Today's policies, on the other hand, led to population growth at that time, impoverishing societies.

The Industrial Revolutions

The stagnancy of the pre-industrial world, which constitutes a major part of human history, ceased to exist with an unprecedented event in European society between the years 1760-1900. This was the Industrial Revolution, a rapid economic growth triggered by a steady increase in the yield of production for the first time, which was made possible by advances in knowledge.

As a result of the industrial revolutions that began with James Watt's discovery of steam power and its use in machines, totally four industrial revolutions have taken place throughout the historical process. In the First Industrial Revolution, the transition from the agricultural economy to the industrial economy was realized; in the Second Industrial Revolution, the transition to petroleum and electricity as the primary sources of energy was realized; in the Third Industrial Revolution, computers began to be utilized, and in the Fourth Industrial Revolution, cyber-physical systems and smart technologies are being adapted to the industrial process.

The First Industrial Revolution

As Wrigley (1990) asserted, the Industrial Revolution represented the beginning of the transition from a largely organic production system to the increasingly inorganic systems of the modern world. In the world before the 1800s, the main portions of food, energy, clothing, and construction materials were produced using organic methods in the agricultural sector. The Industrial Revolution, with its dependence on coal and iron, was

the first step towards an economy that was increasingly dependent on the removal of energy and mineral stocks from the ground, and less dependent on the production through plants and animals.

The organic production system has three important characteristics. The first is that, in the long run, all outputs drawn from the system must be offset by equivalent inputs. This situation posed a constraint on potential output (Clark, 1992). The second characteristic is that, in contrast to inorganic systems in which the lowest possible increase in productivity is zero, the yield increase is negative in organic systems unless the invention is made. The third and final feature of organic production systems is that it is quite difficult to conduct experiments to develop better production methods. Especially in the agriculture and livestock sectors, the main difficulty of performing such experiments is that the production periods are longer and sometimes it takes years in the case of animals (Palumbi, 2001).

The Industrial Revolution emerged only thousands of years after the emergence of institutionally stable economies because, in the past years, institutions themselves interacted with and changed the human culture. Living in stable societies for thousands of years under stringent Malthusian pressures that rewarded effort, accumulation and constrained fertility encouraged the development of a number of cultural forms that facilitated modern economic growth (Clark, 2013).

Various historians, economic historians, economic theorists have incorporated the Industrial Revolution into three basic types of growth theory (Clark, 2013);

Exogenous growth theories; a feature outside the economy (such as the legal institutions of a society or the relative scarcity of different inputs of production) has changed. This change has led to an increase in production techniques by potential innovators within economies. North and Weingast (1989) argued that the arrival of constitutional monarchy in the United Kingdom as of 1689 was a fundamental political innovation that welcomed modern economic development. Mokyr (2005) claimed that the Enlightenment era in Europe was one of the main stimuli of the Industrial Revolution.

Multiple equilibrium theories; a shock (such as illness, war, the discovery of new countries) occurred and steered the economy from a bad, stable balance to a good, dynamic balance of the modern world.

Endogenous growth theories; a feature within the economic system evolved during the long pre-industrial period and eventually created the necessary prerequisites for modern economic development. Thus, the Industrial Revolution was a process that coincided with the first human appearance and it was only a matter of time before the economic preconditions for rapid technological progress were realized. According to the thinkers defending this theory, the main difference of the British economy in 1760 from other economies in the same period is the evolution in the size and characteristics of the population (Kremer, 1993).

The industrial revolution is the most important development of humankind within the last three centuries. Nonetheless, it is not only a historical period. It continues to reshape the contemporary world. Even the oldest industrial societies, for instance, are still trying to adapt to their impact on family relations and the environment. Emerging industrial countries, such as the People's Republic of China, changed the structure in accordance with their own characteristics and repeated the original process of the First

Industrial Revolution. The First Industrial Revolution began about two hundred years ago and changed the world. It changed people's lives by focusing on changing new methods and organizational structures of goods and services (Stearns, 2013).

The Industrial Revolution is unique in the world's history in such a way that sudden and rapid increase in productivity has never been seen in any previous economy. The productivity in any competitive economy, or in any sector of the economy, can be calculated with a very simple formula: The ratio of the average cost per unit of production inputs to the average output price per unit. Productive economies produce more output per input unit. The production efficiency calculated according to this formula is entering a rapid increase process around 1790 for the first time. From the 1790s to 1860s, the productivity growth rate was still only 0.5 percent per year. Although this rate of increase was considerably less than the rate of increase in productivity in the modern era, it was an unprecedented period of a continuous increase in productivity.

There are two main notions of the First Industrial Revolution. The first notion involves the traditional view of Ashton and Landes. According to this view, the Industrial Revolution caused major changes in the British economy and society. This traditional view was challenged by a new perspective of Crafts and Knick Harley. In the opinion of Crafts and Knick Harley, the First Industrial Revolution was a much narrower phenomenon since technical changes have occurred in certain industries, such as the cotton and iron industries. The remaining lines of business were plunged into premodern backwardness (Temin, 1997). The technological change of the first Industrial Revolution took place mainly between the years 1760-1830. This period was called "the Industrial Revolution" in Ashton (1948).

According to Crafts (1996), there are three main features that stand out in this period;

- Overall economic growth has been slow but steady, reaching its peak point in the mid-19th century.
- Despite the rapid developments in the cotton and iron industry, industrial output growth has posed rather stable growth.
- Finally, total factor productivity growth has been very slow at first and has never been able to capture the total factor growth rates captured in the 20th century.

Table 1. Resources of the Industrial Revolution 1760-1860

Sectors	**Productivity Growth Rate (%)**	**Share in National Income (%)**	**Contribution to Productivity Growth Rate (%)**
Whole textiles	-	0.11	0.24
Cotton	2.4	0.06	0.18
Woolen	1.1	0.04	0.05
Iron and steel	1.4	0.01	0.02
Coal mining	0.2	0.02	0.00
Transportation	1.2	0.08	0.09
Agriculture	0.3	0.30	0.07

Source: Clark, 2013, p. 255

Table 1 indicates the overall productivity growth rates between 1760 and 1860, as well as the contributions of the major sectors through which known inventions have been made. As can be seen in the right-hand column of Table 1, the increase in productivity in textiles constitutes the largest part of the productivity increase over the course of a century. Coal and iron have small additional contributions. Other major contributors include transportation and agriculture.

The textile was the leading sector in the First Industrial Revolution. Efficiency in transforming raw cotton into clothing increased fourteenfold from the 1760s to the 1860s, meaning a growth rate of 2.4 percent per year, higher than productivity growth rates in most modern economies. In the 1860s, the output of the economy was approximately 27 percent higher than the output level that would have been without those inventions, only by courtesy of the inventions in the textile sector (Clark, 2013).

The revolutionary nature of economic change in this period underlies the rapid structural changes in employment and, with great success, the prevention of real income levels from declining despite increasing population pressure (Crafts, 1996).

The meaning of the Industrial Revolution is not only the acceleration of economic growth but also the acceleration of economic growth due to and through economic and social transformation. The pioneering entrepreneurs focused their attention on qualitatively new production techniques (machines, factory systems, etc.).

Although the First Industrial Revolution is identified with Britain, it cannot be explained only in British circumstances. Because this country is part of a wider economy, which can be called the European economy or the world economy of European maritime countries. Britain was part of an extensive network of economic relations, including several 'developed' regions, some with or without the potential for industrialization, regions with 'dependent economies', as well as certain parts of foreign economies that have not yet had significant relations with Europe. These dependent economies are partly comprised of the former colonies (such as those in the Americas) or commercial and sovereignty points (such as in Asia), and partly of economically specialized regions (such as some parts of Eastern Europe) to meet the needs of 'developed' regions. The 'developed' countries and the dependent countries were interconnected by a certain division of labor in economic activities: On the one hand a relatively urbanized region, on the other hand, regions producing and largely exporting agricultural products. These relationships - trade, international payments, capital transfers, migration and so on - can be expressed as a system of economic circulation. Although the 'European economy' experienced significant economic downturns and turmoils particularly during the l4th, 15th and 17th Centuries, they have shown obvious signs of enlargement and dynamic development for several centuries. Attributing the Industrial Revolution to various developments only in European economies would not be appropriate. Overseas discoveries of the 15th and 16th centuries and the 'scientific revolution' in the 17th century are very crucial events in shaping the infrastructure of the Industrial Revolution. We can talk about a few important events that triggered the Industrial Revolution. The first of these events, supported by the systematic and even intensive assistance of the state, provided the spark and became the 'driving sector' of the industry along with cotton weaving. Secondly, exports also led to significant improvements in maritime

transportation. Thirdly, the domestic market provided a broad basis for a widespread industrial economy and (through the urbanization process) encouraged major innovations in domestic road transport; furthermore, it formed a solid foundation for the coal industry and some important technological innovations. And consequently, the state provided systematic support for traders and manufacturers, as well as technical inventions and crucial incentives for the development of the investment goods industry.

The human impacts of the First Industrial Revolution were also large. The labor force in industrial society differs in many aspects from its pre-industrial form. Firstly, it is a labor force with an overwhelming majority, with no significant sources of income other than the monetary wage earned for work. On the other hand, the labor force of the pre-industrial period was largely composed of families with the land they rented, craft workshops or wages which supported the direct ownership of the means of production. Besides, employees whose only relationship with the employer is monetary in essence should be distinguished from 'servants' pre-industrial dependent people who have more complex and unequal human and social relationships with their master. The Industrial Revolution introduced the concepts of 'worker' and 'master' in rapidly increasing numbers to benefit the expanding middle class. Secondly, the industrial labor force, and especially the laborforce in mechanized plants, imposes a regularity, routine and monotonicity, unlike the pre-industrial working order, in which occupations in a rational division of labor have not been applied, contingent upon changes in seasons or weather conditions. Thirdly, the industrial-era laborforce took place in an increasingly large urban environment. Fourthly, the pre-industrial experience, tradition, logic, and morality were not sufficient for the type of behavior required by a capitalist economy. This contradiction between the moral economics of the past and the logic of capitalist economics that emerged after the Industrial Revolution was particularly evident in the social security domain. The traditional view that still exists in all classes of rural society and in the internal relations between the working class groups claimed that an individual has the right to earn the wage to provide for his livelihood and to be cared for by the society in which he/she dwells. The view of middle-class liberal economists was that people should accept such jobs offered by the market wherever they are and that a sensible person should take measures through individual or voluntary collective savings and insurance (Hobsbawn, 2003).

The Second Industrial Revolution

Although some characteristic events of the Second Industrial Revolution can be dated to the 1850s, which was called the Industrial Revolution, it is usually dated between 1870 and 1914. After the year 1825, innovative and revolutionary inventions began to slow down. However, in the last thirty years of the 19th century, innovative inventions began to gain momentum again.

The first stage of the British industrialization had reached its limits towards the middle of the 19th century. A new phase of industrialization in this period was about to take over and provide a more solid foundation for investment goods industries based on coal, iron, and steel for economic development. The crisis period of textile-based industrialization was a period of charge for coal, iron, and steel as well as railway construction. There were two connected reasons for this development. The first was

industrialization, which provided a fast-growing market for investment goods that could not be imported in large quantities from another location outside the United Kingdom in other countries of the world and yet could not be produced in sufficient quantities within the country. The second reason was not related to the increase in demand. This was due to the increasing pressure from the enormous accumulation of capital for lucrative investments.

The fashion of the weaving mills of the 1800s began to be outdated in the 1840s. By the year 1850, the railways had reached a level of performance that could not be significantly improved until steam power was abandoned in the mid-20th century. The organization and methods, as well as the use of new and science-based technology of the railways, were unprecedented. There are three crucial impacts of these changes on the direction of the British economy. Firstly, it was the revolution in the heavy industrial sectors that provided the economy with abundant iron and, more importantly, steel for the first time. The tremendous increase in iron production was also due to non-revolutionary innovations. These innovations have led the sector's production capacity level far above the actual output, thus created constant pressure to lower the price of iron, which was subject to major fluctuations for other reasons. The second important change in the British economy throughout this period was the remarkable improvement of employment in all areas besides the mass labor force shift from low-wage jobs to high-wage occupations. Such a shift in employment was due to the developments in the employment of skilled labor in the fields such as investment goods industries, engineering, machinery, and shipbuilding. The third and final development was the remarkable increase in the export of the British capital. Capital issuance had reached such great value so that interest and dividend revenues from foreign investments allowed a drastic increase in investments in these countries without requiring further capital exports.

Along with the Second Industrial Revolution, once the development of steam power as one of the reasons for the dawn of the First Industrial Revolution was completed, and the electricity was discovered by Michael Faraday. The discovery of electrical energy involves a crucial invention that would change the world's history. In this regard, the introduction of electricity in factories for heating as well as lighting purposes significantly reduced the risk of fire (Collin, 1989).

With the Second Industrial Revolution, the United Kingdom entered a period of full industrialization. Its economy was no longer in a dangerous equilibrium on a narrow platform comprised of several sectors. It was broadly based on the foundation of the production of investment goods, facilitating the expansion of modern technology and business organization into a wide range of sectors.

There are two fundamental differences between the First Industrial Revolution and the Second Industrial Revolution. The first of these differences involves the disparities among the countries which participated in both Industrial Revolutions. The First Industrial Revolution involved only a single country (the United Kingdom), whereas other countries also appeared on the world stage beside the United Kingdom by the Second Industrial Revolution. Some of those countries were not of Western society. Although not of the Western world, Japan and Russia are the leading countries that have begun to attain the economic power on a global scale along with the Second Industrial Revolution. The industrial revolutions in Japan and Russia have had various impacts on

emerging economies, some of which were under the British influence (such as Canada). Industrialization was initiated in both countries by the 1870s and they were among the ten most industrialized nations in the World as of the 1950s (Stearn, 2013).

The second main difference was related to technological development. Technology means knowledge. Kuznets (1965) stated that modern economic growth depends upon the growth of useful information. The First Industrial Revolution had a very limited scientific base. In the first revolution, the chemical industry without the development of chemistry, the iron industry without the development of metallurgical science, and the machinery industry without the development of thermodynamic science were created (Mokyr, 1998).

Revolutionary and innovative technological improvements played a critical role in the First and the Second Industrial Revolutions, although there was a fundamental difference between technological innovations that took place in those two periods. The adaptation of steam power to industry and the development of the iron industry were revolutions that had profound impacts on the production processes at macro levels. Nevertheless, the introduction of electrical energy, the fundamental innovations of the Second Industrial Revolution, the development of material technologies, the rapid technological leaps in the chemical and pharmaceutical industries had been increasing the effectiveness of research and development activities by influencing micro-based activities rather than inflicting a major impacts on the production processes (Mokyr, 1998).

The Third Industrial Revolution

Until the year 1974, the world bore witness to two Industrial Revolutions. In the first one, which began in the third quarter of the 18th century, a process was experienced with machines substituting steam engines, spinning wheels, and hand tools. In the Second Industrial Revolution; electricity, internal combustion engines, chemicals based on science, efficient steel casting took place. There are fundamental differences as well as fundamental similarities between the two Industrial Revolutions. The most important of these differences mentioned in Table 2 is that scientific knowledge plays a guiding role in the establishment and direction of technological development following the year 1850.

As Mokyr (1990) pointed out, we witness a period of rapid and unprecedented technological change in both revolutions. A number of major inventions have laid the framework for the growth of micro-inventions in agriculture, industry, and communications.

Table 2. Main Characteristics of Industrial Revolutions

	1st Industrial Revolution	**2nd Industrial Revolution**	**3rd Industrial Revolution**

Dominant technology and raw material	The steam engine, power loom, iron processing	Electricity, chemistry, combustion engine, assembly line, synthetic materials	ICT, microelectronics, new materials, renewable raw materials, cleaner technology, biotechnology, recycling.
Dominant energy source	Coal	Coal, oil, nuclear power	Renewable energies, energy efficiency
Transport/communication	Railway, telegraphy	Car, airplane, radio, TV	High-speed railway systems, internet, mobile communication
Society/state	Freedom of trade, constitutional state	Mass production, mass society, parliamentary democracy, the welfare state	Civil society, globalization, global governance
Core countries	UK	USA, Japan, Germany	European Union, USA, China, Japan

Source: Jänicke and Jacob (2009)

Since the key factor behind the industrial society is the distribution and production of energy, information technologies mean the same for the Third Industrial Revolution, whatever new sources of energy meant for the previous industrial revolutions ranging from the steam engine to electricity, from fossil fuels to nuclear energy.

The distinctive feature of today's technological revolution involves the irrelevance of the origin of knowledge and information. It is essential to apply the generated information and knowledge to information processing and transmitting devices and to establish a link between the use of innovation and innovation through which they both feed on. After all, the spread of technology while being adopted and redefined by its users increases technological power. New information technologies are not only instruments to be applied, but also processes to be developed (Dizard, 1982; Forester, 1985; Hall and Preston, 1988).

Historically, there is another feature that has marked the information technology revolution compared to its predecessors. This feature is that the technological revolution is realized only in a few societies. Compared to other parts of the planet, it is usually experienced in an isolated space and in a relatively limited geographical area (Mokyr, 1990).

The revolution in information technologies has risen over a number of fundamental revolutionary improvements. The first of these improvements is micro-engineering. The scientific and industrial pioneers of electronic-based information technologies began to be encountered before the 1940s (Mazlish, 1993). Nevertheless, major technological breakthroughs in electronics took place during and after the Second

World War. Nonetheless, these new information technologies became widespread only in the 1970s, after which the synergistic developments accelerated and converged within the framework of a new paradigm (Castells, 2003).

The second important circumstance that led to the Third Industrial Revolution was the invention of the Internet. The emergence and development of the Internet in the 1970s is the product of a unique combination of military strategy, a great collaboration of science and technological entrepreneurship (Abbate, 1999; Naughton, 1999). The third crucial phenomenon is the acceleration in network technologies and computerization. In the late 1990s, the communication power of the Internet, along with new developments in the field of telecommunications and computers, led to another technological shift towards the spread of computerization through interconnected computing devices that emerged in a wide variety of formats. In this new technological system, the power of computers stems from their ability to being connected to a communication network.

According to Anderson (2012), the Third Industrial Revolution is a combination of digital production and personal production. There are two aspects to this production. Firstly, digital tools and types of equipment are used more and more for both designing and production purposes. This increases the possibility of sharing and collaborating designs over long distances. Secondly, it enables the production plans to be sent directly to machines in direct digital production industries, enabling a wider production source to be activated than the individual production mode. In this regard, scale advantages are utilized.

According to Rifkin (2011), direct digital production is not a cause but a consequence of the Third Industrial Revolution. The revolution was triggered by the change in the communication infrastructure. The Third Industrial Revolution changed fossil fuel-based organizations in the economic, social and political life of the society. Society is on the verge of a transition from hierarchical power to lateral power. According to Rifkin (2011), society is also evolving towards a society in which green buildings, green production, electric vehicles can be formed and everyone can be their own producer.

Peer-produced commons are other impacts of the Third Industrial Revolution in the production processes besides digital production. The concept involves a community of thousands of volunteers collaborating in a complex economic project. As Benkler (2002) stated, peer-produced commons involve a third type of production model that differs from markets that are adjusted in accordance with price signals or firms established with hierarchical command and control mechanisms. Peer-produced commons are of a system built on lateral relationships. According to Benkler (2002), peer-production is backed by four important features of the internet-based economy. The first of these features is that information is a non-competitive commodity. The use of information by one person does not prevent another person from using the same information at the same time. The second important feature is that information can be produced at very low costs. Many materials are used in the production of physical goods. Direct digital production has reduced costs to a great extent. The third important feature is related to the human factor. Today, the contribution of human capital to production is in the form of the emergence of increasingly creative ideas. The last feature involves information exchange

and communication. This feature is key to the coordination of the production process and has become a cheap and effective tool by courtesy of the presence of the Internet.

The Fourth Industrial Revolution

Industrial revolutions have been important turning points in history since the 18th century. Each new revolution changes the way of doing business and the foundation of life and determines the level of development of countries. The most recent revolution brought about by rapid technological developments, namely, Industry 4.0, will influence the whole world due to its economic and social benefits.

The industrial sector is at the center of economic growth for many countries. Over the last two decades, production lines have shifted from developed countries to rapidly growing economies such as China and India due to low labor costs. In many European countries, the share of industry in the gross domestic product (GDP) declined by 10 - 15 percent. The total industrial production index values for 27 countries in Europe increased from 550 to 620 between the years 2006 and 2011, whereas China increased the production index values from 170 to 580 within the same period, then the western world began to take precautions. Germany, which has come to the fore with its conducted studies, has emphasized that China can be prevented if the speed of product launch to the market is increased, flexible production model can be applied and efficiency would be increased with an integrated system proposal. In order to speed up the outlet to markets, it is stated that time-saving computer simulations, product differentiation, and withdrawal of labor (muscle) factor that increases the production costs are required. When muscle power is withdrawn from production, costs and manufacturing errors would decrease; hence productivity would increase. With this integrated system proposal, the Fourth Industrial Revolution was realized (MTSO, 2017).

The concept of "Industry 4.0", which is based on the high technology and innovation used for the first time in 2011 at the Hannover Messe Fair, the world's largest fair in Germany, is attracting more attention. The German expert team at the fair reported the dawning of a new era of the industrial revolution, then the German government transformed these ideas into a strategy of the state. With this strategy, Germany's objective is to become the smart factory of the world by preventing a large portion of the information and communication technologies and production chain from shifting towards the mentioned countries.

The Fourth Industrial Revolution is a way of describing a series of both ongoing and upcoming transformations in systems that surround our environment. This revolution is as important in human development as the First, Second and the Third Industrial Revolutions, and is again driven by the increasing interaction of a number of extraordinary technologies. The high technologies driving the Fourth Industrial Revolution are based on the information and systems of the previous industrial revolutions, especially the digital possibilities of the Third Industrial Revolution. Although digital technologies with computer hardware, software, and networks at their core are not newly emerged, they are becoming more integrated and more advanced as opposed to the Third Industrial Revolution.

The Fourth Industrial Revolution, nevertheless, is not only concerned with smart and connected machinery and systems. Its scope is much wider and deeper. It is a series

of breakthrough waves ranging from gene sequencing to nanotechnologies, from renewable energy to quantum computers. What distinguishes the Fourth Industrial Revolution from the previous industrial revolutions is that it is the fusion of these technologies and their interaction across physical, digital and biological fields.

According to Schwab (2018), the most important and comprehensive opportunity presented by the Fourth Industrial Revolution is to look beyond technologies as either simple instruments or inevitable forces, finding ways to the greatest number of people the ability to affirmatively influence their families, their organizations or their communities by affecting and directing the systems that surround our environment.

However, there are two main factors that could limit the potential effectiveness and consistency of the Fourth Industrial Revolution. The first of these is that the necessary leadership levels and understanding of change in all sectors in comparison to the need to rethink our economic, social and political systems to meet the Fourth Industrial Revolution are low. Secondly, the world suffers from a lack of coherent, positive, and common narrative that reveals the opportunities and threats of the Fourth Industrial Revolution (Schwab, 2016).

In order to fully realize the benefits of the new technologies that emerged with the Fourth Industrial Revolution, the world must face three difficult tasks as quickly as possible. The first task is to ensure a fair distribution of the benefits of the revolution. The wealth and prosperity of the previous three revolutions were unevenly distributed, and this continues to this day. From the 1970s onwards, although inequality between countries has declined considerably due to the rapid development of nations with rising markets, inequality within countries is boosting. The second task is to manage the externalities of the Fourth Industrial Revolution within the context of the risks and damages it poses. In previous industrial revolutions, little efforts were made to protect fragile societies, the natural environment and future generations from unwanted consequences, the cost of change, second-order impacts, or the consequences of deliberate abuse of new opportunities. Upon considering the uncertainty about the power of the new revolution's technologies and their long-term impacts on complex social and environmental systems, the magnitude of the problem with externalities and undesirable consequences can be more easily understood. The third task is to ensure that the last revolution is human-led and human-centric (Schwab, 2018).

Technological Changes Created by the Fourth Industrial Revolution

The concept of Industry 4.0 is defined as the integration of each part of the supply chains in the production phase beyond automation within itself, and the interaction of machinery with suppliers and customers (intelligent production) (Kabaklarlı, 2016). It is possible to summarize the technological changes resulting from the Fourth Industrial Revolution under four headlines including expanding digital technologies, rearranging the physical world, changing mankind and integrating the environment.

Expanding Digital Technologies

The digital revolution, which is also known as the Third Industrial Revolution, has enabled us to create a world interconnected with general computing, software development, personal computers as well as widespread digital infrastructure and the Internet. Today, researchers and entrepreneurs are making efforts that would increase our

opportunities and expectations in computing. The most important of these studies are new data processing technologies, blockchain technologies and the Internet of Things.

Rearranging the Physical World

Within the Fourth Industrial Revolution, technologies that benefit from increased bandwidth, the expansion of cloud services, and the increased speed and power of graphic processing techniques are entering industrial production, urban transport infrastructure, and interactive devices. The most important of these technologies are artificial intelligence and robotics, advanced materials, additive manufacturing, and multidimensional printers.

Changing the Mankind

The lines between technologies and assets are now becoming quite vague. The main reason for this is more about the possibility of new technologies becoming literally part of our daily lives. Technologies have already begun to affect the way we comprehend ourselves and how we think of each other. Some of the technologies to be developed as a result of the Fourth Industrial Revolution would function within our structure and change the way we interact with the world.

Integrating the Environment

The Fourth Industrial Revolution will be based on technologies that provide opportunities for infrastructure development, operating global systems and opening new paths to the future. Energy production, storage, and transportation facilities, especially based on sustainable materials and practices, are ready to reduce the dependency on fossil fuels and to distribute low-cost electricity for people and technologies. Although geoengineering is still highly theoretical, it forces us to think about what it takes to manage the climate and how we can best face the global risk of boosting atmospheric temperatures.

Impact of the Fourth Industrial Revolution on Labor Markets

In addition to its geopolitical and environmental impacts, technological revolutions can also influence the social landscape by changing the skills required to be considered successful. Since the first industrial revolution, there had been a gradual change in the definition of labor. The first wave of change was on craftsmanship. While the craftsmen acquired their production skills during a long apprenticeship period, they were responsible for all processes from the beginning to the end of the production, from the discovery of raw materials, the purchase, the training of apprentices and journeymen, to marketing and sales. Along with the industrialization process experienced with the development of technology, the craftsmanship left its place to the workers in a wider production process and a technical division has been experienced in the production processes. The planning and implementation of the work were separated by the Taylorist methods and the worker was separated from all kinds of skills and mental activities and became disqualified. Although it turned the workers into machinery extensions, the Fordist production style was developed since Taylorist methods caused the workers to waste time as a result of the commuting among the machines. In the Fordist production style, machinery and workers were relocated to minimize waste of time. The improving technology was included in the production processes along with the post-Fordist production style, and there had been an increase in the qualifications required in the labor

force. With the Industry 4.0 revolution, there has been an unprecedented increase in the qualifications required of employees.

According to Brynjolfsson and McAfee (2014), there are three major economic mechanisms to explain technological unemployment: inelastic demand, rapid change, and severe unemployment. If technology leads to more efficient use of the labor force, there is no need to reduce the demand for the labor force. Decreasing costs would also lower product prices. Cheap products increase demand. This leads to an increase in demand for the labor force. The condition of whether or not this cycle is experienced in real life is that the demand is elastic. Nonetheless, the demand for some goods and services is not elastic. Therefore, lower prices do not affect their demand. Not only on the basis of product categories but also the sectors within the economy as a whole can face inelastic demand. Employment declined, as productivity increased over time in the agricultural and manufacturing sectors. Decreasing prices and the increase in the quality of the products did not lead to a rise in demand high enough to offset the improvements in productivity. The second explanation, namely; rapid change and inadequate adaptation, was an issue that was particularly noted by Keynes. At the core of this fear is the inability to adapt to the pace of technological change of our skills, organizations, and institutions. If a business type ceases to exist due to technology or the need for a particular skill category is completely finalized, these workers need to acquire new skills and find new jobs. This, indeed, takes time, and those workers may become unemployed during this time. The third argument about technological unemployment is closely associated with the second explanation, namely, inadequate adaptation. There is a lower level of wages that people would earn from their efforts. This is a factor that can lead to unemployment at a minimum level. If the employer and the employee fail to find a lucrative area that requires the knowledge and skills of that worker, the worker may be unemployed for a long time. Severe unemployment occurs if such unemployment resulting from inadequate adaptation becomes permanent.

According to Leonhard (2018), the upcoming conflict between the mankind and the machine would be intensified and exponentially increased through the integrated impacts of the ten major shifts, namely; digitalization, mobilization, screenification, disintermediation, transformation, intelligization, automation, virtualization, anticipation, and robotization.

In light of these shifts, one thing is certain: New technologies will dramatically change the nature of working in all sectors and professions. The main uncertainty involves the extent to which automation would replace the workforce.

In order to comprehend the impacts of technological developments on employment, we need to understand two opposite impacts. Firstly, as technology-induced deterioration and automation substitute labor for capital and force workers to become unemployed or use their skills elsewhere, a devastating impact occurs. Secondly, such devastating impact is accompanied by an improving effect, and the demand for new products and services is increasing, triggering the emergence of new professions, jobs, and even sectors. Here, the net impact of the Fourth Industrial Revolution on labor markets can vary depending on which of the two opposite impacts is greater.

The main objectives of the Western economies with the new mode of production are to reverse the ongoing downward trend in production as well as employment and to

provide the emerging sectors with employment opportunities. As a matter of fact, in the non-financial sectors in Europe, the total employment rate decreased from 27% in 2007 to 22% in 2009 (EFFRA, 2013, p. 110). Under the leadership of Germany, which is the locomotive power of European countries, the main aim of the new production style is to create new job opportunities that would mitigate the increasing unemployment by substituting the cheap labor-based production style known as Asian production style with smart production style. In the road map prepared by Europe for the year 2020, it is planned to realize the production of the future in a multisectoral and multidimensional manner in an economic, social and environmentally-sustainable manner. New production style will be effective in many manufacturing sectors such as automotive, microelectronics, telecommunications, textile/clothing, health products, household appliances, electrotechnical equipment, machinery, etc. The adaptation of these sectors to the new mode of production depends on the development of the forward and backward-connected sectors. In this regard, Europe relies on high-tech and high-skilled manufacturing systems and processes and engineering services in terms of more advanced materials, biomaterials, raw materials, nanotechnology, etc. (EFFRA, 2013, p. 110). In this context, since the new production style would allow all sectors to develop at the same time, it will provide employment opportunities for Europe and will have an impact on reducing unemployment.

The impact of the required qualifications of the technology and Industry 4.0 revolution in the laborforce is often concentrated on the axis of qualitative discussions. As a result of the changes in production processes, human capital is another crucial issue as much as smart machines, production facilities, and value chains. All employees such as technicians, researchers, process operators should be interconnected with appropriate practices for their occupations. Managers need dynamic, real-time dashboards that indicate the current situation, trend and potential hazards associated with the production process. Therefore, the labor force of the future should be comprised of individuals with computer and mechanical engineering skills. Because, once the Industry 4.0 Revolution has been fully implemented, employees would try to operate among multidisciplinary units.

The new forms of automation that evolve as a result of the rapid change in robotics and artificial intelligence technologies are not only substituting factory workers but also accountants, lawyers, and other self-employed professionals. This change may lead to an interaction that may result in the accumulation of wealth in the hands of the capital owners and intellectual property owners. Beyond the economic challenges of this process of change, there are also challenges against the role of work in attributing meaning to the lives of individuals, families, and communities. Changes in the roles of productive society members require us to rethink the paradigms that reshape the relationships among the individuals, society and economic activity.

In order for the labor markets to support this transformation, they need to be able to supply human capital with adequate qualifications to replace low-skilled labor. For this purpose, the basic task of the education system is to train the human capital needed by the economy. This is the main reason why advanced industrial societies are called knowledge economics, referring to the fact that knowledge is the fundamental value-creating concept. As stated by Kumar (2013), according to information society theorists,

a new class of knowledge workers is emerging, whose work requires a long learning period, and is determined by high levels of technical qualification and theoretical knowledge. According to Drucker (1994), education would play a critical role in the training of knowledge workers.

Today, upon considering education equal to earning and status, it is presumed that obtaining a highly lucrative job depends on a quality investment in education. The origin of this view is the Human Capital Theory (HCT). Expenditures for education in HCT are considered within the scope of investment expenditures.

Education systems need to be able to keep up with this transformation and change within the scope of the needs of the information economy society. Within the framework of such transformation, education systems in countries that wish to have a modern economy are expected to have the following characteristics (Yazıcı & Düzkaya, 2016);

- Education policies should be compatible with the change in information technologies,
- Training programs should not be limited due to rapid technological developments,
- Research-based education systems should be adopted instead of memorization-based education system,
- The number of individuals learning to learn should be increased,
- Multi-dimensional mental development should be targeted in the education system (visual, rhythmic, etc.)

Conclusion

In almost every economy, with the help of technology, labor is replaced by capital. This has been going on for many years. Ginning machines, which emerged in the middle of the 19th century, unemployed thirty percent of the labor force in the agriculture sector.

Industrialization continued uninterrupted throughout the 20th century. Since the year 2011, the world has been talking about a new industrial revolution, first described by the Germans at the Hannover Fair and described as the Industry 4.0 Revolution. With this new industrial revolution, it is aimed to boost the level of computerization in the manufacturing industry and thus, to equip production with advanced technology. Thus, it is planned to achieve maximum flexibility in production, to accelerate production and, most importantly, to minimize the errors that may arise from the human factor during production, that is, to reduce the need for the human labor force as much as possible.

The Industrial 4.0 Revolution would certainly pose significant impacts on economic units. While changing the consumption habits and preferences of the households, the changes in the production processes based on the changing preferences and consumption habits of the firms would be necessitated. This would influence international competitiveness and cause changes in the overall economic structure. It will also make it compulsory for governments, as other economic units, to develop economic policies in line with the developing and changing process. In this context, the first years of a period in which significant changes and developments take place in the economic policies of countries are being experienced.

As a result of the study, it is possible to draw three main conclusions pertaining to the Fourth Industrial Revolution. The first of these results is a tremendous advance by

courtesy of digital technologies. Hardware, software, and computer networks are at the heart of this progress. Although these technologies have entered into our lives with the Third Industrial Revolution, the full potential of these technologies, that is, the level of maturity required to make major and fundamental changes in society and economy has just been reached. The second conclusion is that such a great movement of change and transformation, which is the seminal work of digital technology, would provide humanity with great benefits. Because human beings can promote the diversity and quantity of consumption. Consequently, digitalization would beget some problems. The negativities in the labor market would lead to those problems. In parallel with the increase in computing power, companies may need fewer employees.

References

Abbate, J. (1999). *Inventing the Internet (inside technology). Editorial* The MIT Press, Cambridge.

Anderson, Chris (2012). *Makers. The New Industrial Revolution*. New York: Crown Publishing Group.

Ashton, T. S. (1948). Some Statistics of the Industrial Revolution in Britain 1. *The Manchester School*, *16*(2), 214-234.

Benkler, Y. (2002). Coase's Penguin, or, Linux and" The Nature of the Firm". *Yale Law Journal*, 369-446.

Brynjolfsson, E., & McAfee, A. (2014). *The second machine age: Work, progress, and prosperity in a time of brilliant technologies*. WW Norton & Company.

Castells, M. (2008). *Enformasyon Çağı: Ekonomi, Toplum Ve Kültür Birinci Cilt Ağ Toplumunun Yükselişi*. İstanbul Bilgi Üniversitesi Yayınları, ISBN: 975-6176-16-4.

Clark, G. (1992). The economics of exhaustion, the Postan thesis, and the agricultural revolution. *The Journal of Economic History*, *52*(1), 61-84.

Clark, G., & Demircioğlu, E. (2013). *Fukaralığa veda: Dünyanın kısa iktisadi tarihi*. İstanbul Bilgi Üniversitesi Yayınları.

Collin, C. (1989). *Science, Technology and Everyday Life*, 1870-1950. Routledge.

Crafts, N. F. (1996). The first industrial revolution: A guided tour for growth economists. *The American Economic Review*, 197-201.

Diamond, J. (1987). The Worst Mistake in the History of the Human Race. Discover Magazine, May: 64-66.

Dizard, W. P. (1982). *The coming information age: An overview of technology, economics, and politics*. New York: Longman.

Drucker, P. F. (1994). *Kapitalist ötesi toplum* (Çev. B. Çorakçı). İstanbul: İnkılâp Yayınları.

Düzkaya, H. (2016). Endüstri devriminde dördüncü dalga ve eğitim: Türkiye dördüncü dalga endüstri devrimine hazır mı?. *Eğitim Ve İnsani Bilimler Dergisi: Teori Ve Uygulama*, *7*(13), 49-88.

European Factories of the Future Research Association. (2013). Factories of the future: Multi-annual roadmap for the contractual PPP under Horizon 2020. *Publications office of the European Union: Brussels, Belgium*.

Forester, T. (Ed.). (1985). *The information technology revolution*. MIT Press.

Hall, P. G., & Preston, P. (1988). *Carrier Wave: New Information Technology and the Geography of Innovation, 1846-2003*. Routledge.

Hobsbawm, E. J. (2003). *Sanayi ve İmparatorluk, çev. A. Ersoy*, Dost Kitabevi, Ankara.

Jänicke, M., & Jacob, K. (2009). A Third Industrial Revolution? Solutions to the crisis of resource-intensive growth. *Solutions to the Crisis of Resource-Intensive Growth*.

Kabaklarlı, E. (2016), *Endüstri 4.0 ve Dijital Ekonomisi; Dünya ve Türkiye Ekonomisi İçin Fırsatlar, Etkiler ve Tehditler*, 1. Basım, Nobel Bilimsel Eserler, Ankara.

Kremer, M. (1993). The O-ring theory of economic development. *The Quarterly Journal of Economics*, *108*(3), 551-575.

Kumar, K. (2013). *Sanayi Sonrası Toplumdan Post-Modern Topluma : Çağdaş Dünyanın yeni kuramları*, Dost Kitabevi (Çev: Mehmet Küçük), ISBN: 978-9-7575-0181-7.

Kuznets, S. (1965). *Towards a Theory of Economic Growth "in Economic Growth and Structure*. New York: W. W. Norton.

Leonhard, G. (2018). *Teknolojiye Karşı İnsanlık*. İstanbul: Siyah Kitap.

Malthus, T. R. (1872). *An Essay on the Principle of Population*.

Mazlish, B. (1993). *The fourth discontinuity: the co-evolution of humans and machines*. Yale University Press.

Mokyr, J. (1990). *The lever of riches: Technological creativity and economic progress*. Oxford University Press, New York.

Mokyr, J. (1998). The second industrial revolution, 1870-1914. *Storia dell'economia Mondiale.*

Mokyr, J. (2005). The intellectual origins of modern economic growth. *The Journal of Economic History*, *65*(2), 285-351.

MTSO Mersin Ticaret ve Sanayi Odası (2017), <http://www.mtso.org.tr/tr/haberler/turkiye-avrasya-nin-endustri-4-0-merkezi-olabilir>, 04.11.2019.

Naughton, J. (1999). *A Brief History of the Internet: The Organs of the Internet*. London: Weidenfeld and Nicolson.

North, D. C., & Weingast, B. R. (1989). Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century England. *The journal of economic history*, *49*(4), 803-832.

Palumbi, S. R. (2001). Humans as the world's greatest evolutionary force. *Science*, *293*(5536), 1786-1790.

Rifkin, J. (2011). *The third industrial revolution: how lateral power is transforming energy, the economy, and the world*. New York: Palgrave Macmillan.

Schwab, K. (2016). *Dördüncü sanayi devrimi*. Optimist Yayın Grubu.

Schwab, K. (2018). *Dördüncü Sanayi Devrimini Şekillendirmek*. Optimist Yayın Grubu.

Stearns, P. N. (2013). *The industrial revolution in world history*. Westview Press.

Temin, P. (1997). Two views of the British industrial revolution. *The Journal of Economic History*, *57*(1), 63-82.

Wrigley, E. A. (1990). *Continuity, chance and change: The character of the industrial revolution in England*. Cambridge University Press.