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**Article**

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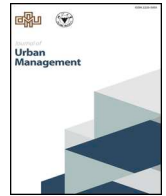
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## Research Article

## Land selection criteria for lights out factory districts during the industry 4.0 process

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## ABSTRACT

The lights out factories that the Industry 4.0 revolution brings will become widespread due to the energy savings and the considerable reduction in labor costs, and will bring a transformation in the land selection for the industrial plants. This study is based on the assumption that existing manufacturing plant sites will be moved from urban centers in the industry 4.0 process and the urban settlement will be changed by transforming the land selection criteria with the direction of new requirements. The study aims to determine the land selection criteria of manufacturing facilities in the urban-rural areas, which will be transformed within the Industry 4.0 process. New land selection criteria for lights out factory districts are important in terms of using the spatial pattern effectively. At the end of the study, the effects of the new land selection criteria on entrepreneurs, urban planners and decision makers are discussed.

## 1. Introduction

The world economy has experienced three different industrial revolutions in the form of mechanical production based on water and steam energy, mass production based on electric energy and division of labor, and global production based on circuit boards and automation of production processes (Alcacer, Cantwell, & ve Piscitello, 2016, p. 500). The driving force of cheap labor to reduce costs led the industrial production in Europe to China at the beginning of the 2000s. In recent years, Europe's inability to reach the desired growth in industrial income and the concerns about competitiveness with China have led the developed industrial countries to unmanned production in order to reduce the labor costs to the lowest level. This trend is embodied with the fact of industry 4.0. The fourth industrial period is based on rapid access to the market in production activities, flexibility in production lines, increasing productivity, change and development of business pattern (Can & Kiyamaz, 2016, p.109). The 4th industrial revolution, which started in 2010 with the leadership of German Siemens Company, is accepted as the beginning of the period when the cyber-physical systems and the production of the objects based on the internet and smart factory began. The rapid development of these technologies has brought the lights out factories into the agenda of the developed countries (Hermann, Pentek, & ve Otto, 2015, p. 15).

The concept of lights out factory, which was first introduced in the 1980s (Null & ve Caulfield, 2003, p.1), is defined as production facilities in which the production activities are carried out entirely by robots through using robotic technology, artificial intelligence and internet technologies and thereby there is no need for labor force, light and windows. In the lights out factories, the transmutation of the system into fully robotics automation increases the efficiency of the plant by both increasing the work hours in terms of time and providing the reduction in the proportion of defective parts (Fernandes & Assuncao, 2017, p. 50). Because it increases labor

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productivity with reducing the labor costs, the use of robotic automation reduces manufacturing energy per product and provides great productivity. For this reason, the lights out factories can be regarded as an environmental friendly, high efficiency, new generation production facilities. Because the productivity increase in the lights out factories offers great advantages in the competition with other factories, the lights out factories have been preferred by the enterprises in the developed industrialized countries since 2010. The most spectacular example of this tendency is that Adidas' factory in China prefers to use robotic technology instead of cheap manpower. The company transformed its first factory into a lights out factory that only works with robots by relocated it back to Germany in 2016; it also moved its second lights out factory to the US city of Atlanta in 2017. Similarly, the factory of the fire extinguishing vehicle in Japan makes production 24 hours of work per day without the need for manpower.

According to the German National Academy of Science and Engineering, in the coming years, with the industry 4.0. the productivity of new production processes will increase by at least 30%. The reduction in energy savings and labor costs demonstrates that lights out factories, which are seen in developed countries, will also become widespread in developing countries and will bring transformation in land selection of industrial facilities (Roblek, Meško, & ve Krapež, 2016, p. 3). Due to the assumption indicating that there is no need for social facilities for employees in the industry 4.0 process, the direction of this transformation to be experienced in the selection of industrial facilities is expected as moving out of the urban area where the land values are cheaper and the accessibility of the infrastructure needed by new technologies is easy and high.

A transformation similar to what the industry 4.0 will bring has emerged since 1960s in the form of establishment of organized industrial zones (OIZ) out of the city by gathering the mass production facilities scattered throughout the city. The establishment of OIZs has brought the joint use of infrastructure and has change the understanding of planning. As a result, OIZs have supported specialization for their production facilities and become more competitive by reducing service and production costs (Piore & Sabel, 1984, p.54; Scott, 1988, p.68; Scott & ve Storper, 1989, p.25; Pyke, Becattini, & Sengenberger, 1990, p. 105; Harrison, 1992, p.98).

This study is based on the assumption that by removing the existing production facilities during the industry 4.0 process from city centers as it is in the case of OIZ will change the selection criteria in the direction of new needs, change the plan schemes, and change the urban spot by creating lights out factory districts. The sustainability of this transformation in a healthy way for the cities and the economy will be based on the determination of the land selection criteria of the lights out factories. The land selection criteria of lights out factories will become an important issue in terms of entrepreneurs, decision makers and urban planners. In this context, the purpose of this research is to determine the land selection criteria for the lights out factory districts coming to the city agenda with the case of industry 4.0. With the aim to identify new land selection criteria, study design were discussed in three stages. In the first stage, industry 4.0 and lights out factory concepts were defined. In the second stage, literatures related to the land selection criteria of OIZ, which had created spatial change in the city during the previous industrial periods, were carried out. In the third stage, the concept of lights out factory were defined, and the differences that might occur in the current situation were discussed by determining the land selection criteria of lights out factory districts.

## 2. Theoretical framework

In order to understand the Industry 4.0, it would be beneficial to make a historical literature review on the other industry periods and to examine the causes and effects of the change.

So far, the world economy has experienced three different industrial revolutions (Alcacer, 2016, p. 501). The first industrial revolution began with the development of the steam engine between 1765 and 1850. The discovery of electricity by Michael Faraday in 1831 initiated the second industrial revolution period (from 1850 to 1975). During the period of the second industrial revolution, which was defined as Industry 2.0, production facilities became more efficient with the electric energy produced in coal plants instead of steam energy and with the mass production based on electric energy and division of labor. Between 1969 and 1988, countries shifted to the sectors based on information technologies and they tended to produce high value added products in their production processes. In this period, defined as industry 3.0, the use of electronic circuits improved the automation systems (Günay, 2002, p. 9). Up to industry 4.0, because the OIZs had presented common infrastructure services for the production facilities, they had come into prominence in terms of competitiveness. The development of communication and transportation technologies and the invention of the internet has revealed the concept of post-Fordist production system; then, knowledge has become the most important tool of labor and production. The innovations emerging as a result of the storing, processing and transmitting of information in various forms have brought a zero-cost production model into the agenda (Dağdelen, 2005), and directed the land selection of production facilities to the overseas countries where cheap labor force is available. In this period, cities have been shaped within the framework of spatial functions such as logistics areas and villages, and urban and regional transport networks such as railways ports, and airports. Rapid population increase in the metropolitan cities and the growth of the urbanization spot press on the OIZs, which has taken place out of town previously, but they are now located in the settlement spots of the cities. Pressures such as over-population, traffic congestion, environmental pollution, high land values cause OIZ companies to select places outside the city (Yüzer, 2011, p.121).

In terms of the history of the industrial revolutions in Turkey, the first production facilities were established during the Ottoman Empire in the early 1800s. During the reigns of Selim III and Mahmut II, military needs were at the core of the industrial initiatives (Erdem, 2016). In 1842, the Ottoman Empire designed an "industrial park" containing industrial production and agricultural zone complexes similar to those of England. Zeytinburnu was planned as the first industrial center comprised of foundries and machines that produced iron pipe, steel rail, plow, sword, knife, stirrup and other iron works (Clark, 1974, p. 66). The Ottoman state was introduced to Industrial 2.0 by a thermal power plant with a power of 15 MW installed in Istanbul Silahtarağa in 1913. The period in which electricity was used and motorized benches became widespread was achieved by the industrialization movement brought by

the Republic after 1924. The industrial production, which had moved in this character until the 1960s, was shaped by the transition to intense outsource relations and capital concentration in the 1970s (Tekeli & İlkin, 1979; Boratav, 2008; Öniş, 1991; Duruiz & ve Yentürk, 1992; Şenses, 1994; Ansal, 1994; Eraydın, 1994; Kaytaç, 1994; Yeldan, 1994; Kazgan, 1995). The years 1980-84 are referred as the period of maturation and transition to automatic computerized workbenches (Türkün-Erendil, 2000). After the 1980s, there were changes in the way products and services were produced. The beginning of the 20<sup>th</sup> century was accepted as a transition process from the industry 2.0 to the industry 3.0 and was followed in Turkey as in all over the world. With the growth of the metropolitan city, the rapid increase in the land prices in the center of the city has made it inevitable to move the industrial investments out of these centers (Yüzer, 2011).

It is not possible to say that the objective of the industrialized society inherited from the Ottomans and continued with the Republic has a widespread influence today. The inability of electric power to reach all production facilities was the greatest reason why the industry 2.0 could not have a widespread effect. Today, the digital maturity level of Turkish industry is between industry 2.0 and industry 3.0 (Tübitak, 2016). In the light of theoretical framework, this study is based on the assumption that the current production facilities will be transformed into lights out factories within industry 4.0 process. Regarding the historical literature review, it can be said that Turkey follows the industrial revolution a hundred year behind of it. In this context, Turkey, which was late to the other industrial revolutions, should enter the Industry 4.0 transmutation as soon as possible.

In accordance with the aforementioned, the fourth industrial revolution, like the second and third industrial revolutions, will also radically change the forms of production and directly affect the morphology of the cities. The Industry 4.0 phenomenon brings many innovative features such as monitoring the system, being sustainable, achieving high efficiency, increasing flexibility in production, reducing costs and developing new service and business models. In addition to this, in the production process, it aims to decrease the error rate to near zero by reducing the human factor to the minimum level (Daneshjo, Majernik, & Ve Danishjoo, 2017). To achieve all of these goals, Industry 4.0 components, which are defined as big data, autonomous robots, simulation, horizontal and vertical system integration, internet of things, cyber security, cloud computing, additive manufacturing and virtual/augmented reality, need to be used together effectively (Rüßmann et al., 2015) (Fig. 1).

These components, which are used in the lights out factories produced by Industry 4.0, will change production patterns and play a strong role in determining the land selection factors of lights out factories. The internet of things technology, by providing the services via internet, enable the smart factories to communicate with each other and thereby it fulfill the principle of interoperability. In the next generation factories, virtualization technology makes it possible to remote control of the sensor data in the factory via virtual plant and simulation models. Intelligent systems enable factories to make their own decisions. Sensors used in intelligent factories allow real-time decision making opportunity by collecting the data in the production process and evaluating them with instant analysis methods (Liu & ve Xu, 2017). In the production processes, with the use of the Internet of the services, by providing remote services to the managers through virtual systems, it is aimed to manage the processes effectively in the factory in a full time. With the modularity component, flexible production possibilities is provided in the smart factories and it is aimed to minimize the human intervention. Industry 4.0 will change the patterns of production as well as changes the traditional manufacturing factors (labor, capital, land, and entrepreneur) used in production processes [Table 1].

In the previous industrial periods, entrepreneurs were investing in the production of goods and services. In the process of gaining the importance of information, the opportunity to realize an individual's idea by receiving support from ideologically angel investors has radically changed the entrepreneurial factor.

The reporting of the data obtained in the production process ensures the sustainability of the associated information production. It is vital that this information is used effectively during the decision-making process in the production process. This change has added the technology and knowledge factors to the four production factors. The technology factor is inevitable in order to obtain fast,

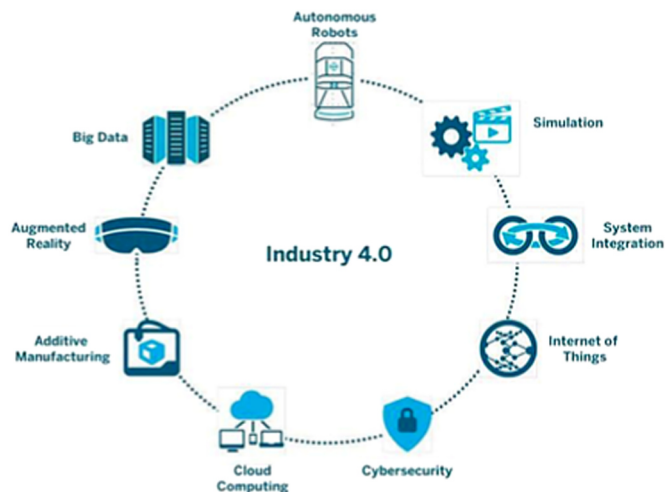


Fig. 1. Industry 4.0 Components. Retrieved from <https://buyukdonusum.com>, Date of access: 2018.

**Table 1**

Change of the production factors after the industry 4.0.

	Pre-Industry 4.0	Post-Industry 4.0
Price	The physical and mental efforts people make in a job	Mainly mental labor Automation and capital-intensive production goods Specialization in workforce
Capital	Physical production tools such as machines, tools, hardware and buildings used in production	Patents, intellectual property and the company's know-how
Natural resources	Provide enough raw material for the production plant Top for land selection	Allow raw material to be transported to the plant with lower cost and easier
Entrepreneur	Organizes capital, natural resources and labor force	Individuality Angel Investor
Technology		Being able to produce products quickly and efficiently To produce high value added products
Information		Reporting and associating the data Information production

productive and high added value products in the production processes.

After monitoring the changes in the industrial period through the production factors, in order to estimate the changes that Industry 4.0 will make in its urban space, it is necessary to follow the reflection of the urban space of the OIZ that shaped the urban space and to identify the elements that are effective on the land selection.

The decision to establish an organized industrial zone is made by decision makers if it meets the certain criteria. For this reason, in order to establish organized industrial zone in a city, it is necessary to select a region that meets the OIZ regional land selection criteria. When the land selection criteria are examined, there are macro-scale factors such as land situation, potential of work force, capital accumulation, transportation, inter-industrial economies, and urban economy. In addition, there are also micro-scale factors such as the agricultural character of the land, the area being suitable for construction, closeness to basic transportation networks, energy, communication and water needs, the development reserve area of the region, and topographic structure (Yaman, 2005).

Along with the development of information and communication technologies, changes in the production methods of the production facilities also directly affect the land selection of the industrial facilities. Examining three different industrial periods, there are differences in the land selection of the industries within the city. In the period of industrial 1.0, which were the period of steam engine, production facilities were nested with the settlement. In the cities, before the industrial revolution, transportation was predominantly pedestrianized, there were intensive construction inside the walls, rural-urban separation was clear, there was no functional separation of the pavilion, no work-house separation, or no significant class separation in the walking distance (Enlil, 2006). In those years, the production was carried out in the factories operating with steam power (Günay, 2002). In this period, with the transformation of the workshops into the factories and starting the agricultural population to work in the factories, migration to the city began. For this reason, worker houses were built within the city and infrastructure was provided for these houses.

With the industry 2.0, since they cause environmental pollution and due to the inadequate urban infrastructure, factories made land selection in the city boundaries and in order to be close to the raw materials. Along with this, new settlements and neighborhoods started to form around the factories that went out of the city. Also with the development of transportation vehicles, the urban area had begun to expand.

Examining the land selection criteria of the industrial plants, it has been determined that there is a tendency to move out of the city. Depending on these findings, the literature was reviewed to determine the land selection criteria for the lights out factories and the land selection criteria of the organized industrial zones were examined in detail. In this context, Demirdöğen and Bilgili (2004) conducted a detailed literature study on the land selection criteria of the OIZ and aimed to determine the factors affecting the land selection decision for the additional OIZ planned to establish in Erzurum, and the importance levels of these factors. In that study, the data were collected from the facilities located in OIZs by questionnaire method, analyzed by statistical methods, and order of the importance of the variables were determined by factor analysis (Demirdöğen & Bilgili, 2004). In another study aiming to determine the land selection criteria of the OIZ, macro and micro scale criteria were determined separately and they were applied in the land selection process of Kütahya OIZ (Yaman, 2005). Yüzer and Giritlioğlu (2011) examined change in the land selection criteria of industrial areas affected by the developments in the information technologies. This study found that the economic growth potential and market factors were the most preferred factors in the land selection preferences of industrial establishments, and the labor force factor were the less important factor in industrial establishments among the other factors (Yüzer ve Giritlioğlu, 2011). In another study, the use of multi-criteria decision making techniques for free-zone location was implemented on the Eastern Anatolia region. In the study, the most suitable place was selected by using AHP, TOPSIS, VICOR and ELECTRE methods from multi criteria decision making techniques (Ağaç, Baki, Peker, & ve Ar, 2015). Geographical information systems and remote sensing methods was used in the study for facility selection in the food and the most suitable place was determined according to the criteria determined in the study (Hazini, Hashim, Rokni, & Shafaghat, 2015). It is anticipated that the need for labor force will be reduced with the lights out factories. In this context, what kinds of movements or migrations the workers of industrial facilities will do has a great importance in urban planning. Related to this issue, Yiğit made an assessment on immigration as a land selection in 2017. In that study, the way of

labor movement was discussed through the dynamics of industrial societies (Yiğit, 2017). A study of the location of small and medium-sized enterprises in Poland also found that with 42.8%, the place where the employees lived was important factor in land selection of the enterprises, and the closeness to the city center was the second factor with 32.4%. Therefore, the enterprises wanted to select the locations near to the center due to the human factor (Martyniuk-Peczek, Martyniuk, Gierusz, & ve Peczek, 2017). Carbon emission cost is one of the factors affecting the land selection decisions of the industrial plants. A study related to this issue formed a new theoretical model that examines the relationship among product demand, production cost, and carbon emission levels (Wu & ve Shyu, 2017). Panhans, Lavric, and ve Hanley (2017) investigated the effects of electricity costs in a new land selection process of the European companies and found that electricity costs and firms' land selection preferences were directly related. Wang, Lestari, and ve Tran (2017) carried out a land selection study with the fuzzy analytical network processes of high-tech manufacturing companies. Factors influencing the land selection of high tech firms in that study were examined according to the regions. Factors were examined under the heading of cost, human, and legislation. Transportation, land value, raw material costs were examined under costs heading. Infrastructure, housing and education, innovation and research and development clusters, production and service concentration, connection with other industries, market relations were examined under the heading of human beings, Finally, under the heading of the legislation, tax reduction, foreign investor support and financial support titles were discussed. Sensitivity analysis was performed on all these factors at 5 different locations (Wang et al., 2017). In another study examining the factors that the companies in the Netherlands used in their land change decisions, factors were also examined under three main headings as internal factors, location factors and external factors of the firm. It was found that the human factor and the infrastructure were at the forefront in the land selection (Dijk & ve Pellenbarg, 2000). In China, the factors taken into account by the biotechnology industry in new land selection for market expansion was examined. Cost, need, macroeconomic, socio-political and strategic factors were examined in the context of that study. It was found that the effects of salary, raw material cost, market size, potential growth, qualified human power were high (Wang, Lestari, & ve Yang, 2015). Discrete selection analysis was conducted to determine the land selection criteria for new production facilities in Japan. Factors such as market size, infrastructure capacity, people, land, energy costs, employee quality and policy incentive measures were considered in the selection of the place (Cheng & Ve Stough, 2006). 50 countries and 6 sectors were examined on how foreign investors decided to select a location for direct investment. Examining the results of that study, it was found that investors invested in technology, transport and electronics sectors (Kunal & ve Chaitali, 2017). Land selection criteria of investigators coming to Vietnam from abroad were examined to determine the appropriate investment locations according to the sectors (Chih-hai, Chung-yueh, & ve Meng-wen, 2017). Changing business patterns with Industry 4.0 also changes the industrial land selection criteria.

### 3. Land selection criteria of the lights out factory district

With Industry 4.0, real factory life is replaced by virtual reality. In the future years, robots working together in factories will acquire new abilities in the robot learning process with the internet of things and machine learning technologies. Intelligent robots will be able to make their own decisions by using big data and co-learning technologies through the cloud. In addition, small and medium sized enterprises will start to use industrial robots. Comparing with the human beings, robots can make dirty jobs easier and faster in environments that are more dangerous. In the past decade, industrial robot market has grown three times. In last year, 193 thousand robots were sold in total; 191,000 were sold in Asia, 56,000 in Europe and 41,000 in the United States. In 2020, robot sales are expected to reach 521,000 in a year. By the end of 2020, the number of industrial robots is expected to reach 3,053,000. 74% of the robot sales are made by developed countries such as China, South Korea, Japan, USA and Germany. The automotive industry is at the forefront as the largest buyer of industrial robots with 35%. The second industry is the electronics industry that produces computers, TVs and communication devices with 31%. It is followed by plastic industry (5%) and food industry (3%) respectively (Executive Summary World Robotics, 2017).

Again in 2020, the number of interconnected computers, called the internet of things, will increase from 13 billion to 29 billion. The economic size of industrial robots will be \$ 1 trillion annually, and 15–25% of the manufacturing processes in developed countries will be based on automation (Tübitak, 2016). When the results of the survey conducted by TUBITAK with companies that received institutional R & D support in June 2016 were examined, it was revealed that only 22% of the companies had heard industry 4.0 until that date (Tübitak, 2016). The three sectors with the highest awareness are software, electronics, and materials. Half of the companies will determine strategies to integrate relevant technologies into their systems over the next five years. Within the context of the conversion of industrial plants to the lights out factory, autonomous robots, large data, simulations, integrated systems, internet of things, cyber security, cloud computing, layered manufacturing and virtual reality technologies will be used as the components of the industry 4.0. These technologies will shape lights out factories and will change the land selection criteria of the lights out factories.

It would be appropriate to explain the components that will be the land selection criteria for the lights out factories during the Industry 4.0 period.

#### 3.1. Big data and cloud computing

Applications will be developed for the remote control, maintenance and updating of production lines with the use of big data and cloud computing technologies in the lights out factories. It is aimed to minimize the breakdowns in the machine manufacturing sector and it is aimed to manage the lines in different places in white goods, automotive and defense sectors from one center. Routing of the end devices in production and assembly lines interactively with each other will be realized. Finally, virtual reality solutions will be

produced in the manufacturing sector so that operators can remotely manage their machines.

### 3.2. Internet of things

Systems that will allow the self-adjustment of devices and machines in lights out factories will be developed. With the mobile based advanced image detection and autonomous quality control systems, remote quality control will be able to be done. Analysis of instant data will be carried out with sensors integrated into decision support systems, which provide wireless communication, and it will be provided that the system will be able to make a decision by itself through intelligent systems. Finally, detection and routing systems that will allow the production process to be done entirely by using robots will be developed.

### 3.3. 3D print technologies

3D printing technology has enabled designers to manage processes spatially independent from production facilities and to create the required prototypes via printers in the offices or home-offices. The ordered prototypes are transmitted to the production facilities via communication technologies and put into mass production by the robots.

### 3.4. Interaction

The development of systems for collecting, analyzing and making decisions in different formats from different machines in the production chain will be provided. Applications, software and hardware solutions that can make control, test and routing by monitoring the production flow of the enterprise will be developed. Software with image processing technologies that can design products in three dimensions and create point clouds will be developed. It is aimed to develop systems that enable the unmanned movements of the materials in the lights out factory and instantaneously controlling the material flow on the production line (Tübitak, 2016).

It is seen that all of these technologies aim to minimize the human factor in the lights out factories and increase the productivity. Because the lights out factories do not need labor force, they don't also need to be close to labor force (Calitz, Poisat, & Cullen, 2017; Robla-Gomez et al., 2017; Bodrow, 2017; Longo, Nicoletti, & ve Padovano, 2017). In this context, in the lights out factory land selection criteria, the labor force criterion, which has a significant place in OIZ land selection criteria, will be removed. This process, together with narrowing the spatial needs of production facilities, allows white-collar workers to be employed during free-working hours in production facilities, even urban centers, office or home offices. In terms of transportation, the relationship between workplace and residence will be weakened, urban spatial organizations and functional networks will be shaped with different patterns. The criteria related to the proximity to residential areas, proximity to schools and health services will lose their importance [Table 2]. Regarding the pressure that the residential areas make on the industrial areas near the city center, it is expected that the lights out factories will select land far away from the city center and in the areas where the land prices are too low. Decentralization

**Table 2**

Lights out factory district land choice criteria.

Land Selection of Organized Industrial Zone	Land Selection of Lights out Factory District
Qualified workforce (++++++)	Proximity to Communication Infrastructure (Fiber optic infrastructure)
Proximity to the market (++++)	Energy
Grants (++++)	Grants
Cheap Land (++++)	Ease of Transportation <sup>a</sup>
Ease of Transportation (+++)	Proximity to raw material
Proximity to residential areas (+++)	Additional facilities opportunity
Infrastructure possibility (+++)	Appropriateness of the land (Proper slope, cheap land, not suitable for agriculture) <sup>b</sup>
Proximity to raw material (++)	
Proximity to school and health services (++)	
Additional facilities opportunity (+)	
Energy (+)	
Water (+)	
Municipality services (+)	
Appropriateness of the Land (+)	
The proximity to the economy between the city and the industry (+)	

<sup>a</sup> Accessibility will change shape though it is a criterion just as it was in previous industrial revolutions. At this point, the ease of transportation will have a context for meeting logistic needs, far beyond the access of employees to the production facilities.

<sup>b</sup> The suitability of land is shaped by criteria such as proximity to raw material, closeness to water, proximity to labor, proximity to transportation networks, lack of fertile agricultural land, and proper inclination in previous industrial periods. With the fourth industrial revolution, it will transform increasingly decisive parameters into conceptual change. Proximity to raw materials, energy, water, transportation networks will have a strong or weak relation depending on the product produced, and closeness to energy and communication technologies will be in absolute relation.

of these industrial facilities makes the phenomenon of transformation and then area allocation and utilization in urban centers important. (Yüzer & Giritlioğlu, 2011).

Qualified labor force, proximity to housing areas, proximity to school-health services, water, municipal services, proximity to the economy between the city and the industry are most important elements in the literature on land selection criteria of organized industrial sites. With the industry 4.0, the lights out factory district land selection criteria will not require the labor force. On the other hand, some criteria such as energy, proximity to communication infrastructure, ease of transportation that are effective in organizing industrial land selection will become more important variables for lights out factories. The land appropriateness criterion will change its shape with what the industry 4.0 bring. The dependence on the concepts of closeness to water and proximity to raw materials will be gradually reduced, and on the contrary, access infrastructure and energy access will be more important concepts for the land appropriateness title. With the industry 4.0, the concept of transportation in this framework will be taken in consideration as the logistics services focusing on transporting raw materials and final products, rather than the transporting network of the labor force. In sum, the changes and transformations in the land selection criteria will undoubtedly change the spatial preferences in cities and the trends in urban systems.

#### 4. Conclusion and evaluation

In the past decade, industrial robot market has tripled. Due to the fact that the biggest buyer of industrial robots are automotive, computer, communication and communication devices, plastics and food industry, it is estimated that the economical size of industrial robots will reach to \$ 0.6–1.2 trillion annually and industrial processes in developed countries will be based on automation by the rate of 15–25%. Autonomous robots, big data, simulations, integrated systems, internet of things, cyber security, cloud computing, tiered manufacturing and virtual reality technologies, which are the components of the Industry 4.0, will be the main mechanisms in the transformation of the production facilities into the lights out factories. Today, industry 4.0 is inevitably approaching, and countries that could not complete industry 3.0 will not be able to move to industry 4.0. In this context, Turkey should complete its digital maturity that is between 2.0 and 3.0 as soon as possible. While these new technologies will shape the lights out factories, they will also affect the land selection of these factories. The existing organized industrial zones are located in the boarder of the cities and in the development zones. Increasing populations in metropolitan cities and the expansion of the city towards the boarder have left organized industrial zones (OIZ) within the cities. For this reason, the OIZ areas within the cities are starting to attract investors' attention. This study argues that today, the areas constructed for production functions in cities are unable to provide suitable conditions and lose their competence. While the industry 4.0 increases the competitiveness of cities and firms, it will radically change the production processes as well as the spatial preferences of the city. While the Industry 4.0 is considered environmentally friendly with low-and high-tech and renewable energy use, it will also reduce the burden of housing-workplace transport brought by industry workers to urban transportation systems. These developments should be seen as an opportunity to prevent the suppression of structuring, which is seen as a problem of urban and rural areas in recent years, and to ensure the sustainability of agricultural lands and natural resources. It will be needed to restructure of the spatial organization of the production facilities especially in the cities that have passed the industry 4.0. Lights out factories are expected to push industrial plants out of the city. In this way, transformation is expected for the areas vacated by the production facilities that are idle in the city. Constructing the future of cities in the transformation process, it is necessary to take into account the debates suggesting that it will create an unprecedented effect in terms of urban dynamics.

Until the fourth industrial revolution, cities have always directed the spatial development according to the land selection of the industrial plants. In this development, the proximity to the labor force and transportation networks were the main actors. Industrial areas have shaped not only their own functional-spatial design but also the functional constructions such as housing, social facilities and the urban systems such as transportation and infrastructure brought by the labor force. In the new era, the elimination of the labor force will overthrow all this urban fiction and reshape the urban planning chain. In this context, urban planners will have to deal not only with the lights out factory land selection but also with idle production sites in the city center, the transformation of urban systems working with these areas, the urban residential areas to be reshaped by the transformed labor force and the social-reinforcement and green circulation systems. It is also possible to say that this radical transformation may lead the central decision-makers to renew the laws and regulations related to the spatial order. In this context, it is certain that the lights out factories will be included in the development plans of the land selection. The transformation of old idle production sites in the city center, the revision of the urban infrastructure systems brought by the transformation in the city center, and the reconsideration of spatial fictions in rural areas will become the current topics of urban planners.

It is envisaged that lights out factories can make the land selection in the rural areas that are not easy to live because natural conditions are difficult for people and far from the city center, and in the regions with available transportation, energy infrastructure and cheap lands. It is certain that because of this situation, the production areas will increase the pressure on the fertile agricultural fields in the rural areas. For these fields, decision-makers need to establish the legal infrastructure for the land selection of the production facilities in the rural areas, and determine how the lights out factory sites will be addressed and displayed in the environmental scheme and development plans. Urban planners will also need to set new criteria for the elements of the rural area planning.

In the industry 4.0 process, it is possible to say that entrepreneurs will invest in production facilities primarily in the lights out factory districts. While automotive, communication, plastics, and food industries will be the priority investment areas, robotics, information technology and software development will be the primary investment areas. In line with the land selection criteria, the regions having completed energy, communication and logistics infrastructure, providing opportunity to the specialization, and



including stable economies will be the entrepreneurs' investment areas for the lights out factory districts.

One of the transformations brought by the lights out factory districts is that the factories do not need the labor force. Therefore, this situation place great responsibility on central decision makers in urban employment transformations and in the framework of education and employment policies. The radical reduction of the need for qualified labor force as well as directing the labor force that is already working and not qualified in the production facilities points to the need for new approaches and labor force strategies. On the other hand, regulations on new concepts in spatial laws must be completed and the necessary incentive policies must be established.

In order to increase its competitiveness, without missing the global trend, Turkey needs to move its digital maturity to 4.0 and form a brand as soon as possible. At this stage, completion of the necessary renewable energy and communication infrastructures quickly and providing digital maturity supports (business plan, road map, etc.) to the companies and firms are required. Furthermore, creation, management and monitoring of databases and integration of the system with city plans, laws, regulations, information technologies, and industry sector are also important. Making decisions through examining the lights out factory areas at three different levels as strategic level decisions in the city, region and country scale will be important in terms of planning hierarchy and in terms of spatial strategic management. In the future studies, it is expected that for the lights out factory districts, land selection inquiries will be made on actual data sets in accordance with the criteria determined within the scope of the study.

## References

- Ağaç, G., Baki, B., Peker, İ., & ve Ar, M. (2015). Çok Kriterli Karar Verme Tekniklerini Kullanarak Serbest Bölge Yer Seçimi: Doğu Anadolu Bölgesi Örneği. *Dokuz Eylül Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 30(1), 79–113.
- Alcacer, J., Cantwell, J., & ve Piscitello, L. (2016). Internationalization in the information age: A new era for places, firms, and international business networks? *Journal of International Business Studies*, 47(5), 499–512.
- Ansal, H. K. (1994). International competitiveness and industrial policy: The Turkish experience in the textile and truck manufacturing industries. *Contributions In Economics And Economic History* (175-175).
- Bodrow, W. (2017). Impact of Industry 4.0 in service oriented firm. *Advances In Manufacturing*, 5(4), 394–400.
- Boratav, K. (2008). *Türkiye iktisat tarihi, 1908-2007*. İmge Kitabevi.
- Calitz, Ap, Poisat, P. Ve, & Cullen, M. (2017). The future African workplace: The use of collaborative robots in manufacturing. *South African Journal of Human Resource Management*, 15.
- Can, A. V., & Kıymaz, M. (2016). Bilişim teknolojilerinin perakende mağazacılık sektörüne yansımaları: muhasebe departmanlarında endüstri 4.0 Etkisi. *CİEP Özel Sayı - süleyman demirel üniversitesi sosyal bilimler enstitüsü dergisi*, 107–117.
- Cheng, S., & Ve Stough, R. (2006). Location decisions of Japanese new manufacturing plants in China: A discrete-choice analysis. *The Annals of Regional Science*, 22–22, 369–387.
- Chih-hai, C., Chung-yueh, C., & Ve Meng-wen, T. (2017). Location choice of multinational and local firms in vietnam: birds of a feather flock together? *Japanese Economic Review*, 68(1), 95–114.
- Clark, Edward C. (1974). Ottoman industrial revolution. *International Journal of Middle East Studies*, 5, 65–76.
- Dağdelen, İ. (2005). Post-fordizm. *Mevzuat Dergisi*, 8(90).
- Daneshjo, N., Majernik, M., & Ve Danishjoo, E. (2017). More exact approaches to modernization and renewal of the manufacturing base. *Tem Journal-Technology Education Management Informatics*, 6(3), 445–449.
- Demirdöğen, O., & Bilgili, B. (2004). Organize sanayi bölgeleri için yer seçimi kararlarını etkileyen faktörler: erzurum örneği. *Atatürk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 4(2).
- Dijk, J. ve Pellenberg P. (2000). Firm Relocation Decisions in The Netherlands: An Ordered Logit Approach. 39th European Congress of the Regional Science Association, Dublin, Ireland.
- Duruiz L. ve Yentürk N. (1992). Facing the challenge Turkish automobile, steel and clothing industries responses. Nadir Kitap.
- Eraydin, A. Y. D. A. (1994). Changing spatial distribution and structural characteristics of the Turkish manufacturing industry. *Contributions in Economics And Economic History* (155-155).
- Enliç, Z. (2006). Modernleşmenin 1. Kuşağı: Sanayi Devrimi Ve Kentler, YÜ Mimarlık Fakültesi Şehir ve Bölge Planlama Bölümü, Kent Planlama Tarihi Ders Notları.
- Erdem, E. (2016). Sanayi Devriminin Ardından Osmanlı Sanayileşme Hamleleri: Sanayi Politikalarının Dinamikleri ve Zaafiyetleri. *Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 48, 17–44.
- Executive Summary World Robotics (2017). Industrial Robots 2017.
- Fernandes, I., & Assuncao, E. (2017). Industry 4.0: Training for Automation in Europe. *Welding Journal*, 96(7), 50–52.
- Günay, D. (2002). Sanayi ve Sanayi Tarihi. *Mimar ve Mühendis Dergisi*, 31, 8–14.
- Harrison, B. (1992). Competition, thrust and reciprocity in the development of innovative regional milieus. *Papers of Regional Science*, 71(2), 95–105.
- Hazini, S., Hashim, M., Rokni, ve K., & Shafaghat, A. (2015). Identifying the optimum locations for food industries in qaemshahrIran, using GIS and image processing techniques. *Jurnal Teknologi*, 74(4), 153–158.
- Hermann, M., Pentek, T., & ve Otto, B. (2015). *Design principles for Industrie 4.0 scenarios: A literature review (Working Paper No. 01)*. Technische Universität Dortmund.
- Kaymaz, M. (1994). Subcontracting practice in the Turkish textile and metal-working industries. *Contributions in Economics and Economic History* (141-141).
- Kazgan, H. (1995). *Osmanlıda Avrupa finans kapitali*. YKY.
- Kunal, S., & ve Chaitali (2017). The location choice of US foreign direct investment: How do institutions matter? *Journal of Institutional Economics*, 13(2), 401–420.
- Liu, C., & ve Xu, X. (2017). *Cyber-Physical Machine Tool - the Era of Machine Tool 4 0 Manufacturing Systems 4 0*, 63, 70–75.
- Longo, F., Nicoletti, L., & ve Padovano, A. (2017). Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context. *Computers Industrial Engineering*, 113, 144–159.
- Martyniuk-Peczek, J., Martyniuk, O., Gierusz, An, & ve Peczek, G. (2017). Determinants of SME location in a suburban area: Evidence from the Gdańsk-Gdynia-Sopot metropolitan area. *Urbani izziv*, 28(1), 122–134.
- Null C. ve Caulfield B. (2003). Fade to Black the 1980s vision of "lights-out" manufacturing, where robots do all the work, is a dream no more. *Business 2.0 Magazine*.
- Öniş, Z. (1991). The Logic of the development state. *Comparative Politics*, 24(1), 109–126.
- Panhang, M., Lavric, L., & ve Hanley, N. (2017). The effects of electricity costs on firm re-location decisions: insights for the pollution havens hypothesis? *Environ Resource Econ*, 68, 893–914.
- Piore, M., & Sabel, C. F. (1984). *The second industrial divide*. New York: Basic Books.
- Industrial districts and inter-firm co-operation in Italy. In F. Pyke, G. Becattini, & W. Sengenberger (Eds.). International Institute for Labour Studies.
- Robla-Gomez, S., Becerra, V. M., Llata, J. R., Gonzalez-Sarabia, E., Torre-Ferrero, C., & ve Perez-Oria, J. (2017). Working together: A review on safe human-robot collaboration in industrial environments. *IEEE ACCESS*, 5, 26754–26773.
- Roblek, V., Meško, M., & ve Krapež, A. (2016). A complex view of Industry 4.0. *SAGE Open*, 1(11).
- Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., ve Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries, [https://www.bcg.com/publications/2015/engineered\\_products\\_project\\_business\\_industry\\_4\\_future\\_productivity\\_growth\\_manufacturing\\_industries](https://www.bcg.com/publications/2015/engineered_products_project_business_industry_4_future_productivity_growth_manufacturing_industries).

- aspx> (02.03.2018).
- Şenses, F. (Ed.). (1994). *Recent industrialization experience of Turkey in a global context*. Greenwood Press.
- Scott, A. (1988). *Metropolis: From the Division of Labor to Urban Form*, Berkeley, London, pp. 67–86.
- Scott, A.J. ve Storper, M. (1989). The geographical foundations and social regulation of flexible production systems, *The power of geography: How territory shapes social life*, ed. J. Wolch and M. Dear Unwin Hyman, Boston, pp. 21–40.
- Tekeli, İ., & İlkin, S. (1979). *1929 Dünya Buhranında Türkiye'nin İktisadi Politika Arayışları*. Bilge Kültür Sanat.
- Türkün-Erendil, A. (2000). Mit ve gerçeklik olarak Denizli-Üretim ve işgücünün değişen yapısı: Eleştirel kuram açısından bir değerlendirme. *Toplum ve Bilim*, 86, 91–117.
- Tübitak (2016). Yeni Sanayi Devrimi Akıllı üretim Sistemleri Teknoloji Yol Haritası. *Teknoloji ve Yenilik Politikaları Daire Başkanlığı*.
- Yaman, M. (2005). Kent planlamasında organize sanayi bölgelerinin yeri: Kütahya Örneği. *Ankara Üniversitesi Sosyal Bilimler Enstitüsü Yüksek Lisans Tezi*.
- Yeldan, A. E. (1994). The economic structure of power under Turkish structural adjustment: Prices, growth and accumulation. *Contributions in Economics and Economic History* (75-75).
- Yiğit, E. (2017). Emeğin mekânda yer seçimi olarak göç hakkında tekeli üzerinden bir değerlendirme. *Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü Dergisi*, 9(19), 301–313.
- Yüzer, A.Ş., & Giritlioğlu, C. (2011). Sanayi alanları yeni düzenleme stratejileri-İstanbul örneği. *İtiDergisi/a*, 2(1).
- Wang, K., Lestari, Y., & ve Tran, V. (2017). Location selection of high-tech manufacturing firms by a fuzzy analytic network process: A case study of taiwan high-tech industry. *International Journal of Fuzzy Systems*, 19(5), 1560–1584.
- Wang, K., Lestari, Y., & ve Yang, T. (2015). Location determinants of market expansion in China's second-tier cities: A case study of the biotechnology industry. *Journal of Business Industrial Marketing*, 30(2), 139–152.
- Wu, P., & ve Shyu, H. (2017). The impact of carbon emission costs on manufacturers' production and location decision. *International Journal of Production Economics*, 193, 193–206.