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Case Study of Intralogistics in the Framework of Logistics 4.0

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Abstract

Industry 4.0 has led to changes that have reduced the labor force and created production environments where machines that bring together information technology and industry communicate with each other. Logistics 4.0, which emerged with Industry 4.0, paved the way for improvement in logistics processes. Using information technologies in logistics reduces the labor force costs of enterprises by leading all stages of activities to digitalization. It can be possible to increase customer satisfaction and product quality by reducing human failures with digitalization. This study was performed by planning intralogistics using Logistics 4.0 technological tools, and also the problem of a manufacturing company was elaborated as a case study. This study was carried out by quantitative data analysis in the case study and a large-scale production company in the automotive industry in Turkey providing the intralogistics of the materials from the supplier in the entrance warehouse with RFID (Radio Frequency Identification) technologies. This paper presents the research, development, and application of logistics 4.0 in the intralogistics process from the entrance warehouse to the production lines. The aim of the case study was provided to information about the technologies available within the scope of Logistics 4.0 and contribute to the literature and industry with solution suggestions depending on the result of the application study within the logistics operations. As a result, depending on the case study, it was determined that Logistics 4.0 improved intralogistics operations costs by 13.37%.

Keywords: Industry 4.0, Intralogistics, Logistic 4.0, Productivity, RFID.

Research Article

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1. Introduction

Industry 4.0 is a collective term that includes the integration of intelligent machines and the introduction of changes in production processes purposed to increase production productivity. Industry 4.0 focused on improving production processes through self-learning robots with RFID (Radio Frequency Identification). RFID is a growing phenomenon in machine communication without the need for human intervention. In production, Industry 4.0 has played a significant role and turned the wheel toward various big changes for the smart factory systems. Industry 1.0 emerged in England from about the 18th century with the use of steam power and mechanization of production. Industry 2.0 is industrialization plays a role in facilitating access to distant markets by increasing the speed of production with the use of electricity from the late 19th century into the early 20th century. The third industrial revolution started at the end of the second world war, with communication technologies, through using computers, and automation industries. Industry 4.0 by the leadership of the Germans emerged in the early 21st century based on cyber-physical systems, big data, artificial intelligence, and the internet of things (IoT) [1].

The defining trend of the revolution that takes place based on Industry 4.0 is to digital the communication of all components of manufacturing processes for creating value in the products [2]. Increasingly heterogeneous markets with shorter product life cycles force many companies to simultaneously new technologies such as industry 4.0 for low costs and high quality. Competitive conditions for production enterprises contain mass customization, flexibility, expanding logistics networks to include and coordinate all suppliers, and optimizing internal/external logistics processes [3]. The term logistics 4.0 is focused on the specific implementations of industry 4.0 and represents the digital logistical system that enables the sustainable satisfaction of effective planning and storage of resources without increasing transfer costs in the process from supplier to customer [4].

Logistics 4.0 supports the industry 4.0 paradigm, such as material and information flow technology in intralogistics two different

ways [5]. In the material flow technology, Automated Guided Vehicle (AGV) is most used in transportation in intralogistics. AGV is a wheeled robot that follows along marked with RFID long lines on the floor, moves parts and products, acting as a shuttle between people picking parts and process who assemble or package parts for production. The information flows technology mainly includes the material storage and transport from the supplier to the production associated and the production planning activities. Logistics 4.0 activities involve many technological methods used in information flow for material and updating the system [6]. Some of those are pick by the scanner (PbS), pick by voice (PbV), pick by light (PbL), pick by augmented reality (PbAR), and pick by tablet (PbT). In this study, materials and information were transferred via a PbS.

Industry 4.0 is one of the most researched topics, as it is expected to have significant impacts on the design, engineering, production, and logistics of products soon. The literature review shows that when the studies on logistics 4.0, it is understood that most of them are theoretical. In applications of companies, as in the case of documentation and work order follow-up is carried out the information flow also in intralogistics at the initiative of the employees. All systems are updated manually. Although this problem, expect the process was faster and error-free by reducing logistics costs, especially labor and non-value-added movement costs, by using smart technologies in intralogistics. Sufficient studies, in this respect, are lacking in the scholarly or industry literature. Due to this problem, this case study can contribute to the industry and literature together with the original approach.

Depending on problem, the study aims to provide information about the technologies available within the scope of Logistics 4.0 and contribute to the literature and industry with solution suggestions depending on the result of the application study within the logistics operations.

This paper is organized as follows: In the introduction, presented an overview of industry 4.0 and logistics 4.0, its basic features, and its enabling technologies. Also, the introduction is the background which briefly introduces the originality of this paper and presents the problem and aim. Section II reviewed pertinent literature on logistics 4.0. Section III presented the method of the steps involved in the case study. Section IV has discussed the technologies and what is the basis of an efficient Logistics 4.0 with reduced labor force involvement. Lastly, Section 5 provides the conclusions and further suggestions.

2. Literature review

It is foreseen that Industry 4.0, which will radically change production systems, will also affect logistics systems that are directly related to production. Accordingly, IoT, which is the keys component of Industry 4.0, is expected to increase the efficiency of intralogistics management [7].

The most common collection system used in the flow of information in production is the manual tracking of the product tree by the labor force with paper [8]. With logistics 4.0, expected that the part distribution performance of the employees will be maximized, and the probability of error will be reduced by using technological tools instead of paper. The aim of logistics 4.0 tools is not only to replace people in their work but to avoid human errors and to have faster processes where information can be shared effortlessly and in real-time [4].

When the studies in the literature on logistics 4.0 are examined, it seems that the theoretical studies are the majority.

[9] analyzed logistics processes with simulation in the context of Logistics 4.0 and made suggestions. [10] proposed a theoretical framework for assessing the challenges and potentials of supply chain management under Industry 4.0. [11] made assumptions about how logistics will evolve in the future by defining six main features of logistics in his book. [12] talked about the concept of "Supply 4.0" within the scope of industry 4.0 and discussed the effects of technology on the supply chain with an empirical study. Hofmann and [7] discussed the effects of industry 4.0 on logistics processes with a conceptual study. [4] reported with a theoretical study that the success of logistics 4.0 will be achieved through the IoT that emerged with industry 4.0. [13] drew attention to the importance of applying big data and IoT technologies in the logistics industry. [14] defined the main features of logistics 4.0 that emerged with industry 4.0 impact and discussed its potential effects. [15] systematically analyzed the advanced technologies available within the scope of logistics 4.0. [5] examined the "Logistics Operator 4.0" paradigm, which defines the machine-operator relations that emerged with Logistics 4.0. [16] conducted a SWOT (Strengths and Weaknesses, Opportunities and Threats) analysis by determining the perspectives and application levels of enterprises providing logistics services in Turkey to logistics 4.0. [17] revealed the advantages of Logistics 4.0 and the obstacles encountered in practice with literature mapping. [18] evaluated the qualitative data they collected from 12 logistics experts in the automotive industry in Bulgaria and reported that production visibility and blockchain technologies have great value for logistics. [19] redefined inventory management from the perspective of logistics 4.0 with their proposed methodology. [20] reported the productivity and efficiency increase provided by artificial intelligence in logistics activities in service businesses. [21] reported that logistics costs can be optimized with the simulation of the use of AGVs, one of the industry 4.0 technologies in intralogistics.

The objective of the previous research review was to explore the literature for current studies that examined the impact of logistics. It is remarkable for the academy that applied research is not done very often, although the studies on the subject of logistics 4.0 have increased in recent years.

In particular, the absence of case studies in the literature on the use of smart technologies in logistics defines a gap in this field. This paper is an original study that provides analysis of current and future technologies within the intralogistics concept. In this case study, solutions for the application of mobile technologies used within the scope of logistics 4.0 in intralogistics are presented.

3. Materials and methods

This research was carried out by quantitative data analysis in the case study. The data on the labor force, working days, logistics

costs, and information technology costs between the years 2017-2021 were collected and converted into a form suitable for analysis. Depending on the collected data, savings are calculated by reducing the technological investment cost for 2021. Furthermore, while collecting data, the processes observed and data collected from the SAP R/3 (Systems Analysis and Program Development) were integrated into the process. The case analysis stages of this study can be summarized as (a) determining the current situation, (b) revealing the new situation according to the innovation brought by the Logistics 4.0 technology, and (c) reporting the difference between the two situations.

Relevant data collected was tested to the suitability of the research purpose in the quantitative data analysis. Moreover, the research result was reported at the point where data was fixed [22]. After extensive data analysis, the researcher used a comparison between the literature and application depending on the result of the case study for harmony/contradiction with the literature [23].

This study was carried out in a large-scale production company in Aksaray/Turkey providing the intralogistics (transporting to the warehouse, storage, and updating the SAP R/3) of the materials coming from the supplier in the entrance warehouse with smart technologies.

The logistics of materials in warehouses is one of the critical elements of supply management [21]. The expectations for RFID sensors that emerged with Logistics 4.0 technologies are as follows: (a) which material will go to which warehouse; (b) which shelf it will be stacked on; (c) when the order of production will come; (d) automatically update information from the SAP R/3.

Providing these expectations prevents all non-value-added movements and times, as in this case study.

4. Results and discussion

In the application made in the production; the current status and the future status in which logistics 4.0 mobile scanner and AGV technologies are used in the transportation, storage, updating in SAP R/3, and distribution of the material coming from the supplier to the entrance warehouse examined.

4.1. Current status analysis

A seven-person team for the application has been consists of managers, engineers, and 1 researcher in the study. The documents from the previous years and observations in the processes for the current status analysis of intralogistics were analyzed using the logistic data from the supplier to production. The current status and the intralogistics performance from the supplier to the production line that could be improved were illustrated with symbols in Figure 1.

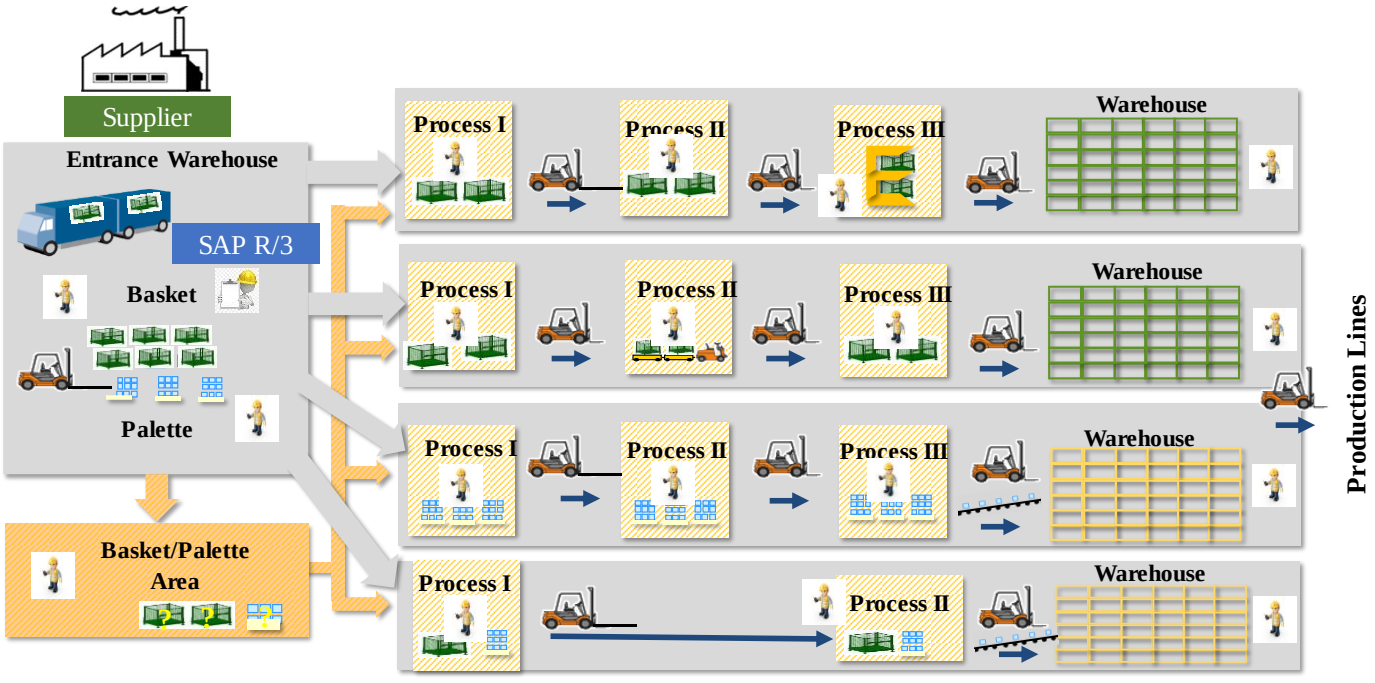

Fig.1 Current status

Figure 1 shows that materials from suppliers are currently transferred to baskets/pallets used for placement and distribution in intralogistics. Materials from the supplier were distributed, to the four large warehouse areas and production lines. At the current status, it may appear that the forklift's 1,235.25 hours annually is worked by 19 operators and 13 forklift operators. A total area of 3,400 m2 is used. SAP R/3 is the name of the source planning software program created by the German company. The SAP R/3 system is what companies of its resource planning software program make monthly payments per module and user. While the company has implemented software systems like SAP R/3, as the number of users increases, the cost of the software increases.

4.2. Future status analysis

Even though problems in intralogistics systems could often still be solved with classic approaches, this can be less costly with the idea of logistics 4.0 technologies. In this study, a case analysis has been done to understand the intralogistics practices of the material from the supplier to increase total productivity and quality. In this case study, PbS from logistics 4.0 technologies were used in the future status. In intralogistics, the products specified in the order come from the supplier to the entrance warehouse, and the parts are distributed to their places in the warehouses according to the data previously uploaded to the mobile scanner. One of the most important advantages of PbS is that the parts coming from the supplier are placed at the warehouse address according to the data they receive from the mobile scanners they attach to their belts, without being left to the initiative of the operator. Another advantage is updating the data in the central software (SAP R/3) system by automatically increasing the number of stocks. Depending on this advantage, the use of PbS is expected to reduce the labor, space, and forklift costs of intralogistics. The future status and the PbS performance from the supplier to the production line are illustrated with symbols in Figure 2.

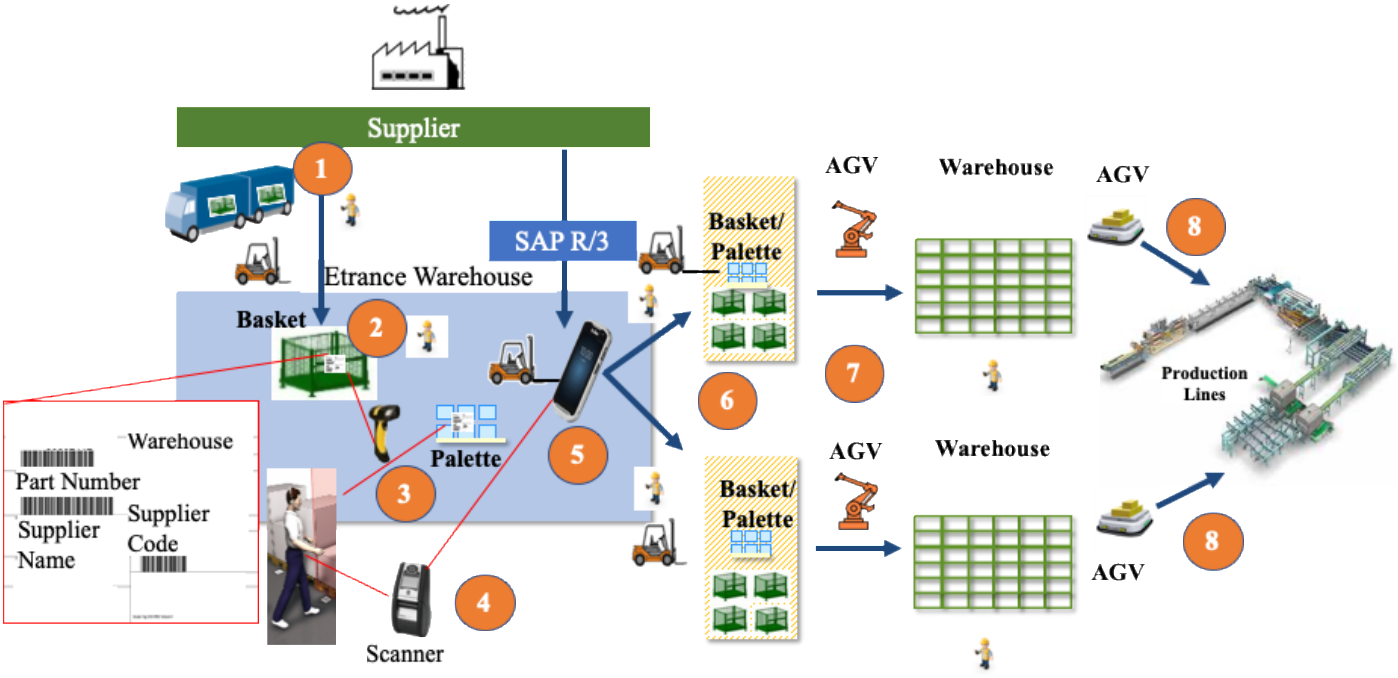

Fig.2 Future status

According to Figure 2, after using logistics 4.0 technology such as PBS, the material coming from the supplier by truck is unloaded to the entrance warehouse with baskets labeled at the supplier. The operator reads the label of the basket with the barcode scanner in his hand. Material data is transferred to the mobile scanner attached to the operator's belt. The mobile scanner transmits data to the forklift operator's tablet. Forklift operator transfers materials to AGVs. When it is the production phase, AGVs carry the loaded material to the production line. The material coming from the supplier for production is located in the most suitable area via the AGV routed with RFID technology. The significant difference between the current and the future status is that investments in information technologies have increased costs in the future. Even if the amount of investment in information technologies is high; it has been observed that savings are achieved by reducing the number the labor force, reducing the square meter of the used area, reducing the user of SAP R/3, reducing the number of forklifts and accordingly reducing the number of forklift operators. Table 1 shows in order to evaluate to improvements the difference between the current and future status.

Table.1. The difference between the current and future status

Cost Units	Current Status (€)	Future Status (€)	Savings (€)	Improvement (%)
Labor Force	78,849.24	29,049.72	49,799.52	63.16%
Used Area	510,000.00	335,550.00	174,450.00	34.21%
Information Technologies:	0.00	19,320.00		
-Mobile Scanner			-19,320.00	0
-Barcode Reader	0.00	11,600.00	-11,600.00	0
-Tablet	0.00	15,300.00	-15,300.00	0
-AGV	0.00	122,064.00	-122,064.00	0
-AGV Routing	0.00	17,620.00	-17,620.00	0
-SAP R/3	12,320.00	5,190.00	7,130.00	57.87%
Forklift	6,299.78	710.18	5,589.60	88.73%
Forklift Operator	53,949.48	16,599.84	37,349.64	69.23%
TOTAL	661,418.50	573,003.74	**88,414.76€**	**13.37%**

It can be seen from Table 1 that the best for company is future status. Future status was applied to identify the ways of intralogistics process improvements using the logistics 4.0 technologies while achieving the operational excellence. According to future status, the improvements were calculated as follows;

(a) Labor Force: Currently, while 19 operators are working in the process, the number of operators has been reduced to 7 with the use of mobile scanners, barcode readers, tablets, and AGVs from logistics 4.0 technologies. The annual cost of 1 operator 4,149.96 €. Accordingly, the operator cost, which is currently 78,849.24 €, has been reduced to 29,049.72 €.

49,799.52 € improvement achieved in the labor force.

(b) Used Area: The time losses in importing data from SAP R/3 were avoided owing to mobile scanners and barcode readers. In this context, non-value-added movements have decreased, and the area has been saved. The warehouse area used in the future status has been reduced from 3,400 m2 to 2,237 m2. The annual cost of 1 m2 warehouse 150 €.

174,450.00 € improvement achieved in the used area.

(c) Information Technologies: Due to the need to invest in information technologies using logistics 4.0 technologies, costs that are not in the current status have emerged. 30 mobile scanners for 19,320.00 €, 50 barcode readers for 11,600.00 €, 30 tablets for 15,300.00 €, 6 AGV vehicles for 122,064.00 € were purchased. There is a routing cost for using AGV in wireless sensor networks, where the property of RFID is significant. The annual cost of the routing, including administrative expenses, is 17,620.00 €.

At the current status, all modules of SAP R/3 software were used by operators. In the future status, the number of users in the modules has decreased as the data from mobile technologies is automatically integrated with SAP R/3. In SAP R/3 software, the cost decreases as the number of users decreases. The annual cost, which is currently 12,320.00 €, has been reduced to 5,190.00 €.

7,130.00 € improvement achieved in the software. As a result, the information technology investment costs are -185,904.00 € (19,320.00€ + 11,600.00€ + 15,300.00€ + 122,064.00€ + 17,620.00€), the savings are 7,130.00 €.

(d) Forklift: AGVs are capable of not only reducing the cost of forklifts and their operators but also running 7 days / 24 hours, without any operator supervision. The annual working time, which is current status 1,235.25 hours, in future status has been reduced to 139.25 hours. The hourly cost (including rent, maintenance, energy, etc.) of a forklift is 5.10 €. The forklift cost, which is 6,299.78 €, was reduced to 710.18 €, resulting in a savings of **5,589.60 €.**

(e) Forklift Operator: Logistics 4.0 reduced the cost with a reduced number of operators with its advantages of unmanned technologies. While 13 forklift operators are in their current status working, in this way, the number of forklift operators has reduced to 4. The annual cost of 1 operator 4,149.96 €. Accordingly, the operator cost, which is currently 53,949.48 €, has been reduced to 16,599.84 €.

37,349.64 € improvement achieved in the labor force.

Findings from this case study show that with the use of logistics 4.0 technologies, significant improvements were achieved in the intralogistics processes from the entrance warehouse to the production lines. The success of the logistics 4.0 application is depending on the results of the case study. In this case study, savings of € 88,414.76 were provided, which corresponds to an amount of 13.37% per year with the reduction of non-value-added activities and operators.

5. Conclusions

This paper presents the research, development, and application of logistics 4.0 in the intralogistics process from the entrance warehouse to the production lines. An overview of the main principles of logistics 4.0 and its effect in the field of intralogistics is given. Logistics 4.0 is a field that is still having researched, and the case study focused on sustainability parameters such as the labor force, area, and vehicles used.

This study, characterized by using logistics 4.0 technologies in intralogistics, has made the internal material and information flow more efficient. After the case study of logistics 4.0, the total annual costs decreased from 661,418.50 € to about 573,003.74 €, and these enhancements in a savings of 88,414.76 €.

The amount of 88,414.76 € corresponds to approximately % 13.37. Overall, quantitative evidence showed that logistics 4.0 has an expected effect related to the reduction of costs, and the aim of the study was met with the improvements made.

In addition, the materials coming to the enterprise were delivered to their addresses in the warehouse with RFID devices, preventing document confusion. That is a process improvement as it avoids operator error in the long run. It has seen that this study, which contains important clues that the use of smart technologies in logistics processes can achieve effective results in ensuring efficiency, is compatible with the literature.

The findings of this study were suitable for especially the labor and non-value-added movement costs, as this case study intralogistics costs of smart technologies used in the study reduced from in entrance warehouse to production lines. The intralogistics costs of Logistics 4.0 used in the study were applied locally from in entrance warehouse to production lines. The findings of this local study can be used for the whole process in industrial application. Due to its originality, this study contributed to the logistics activities and literature. In this context, the results of this study are consistent with the literature, and it is recommended that future studies to reduce the intralogistics costs for production enterprises. As another suggestion, optimization studies can be carried out within the framework of Logistics 4.0 with unmanned technologies (sound assisted, light assisted, augmented reality and tablet assisted picking/distribution) other than the technologies used in this study within the scope of Industry 4.0. Regarding the limitations of the research concerned, it should be mentioned has been conducted within one location only and intralogistics.

Conflict of Interest Statement

The authors declare that there is no conflict of interest in the study.

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