Gaining Strategic Insights into Logistics 4.0: Expectations and Impacts[1]

Berk Kucukaltan[*,a,b], Omur Y. Saatcioglu[c], Zahir Irani[b], Okan Tuna[c]

[a]*Trakya University, 22030, Edirne/TURKEY*
[b]*University of Bradford, BD71DP, Bradford/UK*
[c]*Dokuz Eylul University, 35390, İzmir/TURKEY*

Abstract

The developments brought by Industry 4.0 have spread to various components in a supply chain, where logistics is of utmost importance due to the intermediate role of logistics service providers (LSPs) operating among different actors. Despite such a vital role, the extant literature lacks from the extensive analysis of Industry 4.0 implementations in the logistics industry, particularly for LSPs. Accordingly, this study sets out to investigate, comprehensively, Industry 4.0 projections in logistics and their reflections on LSPs by adopting a multidimensional approach. In this respect, the key themes influenced by Industry 4.0 developments are initially determined through a structured survey conducted in the Turkish logistics industry. Then, in the same industry, both the probabilities and the impacts of Industry 4.0-focused thematic statements are examined through an integrative interview survey, which also incorporates "why-type" of questions. Consequently, this study offers academic implications in terms of demonstrating possible changes in the logistics industry from the operational, financial, and human resources aspects. Additionally, the findings serve as a reference for logistics professionals while fostering their competitive Industry 4.0 initiatives and facilitating their strategic decisions.

Keywords: Competitive Advantage, Future Projections, Industry 4.0, Logistics 4.0, Logistics Service Providers.

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1. Introduction

Up to the present, the world has been through four industry revolutions and, given the evolutionary progress of these revolutions, it is evident that the industry has experienced different paradigm shifts (Shamim et al., 2016), ranging from automation to digital and robotic systems (Wahrmann et al., 2019). Among these revolutions, as never seen before, the latter industry revolution that occurred in the more recent past has revealed new potentials and brought forward new catchwords, such as digitalisation (Hofmann and Rüsch, 2017).

Digitalisation is a more structural change than just digitising existing processes or products (Gassmann et al., 2014; Henriette et al., 2015; Parviainen et al., 2017). The scope of digitalisation is widely defined as, "*the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business*" (Gartner, 2019). Indeed, the latest exponential development of technology has accelerated the transition towards digitalisation process, where a bundle of interconnected and sophisticated systems exists (Schwab, 2016). Today, digitalisation has been used as the most preferred keyword (Maslarić et al., 2016) and paves the way for constructing fundamental components of the emerging term: Industry 4.0 (known also as the fourth industry revolution), appeared firstly in Germany (Maslarić et al., 2016).

Industry 4.0 holds a supreme potential to offer several promises, such as full transparency from suppliers to customers, connected processes, and decentralised as well as autonomous management (Kayikci, 2018). Depending on these promises, it is clear that digital transformation coming along with the fourth industry revolution does not only occur at its initially starting point, which is the manufacturing phase, but also within various phases existing in a supply chain, where logistics is of great importance as a core component (Mehami et al., 2018). In fact, due to the transportation requirement of various products, logistics becomes key to integrate activities within a supply chain (Lin, 2009) and logistics

service providers (LSPs) undertake an intermediate role between different supply chain members. From this point forth, owing to probable impacts of Industry 4.0 on some particular activities that production has close relationships, such as distribution and storage, the fourth industry revolution holds, inherently, a strong potential of influencing the logistics industry (Maslarić et al., 2016) and, as such, makes logistics a key domain for examining a successful Industry 4.0 implementation.

In the logistics domain, Industry 4.0 brings along a number of innovations and improvements from different aspects. For instance, a full implementation of digital technologies enables companies to build hyper-connected logistics solutions at the strategic level (Bányai, 2018), to operate at a new level of resiliency and responsiveness, to acquire a large-scale data (e.g. Big Data), and to increase financial and operational margins (Kayikci, 2018). More specifically, from the financial angle, the importance of innovative thinking through knowledge resources has become more prominent for LSPs, since it leads to cost advantages and, in turn, provokes competitiveness (Karia, 2018). Despite this importance, as Karia (2018) pointed out, the extant literature remains insufficient for explaining how LSPs can hold cost advantages through technological and knowledge resources.

From the operational process perspective, it can be observed that, in the context of Industry 4.0, flexibility and responsiveness to dynamic changes have received a great emphasis in transportation and distribution systems (Teschemacher and Reinhart, 2017). Besides, when considering different supply chain members, logistics, in fact, remains as one of the core disciplines for the success of Industry 4.0 projections during the process setups (Herter and Ovtcharova, 2016). In this respect, innovation-oriented advancements occurred in production processes, by virtue of Industry 4.0, affect similarly the service sector and, hence, the smart systems and digitised value-added activities enable to bring out the equivalent term of Industry 4.0 in the logistics industry, which is “Logistics 4.0” (Barreto et al., 2017).

The nascence of Logistics 4.0 from the Industry 4.0 concept is not only important for different operational matters, such as sustainability, efficiency, and responsiveness to customers, but also critical for facilitating improvements in whole fundamental business elements (Strandhagen et al., 2017). Accordingly, since logistics provides inputs for production systems with the right quantity and quality at the right time and place, the logistics industry can be regarded as an appropriate area for examining practical applications and reflections of Industry 4.0 (Hofmann and Rüsch, 2017). In this sense, for increased efficiency and effectiveness of an entire supply chain, operational processes of LSPs in respect of Logistics 4.0 advancements are of substantial importance.

In addition to the former two technical aspects (i.e., financial and operational), there is another aspect that needs particular attention from LSPs, which is the aftermath of human capital and workforce in the logistics domain. As widely known, the logistics field, which usually allows business-to-business relationships (Özaydın, 2016), is a service area that human resources and managerial skills have critical roles. In fact, such importance of human capital matches up with the nature of Industry 4.0 since the innovation notion, which constitutes the basis of Industry 4.0 developments, hinges upon learning and knowledge capabilities of individuals (Shamim et al., 2016). Within this scope, as a consequence of Industry 4.0 implementations in the logistics industry, some changes are also anticipated in the demographics, such as varying number of employees and their qualifications. Yet, as Shamim et al. (2016) underlined, it is evident that Industry 4.0-related studies focus largely on the technical and technological aspects while paying relatively little attention to some other aspects, such as human resources, workforce, and managerial skills. In parallel to this, from the practical side, logistics companies confront difficulties in utilising knowledge and technology resources for enhancing their competitiveness and, as such, sparks off a requisite

for LSPs to preserve human capital, as it is a catalyst for reaching superior performance (Karia, 2018).

In light of these aforementioned matters, Industry 4.0 can be widely regarded as an umbrella term that reveals rapidly developing technologies and the new terms (e.g. Logistics 4.0), (Strandhagen et al., 2017). Despite these potentials, Industry 4.0 also poses some critical challenges, such as cost reduction pressure, lack of skilled workforce, ageing society, and the need of a specialised management to cope with operational shortages (Shamim et al., 2016). While addressing these challenges by providing a non-lopsided harmony between different supply chain members, it is critical to understand that Industry 4.0 components (e.g. digitalisation, Big Data) are more than buzzwords (Rakyta et al., 2016) and LSPs are crucial actors for disseminating this harmonisation in a supply chain. However, in terms of the digitalisation, logistics still remains immature and far to reach the maturity level (Kayikci, 2018), although it is an essential concept for the future of Logistics 4.0 (Delfmann et al., 2018). Likewise, with regard to Big Data, in spite of its criticality in the development of the logistics area (Szymańska et al, 2017), it is still in its infancy (Frehe et al., 2014; Mishra et al., 2018). To this end, as Zijm and Klumpp (2017) pointed out, the logistics field has to reinvent itself with the upcoming advancements in this era.

Therefore, in this research, we seek answers to the following research questions: 1) What are the major themes (dimensions) in the logistics field influenced by the Industry 4.0 developments and applications? 2) What are the probabilities of discussed remarkable statements under these major themes (dimensions) to occur in the logistics field, their potential degrees of impact on the logistics industry, and why? Accordingly, in order to answer these questions, the present paper initiates an aim of investigating Industry 4.0 developments comprehensively in the logistics industry. In line with this aim, we first determined the major themes (dimensions) through a survey conducted in the Turkish

logistics industry. Afterwards, we initially prepared thematic statements to place under these revealed themes with the help of the examined literature. Subsequently, we carried out an integrated interview survey to obtain opinions of experienced professionals from the logistics domain regarding both the probabilities and the impacts of the Industry 4.0 implementations, through the determined thematic statements, in addition to the exploratory "why-type" of question in each statement. Thus, by performing this multidimensional multiple-stage approach, anticipated changes in operational activities, financial management, and human resources, which were inadequately discussed in previous studies, are comprehensively evaluated in this research for the specific context of the logistics industry.

In accordance with these objectives, the remainder of this study is organised as follows. The literature review conducted for this study is discussed in Section 2, while the methodological approaches are explained in Section 3. In Section 4, the case background and the examination of various Industry 4.0 developments in the logistics industry are introduced. Finally, the conclusions, critical discussions, implications, and limitations are noted in Section 5.

2. Literature Review

Industry 4.0 is a fresh reality of the modern economy (Ślusarczyk, 2018) and Logistics 4.0, as a derivative of Industry 4.0, is a nascent term (Barreto et al., 2017) that paves the way for numerous opportunities for improvement in the supply chain network, more particularly in the logistics domain. In order to explore these opportunities and themes discussed by previous researchers, it is important to critically analyse the extant literature on Industry 4.0 applications in logistics. Thus, in this study, with the intent of identifying relevant Industry 4.0-related studies in the logistics field, we used the following search terms: "industry 4.0" and "logistics*" and "scenario*"; "industry 4.0" and "logistics*" and "service provider*"; "Logistics 4.0". The searches were systematically carried out mainly in the abstract, title, and keywords of the articles and articles in press indexed in two widely-known databases, which

are: ScienceDirect and Scopus (similar to Bányai, 2018). In addition to these keyword pair searches, we also conducted the cross-referencing technique on seminal papers (similar to Kucukaltan et al., 2016; Thanki and Thakkar, 2016), which yielded to reach out several additional research. At the end of these phases, the generated list constituted the sample of this research for reviewing the literature. Yet, among these papers, one was in another language whereas two were not accessible via the university database systems of the authors. Besides, it is worthy of mentioning that although some articles appeared relevant after the keyword searches, their research scopes were slightly different (e.g. national forest policy) and, therefore, only the logistics-related articles made available until the time of this research were selected as the core of the literature review of this study.

First of all, from past to present, logistics has been deemed as a core operation in supply chain management (Papadopoulos et al., 2017) and positioned at the heart of any supply chain system (Shibin et al., 2018). As a subset in the supply chain network, logistics, today, means operating in complex networks between interdependent organisations. To deal with this complexity, intelligent solutions offered via information technologies, especially through up-to-date Industry 4.0 technologies, become essential and are regarded as control and support instruments of such networks (von der Gracht and Darkow, 2010).

Additionally, in these complex network structures, where interdependent connections exist, integrative Industry 4.0 operations bring out, ultimately, the indispensable role of logistics. In this sense, as Hofmann and Rüsch (2017) argued, Industry 4.0 can only become reality in its pure vision, if logistics is capable of providing production systems with the required input items at the right time, in the right quality, and in the right place. That is to say, in order to obtain the maximum benefit from Industry 4.0 applications, integration with other components in a supply chain becomes requisite and, for a well-designed integration, collaborations between different supply chain actors (e.g. suppliers, manufacturers,

customers), through LSPs, are of critical importance to increase the transparency of whole product life cycle. In this respect, it is clear that logistics plays a central role in providing the integration of supply chains (Caputo et al., 2003; Delfmann et al., 2018) and becomes a driving force for putting Industry 4.0 novelties into practice (Delfmann et al., 2018). By undertaking such a pivotal role in this integration, logistics emerges as a key area for observing the success of Industry 4.0 applications (Hofmann and Rüsch, 2017). In a similar vein, Tjahjono et al.'s (2017) findings reinforced this argument by noting that transport logistics is one of the most affected areas by the introduction of Industry 4.0 in the supply chain domain and the majority of the impacts in this area are comprehended as opportunities.

Within the logistics scope, previous researchers studied opportunities and advantages coming along with Industry 4.0 adoption from different aspects. Based on the aforementioned keyword searches, the research concepts revealed from earlier research can be summarised as follows: workforce-related changes after Industry 4.0 developments, adoption of Industry 4.0 technologies in business processes, benefits of Industry 4.0 applications from different aspects, and changes leading to competitive advantages, especially within the policy formulations in different contexts.

In the new industrial era, although business processes and technical aspects are largely centred on the focal point of studies, some particular subject matters, such as human capital and the level of employee involvement are remained more shallow (Shamim et al., 2016). Yet, while addressing possible scenarios anticipated from Industry 4.0 advancements, it is evident that the balance between technology adoption and human intervention holds a great importance for organisations since a complex interaction between humans and machines tends to emerge (Alqahtani et al., 2019). In fact, effectiveness and success of Industry 4.0 depend on the knowledge and adaptation capabilities of workers paired with machine precision and speed. As a similar supportive argument, Sauter et al. (2015) commented that the success of

Industry 4.0 applications hinges substantially upon the presence of a competent workforce at all levels. From this point forth, the quality and accessibility of human competencies turn out to be the most significant limiting and key factors in organisational success for Industry 4.0 adoption.

Despite this crucial role of human competence in making innovations, there are different workforce-related scenarios proposed by researchers in the Industry 4.0 literature. For instance, Lasi et al. (2014) proposed that in the design of new manufacturing systems, human needs should still be considered by organisations. In another study, Strandhagen et al.'s (2017) Logistics 4.0-oriented research further advanced this discussion by expressing that, in the high degree of automation, human capital will still remain essential; however, their roles are expected to show alterations. Likewise, in the logistics domain, Barreto et al. (2017) remarked that the profile of human resources will dramatically change, due to the requirement of higher level of analytical skills, and there will be a reduced human involvement in the activities. Thus, as similarly highlighted in Hofmann and Rüsch' s (2017) study, it is clear that human decision making at the operational level is expected to be majorly changed, although it will still remain somehow needed at the strategic level.

In parallel, these diverse opinions unveil that the advancements brought by Industry 4.0 cause vagueness on the future projections of human capital, which, in fact, needs to be uncluttered. More particularly, in the logistics field, dealing with this challenge becomes far more crucial since the logistics industry has a labour-intensive nature (Staub and Akkaya, 2018) and LSPs undertake an intermediate role between the components in the supply chain network (Hertz and Alfredsson, 2003; Bealt et al., 2016). In this sense, it is worth mentioning that the advancements in technology, just as Industry 4.0 applications, hold a potential for generating different projections occurred in the human capital aspect, which, in turn leads to a change also in business processes.

In terms of the adoption of Industry 4.0 developments in business processes, it is initially significant to note that Industry 4.0 encapsulates not a single technology but a combination of various technologies that can conjointly unleash their full potential (Lasi et al., 2014; Schröder, 2017). Adoption of these multiple technologies has different influences on business processes and, thereby, Industry 4.0 developments have substantial impacts on processes that can potentially lead to renewal of products and services (Engelbertink and Woudstra, 2017).

Moreover, adoption of Industry 4.0 technologies has positive impacts not only on products and services, but also on some other aspects of organisations, such as economic (e.g. cost reductions), social (e.g. energy efficiency in relation to the environment), and political (e.g. policies). In line with this argument, Lasi et al. (2014) underlined that social, economic, and political changes coming along with Industry 4.0 can be represented by some parameters, such as short development periods, high innovation capability, individualisation on demand, resource efficiency, and cost reduction.

Among these parameters, Sauter et al. (2015) particularly noted that the main driving force for Industry 4.0 applications is the possibility of reducing costs. In this sense, according to their case findings in the context of Germany, the cost reduction was shown as a direct or an indirect target in almost three quarters of the applications. In a similar vein, in the logistics field, Karia (2018) explored the relationships between knowledge resources, technology resources, and the cost advantages for Malaysian LSPs by performing the survey technique. Her research findings, based on the data obtained from 122 LSPs in Malaysia, demonstrated that there is a direct relation between knowledge resources and cost advantages whereas technology resources indirectly influence cost advantages. That is to say, for LSPs, knowledge is a core resource to enhance the technological performance and to possess the cost advantages. Accordingly, from these studies, it can be concluded that the knowledge

acquired through human capital serves as a basis to reach cost advantages for organisations, especially for LSPs.

In addition to these economic impacts, some researchers in the logistics area also emphasised the environmental advancements and the smart system innovations in operations, as a consequence of Industry 4.0 developments. Concerning the former matter, Bányai (2018) focused on energy efficiency and environmental issues in logistics and used a black hole optimisation-based heuristic model in order to evaluate the energy efficiency in the last mile logistics. For comparing energy consumption of the proposed alternative solutions, the researcher conducted the scenario analysis technique. With regard to the latter concept, Rakyta et al. (2016) adopted a proactive approach and studied on the upcoming changes along with the transmission towards smart maintenance and smart logistics since these have become more complex after the arrival of Industry 4.0. Yet, their research majorly remained as a discussion of recent trends. Likewise, smart logistics concept was also incorporated by Zhong et al. (2017) among several demonstrative scenarios in a manufacturing company, where logistics operations are detailed with internet of things devices (e.g. using RFID tags). As can be seen from these three studies discussed in the social end, either the logistics industry was not placed on the focal point or the underlined changes in logistics were remained largely conceptual. However, in the Logistics 4.0 concept, some of the technological developments that are mainly expected in the shorter term are intelligent containers, smart devices, and driverless vehicles, which will interact with human through speech, gestures, and physiological parameters. In the longer term; autonomous trucks, robots or complex machines are thought to be influential in Logistics 4.0 (Delfmann et al., 2018).

On the other hand, changes leading to competitive advantages were especially underlined by some researchers. In this respect, in order to draw the whole picture, Zijm and Klumpp (2017) initially categorised the themes of articles on logistics and supply chain management from

2005 to 2015 and identified four main areas (i.e., business process management, competitive advantage, strategic management, network structure), where information technology and Industry 4.0 concepts were encapsulated in the competitive advantage area. With a more specific approach, Kovács and Kot (2016) highlighted the importance of adoption of innovative technologies for successful business operations that sparks off competitiveness in the logistics area. However, despite the emphasised importance of implementing Industry 4.0 applications for possessing competitive advantages, it is apparent that the degree of impact of Industry 4.0 on logistics has still remained unclear. In order to disambiguate this vagueness in the logistics field, the projections proposed by professionals in logistics industries can be used as an early signal, from the policy-based angle, to improve level of competence either at a micro level (e.g. organisational) or a macro level (e.g. country). Thus far, the aforementioned parameters in this section have been extensively elucidated for the logistics industry at a micro level.

At a macro level, based on PwC's global Industry 4.0 survey carried out for different sectors in 26 countries, Geissbauer et al. (2016) pointed out that the rate of digitalisation in the transportation and logistics sector was 28% in 2016 and is expected to be 71% by 2021. In another context, Özcan et al. (2018) remarked that Turkey has been mapping out logistics-based new policies both at the nation-wide and at the regional level to acquire strategic advantages. Although they presented several foreseeable projections for the Turkish logistics industry (e.g. a better position in the logistics performance index), in sum, it was stressed that as long as new policies are adopted by considering the obtained outcome from the impacts of Industry 4.0, it can possibly bring more new insights to forecast the future impacts of Industry 4.0 on logistics. For a more specific impact, Kayikci (2018) studied on the sustainability effect of digitalisation on logistics across six characteristics, through a case study in the Turkish logistics industry, and incorporated a Delphi panel consisting of four fast-moving

consumer goods companies and their two transport service providers. According to the Delphi results, it was pointed out that, in spite of implementing digital technologies in logistics has a great impact in respect to sustainability, digitalisation is still in its infancy in the logistics field due to the lack of comprehensive study in the extant literature.

To sum up, in the reviewed literature, various conceptual scenarios were highlighted at different levels. In this regard, Table 1 helps to summarise the foremost concepts emerging from the literature and to show example references in relation to these concepts. However, concerning the references presented in this table, it is worthy of noting that there is no strict line to distinguish these research since majority of the studies were conceptual and discussed various scenarios that fall into different concepts and fields (e.g. Sauter et al, 2015). Nevertheless, in the present study, the main emerging concepts tackled in these references were diligently determined and, if logistics and/or LSPs were predominantly discussed, such references are highlighted bold in the table.

Table 1. Summary of the foremost concepts from the reviewed literature and example references

Foremost Concepts	**Example References**
Workforce and Human Capital	**Strandhagen et al. (2017)**, **Barreto et al. (2017)**, **Hofmann and Rüsch (2017)**
Business Processes and Impacts on Different Aspects: A. Economic Aspects B. Social Aspects C. Political Aspects	Lasi et al. (2014), Sauter et al. (2015), **Karia (2018)**, **Bányai (2018)**, **Rakyta et al. (2016),** Zhong et al. (2017), **Delfmann et al. (2018)**, **Geissbauer et al. (2016)**, **Özcan et al. (2018)**, **Kayikci (2018)**
Competitive Advantages	Zijm and Klumpp (2017), **Kovács and Kot (2016)**

All in all, as a consequence of the reviewed research in this section, although different concepts and advantages from various perspectives were underlined by previous researchers, as can be seen from Table 1, it is evident that the logistics industry was not taken on the focal

point in the majority of these studies. Besides, in addition to the scarcity of Industry 4.0-related research in the logistics sector, the discussed themes and concepts remained largely conceptual, especially in a limited view. In line with this argument, due to a lack of comprehensive research, exploring possible changes for LSPs from multiple aspects were remained under-researched in the existing studies and such insufficiencies cause a lack of precision about what Industry 4.0 can and will bring for the logistics sector. Accordingly, this study sets out to advance the extant knowledge presented to date by listing a number of thematic statements from multiple aspects for providing information about both the probability and the degree of impact of prospective Industry 4.0 projections in the Turkish logistics industry, particularly for LSPs. Meanwhile, it is worth mentioning that the discourses discussed in previous studies were broadly considered while listing the thematic statements in the present study and the statements were grouped under relevant categories, as elaborately explained in Section 4.

3. Methodology

The methodological process of this study is designed in accordance with the research questions and objectives, which require obtaining reliable information from professionals in the logistics area. In the wake of accomplishing the research objectives and addressing the research questions, the research design is formed, as demonstrated in Figure 1, so as to present a clear picture regarding the procedures of this study. Moreover, the methodology of the present research, which consists of two stages, is explained in detail in the following sub-sections.

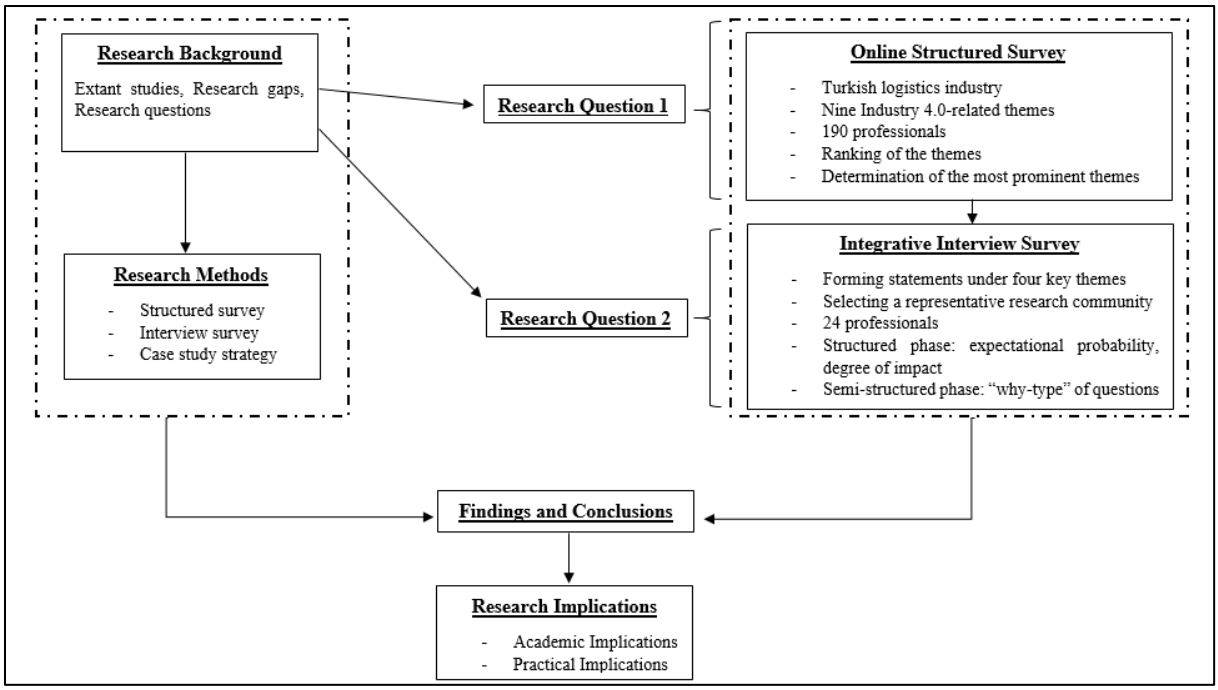

Figure 1. The research design

As exhibited in Figure 1, both the quantitative and the qualitative techniques are used as the methodologies of this study. In this regard, we followed Eisenhardt's (1989) seminal research, where it was pointed out that case studies combine either qualitative (e.g. interviews), quantitative (e.g. questionnaires) or both data collection methods and, among these, the combination of both data types can particularly generate a high synergy. Indeed, combining the techniques of structured survey and interview has attracted much attention of various researchers (e.g. Karia and Wong, 2013; Creazza et al., 2015; Addis et al., 2019). Given these, the combination of the structured survey and the integrative interview survey was adopted in order to provide the best possible answer to the mentioned research questions.

3.1. Structured Survey

In the first stage, as a response to the first research question, we carried out an online structured survey by listing the major themes (dimensions) revealed from the literature. Yet, it is worthy of noting that, following a similar objective with several researchers (e.g. Gasiea et

al., 2010; Chang, 2013), the purpose of this survey was only set to highlight the most prominent themes through the obtained answers from professionals in the logistics field, rather than initiating advanced statistical analyses. In fact, this purpose matches with the standpoint of Ketokivi and Choi (2014) since they noted that the aim of case research is not to produce theories for being tested or validated by other researchers. In this way, we were in quest for offering both a reliable approach to answer the first research question, in a best possible way, and a robust basis for the second stage. Moreover, in order to reach out more respondents in the logistics field, where large business-to-business connections (Grant et al., 2005) and various stakeholders (Kucukaltan et al., 2016; Vural and Tuna, 2016) exist, snowball sampling was also practiced in this study. In this way, as Hair et al. (2003) noted, respondents participated into the survey helped identifying additional prospective respondents to be reached.

3.2. The Integrative Interview Survey

Subsequent to the identification of key major themes at the end of the first stage, there was a need of determining the probabilities and the potential impacts of previously proposed Industry 4.0 thematic statements for the logistics industry, as a response to the second research question. In this respect, our comparative investigations on research methods revealed the importance of using the interview technique in the second stage since interviews are predominantly preferred to uncover unknown practices and facts (Qu and Dumay, 2011; Simpson et al., 2016). Among the commonly accepted three interview types, which are structured, semi-structured, and unstructured (Clifford et al., 2010), structured interviews have a critical position for empirically giving new insights to researchers (Saunders et al., 2009) whilst semi-structured interviews are pivotal for building on a theory (Alexander and Childe, 2013) and developing an in-depth understanding (Foresti et al., 2007; Kreye, 2016) as a qualitative technique (Scuotto et al., 2017). In this sense, due to the research objective of

determining the expectational probabilities of the incorporated thematic statements and their degree of impacts on the logistics field, we asked respondents to provide empirical answers on structured statements. Simultaneously, after each statement, we also placed an open-ended question (i.e., "why-type") to enable participants explaining their rationales on given scores and, thereby, the integrative interview type was adopted in this study.

The integrative interview approach was indicated by several researchers (e.g. Brannen, 1992; Qureshi, 1992; Arthur and Nazroo, 2003) as more depth than a traditional interview approach. In fact, regarding the methodological gap on this implementation, Barratt et al. (2011) emphasised that the deductive use of qualitative case studies is in need of further development and, especially, the adoption of semi-structured insights advances such use in studies. On the other hand, concerning the overarching view on conceptual and contextual issues, Childe (2011) underlined the importance of using the exploratory research purpose when technology is being applied in a different setting. Thus, the complementarity of both quantitative and qualitative structures in this technology-focused research was used to fill in gaps for issues and to explore the meanings with the aim of adding more depth to the findings, as pointed out by Saunders et al. (2009) and Flick (2010).

On the other hand, selecting the target respondents from a focused community play a crucial role for the success of a study. In this connection, as elucidated in Section 4.3, we selected our sample from an extensive logistics association (i.e. UTIKAD). Additionally, while selecting the target respondents at the second stage, the purposive sampling technique (also referred to as "judgmental sampling") was used by the authors. Generally speaking, this technique is adopted in order to utilise own judgments of researchers to select cases that will best answer research objectives and questions (Saunders et al., 2009). Besides, this technique holds a better potential than others (e.g. convenience sampling) for considering the expertise of the respondents (Hair et al., 2003). Owing to these reasons, the purposive sampling is widely used

both in qualitative and in quantitative studies and guides researchers to deliberately choose particular people for obtaining specific information (Al Shibli et al., 2018). Accordingly, in order to establish a control over the type of people that are experts for acquiring substantial information (Aghapour et al., 2017), this technique was decided as appropriate for this research.

On the other hand, in the structured interviews and surveys, reaching out more respondents usually becomes a remarkable issue for the significance of findings and, on this matter, the Web provides new opportunities for logistics researchers to distribute their surveys (Grant et al., 2005). In parallel to this motive, we decided to administer our surveys at both methodological stages on the Internet. Thus, we exploited the advantages of conducting online surveys, such as reaching a large number of respondents, saving time and money (Schmidt, 1997).

4. Analysis of the Probable Industry 4.0 Themes and Statements in the Turkish Logistics Industry

4.1. The Case Background: Turkish Logistics Industry

The present study draws upon the Turkish logistics industry and the rationales of choosing Turkey as a case are manifold. Firstly, as highlighted by Aktas et al. (2011), Turkey possesses a significant potential for becoming a logistics base due to its geopolitical location that connects Asia and Europe. Secondly, the Turkish logistics industry holds the largest fleet of trucks in Europe (Büyüközkan et al., 2008; MÜSİAD, 2013), as a result of the extensive use of road transportation in the international trade (Büyüközkan et al., 2008). Thirdly, Turkey is a developing country and an emerging economy (Vural and Tuna, 2016) where the logistics industry significantly contributes to the foreign trade of Turkey (Acar, 2012). However, the density of transport infrastructure is lower than some developed countries and the dominance

of the road transportation remains a major issue for Turkey that causes a lopsided modal split and an inefficient transport system (Özcan et al., 2018). Yet, from the technological aspect, Turkey is among the leading economies performing Industry 4.0 developments with a growing workforce and, according to Boston Consulting Group's Global Manufacturing Cost-Competitiveness Index, lower direct manufacturing costs in Turkey, compared to several leading countries (e.g. Germany, USA), position Turkey at the competitive edge along the value chain (TUSIAD, 2016).

Overall, while the mentioned distinctive advantages reveal the Turkish logistics industry as a strategic case to be examined, some major challenges, such as the transportation preferences and the infrastructure of the transport system, also need to be considered for the applicability of Industry 4.0 practices. Consequently, in order to provide a robust and realistic approach to analyse the potentials of Industry 4.0 advancements in a developing but a strategic country, the Turkish logistics industry was investigated in this study.

4.2. Administration and Outcome of the Structured Survey

As previously mentioned in the literature, various projections exist in relation to Industry 4.0 applications in the logistics field; however, the extant discourses regarding these projections are usually gathered around several particular themes. To illustrate, the highlighted concepts or themes discussed in different sources are listed in Table 2 and the example list of references is also provided in the same table.

During the formation of these highlighted themes, first, the extant studies were examined so that diverse Industry 4.0-oriented concepts were revealed by the authors. Then, since some themes in the literature either refer to similar concepts, although they are noted different, or are too specific/broad to be evaluated with other highlighted themes at the same level, such similar concepts were attempted to be grouped under an overarching denotation. For instance,

Zijm and Klumpp and Witkowski (2017) noted IoT and robotics-related scenarios whereas Hofmann and Rüsch (2017) pointed out the key Industry 4.0 technologies, of which impacts on key performance indicators were specifically emphasised by Tjahjono et al. (2017). Given these studies, it was decided by the authors that all these concepts can be denoted as "Latest technology-oriented operational activities". Likewise, after completing the formation of all themes, the authors commenced the survey preparation.

In the preparation process, firstly, before sharing the survey with the large mass of respondents, the initial survey draft composed by the authors was sent to 10 professionals working in the Turkish logistics industry for receiving feedback on readability and clarity of the survey. After making several minor alterations on the expressions based on the obtained comments, the final survey draft was composed electronically and the link was distributed to academics and practitioners in Turkey, who are in the contact list of the authors. In addition to this list, the survey link was also shared on several professional Turkish logistics network groups (e.g. UTIKAD) on LinkedIn (as similarly used by Bealt et al, 2016; Richmond et al., 2018). Since the purpose of this survey was merely to bring out the most significant themes (dimensions) in the logistics field, which are under the influence of Industry 4.0 developments and applications, the target population was composed of diverse professionals, such as academics, white-collar practitioners, and government officers in Turkey.

Furthermore, in order to increase the number of respondents and to overcome several challenges, such as the difficulty of reaching out some certain occupational groups (e.g. government officers), the snowball sampling technique was also employed during the distribution of the survey. However, due to exploiting the snowball sampling technique, calculating the certain return rate became difficult, as it is similar in other snowball sampling studies (e.g. Sims and Boytell, 2015). Ultimately, at the end of a six-week time period, the

number of participants remained the same for around one week and such circumstance implied that the saturation level for the survey was reached with 190 completed answers.

In the survey, the following question (in Turkish) was asked to the respondents: "To what extent, do you think, the Industry 4.0 developments and applications will influence on the following themes (dimensions) in the logistics field?" and the following 5-point Likert scale was provided them to assign a score for determining the importance of the given themes: 1- Not Influential, 2- Slightly Influential 3- Somewhat Influential 4- Influential 5- Very Influential.

Based on the obtained outcome from 190 respondents, the average working-year was calculated as around 16 and the highest number of respondents were from the academics (30%) category, followed by other management positions (27.4%), high level management or owners (18.4%), officers/specialists (12.6%), engineers (6.3%), and government officers/policy makers (5.3%) categories, respectively. Furthermore, in terms of the education level, the majority of these participants hold the postgraduate degrees (61.6%) while 34.7% of them have the bachelor's degree. Thus, such diverse backgrounds, advanced education levels, and high average working-year of the respondents indicate that the participants are both experienced and competent to provide valuable information to this survey. All in all, regarding the importance of the themes (dimensions) listed in the survey, the calculated mean values, which were rounded to the nearest half (.5) percent, are shown in Table 2 in a descending order.

Table 2. Ranking of the mean values of the themes (dimensions) in the survey

Themes (Dimensions)	Mean Values	Example References
Latest technology-oriented operational activities	**4.72**	Zijm and Klumpp (2017), Bokrantz et al. (2017), Hofmann and Rüsch (2017), von der Gracht and Darkow (2010), Sauter et al. (2015), Witkowski (2017), Tjahjono et al.

		(2017), Horenberg (2017)
Benefit perception in logistics and supply chain network	**4.47**	Bokrantz et al. (2017), Hofmann and Rüsch (2017), Witkowski (2017), Tjahjono et al. (2017), Horenberg (2017), Sauter et al. (2015), Zijm and Klumpp (2017)
Human resources/workforce	**4.25**	Zijm and Klumpp (2017), von der Gracht and Darkow (2010), Witkowski (2017), Horenberg (2017), Sauter et al. (2015), Hofmann and Rüsch (2017)
Financial management	**4.02**	Hofmann and Rüsch (2017), Sauter et al. (2015), Bokrantz et al. (2017), von der Gracht and Darkow (2010)
Decision making	3.82	Bokrantz et al. (2017), Hofmann and Rüsch (2017), Sauter et al. (2015)
Stakeholder relationships	3.63	Bokrantz et al. (2017), Zijm and Klumpp (2017), Hofmann and Rüsch (2017), von der Gracht and Darkow (2010), Witkowski (2017), Tjahjono et al. (2017), Özcan et al. (2018)
Corporate sustainability	3.58	Bokrantz et al. (2017), Zijm and Klumpp (2017), von der Gracht and Darkow (2010)
Organisational learning	3.52	Bokrantz et al. (2017), Zijm and Klumpp (2017), Shamim et al. (2016)
Country infrastructure	3.51	Özcan et al. (2018)

According to Table 2, all listed themes were evaluated by the respondents as at least "somewhat influential" for the Turkish logistics industry. Yet, in this list, in order to determine the most influencing themes and to reduce these themes to a manageable number, we set a threshold value at 4, which represent the "influential" denotation, and, thereby, we singled out the most prominent themes. In this respect, the first four themes were selected as the core themes to be considered in this research. In fact, these themes are in accordance with the concepts largely discussed in the reviewed literature of this study. Thus, after determining these four prominent themes, the thematic statements to be incorporated under these themes

were identified from the literature at this stage. In the subsequent stage, the probability of these statements to occur, their impacts on the logistics domain, and the detailed comments on each statement were examined under favour of the given answers by professionals in the Turkish logistics field.

4.3. Examination of the Industry 4.0 Statements in the Turkish Logistics Industry

Innovation and digitalisation have become the factors enabling companies to step forward among others in the intensive competitive environment. In this respect, the role of the recently emerging concept, Industry 4.0, should not be ignored by businesses. More particularly, as underlined by previous researchers in the logistics domain (e.g. Özcan et al., 2018; von der Gracht and Darkow, 2010), Industry 4.0 projections reported by the professionals in logistics industries can be used as an early signal to improve level of competence. However, although the logistics industry is of critical importance in a supply chain due to its connections with other components, Industry 4.0 have not yet surpassed the primary phase in the logistics domain and, therefore, the impacts of Industry 4.0 on logistics have still remained unclear. For instance, in the Turkish logistics context, Özcan et al. (2018) stated that Turkey has been planning logistics-based new policies at the nation-wide and regional level to acquire strategic advantage and, once the outcomes are obtained, more new insights will help forecasting the future impacts of Industry 4.0 on logistics. To this end, in this study, we tackle the applicability of the Industry 4.0 concept in one of the best suitable field to observe its reflections, which is the logistics sector, and set out to investigate the projections of Industry 4.0 for the logistics industry from multiple aspects. By doing so, the present paper holds a significant potential for showing realistic information on to what extent the Industry 4.0 concept is transformed into practice in the logistics industry.

To begin with, since there are various criteria affecting the success and occurrence of Industry 4.0 applicability, there is a need of identifying remarkable statements to be included in the

determined key themes. In line with this need, by adopting a similar approach to the studies of von der Gracht and Darkow (2010) and Özcan et al. (2018), we carried out the following three steps to broadly explore the statements discussed in previous studies.

Step 1: We examined the extant literature through selected keywords in accordance with the research aim and questions.

Step 2: As shown in Table 3, we scrutinised the key concepts and approaches of several illustrative Industry 4.0-related papers, where we gained the impression on the probable projections and their possible effects on logistics. Meanwhile, it is worthy of noting that due to the paucity of Industry 4.0-oriented articles in logistics, particularly for LSPs, we attempted to move beyond the peer-reviewed journal articles at this step so as to pave a deeper and wider understanding.

Table 3. Illustrative studies for the thematic statements

Author(s) and Year of Study	Research Type	Key Research Concept
von der Gracht and Darkow (2010)	Journal Article	Developing scenarios for logistics service industry 2025
Sauter et al. (2015)	White Paper	Cases and examples of industry 4.0 applications in different sectors
Bokrantz et al. (2017)	Journal Article	Developing scenarios for digitalised manufacturing
Witkowski (2017)	Journal Article	Industry 4.0 applications in logistics and supply chain management
Tjahjono et al. (2017)	Journal Article	Industry 4.0 technologies in supply chain
Horenberg (2017)	Thesis	Logistics 4.0 applications in logistics service providers
Hofmann and Rüsch (2017)	Journal Article	Industry 4.0 applications in logistics
Özcan et al. (2018)	Journal Article	Scenario analysis of Turkish logistics industry

Based on these steps, at first, Industry 4.0-related logistics concepts were extracted and 46 statements were initially formed by the authors. In these processes, one of the authors listed all possible thematic statements and, then, other co-authors of this research checked the statements. Subsequently, the statements were categorised under the predetermined four themes, which allowed that some statements were concurrently merged, changed (rewritten) or removed by considering the above mentioned major themes and the local conditions in the

field. After all these processes, 30 statements were finalised in the wake of several discussions between the authors. In fact, as highlighted by Hofmann and Rüsch (2017), it is impossible to incorporate all ideas, concepts, and elements of Industry 4.0 in analyses and the projections should only contain a selection of the key ones. Accordingly, in the present study, we diligently selected the prominent thematic statements to be considered in the logistics domain.

Step 3: We carried out an online interview survey (in Turkish) and sought out both the probability to occur and the importance (or impact) of the formed statements by obtaining numerical answers of professionals in the Turkish logistics industry. In addition, we also asked about the open-ended comments of professionals on each statement.

In the Turkish logistics industry, there exist different associations representing LSPs and, among these, the Association of International Forwarding and Logistics Service Providers (acronym in Turkish: UTIKAD) is the most comprehensive non-profit organization for third-party and fourth-party logistics (Vural and Tuna, 2016). In this sense, in order to obtain information from knowledgeable and experienced respondents, we determined UTIKAD as a main source for reaching out professionals in Turkey. After selecting the main source for data collection, a list of contacts comprised of general managers or representatives of a large number of logistics companies, which are registered at UTIKAD, was initially formed with the help of two widely-known experts in the Turkish logistics industry and then attempted to reach by the authors.

Under favour of the answers given by the professionals, the projections that have both the high probability to occur and the significant importance for the logistics industry are aimed to be presented. Meanwhile, for the structure of our survey, we similarly followed von der Gracht and Darkow's (2010) study in order to be guided on the direction of an appropriate approach and, thereby, we designed a two-phased question pair for the statements, consisting of expectational probability (based on percentages) and the degree of impact (based on the 5-

point scale used in Section 4.2). In addition to this question pair, we also employed a "why-type" of open-ended question after each statement in order to acquire more in-depth information from professionals regarding the incorporated thematic statements.

After these processes, we obtained the initial answers from 33 professionals, including academics and practitioners, in a three-week time period. Yet, out of these 33 answers, only 24 responses were found usable for our research since the remaining surveys were not duly completed (i.e., either rates or percentages were given, rather than both). Regarding the representativeness of this sample size and the generalisation of the findings from this size, Saunders et al. (2009) expressed that there are no set rules for the sufficient sample size in non-probability sampling techniques, such as purposive sampling. Likewise, Hair et al. (2003) pointed out that determining an appropriate sample size depends on different factors, such as research questions, research objectives, past studies, and industry standards. In this respect, while deciding on the sample size of this research, we initially aimed at obtaining different opinions from diverse respondent backgrounds (e.g. practitioners, academics, engineers, government officers) with caution. In addition to this, we also adopted a similar approach with several example papers to follow their principles (e.g. von der Gracht and Darkow, 2010; Özcan et al., 2018) pertaining to the acceptable sample size arguments. Based upon these supportive arguments, we accepted our sample size as satisfactory.

The demographic findings of our survey showed that the average working-year of the respondents was around 19 years, which is higher than the average working-years of experts included in Özcan et al.'s (2018) and von der Gracht and Darkow's (2010) studies. Additionally, half of the respondents were high-level managers (e.g. CEO, president, general manager, vice-president) whereas nine were academics and three had a role at other management positions (e.g. director, chief, department manager). Moreover, in terms of the education level of respondents, 10 hold Ph.D. title, and the remaining numbers are equal for

Master's degree and Bachelor's degree titles. Thus, these findings reveal that the sample of this research was constituted by experienced and knowledgeable respondents.

In terms of the given answers on the statements classified under the four themes, namely, human resources/workforce, financial management, latest-technology oriented operational activities, and benefit perception in logistics and supply chain network, the results are presented in Table 4, Table 5, Table 6, and Table 7, respectively. In these tables, it is worth noting that the statements under each theme are presented in a descending order of both percentages and ratings and, in order to provide a clear insight, the numbers were rounded to the nearest half (.5) percent. Furthermore, regarding the posed open-ended questions, the obtained remarks on commented statements were summarised by the authors and are mentioned below these tables so as to provide a deeper and appropriate understanding on the projections and themes.

Table 4. Results with regard to human resources/workforce

Thematic Statements	**Expectational Probability (Percentage)**	**Degree of Impact (Rating)**
At the end of Industry 4.0 applications, the need for employees working at the operational level will decrease.	78%	4
Along with autonomous vehicles in the logistics industry, workforce will decrease while efficiency in delivery processes will increase.	74%	4
Due to robot technologies, workforce in logistics operations will decrease.	74%	3.9
Due to augmented reality applications at warehouses, within logistics activities, workforce failure will decrease.	74%	3.9
There will be a human-robot collaboration in logistics processes through interactive systems.	73%	4
At the end of Industry 4.0 applications, the need for white-collar employees will increase.	62%	4
At the end of Industry 4.0 applications, blue-collar employees will be unemployed.	62%	3.5

According to Table 4, the majority of the respondents agree that, as a result of employing robot technologies, the number of employees in logistics operations tends to decrease and, thereby, the workforce failures in operations are also expected to decrease, which ultimately hold a potential for leading to an increase in the efficiency of delivery processes. However,

when we specifically look at the breakdown of the workforce, in terms of the white-collar and the blue-collar employees, it also appears that there is a lower level of consensus among professionals compared to more general expectations regarding the aftermath of human resources in logistics operations. Accordingly, these initial findings in human resources highlight the importance of a need for delving into reasons about what consequences are expected for white-collar and blue-collar employees in the logistics field since there is still a vagueness between professionals on these specific projections. Nevertheless, despite the expected decrease in the need of employees in logistics operations, it can be concluded based on these results that there appears a collaboration potential between humans and robots in the logistics industry. Regarding the importance of these statements, it is worthy of noting that the impacts of all these statements are considered more than somewhat important for the logistics industry.

Regarding the highlighted remarks on statements, it can be summarised that the growing demand and the increasing workload are expected to cause partially a decrease in the need of employees working at the operational level, as a result of involving digital applications more in processes. More specifically, while it is probable that new branch of activities can occur for white-collar employees, artificial intelligence might also take the place of some works of while-collar employees. Concerning the employment of blue-collar employees, their qualifications and job contents are expected to change. In contrast to the decrease of workforce, utilising autonomous vehicles holds a potential for increasing the delivery efficiency; however, to use these vehicles, further legal and techno-social requirements are still essential, and as such reduces the expectational probability of this projection to occur. Likewise, the augmented reality applications at warehouses are not completely interpreted effective since they are currently at their early stages. Lastly, despite the high possibility, there is also a negative expectation against the full human-robot collaboration due to more

advantageous conditions of one party over another in some instances (e.g. low labour-costs, effective handling of different-sized goods). Thus, such question marks lessen the expectational probabilities of the mentioned projections.

Table 5. Results with regard to financial management

Thematic Statements	Expectational Probability (Percentage)	Degree of Impact (Rating)
With Industry 4.0 technologies, security costs and protection costs will be substantially increased.	80%	4.1
With the applications of Industry 4.0 in the logistics area, the maintenance process will be estimated and the maintenance costs will decrease.	78%	3.8
Innovations in transport logistics (i.e., new vehicle types, alternative propulsion, innovative materials) have considerably contributed to the reduction of resource consumption.	77%	4.3
New technologies in logistics obtain faster acceptance as compared before.	77%	4.2
Industry 4.0 applications will cause a decrease in costs.	71%	4
Required information and communication technology demands large capital investments, which can hardly be raised by small and medium sized logistics service providers alone.	68%	4.1
At the stage of Industry 4.0 applications, the logistics industry will work closely with the academia.	68%	3.7

In Table 5, it becomes evident that the security and protection costs in logistics are expected to increase with Industry 4.0 technologies whilst there are also positive expectations in terms of the decrease in maintenance costs and the better estimation of maintenance process. Likewise, the majority of respondents also agree that innovation in transport logistics holds a significant potential to reduce resource consumption and to enable faster acceptance. In sum, the respondents mostly agree that Industry 4.0 applications tend to diminish the general costs in logistics. Yet, compared to the other statements in this theme, a lower level of consensus is reached on the statement of large capital investments that are required for small and medium sized logistics companies and on the statement of a close collaborations between the academia and the industry. Regarding the degree of impacts, all statements examined in this theme are regarded as more than somewhat important for the logistics industry.

Concerning the underlined remarks on statements, the summaries of the comments indicate that, despite the high probability, it is expected to take a long time to realise the substantial contribution of innovation to the reduction of resource consumption. Accordingly, more technical knowledge is imperative on this matter. In terms of the expected reduction of costs by virtue of Industry 4.0 applications, high investments costs and the long-term return of investments remain as possible challenges against their full and immediate implementation. Therefore, irrespective of government supports and incentives, it becomes arduous for small and medium-sized logistics companies to invest on and adopt these technologies. With respect to the industry-academia collaboration, intensive teaching duties of academics and their less practical knowledge on the industry norms cause critical drawbacks for this partnership. Hence, all these hazy backdrops reduce the expectational probabilities of the stressed financial projections.

Table 6. Results with regard to latest-technology oriented operational activities

Thematic Statements	**Expectational Probability (Percentage)**	**Degree of Impact (Rating)**
Automated identification (e.g. RFID, barcode, sensors) will be a standard identification technology in logistics and will enable both fast and secure access control.	91%	4.5
With the usage of Industry 4.0 technologies, intelligent, automated planning and control systems will be widely used in logistics.	86%	4.3
With the usage of cloud technologies, new platform-based business models will be practiced in logistics which allow increasing the efficiency.	83%	4.2
Cyber-attacks will be a real threat for both connected machines and personal data.	81%	4.4
The decentralised production of many goods on-site in small-scale factories (fabbing, 3D printer, digitised products) will lead to substantial structural changes in the logistics industry.	69%	4
With the usage of drones in the logistics field, personalised delivery will take place.	62%	3.7
3D printing will lead to lower transportation demand.	58%	3.3
With 3D printing, transported goods within the logistics operations will be mostly raw materials.	58%	3.1

Regarding the operational processes indicated in Table 6, it is apparent that the automated identification has a supreme potential to become a standard identification technology in

logistics by providing fast and secure access control. In addition, there is a high expectation both for a broader practice of automated planning and control systems and for the new platform-based business models in logistics, notwithstanding the expected threat of the cyber-attacks on connected machines and personal data. Furthermore, these results unveil that the decentralised production of many goods on-site in small-scale factories tends to change the structure of the logistics industry. Yet, among these statements, relatively lower percentages are given on the probability of the usage of drones in personalised delivery and on the influence of 3D printing both on the transportation demand and on the content of the transported goods. Regarding the degree of impacts of these operational projections, all examined statements are deemed more than somewhat important for the logistics industry.

In terms of the provided remarks, the comments reveal that despite the high probability to occur, there are also some concerns about the decentralised production and its reflection on logistics processes, such as organisational hurdles in establishing such partnerships, quality and standardisation matters for 3D printing, and high investment costs. More particularly, the 3D printing technology is expected to be used majorly for copying purposes and relatively less for transporting some particular materials, such as basic and intermediate materials, rather than hard materials (e.g. steel). Furthermore, due to differentiation strategy and competitiveness matters, the final product delivery is also considered as a drawback against the usage of 3D printing in logistics. Similarly, the usage of drones seems probable; however, less share of drone-related deliveries in total deliveries and both the security issues and their low capacities raise question marks in terms of its total applicability in the logistics domain. Thus, all these blurry gaps cause a distinct decrease in the expectational probabilities of some particular projections.

Table 7. Results with regard to benefit perception in logistics and supply chain network

Thematic Statements	Expectational Probability (Percentage)	Degree of Impact (Rating)

With the usage of Industry 4.0 technologies in logistics, inventory visibility will be increased.	90%	4.4
Transportation applications in the electronic environment will become common applications in national and international business environments.	85%	4.3
With the usage of Industry 4.0 technologies in logistics and supply chain, transparency and efficiency will be increased.	85%	4.3
At the end of the Industry 4.0 technologies, there will be an improvement in sustainability applications.	82%	4
With the usage of Industry 4.0 technologies in logistics, there will be an improvement in data analytics, customer experience and operational efficiency.	81%	4.2
Smart products and cloud-supported network will protect the information flow in logistics against being damaged.	80%	4
Using Industry 4.0 technologies will increase the innovation capability of logistics companies.	77%	4.2
Real-time exchange of information among different actors will remove traditional boundaries in logistics which cause reduction under the influence of bullwhip effect.	73%	3.9

Overall, Table 7 presents a higher level of expectations on the benefits of using Industry 4.0 in logistics, such as the increased inventory visibility, a wider practice of transportation applications in the electronic environment at national and international levels, enhanced transparency and efficiency in the logistics and supply chain network, improved sustainability applications and data analytics that result in better customer experience due to operational efficiency, and the protection of information flow in logistics through smart products and the cloud-supported network. Furthermore, in this theme, the majority of respondents agree that using Industry 4.0 technologies potentially increase the innovation capability of logistics companies and the traditional boundaries in logistics tend to be removed through the real-time exchange of information among different actors. Regarding the degree of impacts of these benefits, nearly all statements incorporated in this theme are regarded as important, more than the results of other themes, for the logistics industry. Thus, it can be concluded that Industry 4.0 applications offer various benefits and these benefits hold high impacts on the logistics industry.

Concerning the given remarks on statements, it can be summarised that, although Industry 4.0 applications offer surpassing benefits, there are still some vagueness about several matters, such as the negative impacts of high energy requirements on sustainability and the negative consequences of the brain drain factor on innovation capabilities of companies, as a result of the political and social changes of countries. Moreover, unbalanced infrastructure level of different actors in the field and the lack of cooperation among them, due to security concerns, might be the possible drawbacks to reduce the potentiality of the maximum level real-time exchange of information. Accordingly, all these concerns and vagueness cause a diminish in the expectational probabilities of some benefit-oriented projections in logistics and supply chain network.

As can be seen from these tables, although all noted statements in these four themes are assessed as probable to occur by more than the half of the respondents, a relatively lower level of percentage was obtained for some specific statements. From this point forth, in order to delve into the rationales of these given values, the “why-type” of question was also asked to the participated professionals, although not all statements were commented by all respondents at this phase. Hence, these in-depth interviews reveal that the broad usage of cloud technologies in the digital environment and the maximum utilisation of big data tend to occur in the short-term. Moreover, the advantages provided by Industry 4.0 developments hold a supreme potential to substantially decrease the operational- and industry-oriented chronic problems. However, it is also evident from these findings that the implementation of Industry 4.0 applications, such as integrating robotic technologies, utilising 3D printing technologies, and the usage of both drones and autonomous vehicles in logistics operations might take a while. What is more, for the specific Turkish logistics context, the potentiality of the industry is far from being completely digitised. Therefore, following a hybrid strategy, where mutual exploitation from robotic technologies and human capital incorporated, appears as more

suitable for the long journey of the Turkish logistics industry on the route to gaining maximum benefit from Industry 4.0 technologies.

5. Conclusions

5.1. Research Findings

Logistics is a critical activity in the supply chain network and LSPs undertake an intermediate role between different supply chain members. In this digital era, LSPs are, especially, of utmost importance for disseminating efficiency and effectiveness among these members. Despite this vital role, the extant literature on Industry 4.0 remains insufficient to place the LSPs on the focal point. More specifically, Industry 4.0-related studies concentrate, to a large extent, on the technical and technological aspects, rather than the human capital side, and inadequately discuss how LSPs can both hold cost advantages and maintain operational processes by using the recent technological and knowledge advancements. Given these facts, the field encounters a dearth of Logistics 4.0 research that comprehensively deal with these multidimensional issues. In addition to these, from the practical side, it is also apparent that the logistics domain is still in its infancy in terms of the digitalisation and the Big Data implementations. Accordingly, in the present study, it is aimed to investigate Industry 4.0 developments, from multiple aspects, in the logistics industry, more particularly by taking LSPs on the central point. In light of these gaps and motivations, this study proposed two main stages in order to comprehensively tackle these mentioned matters:

- Firstly, the major themes (dimensions) were identified with the help of the literature. Afterwards, an online structured survey was conducted to capture the key themes that receive relatively higher scores by professionals in the Turkish context. As a result of the survey, four themes were revealed as more important and, thereby, the first research question was addressed at this stage.

- Secondly, following the findings of the first stage, a number of prominent statements discussed in previous studies from multiple aspects were incorporated in relevant themes (dimensions) and another online survey was formed to obtain structured information from the logistics professionals regarding both the expectational probabilities of these statements (in percentages) and their degree of impact (in rating scale). Meanwhile, in order to delve into the insights on these statements and given scores, a "why-type" of question was concurrently asked to professionals at each statement. By doing so, we were able to explore thoroughly the rationales of given values on the expectations and impacts of the presented statements. Thus, this stage helped seeking answers to the second research question of the present study.

5.2. Discussion of the Findings with the Reviewed Literature in Logistics

Although different developments were highlighted in the systematically selected studies in the literature, there is still apparent vagueness about the consequences of the new business order brought by the Industry 4.0 concept in the logistics industry, such as the aftermath of human resources, the financial and operational processes and benefits of Industry 4.0, and the probabilities of expectations with their degree of impact on the logistics field. For instance, in terms of the workforce, Strandhagen et al.'s (2017) conceptual study discussed the operational transition towards developments in business models and pointed out that human capital still tends to become essential, although staff roles may change. Likewise, Barreto et al. (2017) overviewed the potential developments to be occurred along Logistics 4.0 in relation to human-operation interaction, despite the major emphasis was given on the expected less human involvement in the activities. Similarly, Hofmann and Rüsch (2017) presented both the current status and the future prospects of logistics management by underlining the fact that human decision making will be needed at the strategic level. As can be seen from these studies, the extant literature regarding the workforce projections remained largely conceptual

and became insufficient to profoundly enlighten the vagueness of aftermath of human in the logistics industry after Industry 4.0 implementations.

Similar to these workforce projections, the drawn picture on the positive impacts of the developments in business process do not also present a clear vision for the logistics industry. In this sense, Karia's (2018) empirical study on the relationships between knowledge, technology resources, and cost advantages focused solely on the economic aspect while Rakyta et al.'s (2016) smart logistics-oriented discussions and Bányai's (2018) environment-related conceptual study allowed to tackle the issues from the intersection of social and operational aspects. Similarly, Delfmann et al. (2018) underlined the potential connection between the interfaces of humans, technology, and organisations in logistics whereas Kovács and Kot (2016) stressed particularly on the competitive advantages and tendencies enabled by Industry 4.0-based innovative technologies in the logistics field. In a nutshell, these studies explored the financial and operational benefits of Industry 4.0 for the logistics industry; however, fell short for adequately and empirically presenting the potential future prospects of Industry 4.0 applications in the logistics industry.

In an attempt of providing empirical investigations, at a macro level, Geissbauer et al. (2016) depicted a global Industry 4.0 survey where transportation and logistics was one of the industries to give insights about the expectations and trends. Yet, as distinct from their research, the present study focused both on a specific context-Turkey- and on a particular industry-the logistics industry- so that more insights and potentials into Logistics 4.0 are provided from various angles in the findings.

On the other hand, von der Gracht and Darkow (2010) carried out a Delphi study, with 30 experts in Germany, and evaluated expectational probabilities and impacts of projections for the logistics industry from different aspects (e.g. economic, political–legal, socio-cultural, technological, industrial structure). In a similar vein, Özcan et al.'s (2018) Delphi-based

study, with 24 in the first round and 20 experts in the second round, attempted to classify future projections of the Turkish logistics industry into six concepts, which are: the general tendencies, the geography, the cost structure, the market structure, the infrastructure and capacity, and e-commerce. In the same context, Kayikci (2018) evaluated the implementation of digital technologies in logistics but her research was mainly from the sustainability viewpoint. Despite the existence of these example research, especially in terms of investigating probabilities and impacts of projections, the present study differentiates with its structured and comprehensive approach in respect of initially drawing an overall picture on the themes and highlighting the key dimensions through the online survey, followed by incorporating previously discussed thematic statements into these prominent dimensions through the integrative interview survey, which contains structured and open-ended questions. Thus, this study systematically and distinctly provides breadth and depth insights on the listed projections from various aspects for the logistics industry, especially by taking LSPs on the focal point.

5.3. *Research Implications*

In line with these performed processes, this study has provided the following contributions to the management studies that are related to the Industry 4.0 and logistics concepts. First, although Industry 4.0 is still a nascent term and does not have a commonly agreed definition, the potential impacts of Industry 4.0 elements (e.g. digitalisation) on the logistics industry are comprehensively discussed in this research. In this way, as the reviewed literature is summarised and exhibited in Table 2, we hereby focused on a shallow domain as regards to Industry 4.0 implementations for LSPs. In this sense, our research is a first step for enriching this domain through the information obtained from multiple aspects.

Second, the present study sheds light on the vagueness about the consequences of the new business order brought by the Industry 4.0 concept in the logistics industry, such as the

aftermath of human resources, the financial and operational processes and benefits of Industry 4.0, and the degree of impact of these expectations on the logistics field. Therefore, the major contribution of this research is the empirical investigation of probable and unforeseen projections of the future, from different aspects, to steer the strategy development of LSPs. What is more, the summarised comments regarding each thematic statement, based on the open-ended explanations of the participated professional, enriched the insights of Industry 4.0 implementations for the logistics industry. Ultimately, in terms of the Turkish context, scrutinising a young but developing economy that possesses both a competitive geopolitical location and a growing workforce offer a great potential to contribute to the Industry 4.0-related literature, especially for the logistics industry. As a consequence of these findings and highlighted insights, this study holds a substantial novelty in advancing the existing knowledge about: what LSPs can offer, how they can strategically adapt to the recent changes in this digital age, and to which particular thematic statements they need to primarily consider in the short- and the long-term in order to become more competitive.

Meanwhile, it is worthy of noting that this study does not offer the pretence of developing or testing a theory. Rather, it seeks to provide a significant insight into the intersected area of Industry 4.0 and logistics concepts when seen through the lens of LSPs in a case study strategy. In line with this, Childe (2011) underlined that cases can be used to develop concepts that enable researchers and managers to comprehend or deal with a situation. Furthermore, Kovács and Spens (2005) added to this argument by stating that, even if previous theories are given, observations in some empirical research does not match these theories and, in such cases, abductive reasoning, which starts with creativity and relies on the loop between theory and empirical study, leads to new insights and re-contextualisation for existing phenomena. In fact, this approach is widely used in case studies. In this regard, both the presented findings

regarding the projections drawn from the Turkish logistics context and the adopted approach add to the proposed novelty and insight of this research.

Moreover, in terms of the managerial implications, practitioners in the logistics area can exploit the presented projections and adapt their strategies by considering indicated probable future conditions. That is to say, practitioners can use the described statements and the findings as a reference to promote their own Industry 4.0 attempts pertaining to their logistics management. On this wise, the noted expectations and further remarks on the listed thematic statements are particularly suitable for future contingency plans of LSPs. Accordingly, by virtue of these findings, managers in logistics companies will be able to manage their operational, financial, and human resources with the effective management mind in the compelling competitive environment. Thus, the present study attempts to help managers to figure out where and how to start building their organisational capabilities and resources with regard to different Industry 4.0 projections.

5.4. Research Limitations and Suggestions for Future Research

The present study is not free from limitations. First, the keyword pairs of this research were searched in titles, abstracts, and keywords in two databases. Second, during the formation of thematic statements, different scenarios could be generated and categorised under different-named themes. However, due to both the limited number of Industry 4.0-related studies in the logistics domain, particularly for LSPs, and the need of a subjective judgment during these processes, we were, nevertheless, careful about forming reasonable statements. Furthermore, in the Turkish logistics industry, in addition to the difficulties on reaching out more professionals and obtaining a satisfactory return rate, it is also a challenging process to obtain a fully completed survey from respondents. What is more, some corporate systems block the staff e-mails to receive a survey content and this adds another barrier for researchers. All in

all, such challenges hold a significant potential to be extensively dealt with in the future projection-oriented studies and to advance the existing knowledge presented in this study.

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