

## RESEARCH OF INDUSTRY 4.0 AWARENESS: A CASE STUDY OF TURKEY

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**Abstract.** Rapid development of technology, particularly in the field of artificial intelligence, has fuelled the concept of Industry 4.0 among all types of businesses across the globe. This has driven sustainable growth for those businesses as well as promoted economic prosperity in the countries where they operate in. In view of this information, it is of absolute importance that the entire business landscape in Turkey avails itself to greater awareness and education about the benefits of embracing a comprehensive Industry 4.0 philosophy. It is also important to shed the light on the problems these businesses may face in transition from the old industrial philosophies to the new philosophy of Industry 4.0. Therefore, the aim of this study is to measure the level of Industry 4.0 awareness among businesses in Turkey. The research also seeks to determine how targeted Industry 4.0 educational programs and policies vary in relation to the demographic characteristics among some business operators in Turkey. A multiple case study design governed this entire research. Thus, views and in-depth data from 32 companies based in Turkey were collected by questionnaire and subsequently analysed in a detailed format. At the end of the study, the findings revealed that Industry 4.0 awareness differed depending on the employees' levels of education. The researchers also discovered that the status or extent of relationships these companies had with foreign partners abroad has a significant impact on the awareness levels of Industry 4.0.

**Keywords:** *Industry 4.0 Educational Awareness, Businesses in Turkey and International Business Partnerships, Fourth Industrial Revolution.*

**JEL Classification:** O0

## INTRODUCTION

Industry 4.0, the concept first announced at a 2011 Hannover Fair, is rapidly making gaining prominence throughout academia and business enterprises due to its endless possibilities, ramifications and in some cases even dire ones (Sommer, 2015; Lasi *et al.*, 2014). Primarily a German originated term, Industry 4.0 is seen as a 21st-century industrial revolution and modernization concept and/or philosophy that prioritizes smart products and services through continuous decentralization and integration. This is in sharp contrast to its predecessors (i.e. the first three revolutions) that focused entirely on patent and market protection policies through unique, inimitable and purposefully centralized resources and systems.

Industry 4.0, also known as the Fourth Industrial Revolution, is a new approach to initiate a wave of change across all spheres from economics to social order. At the heart of this is a Cyber-Physical Systems that use high technology in production at a global level (Hellinger *et al.*, 2011). In order to fully understand Industry 4.0, the cues from Schneider Electric may be considered. They characterized Industry 4.0 as an evolution (rather than a revolution) that allows businesses to maintain a competitive edge on a never-before-seen global scale. This creates an endless and reinforcing loop of business adaptation, integration, and sustainability.

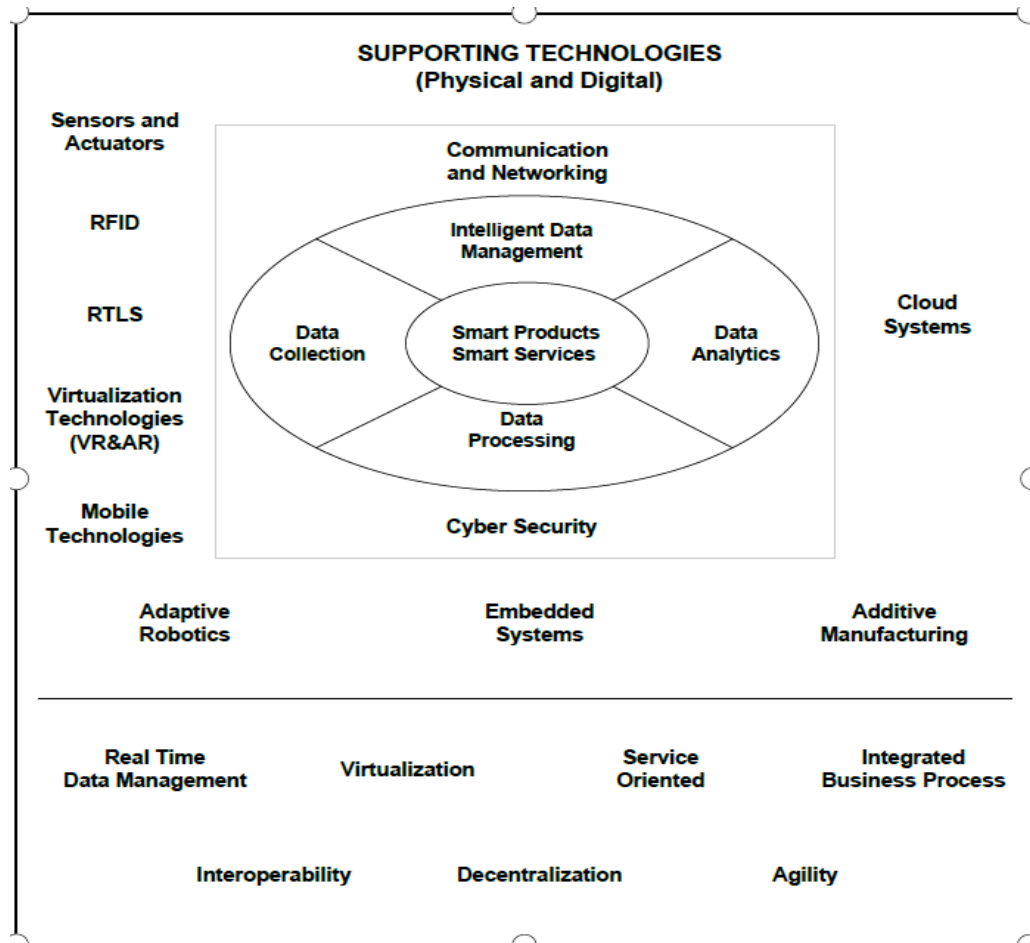
In order for Industry 4.0 to fully realize its potential, the following supportive technologies and interaction principles must be successfully implemented or at least advanced. Industry 4.0 principles and technologies are presented in Table 1.

**Table 1.** Industry 4.0 Principles and Technologies (Akdil, Ustundag & Cevikcan, 2018)

Principles	Technologies
Real time data management (Collection/Processing/Analysis/ Inference)	Adaptive robotics
Interoperability	Data analytics and Artificial Intelligence
Virtualization	Simulation
Decentralized	Embedded systems
Agility	Communication and Networking
Service - oriented	Cybersecurity
Integrated business processes	Cloud
	Adaptive manufacturing
	Virtualization technologies
	Sensors and Actuators
	RFID and RTLS technologies
	Mobile technologies

A flexible production structure and the system can be actualized through the usage of the above-mentioned technologies in an integrated manner. Thus intelligent machines will mark the beginning of more efficient and refined production system capable of delivery of better goods and services to consumers. Ultimately, this will reduce production costs and waiting times. In addition, adaptive robots have been theorized to facilitate the resolution of problems, especially when tasks assigned in the design, fabrication and assembly phases are separated into simpler subparts and series of submodules. This transformation will enable wi-fi networking, easy integration in existing machine communication systems, optical and image processing of part positioning, integrated robot controller, memory based or case-based learning mechanism for high-speed data transmission (Salkin, Oner, Ustundag & Cevikcan, 2018).

Considering the pyhsical and digital dimension of supporting technologies, a general framework for Industry 4.0 adaptation is presented in Fig. 1.



**Fig. 1.** Industry 4.0 framework transmission (Salkin, Oner, Ustundag & Cevikcan, 2018).

According to Fig. 1, the principles underpinning Industry 4.0 allow for the use of adaptive technologies for smart products and services, data collection, data processing, data analytics and intelligent data management between communication and networking, and cybersecurity.

When the factories adapt these technologies to Industry 4.0, it is envisaged that efficient implementation of Industry 4.0 will lead to increased efficiency. This will serve as a catalyst for the national economic growth. As a result, the country becomes highly competitive in the global economy.

The expected benefits of converting or transitioning to these smart Industry 4.0 platforms are given in Figure 2 (EBSO, 2015).

With the exception of raw materials, the decreasing manufacturing and workforce costs are expected to result in positive benefits beyond productivity and turnover. These benefits will include sustainable investments and employment of qualified workforce (EBSO, 2015). All these benefits can be realized if the transforming industry has a clear strategic roadmap capable of timely and correctly delivering Industry 4.0. It is for this reason that special attention should be paid to acquiring technologies compatible with Industry 4.0.



**Fig. 2.** The expected benefit chain for Industry 4.0.

Awareness should also be created among employees about the vast technological opportunities for transforming management processes and production systems. These processes will be successfully implemented by firms backed up with the adequate training.

The outcomes and benefits of Industry 4.0 and the type of training provided often display iterative relationships. Together, these two factors will determine the institutional framework and the necessary structure. As a result, particular attention should be paid to ensuring that the training provided is competent and effective. In view of the above, it is possible to improve the quality of education by appropriately developing the education curricula in sync with the changing information technology needs, creating an environment where individuals can freely express their ideas, and planning the training period taking into consideration the speed of technological change (Yazici & Duzkaya, 2016).

## 1. LITERATURE REVIEW

### 1.1. Nature of Industry 4.0 and Sustainability Initiatives

To some extent, Industry 4.0 is a huge gold mine with endless possibilities, ramifications and in some cases complexities (Sommer, 2015; Lasi *et al.*, 2014). However, unlike its predecessor, Industry 4.0 ultimately gravitates towards greater global sustainability and efficiency (Seliger & Stock, 2015). This is driven by increased international competition, flexible production and systems, increased individualisation of customer needs, and demographic changes (Sommer, 2015) (Almada-Lobo, 2015). As a result, radical changes in the way business organisations look at their operations are necessary (Roblek, Mesko & Kropez, 2016).

Industry 4.0 technologically fuses the physical, digital and biological fabrics of different societies across the globe. For example, Sommer (2015) describes it as a cyber-physical system that comprises merging products and machines. Similarly,

Seliger and Stock (2016) describe it as the integration of smart factories that produce smart products and services that constantly interact and communicate within an embedded ‘internet of all things’ platform. Apart from the usual benefits regarding greater efficiency and environmental sustainability, Industry 4.0 ultimately results in creating a more satisfied global customer (Seliger & Stock, 2015).

Thus, digitalising things and products fuels an endless loop of exponential rewards for the global society (i.e. economic, social and environmental sustainability). The following section explores various distortions that may occur in an ‘internet of all things’ world.

### **1.2. Education and the Labour Market**

One of the distortions for the society may be seen in education, specifically, in higher education and training. Current educational status quo will have to evolve to make room for the unique demands of a fast-paced knowledge economy. For now, it is evident that there will be a huge skill and competency gap. However, what is not clear is the nature of this gap. Thus, the specific implication of Industry 4 is lacking. There are generic predictions about the type of skill sets the evolving labour market and actual jobs will need. Examples include high flexibility, quickly teachable and adaptable personnel. The Economist (2018) notes that artificial intelligence will most likely perform repetitive tasks. On the contrary, non-repetitive tasks involving human ingenuity and artistry will still be performed by humans.

This speculation and lack of certainty about the future nature (to some extent, current nature) of Industry 4.0 have resulted in the split verdict (Lasi et al., 2014) (Hermann, Pentek & Otto, 2016). The optimistic view of the future envisages massive job gains. Some authors predict creation of about half a million net jobs. On the contrary, the pessimists predict that half of all jobs today will be lost in 35 years from now.

The technology-driven world must have elements that are practically useful and society-serving across the globe. It is for this reason that Marwala (2018) advocates a readjustment and change in higher education learning. The goal is to create more comprehensive and integrated educational curricula that draw mainly from the liberal arts. This is because skill requirements of Industry 4.0 will transcend mere problem-solving abilities. Adaptable skill sets in the arts and social networking will allow for sounder judgements and greater emotional intelligence. Marwala (2018) notes that due to high levels of integration by Industry 4.0, educational training will be decentralised. Training will be done in a more generalised way that is free of demographic and cultural dispositions.

### **1.3. General Ramifications and Drivers of Industry 4.0 for Business**

The ‘internet of all things’ is a double edged-sword capable of creating both challenges and benefits for businesses. These effects will be devoid of regional and cultural boundaries, the extent of its impact will largely depend on the size and capability of the business. Sommer (2015) notes that the real questions pertain to

awareness, readiness and capability to withstand this storm that is evidently present now. Thus, firms have started acknowledging this changing trend in all facets of the business world. However, what is lacking is that some firms (especially SMEs) do not know how and where to implement the required changes. A carefully designed change in a business model or process will enable firms to compete effectively in this new landscape. Ultimately, the greatest distortion will be seen in and fuelled by business organisations across the globe. This is because Industry 4.0 allows organisations to digitalize the entire life cycle phases of their product/service offering.

From a business point of view, there are two key drivers for a cyber-physical system. They can be seen as the application pull triggers and technological push factors (Lasi *et al.*, 2014).

The pull factors are elements alluring to the entrepreneur or business. They are mostly triggered by political, social, environment, and economic conditions of the society (Seliger & Stock, 2015). The changing social fabric we see across the globe due to mass migration and integration of cultures may be seen a good example to the point. Businesses must be extremely sensitive to varying views and norms of their diverse customer base. This puts the power firmly in the hands of the buyer. Businesses that want to exploit the benefits of Industry 4.0 should be willing to relinquish greater power to their various individualized buyers/consumers.

Another ramification of the above-mentioned considerations comes in the form of increased need for flexible production systems. Production systems cannot be rigid if the products being produced are to communicate smartly among themselves. A more empowered consumer market will put a lot of pressure on firms' production systems to meet their individualised needs (Lasi *et al.*, 2014; Kagermann, Wahlster & Helbig, 2013). This necessitates changes in most firms' organisation systems. Thus, more and more firms start to move from centralized hierarchical systems to decentralized ones.

The environment is related to the above pull factor from consumers. Consumers across the globe are increasingly basing their purchasing decisions beyond the physical attributes of the product or service value. Firms must constantly balance their need for greater sales and performance with the demands of the physical environment (Seliger & Stock, 2015). Being environmentally sustainable is an example a broad pull factor for firms. Corporate social responsibility initiatives are designed to leave the least carbon footprint on the Earth. This requires that firms become more and more efficient at extracting, distribution and consumption of resources. Smart factories with self-organising elements are better equipped for doing this. This means those factories and their machines will become increasingly autonomous, devoid of centralized organisational systems and controls (Sommer, 2015; Almada-Lobo, 2015).

The above considerations actualize the need for new products/services and business models like never imagined (Almada-Lobo, 2015; Roblek, Mesko & Kropez, 2016). Thus, Industry 4.0 needs smarter machines, people, products and processes to function effectively in a cyber/cloud system. Seliger and Stock (2015) note that these new business models and products ultimately become a self-replicating loop of innovation. It is for this reason that there seems to be lack of a

comprehensive understanding of the current and future path of Industry 4.0 (Hermann, Pentek & Otto, 2016). This has resulted in innumerable propositions and implications of Industry 4.0 but very few empirical results and tangible outcomes (Sommer, 2015).

#### **1.4. Dimensions of Industry 4.0 for Business**

The dimensions of the digital world for businesses can be characterised by three main components: horizontal integration, product life-cycle constituents and vertical integration and networking (Seliger & Stock, 2015). All three dimensions occur simultaneously in the sense that internal cross-linking and digitisation allows for comprehensive solutions that in turn spur further external integration.

Thus, the system is designed in such a way that sensors collect data, then an actuator system implements the automated physical action. A system of constant and fluent data exchanges is embedded in a 'cloud'. Seliger and Stock (2015) describe a cloud as a cyber-physical system that is self-organised and decentralised. The system has the product-life cycle as a core driver that links the horizontal integrators with the vertical aspects.

Also, there is the macro-level component that encompasses issues pertaining to networks of value creation among the firms themselves. It is an amalgamation of different value creation factors such as equipment, human, organisations and products. As stated by Sommer (2015), the 'internet of all things' primarily distorts the way businesses interact with each other. For more streamlined network dealing among businesses, the data on the products should be very much accessible and acted upon by automated systems. These automated systems spur off new and varied business models and network systems. These systems function smoothly in tackling environmental issues and minimizing carbon footprints (Seliger & Stock, 2015). They are highly effective and efficient business models that increase the overall competitiveness of the industry. As a result, firms are better poised to meet the ever-changing needs of their customers.

On the other hand, the micro-level looks at internally integrating and digitalising the unique elements of the firm. It combines different value creation modules with smart material flows and logistics (Seliger & Stock, 2015). It bears semblance with the traditional value chain items and activities, only in this case they are digitalised and decentralised. Some examples of the value chain items are people, equipment, and product. The value chain processes and organisation include marketing, sales, services and procurement.

#### **1.5. Industry 4.0 in Turkey**

The Turkish Industrialists' and Businessmen's Association (TUSIAD) Industry 4.0 report (2016) contains steps and recommendations Turkey businesses ought to implement for a smooth transition. The report details how success stories from Germany and the US industries can become an input for Turkey's version of Industry 4.0 (TUSIAD, 2016).

TUSAID and the Boston Consulting Group (BCG) (2017) report emphasizes directing company investments, strategies and governance competencies in accordance with their strategic objective (TUSIAD, 2017).

It has long been acknowledged that increased spending on research and development (R&D) is a tool of sustainable economic growth that continues to promote transition efforts of the developed countries into Industry 4.0. In view of this, E. Bulut and T. Akcaci (2017) recommend that Turkey set up an Industry 4.0 commission in order to reach the levels of those countries. They have debunked the popular rhetoric by some sceptics that Industry 4.0 will have damaging effects on the employment and will facilitate job losses. They noted that those sceptical studies are not based on scientific facts and that no previous industrial revolution has ever been associated with unemployment. Instead of having those apprehensions, emphasis should be made on investment in new industrial structures in both government and private sectors (Firat & Firat, 2017).

In the works of Koseoglu and Demirci (2017), the effects of Big Data and data mining on public services, policies and documents in Turkey are explored. They highlight the ramifications Industry 4.0 has on strategic plans of ministries and other government agencies. Consequentially, more comprehensive strategy and action plans are needed to raise awareness among those agencies concerning large data mining and management (Koseoglu & Demirci, 2017).

In the work of Dengiz (2017), it is explained how such concepts as “Internet of Things”, “Cloud Computing”, “Production Cloud”, “Augmented Reality” will promote digital transformation and industrial revolution. Thus, this roadmap lays down the basic steps to be taken in transition towards a more advanced and global digital world (Dengiz, 2017).

Davutoglu, Akgul and Yildiz (2017) introduced the concept of Industry 4.0 and aimed to raise awareness among academics and students about Industry 4.0, especially for private and public institution managers and employees. New perspectives can be seen in the literature on Industry 4.0. The aim of the study was to enable companies to define, explore and evaluate new adoptive approaches as well as the resulting opportunities that may accrue from them.

Yazıcı and Duzkaya (2016) studied the impact of Industry 4.0 on social institutions as well as Turkey’s industrial and educational infrastructures. The study identified the necessary steps that should be made to determine the basic examination strategy capable of effectively linking the field of education with the digital economy in Turkey. Also, they suggested how compliance to these industries transformational and digital arrangements can be obtained.

Similarly, Genc (2018) identified the issues worth paying attention if Turkey is to implement a smooth transition. The study argues that due to the vast potential of the real sector, government and academia should cooperate and develop strategies that would allow for fundamental educational changes as well as increased awareness of Industry 4.0. These small but tentative changes will allow Turkey to attain the competitive edge desired on the global stage.

Regarding the current competitiveness of Turkey on the global stage, Yalçın (2018) explored how a well-planned digitalization will make the largest contribution to the economy. For instance, various technoparks or extensive R&D



investments go a long way in instilling an innovative work culture capable of handling global opportunities and threats.

The above-presented literature review highlighted fundamental issues arising from adopting Industry 4.0 structures. It demonstrated how this can become an important asset for firms in the environments that require them to be globally competitive in order to meet the needs of increasingly powerful consumers. The main goal of this research is to determine various educational initiatives taken by firms in Turkey to create adequate awareness of Industry 4.0. Along with this primary goal, the researchers explored how the institutional framework in Turkey enables or inhibits those initiatives.

What is uniquely different about this study is that specific data were collected from 32 Turkish companies. By determining and analysing the level of knowledge and awareness of these companies, a deduction can be made to gauge the overall level of preparedness in Turkey. The study delves into the keys issues and considerations in terms of firm policy and structure requirements for a smooth transitioning to Industry 4.0. It is envisaged that these empirical findings will generate a lot of productive debate among entrepreneurs, managers, and educational policy-makers within the business environment in Turkey.

This study aims to emphasize the importance of education in the process of transition to the fourth industrial revolution in enterprises to determine strategic targets, to form strategic roadmaps and to ensure the discipline of planned work.

## **2. MATERIALS AND METHODS**

This study is based on a survey research. The survey was run in January, February and March 2018 involving 32 businesses based in Turkey. A total of 12 questions were prepared about company 4.0 awareness and practice at the company. A five-point Likert scale was used (1 “No work is done”, 2 “Work is at a low level”, 3 “Work is at a moderate level”, 4 “Work is at a good level”, 5 “Work is at a professional level”). Another 8 questions were designed to measure the social responsibility of the company. These were measured in terms of a three-grade scale – 1 “Yes”, 2 “No”, and 3 “In the process of creating Industry 4.0”.

In the survey, the participants were asked questions regarding the “Social responsibility of the company and “Industry 4.0 awareness and applicability” as well as “Demographic information”. In education awareness scale; enterprise-related information about cloud computing systems, data science, simulation and modelling, autonomous robot technologies and ERP, and application status was explored.

In the research analyses, nonparametric tests in the form of Mann Whitney U test and Kruskal Wallis H test were used.

## **3. FACTOR ANALYSIS**

The inferential statistics were concerned with: (i) the estimation of population parameters as well as the study constructs’ dimensions (for example, normality tests and factor analyses). The above-mentioned core issues were accomplished using

SPSS 12.0. In order to do this, the ordinal variables were considered as non-continuous variables.

The researchers conducted factor analysis to eliminate redundant items in the data. DeCoster (1998) describes it as a collection of methods used to examine how underlying constructs affect the responses of the measured variables. It is conducted to determine the structure and interrelationships among the items and condense these items into underlying dimensions or components. In factor analysis, redundant items in data are eliminated (Saunders, Thornhil & Lewis, 2009).

There are two broad types of factor analysis: Exploratory Factor Analysis (EFA) and the Confirmatory Factor Analysis (CFA). Ultimately, factor analysis examines the pattern of correlations between the observed measures. Constructs with high correlations are influenced by the same factors. However, constructs with few and low correlations are influenced by different factors (DeCoster, 1998).

Also, conducting factor analysis requires that the Kaiser-Meyer-Olkin (KMO) and Barlett's tests values be usually greater than 0.6 and  $p$ -values less than 0.001. Values greater than those are considered satisfactory. Finally, the assumptions that hold factor analysis will have at least 5 cases for each of the variables (often the 5:1 ratio rule), (Creswell, 1995).

### 3.1. Mann-Whitney U Test

The Mann-Whitney U-test (also known as Wilcoxon rank sum test) is used to compare two independent samples. It is used to test whether the two groups have the similar median, thus, comprise the same population (Kothari, 2004). The assumptions peculiar to this test are: the two samples are random; the samples must be independent of each other and the measurement scale should be ordinal (Ersoz & Ersoz, 2018).

### 3.2. Kruskal-Wallis H Test

This test is used to compare more than two samples that are independent. It is the corresponding parametric test of the one-way Anova. Unlike the one-way Anova, Kruskal Wallis tests do not have to meet the normally distributed assumption. For this test, different samples must have similar distributions regarding the shape and variances. The data should also be ranked. Ultimately, comparisons cannot be made if the samples are not independent (Ersoz & Ersoz, 2018).

## 4. RESULTS

In order to measure the perception of education in Industry 4.0, questions on education in the questionnaire were evaluated on a separate scale. Exploratory Factor Analysis was used by conducting Kaiser-Meyer-Olkin Measure and Bartlett's test of sphericity of Sampling Adequacy Test on a set of 20 items instrument. It was found that the results are significant ( $\chi^2 = 600.328$ ). The KMO measure of sampling adequacy yielded a value of 0.642, indicating that the sample size was large enough to assess the factor structure. The procedures generated

Kaiser–Meyer–Olkin value for each construct which was above 0.6 with a significant Bartlett’s test of sphericity value, indicating that the data were sufficient to proceed for the factor analysis (Tabachnick & Fidell, 2007). Table 2 shows the KMO and Bartlett’s Test results.

**Table 2.** Kaiser-Meyer-Olkin and Barlett’s Test

Test	Results
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	0.642
Approx. Chi-Square	600.328
Bartlett’s Test of Sphericity df	190
Sig.	<b>0.00*</b>

\* $p < 0.05$

The Kruskal-Wallis H and Mann-Whitney U test were used for non-parametric tests in comparison analyses of demographic variables and education level scale, since the education awareness level data did not show a normal distribution. Table 3 contains the Kruskal Wallis H test results and demographic variables.

**Table 3.** Research Analysis Results of Kruskal H Test for Demographic Characteristics of the Enterprise Related to the Level of Education Awareness

Demographic variables		N	Mean $\pm$ S.D.	KW	<i>p</i>
Sector	Automotive	12	3.06 $\pm$ 0.23	15.897	<b>0.026*</b>
	Food	6	4.59 $\pm$ 0.14		
	Grain Storage	3	3.44 $\pm$ 0.17		
	Textile	2	2.83 $\pm$ 0.28		
	Stationery	3	2.14 $\pm$ 0.62		
	Plastic	1	2.33 $\pm$ 0.00		
	Steel construction	2	2.22 $\pm$ 1.11		
	Machinery production	3	3.04 $\pm$ 0.96		
Number of Employees	50 and less	7	2.19 $\pm$ 0.49	15.513	0.050
	51–100	3	2.93 $\pm$ 0.30		
	101–200	2	2.94 $\pm$ 0.28		
	201–300	3	2.74 $\pm$ 0.30		
	301–400	3	3.19 $\pm$ 0.07		
	401–500	2	3.00 $\pm$ 0.78		
	501–1000	2	3.22 $\pm$ 0.11		
	1001–2500	6	4.17 $\pm$ 0.37		
	2501–5000	0	–		
	5001–10000	0	–		
	10001 and above	4	4.36 $\pm$ 0.13		

Demographic variables		N	Mean $\pm$ S.D.	KW	p
Level of Knowledge	Inadequate	5	2.16 $\pm$ 0.49	7.717	0.103
	Insufficient	10	3.08 $\pm$ 0.33		
	Undecided	3	3.89 $\pm$ 0.29		
	Adequate	13	3.44 $\pm$ 0.27		
	Very adequate	1	4.67 $\pm$ 0.00		
Resource Adequacy	Inadequate	1	2.50 $\pm$ 0.00	7.431	0.115
	Insufficient	5	2.33 $\pm$ 0.51		
	Undecided	9	3.35 $\pm$ 0.32		
	Adequate	16	3.45 $\pm$ 0.22		
	Very adequate	1	4.67 $\pm$ 0.00		
Changeover to Industry 4.0 is a must	No answer	1	3.33 $\pm$ 0.00	1.965	0.742
	Disagree	3	3.26 $\pm$ 0.58		
	Neutral	6	2.76 $\pm$ 0.53		
	Agree	13	3.22 $\pm$ 0.28		
	Strongly agree	9	3.46 $\pm$ 0.41		

\* $p < 0.05$

According to Table 3, the majority of the surveyed companies are operating in the automotive sector with the highest rate of 37.5%, 20.8% have 50 or fewer employees. 31.30% participants consider that the level of knowledge for transition to Industry 4.0 is insufficient, but 50% think that the resources are sufficient for the transition stage and 40.60% think that it is necessary to move to Industry 4.0. When the relationship between the demographic characteristics of the enterprises and the level of education is examined, it may be concluded that Industry 4.0 education awareness level varies depending on the sector in which the business operates.

Table 4 contains the Mann Whitney U test results and demographic variables.

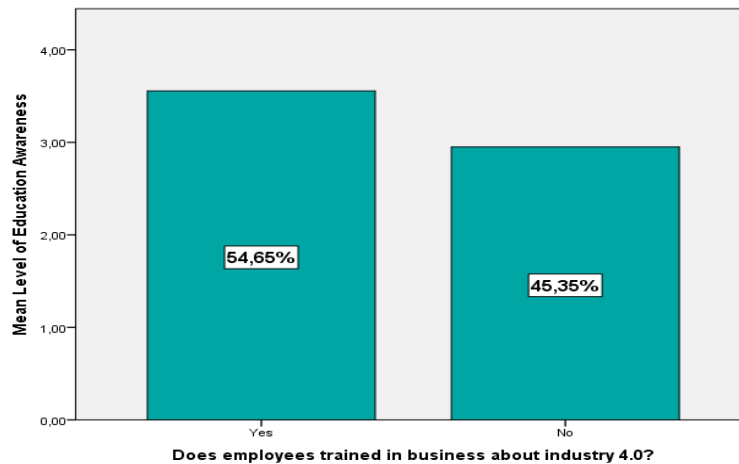
**Table 4.** Results of Mann Whitney U Test for Demographic Characteristics of the Enterprise Related to the Level of Education Awareness

Demographic Features		N	Mean $\pm$ S.D.	MW	p
Capital	Yes	25	3.11 $\pm$ 0.23	67.00	0.348
	No	7	3.56 $\pm$ 0.30		
Foreign partner	Yes	11	3.82 $\pm$ 0.25	62.00	0.033*
	No	21	2.89 $\pm$ 0.24		
Export	Yes	28	3.34 $\pm$ 0.20	26.50	0.092
	No	4	2.28 $\pm$ 0.45		
Education in Industry 4.0	Yes	13	3.56 $\pm$ 0.29	83.50	0.007*
	No	18	2.95 $\pm$ 0.26		
Platform membership	Yes	3	2.41 $\pm$ 0.74	18.50	0.105
	No	29	3.29 $\pm$ 0.21		

\* $p < 0.05$

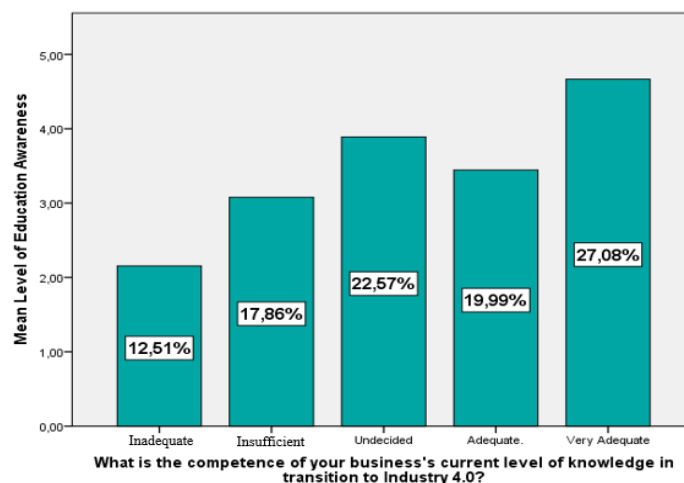
According to Table 4, 78.10% of the surveyed enterprises are located in big cities, 65.60% do not have foreign partners, 87.50% of them deal with export, 56.30% do not train their employees in the issues pertaining to Industry 4.0, 90.6% of them do not hold any platform membership related to Industry 4.0.

When the relationship between the demographic characteristics of the enterprises and the level of education is examined, it is observed that the level of education awareness of Industry 4.0 varies depending on the status of a foreign partner and Industry 4.0 education. The training status of employees in industry 4.0 is given in Figure 3.



**Fig. 3.** Employees receive training on industry 4.0

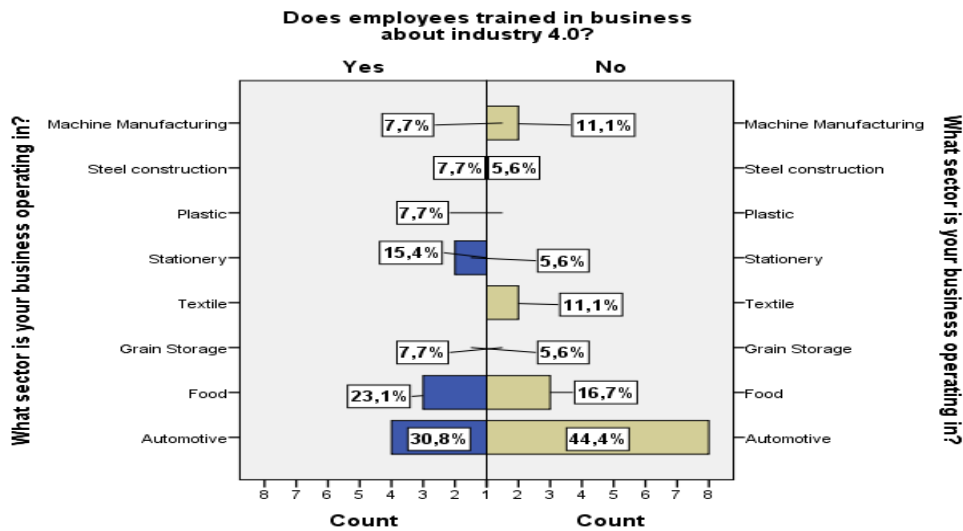
According to Figure 3, 54.65% of the employees were trained in industry 4.0, 43.35% were not trained. The training situation of the employees in industry 4.0 is given in Figure 4.



**Fig. 4.** Educational awareness distribution based on Industry 4.0 knowledge

When the level of knowledge level depending on the educational awareness level of the enterprise employees as shown in Figure 4 is examined, 27.08% of the enterprises find the level of knowledge of Industry 4.0 fully adequate, 12.51% were not found sufficient.

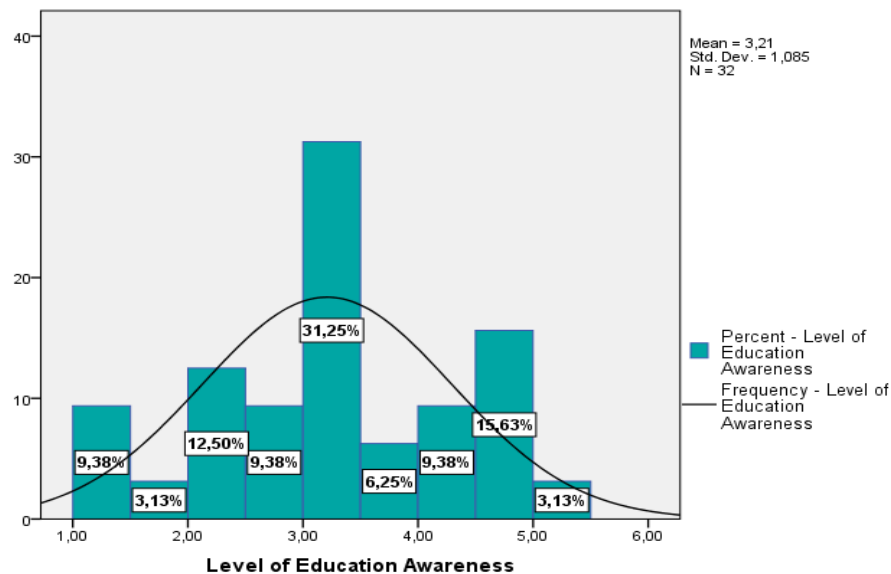
Figure 5 shows the sectoral distribution of employees' training in industry 4.0.



**Fig. 5.** Sectoral distribution of employees' training in industry 4.0.

According to Figure 5, a significant part of the enterprises operating in the stationery, food and automotive sectors participating in the survey have organized Industry 4.0 education.

Figure 6 shows distribution of the level of education awareness in Industry 4.0.



**Fig. 6.** Level of education awareness in Industry 4.0.

According to Figure 6, the mean of education awareness scale is 3.21 and the standard deviation is 1.09. Also, the figure showed that the participating enterprises were engaged in medium level work on Industry 4.0 technologies.

## CONCLUSION

Ever since the popularization of the concept Industry 4.0, steady progress continues to be made across the globe towards establishing a much more fluid and effective knowledge acquisition and sharing systems. From the economic point of view, the transition efforts made by Turkey are aimed at reducing the associated marginal costs of cyber-physical systems within businesses and public institutions. This would allow the country to gain a greater foothold in the global business arena. It is for this reason that strategic plans have to be put in place to guide the transformation process. To do this, greater Industry 4.0 awareness is needed in all spheres of academia, public and private institutions.

This study explored the current level of awareness among 32 business enterprises operating in Turkey. The study delved into the businesses' state of knowledge and competences as well the training measures put in place by them.

The study revealed that Industry 4.0 awareness levels differ depending on the sectors these businesses operate in. These variations ultimately led to varying levels of training that employees received. Also, awareness levels influenced the capacity of these firms to establish foreign partnerships. In addition, the study showed that the participating enterprises were engaged in medium level work on Industry 4.0 technologies that included cloud computing systems, data science, simulation and modelling, autonomous robot technologies and ERP. As a whole, there was enough evidence that the level of qualified and skilled employees continues to increase in transition towards Industry 4.0. Thus, the employees in Turkey are becoming more aware of the digital trend and are looking for more and varied education and training programs for themselves.

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