Electronic Journal of Applied Statistical Analysis
EJASA, Electron. J. App. Stat. Anal.
http://siba-ese.unisalento.it/index.php/ejasa/index
e-ISSN: 2070-5948
DOI: 10.1285/i20705948v16n2p272

A New Technology Acceptance Model on Industry 4.0: A Firm Based Regional Analysis

By Selim, Şen Doğan and Şen

14 October 2023

This work is copyrighted by Università del Salento, and is licensed under a Creative Commons Attribuzione - Non commerciale - Non opere derivate 3.0 Italia License.
For more information see:
http://creativecommons.org/licenses/by-nc-nd/3.0/it/

Electronic Journal of Applied Statistical Analysis
Vol. 16, Issue 2, 2023, 272-293
DOI: 10.1285/i20705948v16n2p272

A New Technology Acceptance Model on Industry 4.0: A Firm Based Regional Analysis

Sibel Selim*[a], Rana Şen Doğan[a], and Mustafa Şen[b]

[a]*Department of Econometrics, Manisa Celal Bayar University , Manisa, Turkiye*
[b]*Department of Econometrics, Suleyman Demirel University , Isparta; Turkiye*

14 October 2023

The aim of this study is to reveal the factors affecting Industry 4.0 technology acceptance within the framework of a newly proposed Technology Acceptance Model (TAM) of medium and large-scale firms in Manisa and Izmir Organized Industrial Zones, which are important industrial centres in Turkey. Within the scope of the study, managers of 204 firms operating in Manisa and Izmir Organized Industrial Zones have been interviewed and the data obtained has been analysed by Structural Equation Modelling (SEM) within the scope of TAM. According to the findings, it has been found that perceived usability, perceived ease of use, perceived self-efficacy and financing factors affect attitude towards Industry 4.0 use. In addition, it has been concluded that the attitude towards the use of Industry 4.0 also affects the Industry 4.0 usage intention and the Industry 4.0 usage intention affects the usage behavior.

keywords: Industry 4.0, Digitalization, Technology Acceptance Model, Structural Equation Model.

1 Introduction

Industry 4.0 is a new concept that emerged by combining industrial technologies and information technologies. It was initially introduced at a fair held in Hannover, Germany in 2011. Regarding production technologies, it is observed that mostly highly advanced

*Corresponding authors: sibel.selim@cbu.edu.tr

©Università del Salento
ISSN: 2070-5948
http://siba-ese.unisalento.it/index.php/ejasa/index

technologies are currently used in different business processes and various R&D studies are carried out to develop new technologies. Industry 4.0 creates a paradigm shift by enabling new advanced technologies to be integrated with each other and work autonomously. Various definitions of Industry 4.0 have been made in the literature. Colli et al. (2018), Mrugalska and Wyrwicka (2017), Kiraz et al. (2019), TÜSİAD (2016) define Industry 4.0 as a process of creating value chain that combines sophisticated systems. These systems include the internet of things, big data, cloud computing, artificial intelligence, cyber-physical systems, sensors, additive manufacturing and robotics at the digital platform, extending from raw materials to the final product. Describing Industry 4.0 as an industrial paradigm shift, Lichtblau et al. (2015) and Barreto et al. (2017), emphasize its objective of optimizing customer benefits through intelligent managerial processes and the integration of innovative manufacturing and information technologies, leading to a significant transformation in production methods Tjahjono et al. (2017). According to Tjahjono et al. (2017), the smart factory is the ultimate goal of an enterprise at the end of Industry 4.0 transformation. The smart factory enables different platforms such as advanced robotics, artificial intelligence, high technology sensors, cloud computing, internet of things, data collection, additive manufacturing, software service, mobile applications which can directly use motor vehicles to work mutually. Barreto et al. (2017), describe Industry 4.0 as an industrial paradigm shift, which helps to develop smart product networks in the value chain using smarter managerial processes and to maximize customer satisfaction by offering innovative products and services.

Industry 4.0 is an inclusive notion that combines many components. The components of Industry 4.0 are connected to each other with the internet. The data generated through this connection are used for decision making purposes and autonomous implementation by all devices, machines, and computers that participate in the process. This framework creates a digital value chain from raw material to the end of the life cycle of the final product. These developments and integrations create a new generation of production fields known as smart factories, which operate with minimal human intervention. The smart factory maximizes safety in a dangerous working environment, if any, and makes the factory manufacturing process more stable, agile, and instantly customizable by eliminating all human-included factors (manufacturing defect, motion instability, etc.).

The development of Industry 4.0 includes the change of business culture beyond the technological changes that occur in a factory. Taken together, it seems more appropriate to allow this formation to be updated with holistic cultural and organizational developments. Considering previous industrial revolutions will make it easier to understand the development of Industry 4.0. Three industrial revolutions took place prior to the entry of Industry 4.0 concept into the literature (see Figure 1). All these revolutions embody creative destruction with significant socio-economic consequences. With the introduction of steam power to machines in 1784, a transition from muscle power to steam power took place, leading to increased capital and resulting in the emergence of concepts such as factories and urbanization. The second industrial revolution covers the period of early 20th century, when electrical energy was used, mass production was made on the assembly line, and the division of labour arose (Kagermann et al., 2013).

The invention of internal combustion engines in 1870, improvements in the field of communication, and the use of electricity in manufacturing ended the era of steam power. Basic digital products, which indicated the transition to the information age, emerged in 1969, and automation technologies were integrated into production systems (Odası, 2018; Zhou et al., 2015). New developments in communication technologies, on the other hand, have brought automation technology to a more advanced stage and the concept of Industry 4.0 has emerged.

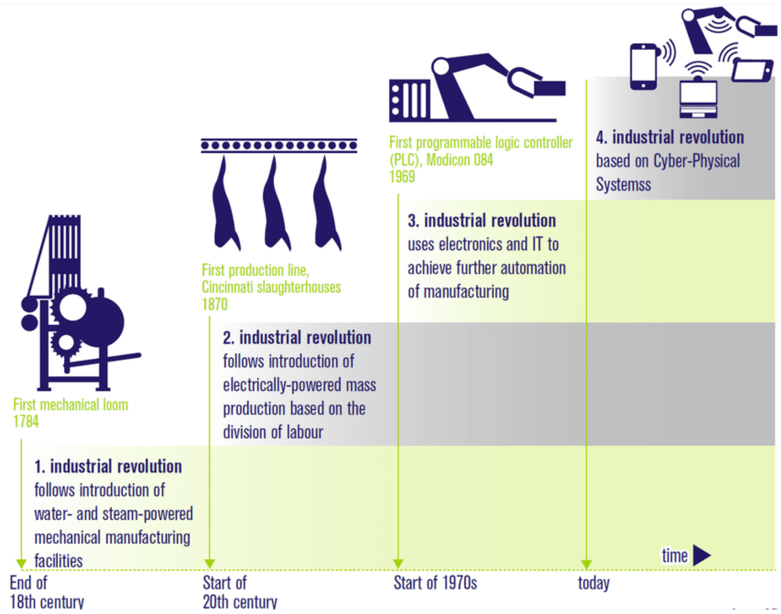

Figure 1: From Industry 1.0 to Industry 4.0

The convergence of Industry 4.0 and digitalization has triggered significant transformations within the context of the 3rd Industrial Revolution. The framework of Industry 4.0 comprises a set of integral components, encompassing Big Data Analytics, Cloud Computing, the Internet of Things (IoT), Autonomous Robots, Simulation, Augmented Reality, Additive Manufacturing, and Cybersecurity.

One of the most important differences of Industry 4.0 is to fully integrate new technologies and the technologies of the 3rd Industrial Revolution on a digital platform. There are great differences between the enterprises that use all these technologies separately and the enterprises that use them all connected to each other on a digital platform in terms of the operating process, products, competitiveness, costs, innovation skills, sustainability and working conditions. Turkey has seen the emergence of numerous studies aimed at advancing Industry 4.0. For example, the Supreme Council of Science and Technology conducted a comprehensive survey involving 1000 private sector organizations to identify key and leading technologies, assess the current status, and pinpoint deficiencies and competencies relevant to smart production systems. Furthermore, a roadmap study has been conducted led by Turkey Ministry of Science, Industry and Technology with the contribution of public and private sector shareholders for planning and implementing the digital transformation process effectively (Bilim and Bakanlığı, 2018). The study's outcomes identified human resources, technology, infrastructure, suppliers, users, and governance as the key components of the Industry 4.0 roadmap. These comprehensive studies, aimed at planning the Industry 4.0 transformation, have yielded results that span across Turkey. However, making more customized analyses and evaluations is critical in the Industry 4.0 transformation process, where many companies are exposed to more intense competition and have to adapt quickly to changing conditions (Felch et al., 2019).

Distinguishing itself from prior research, this study introduces a novel TAM to reveal the factors affecting the acceptance of Industry 4.0 by medium and large firms operating in Manisa and Izmir Organized Industrial Zones, which are important industrial centres in Turkey. Although some firms may currently be using Industry 4.0 components partially or completely, they cannot reap the benefits that Industry 4.0 promises if these components are not integrated in the digital plane. This study will serve as a comprehensive guide for firms aiming to adopt Industry 4.0 practices. It aims to not only investigate the cause-and-effect relationships between the influencing factors but also to analyze the current situation and identify deficiencies on a regional basis. By doing so, the study seeks to ensure that companies effectively manage the Industry 4.0 transformation process.

2 Theoretical Background

When the literature related to Industry 4.0 is examined, the studies gathered on the conceptual and descriptive (Akın, 2017; Atalay Davutoğlu, 2017; Barreto et al., 2017; Benešová and Tupa, 2017; Carvalho et al., 2018; Crnjac et al., 2017; Düzkaya, 2016; Iyer, 2018; Paravizo et al., 2018; Pereira et al., 2017; Vaidya et al., 2018; Yıldız, 2018; Zhong et al., 2017), maturity measurement which aims to help companies plan the transformation process (Duffy, 2001; Backlund et al., 2014; De Carolis et al., 2017; Lichtblau et al., 2015; Mettler, 2011; Nikkhou et al., 2016; Proença and Borbinha, 2016; Schumacher et al., 2016; Tarhan et al., 2016) and empirical studies based on readiness measurement. Empirical studies about technology acceptance, which are also subject of this analyze the components of Industry 4.0 individually, there is no study that investigates Industry 4.0 holistically (Winberg and Ahrén, 2018). The section about the mentioned studies is presented below.

Bulut and Akçacı (2017) discussed Industry 4.0 with its components and evaluated Turkish economy in terms of Industry 4.0. According to Bulut and Akçacı, although the technology level seems high, it is not sufficient for Industry 4.0 transformation. Use of digital platforms and R&D are not at an adequate level. These shortcomings affect Industry 4.0 transformation directly. The rapid construction of internet infrastructure in Turkey is a positive factor in terms of Industry 4.0 conversion. Nuroğlu and Nuroğlu (2018) have compared conversion roadmaps and factories of Germany and Turkey. According to the results of the comparison, it has been revealed that Turkish companies focused on cost factor when compared with the other factors while German companies faced the problem that the stuff refusal to accept conversion, data, internal coordination problems and the existing firm structure making conversion difficult. Lichtblau et al. (2015) investigates the companies' readiness for Industry 4.0, their demands, and their capacity to implement the innovations that come with Industry 4.0. Companies' readiness levels are scored between 0-5. Also, based on this research, an online platform has been created where companies can evaluate themselves. According to results, it has been determined that generally data focused services have a lowest readiness score among the others, large-scale companies are ahead in all dimensions compared to small and medium-sized companies, and among the companies operating in Germany, mechanical engineering companies are more advanced in the field of Industry 4.0 compared to other companies. In addition, it has been determined that basing the transformation on the strategy, low investment amounts in transformation, collecting process data, using autonomous systems, using cloud system, collecting final product data, employees not having competence are the factors that affect the transformation.

TÜSİAD, SAMSUNG Electronics Türkiye Deloitte Türkiye, GfK (2016) study aims to reveal process of perceptions, focuses and changing management about digital change of senior executive of 58 companies that operating different sectors. Research shows that there is a significant correlation between digital maturity and digital strategy. Participants state that a clear and understandable strategy is the key to digital change. The motivation of digitalization as for has been determined as increasing productivity and responding quickly to customer demands. Nazlıcan and Meçik (2018) assessed Turkey's current conditions in terms of Industry 4.0 and researched the situations that labor market will face in this process. According to the findings obtained from interviews with executives, it has been determined human-oriented problems' such as that the problem of digital conversion is human based, incompatibility of labor qualifications with Industry 4.0 and absence of regulations of make conversion easy come forefront. Eğilmez and Gözde (2018) has analyzed possible difficulties that Turkish production sector may face, investigating the Industry 4.0 conversion from different perspectives. For the research the questionnaire was applied to 150 people who were manager in the Industry 4.0 field, the main difficulties and sub-difficulties were determined using Explanatory Factor Analysis and analyzed with the Analytical Hierarchy Process. It has been determined with factor analysis that technological, organizational, legal and ethical, and strategic difficulties are main challenges in the conversion of Industry 4.0.

Prause (2019) has researched the difficulties that may be encountered in the adoption process of Industry 4.0 technology using the Technology Adoption Model. In the analysis that performed linear regression model, while 'technology adoption intention' is used as dependent variable, as explanatory variables 'perceived complexity, compatibility, relative advantage, cost/benefit ratio, market uncertainty, diversity in the industry area, senior management support, satisfaction with the current system, decentralized decision system, market transparency, high security concern' were used. It was determined that market uncertainty in short-medium and long term, relative advantage in short term and executives' support affect positively the Industry 4.0 adoption intention. Agostini and Nosella (2019) has researched whether the investment made in advanced production technologies and social capital influences the adoption of Industry 4.0. Findings showed that SMEs which have stronger domestic and external social capital, have investments to advanced production technologies are more likely to adopt Industry 4.0. Ünlü and Atik (2019) measure the relative performance of the countries in transition towards Industry 4.0 by using industry level indicators such as big data, CCS and CPS. In this study, industry 4.0 performance index for Turkey and European countries is developed. According to the findings from this study, Denmark has the highest performance among the European countries, Romania has the lowest performance. Turkey is, also, 31st in the ranking of European countries. Raj et al. (2020) has investigated obstacles in front of the Industry 4.0 application using Decision making trial and evaluation laboratory (DEMATEL) method. According to results it has been determined that absence of strategy is a quite important obstacle, on the other hand technological infrastructure investments and regulations can make the conversion easy. Masood and Sonntag (2020) analyzed the effect of SMEs qualifications on the Industry 4.0 application intention using Technology Acceptance Model. Perceived benefit and perceived difficulty were used instead of perceived usefulness and perceived ease of use that use in the classical TAM. According to results of analysis which includes 270 observations, have been determined that the external factors which firm size and the attitude towards Industry 4.0, the perceived benefit of the application and the complexity of the production affect positively the difficulty of the application. Ronaghi and Forouharfar (2020) study investigates the acceptance of internet of things. In the study that investigates technology acceptance for increase crop quality and yield, it was determined that expectation of effort, social effect, individual factors and facilitator factors affect positive intention to use of internet of things.

3 Methodology

The new TAM proposed within the scope of this study has been tested with the help of Structural Equation Modelling (SEM) and the factors affecting the acceptance of technology for Industry 4.0 have been investigated.

Structural Equation Models (SEM) are a multivariate statistical method that handles observed and latent variables together. SEM assumes that latent variables can be measured through observed variables and takes into account measurement errors in describing the relationships between latent variables. At the same time, it enables the model to be developed and tested by handling direct and indirect effects together (Raykov and Marcoulides, 2012). he purpose in using SEM is to reveal the predicted cause and effect relationships between latent variables. Research hypotheses are used to reveal these cause-and-effect relationships. In other words, SEM assumes that there is a causality structure among latent variables and that latent variables can be measured through observed variables (Yilmaz and Çelik, 2009). Describing the relationships between latent variables and taking into account measurement errors reveal the characteristic features of SEM (Raykov and Marcoulides, 2012).

SEM consists of a combination of the structural model and the measurement model

(Bollen, 1989; Byrne, 2010; Kaplan, 2000; Sharma and Sharma, 1996). TThe structural model includes structural equations that summarize the relationships between latent variables. The structural model is as given in Equation 1:

$$\eta = \beta\eta + \Gamma\xi + \zeta \tag{1}$$

Here, m: is the number of internal latent variables, n: is the number of external latent variables; η: is the internal latent variable vector with a dimension of $mx1$, β: is the matrix of coefficients between internal latent variables with a dimension of mxm and with zero main diagonal, Γ: is the matrix of coefficients between internal and external latent variables with mxn dimension, ξ: is the external latent variable vector with $nx1$ dimension, ζ: is the vector of latent error terms with $mx1$ dimension. Assumptions belonging to the structural model are: $E(\eta) = 0, E(\xi) = 0, E(\zeta) = 0, (1-\beta)$ non-singular matrix, ξ and ζ's are unrelated and $Var(\zeta_i)$ are constant (Yilmaz and Çelik, 2009). A visual example of the structural equation model, which consists of the combination of the structural model and the measurement model, is given in Figure 2.

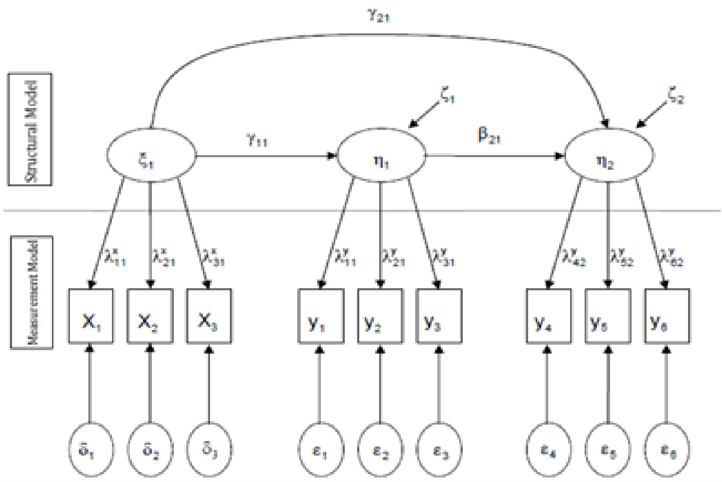

Figure 2: An Example of a General SEM

The measurement model, on the other hand, includes equations that define the relationships between observed variables and the latent variables they depend on. The measurement model is as given in Equation 2 and Equation 3.

$$y = \lambda^y\eta + \varepsilon \tag{2}$$

$$x = \lambda^x\eta + \delta \tag{3}$$

Here, p: is the number of latent variables, q: is the number of observed variables, y: is the vector of observed variables belonging to the internal latent variables with a dimension of $px1$, λ^y is the coefficient matrix of the observed variables (factor loadings or structural coefficients matrix) of the internal latent variables, ε: is the error vector of observed variables belonging to internal latent variables with $px1$ dimension, x: is the observed variables vector belonging to external latent variable with $qx1$ dimension, λ^x is the coefficient matrix of observed variables belonging to external latent variables with qxn dimension (factor loadings or structural coefficients matrix), δ: is is the error vector of observed variables belonging to external latent variables with a dimension of $qx1$. Assumptions belonging to the measurement model are: $E(\eta) = 0, E(\xi) = 0, E(\varepsilon) = 0, E(\delta) = 0, \varepsilon$ and δ, ξ and η's and δ and ε, ξ and η's are unrelated (Zhong et al., 2017). The first step of SEM is to test the measurement model and the next step is to test the structural model. Within the scope of this study, Confirmatory Factor Analysis (CFA) has been conducted to test the fit of the measurement model and the results related to the fit, reliability and validity of the model have been presented. Causal relationships between latent constructs (variables / factors / dimensions), on the other hand, have been tested with SEM. As a result of SEM, model fit has been evaluated and information has been given about the acceptance of the hypotheses. Hypotheses have been determined with a view to revealing the Industry 4.0 acceptance. CFA and SEM analyses have been performed using LISREL 10.10 software.

TAM is an information systems theory that models how users accept and use technology. TAM consists of Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude (A), Intention to Use (IU) and Usage Behavior (UB). TAM argues that individuals' intentions towards behavior are determined by individuals' attitudes, and perceived usefulness and perceived ease of use directly affect attitude. In addition, it argues that intention to use triggers actual usage behavior (Lin et al., 2007). Perceived Usefulness is defined as a person's degree of belief that s/he will increase his/her job performance by using a particular system. A system with high perceived usefulness means a system in which the user believes there is a positive use-performance relationship. Perceived Ease of Use refers to the degree of beliefs about the increase in performance that will be achieved when performing certain tasks and solving problems (Davis, 1989). Attitude refers to the perspectives individuals personally adopt regarding another person, object, behavior or policy (Ajzen and Fishbein, 1977). Intention to Use is the sum of the motivational factors that affect human behavior. These motivational factors are indicators of how much effort people are prepared to make to realize their behavior and how intense an effort they will make in this respect. Usage Behavior, on the other hand, is the degree of frequency and intensity of use of technological products (Ajzen, 1991). Basic TAM is given in Figure 3.

4 Empirical Analysis

In addition to the meagre studies about industry 4.0 technology, there are no studies in the relevant literature investigating the firms' acceptance of Industry 4.0 technologies in Turkey. With this study, the factors affecting the acceptance of Industry 4.0 technology of medium and large-scale companies operating in Izmir and Manisa Organized Industrial Zones, which are important industrial centres in Turkey will be addressed within the

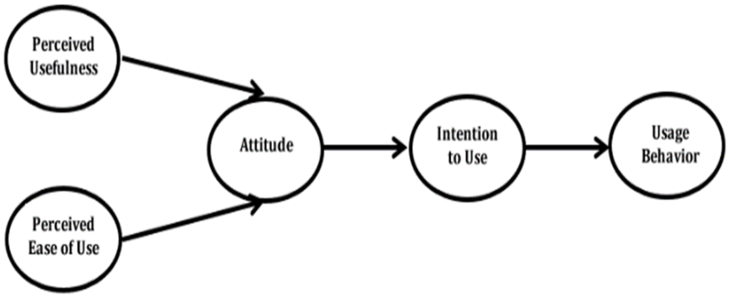

Figure 3: The Basic Technology Acceptance Model

framework of a newly proposed TAM, and thus a significant contribution will be made to the literature.

4.1 Data Collection Tool

The questionnaire technique has been used for data collection in this study. The questionnaire consisted of demographic questions and TAM questions to determine Industry 4.0 acceptance. In this study, Perceived Self-Efficacy and Financing factors have been also added to the new TAM, which has been proposed for the first time in this study, in addition to its sub-dimensions of Perceived Usefulness, Perceived Ease of Use, Attitude, Intention to Use and Usage Behaviour, as they have been thought to have an indirect or direct effect on the use of Industry 4.0 technology. A 5-point Likert scale with the statements 1: strongly disagree, 2: disagree 3: neither agree nor disagree, 4: agree 5: strongly agree has been used to measure to what extent the firms participated in Industry 4.0.

4.2 Pilot Study

In this study, a pilot study has been carried out after the creation of the questionnaire items to test under real conditions whether there have been statements in the questionnaire that have been incomprehensible or perceived to be similar and to reduce the possibility of encountering problems in later stages. The Cronbach's Alpha (α) ccoefficient, which is the reliability coefficient for all Likert-type expressions related to general Industry 4.0 in the questionnaire, has been calculated as 0.888. After the pilot study, the expressions that have been not understood or perceived similar in the questionnaire have been removed from the questionnaire and the final questionnaire has been created.

4.3 The Population and Sample

The population of this study consists of all the medium-sized and large businesses operating in Izmir and Manisa Organized Industrial Zones. In this study, the provinces and the scales of the firms have been considered as strata and 204 firms have been determined with the stratified sampling method using proportional distribution technique. Firm managers have been interviewed in 70 out of 204 companies, and face-to-face surveys have been conducted with the firm managers who agreed to participate in the survey. Face to face surveys, which began in January 2020, continued from March 2020 onwards in the form of telephone call surveys due to the emergence of the Covid-19 pandemic in Turkey and in the world. A total of 204 firms were surveyed. Since 34 questionnaires were detected as outliers, data from 170 firms have been used for the analysis.

4.4 A New Proposed Technology Acceptance Model

In this study, the dimensions forming the basic TAM model are Perceived Usefulness (PU), Perceived Ease of Use (PEU), Attitude (A), Intention to Use (IU) and Usage Behavior (UB). The model has been expanded by adding the dimensions of Financing (F) and Perceived Self- Efficacy (PSE) to this basic model and a new model has been proposed within the scope of this study.

In the proposed TAM model, as in the TAM, Perceived Usefulness (PU) and Perceived Ease of Use (PEU) affect attitude (A) towards Intention to Use (IU). In addition, the dimensions of Financing (F) and Perceived Self-Efficacy (PSE) are also thought to affect the attitude (A) variable. The research hypotheses formed through the proposed model have been tested and the cause-effect relationships between the dimensions have been revealed. The TAM model developed and proposed within the scope of the study in a micro scale in order to understand the acceptance of Industry 4.0 technology is presented in Figure 4.

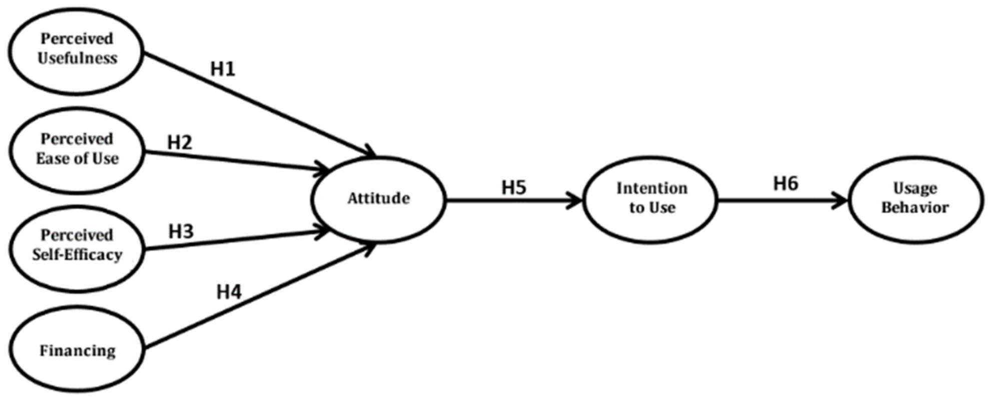

Figure 4: The Proposed Technology Acceptance Model

First, descriptive statistics have been obtained within the scope of the study. The sectoral distribution of the firms and their strategies and investments regarding Industry 4.0 has been examined with the help of the descriptive statistics. In the subsequent stages of the study, the measurement model has been tested with the help of Confirmatory Factor Analysis (CFA) in order to evaluate the fit of the measurement model to the proposed TAM, and the results regarding the fit, reliability and validity of the model have been presented. Relationships between latent structures in the model have been examined with the help of SEM. As a result of SEM, the fit of the model and the following hypotheses created within the scope of the research have been tested.

Hypotheses: H_1: Perceived usefulness affects attitude towards Industry 4.0 use. H_2: Perceived ease of use affects attitude towards Industry 4.0 use. H_3: Perceived self-efficacy affects attitude towards -Industry 4.0 use. H_4: Financing affects attitude towards Industry 4.0 use. H_5: Attitude towards the use of Industry 4.0 affects the intention to use Industry 4.0. H_6: Intention to use industry 4.0 affects Industry 4.0 usage behavior.

4.5 Descriptive Statistics

Information on the sectors which the firms participating (participate) in the study are presented in Table 1.

	Frequency	Valid Percent	Cumulative Percent
Woodworking, Paper and Paper Products	7	4.1	4.1
Packaging	5	2.9	7.1
Glass, Cement and Soil	7	4.1	11.2
Electric and Electronic	9	5.3	16.5
Energy	1	0.6	17.1
Food	19	11.2	28.2
Construction	20	11.8	40.0
Chemical, Petroleum, Rubber and Plastics	6	3.5	43.5
Mining	3	1.8	45.3
Machine	28	16.5	61.8
Metal	22	12.9	74.7
Automotive	9	5.3	80.0
Health and Social Services	7	4.1	84.1
Agriculture, Hunting and Fishing	1	0.6	84.7
Textile, Ready-Made Clothing, Leather	14	8.2	92.9
Social and Personal Services	12	7.1	100.0
Total	170	100.0	

Table 1: Sectors of the Firms

The firms' predispositions towards Industry 4.0, the investments they had made in Industry 4.0 in recent years and the investments they planned to make in the future have been examined to reveal firms' Industry 4.0 strategies, which is given in Table 2. It is seen that 25% of the firms are in the strategy development stage, while 16% are performing pilot applications and 20% are implementing a strategy. Another remarkable result presented in Table 2 is that while 5% of the firms fully implemented their strategies, 35% of them did not have any strategy related to Industry 4.0.

The investments made by the firms in Industry 4.0 are given in Table 3 and the investments planned in the future are given in Table 4. As seen in Table 3, the firms surveyed invest more heavily in R&D and Production. When firms are asked to evaluate the investments, they want to make in the future, it is revealed that companies plan to invest more intensively compare to current investment levels in all areas (R&D, Production, Purchasing, Logistics, Sales Services, IT) (see Table 4).

	Frequency	Valid Percent	Cumulative Percent
No written strategy	58	34.9	34.9
Strategy is being developed	42	25.3	60.2
Pilot applications are underway	26	15.7	75.9
A strategy is being implemented	33	19.9	95.8
A strategy has been fully implemented	7	4.2	100.0
Total	166	100.00	

Table 2: The Status of Firms Regarding Their Industry 4.0 Strategies

	R&D	Production	Purchase	Logistics	Handling Services	BT
None	67 (%40)	42 (%25)	65 (%38)	65 (%39)	69 (%41)	58 (%35)
Small Level	33 (%20)	25 (%15)	32 (%19)	37 (%22)	26 (%15)	23 (%14)
Medium Level	49 (%29)	57 (%33)	44 (%26)	41 (%24)	42 (%25)	51 (%30)
Ample	11 (%7)	34 (%20)	20 (%12)	17 (%10)	21 (%12)	24 (%14)
Substantial	7 (%4)	11 (%7)	8 (%5)	8 (%5)	11 (%7)	11 (%7)
Total	167	169	169	168	169	167

Table 3: The Status of the Firms Regarding the Amount of Industry 4.0 Investments They Have Made in the Last Two Years

	R&D	Production	Purchase	Logistics	Handling Services	BT
None	42 (%25)	25 (%15)	46 (%27)	47 (%28)	50 (%29)	41 (%24)
Small Level	32 (%19)	25 (%15)	35 (%21)	32 (%19)	32 (%19)	26 (%16)
Medium Level	45 (%27)	47 (%27)	52 (%30)	48 (%28)	45 (%27)	49 (%29)
Ample	36 (%22)	55 (%32)	31 (%18)	35 (%21)	34 (%20)	42 (%25)
Substantial	12 (%7)	18 (%11)	6 (%4)	7 (%4)	9 (%5)	10 (%6)
Total	167	170	170	169	170	168

Table 4: The Amount of Investment the Firms Intend to Make in Industry 4.0 in the Future

4.6 Findings

When the data obtained in the study to test TAM have been examined, the variables seemed to violate the multivariate normality assumption (Mardia Chi-square = 1375, $p < 0.001$). Therefore, the model estimation has been analysed by Robust Maximum Likelihood method. Within the scope of the analysis, firstly, the fit of the measurement model, then the fit of the structural model and finally the results of the hypothesis test have been evaluated.

4.6.1 Results Regarding the Measurement Model

With the Confirmatory Factor Analysis, it has been checked whether the observed variables in each factor have been included in the relevant factor with TAM. According to the results of the CFA analysis for each factor, the items (observed variables) that did not explain the relevant factor sufficiently (those whose standard factor loads have been below 0.50) have been excluded from the model. The CFA results revealed that Perceived Usefulness has been explained with 8 items, Perceived Ease of Use 4, Perceived Self-Efficacy 4, Financing 2, Attitude 4, Intention to Use 6 and Usage Behavior with 3 items.

Validity of the Measurement Model

The fit of the measurement model has been tested with the RML method using LISREL 10.10. With the help of the calculated fit criteria, it has been determined that the model has been within acceptable limits. ($\chi^2/sd = 790/413 = 1.91 < 3.00$ (Hayduk, 1987), Normed Fit Index (NFI) = 0.94 > 0.9 (Bentler and Bonett, 1980), Non-Normed Fit Index (NNFI) = 0.97 >0.95 (Ajzen and Fishbein, 1977)(joreskog1996lisrel), Comparative Fit Index (CFI) = 0.97 > 0.9 (Bagozzi and Yi, 1988), Root Mean Square Error of Approximation (RMSEA) = 0.073 < 0.08 (Bagozzi and Yi, 1988), Standardized Root Mean Square Residual (SRMR) = 0.067 < 0.10 (Schermelleh-Engel et al., 2003), Incremental Fit Index (IFI) = 0.97 > 0.90 (Bentler and Bonett, 1980).

Factor loads for the measurement model are given in Table 5. When Table 5 is examined, it is observed that all the factor loads are greater than 0.57 and statistically significant.

Whether the structures that formed the model have been explained sufficiently by the relevant items has been checked with convergent validity. Three conditions must be fulfilled in order to confirm convergent validity. The first condition is that the standardized factor loads of the observed variables belonging to latent variables should be greater than 0.50 and statistically significant (Fornell and Larcker, 2018). Second, the Composite Reliability (CR) and Cronbach Alpha (CA) value for each structure/construct must be greater than 0.70 (Hair et al., 1998). Third, the Average Variance Extracted (AVE) value of each latent variable must be higher than 0.50 (Fornell and Larcker, 2018).

Correlations between CA, CR, AVE values and latent structures are given in Table 6. When the construct validity is checked according to Table 6, it is seen that the CR values are greater than 0.71, the CA values are greater than 0.72 and the AVE values are greater than 0.53. Convergent validity has been confirmed according to these values.

Latent Variables	Observed Variables	λ	t
Perceived Usefulness	PU1	0.90	13.75*
	PU2	0.78	5.72*
	PU3	0.93	12.51*
	PU4	0.92	12.79*
	PU5	0.86	12.16*
	PU6	0.90	12.91*
	PU7	0.86	10.19*
	PU8	0.84	10.42*
Perceived Ease of Use	PEU1	0.57	6.53*
	PEU2	0.89	14.09*
	PEU3	0.94	18.29*
	PEU4	0.71	8.86*
Perceived Self-Efficacy	PSE1	0.75	11.66*
	PSE2	0.78	11.53*
	PSE3	0.87	14.78*
	PSE4	0.79	12.55*
Financing	F1	0.60	5.97*
	F2	0.87	8.62*
Attitude	A1	0.80	11.69*
	A2	0.81	13.99*
	A3	0.66	7.74*
	A4	0.61	6.80*
Intention to Use	IU1	0.78	14.55*
	IU2	0.79	12.13*
	IU3	0.81	14.52*
	IU4	0.83	12.75*
	IU5	0.74	10.58*
	IU6	0.80	9.95*
Usage Behavior	UB1	0.97	20.44*
	UB2	0.95	24.19*
	UB3	0.96	21.71*
* p<0.01. t<2.58			

Table 5: Factor Loads and t Values for the Measurement Model

	CA	CR	AVE	Correlation between Latent Variables						
				1	2	3	4	5	6	7
1: PU	0.95	0.96	0.77	0.88						
2: PEU	0.88	0.87	0.63	0.42	0.79					
3: PSE	0.89	0.88	0.64	0.37	0.65	0.80				
4: F	0.72	0.71	0.56	0.49	0.23	0.36	0.75			
5: A	0.82	0.81	0.53	0.47	0.47	0.54	0.55	0.73		
6: IU	0.90	0.91	0.63	0.51	0.47	0.54	0.52	0.70	0.79	
7: UB	0.96	0.97	0.92	0.25	0.51	0.75	0.28	0.47	0.49	0.96

Note: The diagonal elements in the correlation matrix are the square roots of the AVE values for the structure/construct.

Table 6: CA. CR. AVE and Correlation Values

Discriminant validity should be checked to show that the resulting constructs measure different phenomena. The discriminant validity of the measurement model is checked by comparing the square root of the AVE value of each construct to the correlation between that construct and other constructs. As a result of these comparisons, if the square root values of AVE are greater, discriminant validity is accepted (Fornell and Larcker, 2018). The discriminant validity values of the model discussed are given in Table 6. It has been observed that discriminating validity has been confirmed according to Table 6.

4.6.2 Results Regarding the Structural Model

After the acceptance of the fit, reliability and validity of the measurement model, the structural model has been tested using the RML method. It has been determined that the calculated fit criteria have been within the acceptable limits and the validity of the structural model has been confirmed ($\chi^2/sd = 836/422 = 1.98 < 3.00$, NFI = 0.94 > 0.9, NNFI = 0.97 >0.95, CFI = 0.97 > 0.9, RMSEA = 0.076 < 0.08, SRMR = 0.094 < 0.10, IFI = 0.97 > 0.90).

Path Coefficients and Hypothesis Testing

The path diagram for the model proposed according to the RML method is given in Figure 5 together with the path coefficients. According to the results of the analysis, no significant relationship has been found between the external latent variables of perceived usefulness and perceived ease of use and the latent variable of Attitude. On the other hand, a statistically significant relationship has been found between the external latent variable of Perceived Self-Efficacy and the internal latent variable of Attitude. This value means that a one-unit increase in Perceived Self-Efficacy will cause an increase of 0.28 units in Attitude. A positive, strong and statistically significant relationship has been found between the external latent variable of financing and the internal latent variable of Attitude. This value indicates that a one-unit increase in Financing will cause an increase of 0.34 units in Attitude. On the other hand, a positive, significant and strong relationship has been found between Attitude and Intention to Use. This value means that a one-unit increase in Attitude will cause an increase of 0.92 units in Intention to Use. It is seen that there is a positive and statistically significant relationship between Intention to Use and the latent variable of Usage Behavior. A one-unit increase in Intention to Use causes an increase of 0.52 in Usage Behavior.

Results related to the hypotheses for the model are given in Table 7. According to the table, all the hypotheses except H_1 hypothesis have been statistically supported.

5 Conclusion

This study aimed to measure the attitudes of businesses operating in Manisa and İzmir Organized Industrial Zones towards the acceptance of Industry 4.0 technology within the framework of a newly proposed TAM and to make an evaluation on a regional basis according to the results obtained. With this goal, technology acceptance of businesses operating in Manisa and Izmir Organized Industrial Zones has been analyzed with the Structural Equation Modelling within the scope of the newly proposed TAM.

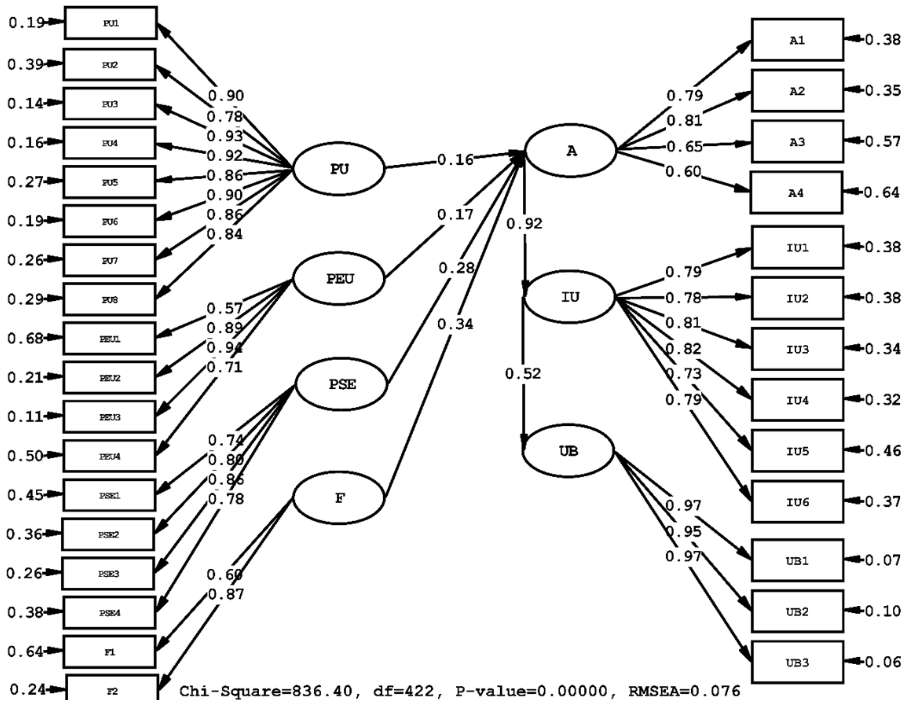

Figure 5: Path Diagram for the Proposed Model

The findings related to the businesses' attitudes toward Industry 4.0 can be summarized as follows: i) most of the firms have developed strategies for Industry 4.0, ii) the firms are considering increasing their investment in the future even though the investment amount related to Industry 4.0 has been low in the last two years.

In this study, we have attempted to explain the attitudes, intentions, and behavioural constructs for the use of Industry 4.0, by revealing the relationships between these constructs and the factors affecting these constructs with the newly proposed TAM. Although, Perceived Usefulness (PU), Perceived Ease of Use (PEU), Perceived Self-Efficacy (PSE) and Financing (F) factors have been claimed to affect Attitude (A), PU and PEU were found not to affect Attitude (A). PU expresses the belief that utilizing a specific

Hypotheses	λ	t	Result
H1: PU -> A	0.16	1.26*	Not Supported
H2: PEU -> A	0.17	1.72*	Not Supported
H3: PSE -> A	0.28	2.96*	Supported
H4: F -> A	0.34	2.61*	Supported
H5: A -> IU	0.92	9.71*	Supported
H6: IU -> UB	0.52	7.68*	Supported
* p<0.01. t<1.96			

Table 7: Standardized Parameter Estimates and Hypothesis Test Results

system will enhance a firm's business performance. Thus, it can be concluded that even if the firm believes that it will increase business performance by using Industry 4.0. the firm does not change its attitude towards the use of Industry 4.0. Therefore, the existence of different factors affecting the attitude towards the use of Industry 4.0 should also be investigated in future studies. Another latent variable that does not affect Attitude, i.e., PEU reflects the perception that Industry 4.0 technology is easy to use and adapt to. It is observed that the perception that it is easy to use Industry 4.0 does not affect the attitude towards it. Hence, it can be said that the firm managers in Turkey do not have adequate information about the process of Industry 4.0. This result reveals the necessity for informing companies about Industry 4.0. The PSE factor, which is not included in the general TAM but is thought to affect the attitude towards the use of Industry 4.0, is related to the firm seeing itself ready for Industry 4.0 technology. The study's findings reveal that, it is seen that as the perceived self-efficacy increases, the attitude towards the use of Industry 4.0 also increases. Based on this result, it can be said that there is another factor that affects attitude. Furthermore, the study's results indicate that the financing factor, which is not covered by the general TAM, also plays a role in shaping attitudes toward the adoption of Industry 4.0. The financing factor involves the fact that the government incentives and especially the issue of the cost of Industry 4.0 technology affect the decision of the business. Therefore, financing is a factor that is expected to positively affect the attitude towards the use of Industry 4.0. Therefore, a reduction in the cost of Industry 4.0 technologies in Turkey along with comprehensive government incentives is likely to foster a positive attitude toward Industry 4.0.

So why is it important to develop a positive attitude towards Industry 4.0? Because it is predicted that the attitude towards the use of Industry 4.0 affects the Intention to Use Industry 4.0 and Intention to Use affects the Industry 4.0 Usage Behaviour. The Intention to use Industry 4.0 technology indicates that the firm intends to follow the relevant technology closely and when the necessary conditions are met, the firm intends to use Industry 4.0. As a result of this study, it has been found that the attitude towards Industry 4.0 positively affected the Intention to Use Industry 4.0. At the same time, it has been concluded that the Intention to Use Industry 4.0, as predicted, affected the Industry 4.0 Usage Behaviour. In addition to the Intention to Use factor that directly affects the Usage Behaviour, it is important to handle together the attitude towards use, which affects Intention to Use, and the factors affecting the Attitude, because the aim is to reveal the Industry 4.0 Usage Behaviour.

In addition to the findings of this study, it would be valuable to conduct a study on how firms perceive the concept of Industry 4.0 and how it may contribute to medium and large-scale firms located in İzmir and Manisa Organized Industrial Zone in the future. In order to raise awareness related to the concept of Industry 4.0 and its applications, events such as panels, conferences and symposiums, can be organized at certain times in relevant regions. It is also necessary to enhance University - Industry cooperation especially in the regions where the companies are located. By encouraging academic faculty members' participation in these activities, scientific consultation for the adoption of Industry 4.0 by companies will be facilitated. It will also be beneficial to organize visits to companies that use Industry 4.0 and its components effectively to accelerate the knowledge transfer. As mentioned before, in-house training on Industry 4.0, especially corporate development training, is important in terms of increasing the self-efficacy of companies. In short, awareness development, training, strengthening the corporate infrastructure of companies, providing financial incentives, and having qualified workforce for Data-Oriented Service are very important for increasing Industry 4.0 readiness of companies in İzmir and Manisa Organized Industrial Zones.

The results of this study highlight the importance of attitudes towards Industry 4.0 for the competitiveness and sustainability of businesses operating in the İzmir and Manisa Organized Industrial Zones. Future research should delve deeper into exploring additional factors that influence attitudes towards Industry 4.0 among businesses. Additionally, there is potential for investigating how the concept of Industry 4.0 is perceived by businesses and how it can contribute to medium and large-scale enterprises in the İzmir and Manisa regions. Fostering positive attitudes towards Industry 4.0 among businesses will not only enhance their competitiveness but also enable them to better adapt to future industrial transformations. This significance extends beyond individual enterprises, contributing to regional and national economic growth.

This study investigated the attitudes and behaviors of businesses operating in the İzmir and Manisa Organized Industrial Zones towards Industry 4.0. The findings showed that businesses have a generally positive attitude towards Industry 4.0, but some businesses need more information about the challenges and opportunities of Industry 4.0. These businesses can develop more positive attitudes by better understanding the benefits and risks of Industry 4.0. To enhance preparedness for Industry 4.0 among businesses, it is recommended to implement measures such as raising awareness, providing training, strengthening corporate infrastructure, offering financial incentives, and cultivating a skilled workforce for Data-Oriented Service. Additionally, initiatives to foster university-industry collaboration, organize company visits, and conduct training sessions can accelerate knowledge transfer. These recommendations will help businesses operating in the İzmir and Manisa Organized Industrial Zones prepare for Industry 4.0 and benefit from this transformation.

References

Agostini, L. and Nosella, A. (2019). The adoption of industry 4.0 technologies in smes: Results of an international study. *Management Decision*, 58(4):625–643.

Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2):179–211.

Ajzen, I. and Fishbein, M. (1977). Attitude-behavior relations: A theoretical analysis and review of empirical research. *Psychological bulletin*, 84(5):888.

Akın, Ö. (2017). Hizla artan endüstriyel robotlarin Üretim süreçlerinde yarattiği değişimler ve türkiye İşgücü piyasasinda yaratacaği olasi etkilerin değerlendirilmesi. *İş ve Hayat*, 3(6):42–71.

Atalay Davutoğlu, N. (2017). İşletme yönetiminde sanayi 4.0 kavrami ile farkindalik oluşturarak etkin bir Şekilde değişimi sağlamak. *the Journal of Academic Social Sciences*, 52(52):544–567.

Backlund, F., Chronéer, D., and Sundqvist, E. (2014). Project management maturity models – a critical review. *Procedia - Social and Behavioral Sciences*, 119:837–846.

Bagozzi, R. P. and Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the academy of marketing science*, 16(1):74–94.

Barreto, L., Amaral, A., and Pereira, T. (2017). Industry 4.0 implications in logistics: an overview. *Procedia Manufacturing*, 13:1245–1252.

Benešová, A. and Tupa, J. (2017). Requirements for education and qualification of people in industry 4.0. *Procedia Manufacturing*, 11:2195–2202.

Bentler, P. M. and Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological bulletin*, 88(3):588.

Bilim, S. and Bakanlığı, T. (2018). Türkiye'nin sanayi devrimi: Dijital türkiye yol haritası. *Erişim adresi: https://www. sanayi. gov. tr/tsddtyh. pdf.*

Bollen, K. A. (1989). *Structural equations with latent variables*, volume 210. John Wiley & Sons.

Bulut, E. and Akçacı, T. (2017). Endüstri 4.0 ve inovasyon göstergeleri kapsaminda türkiye analizi. *ASSAM Uluslararası Hakemli Dergi*, 4(7):55–77.

Byrne, B. M. (2010). Testing for the factorial validity of a theoretical construct. *Structural equation modeling with AMOS: Basic concepts, applications, and programming*, pages 74–82.

Carvalho, N., Chaim, O., Cazarini, E., and Gerolamo, M. (2018). Manufacturing in the fourth industrial revolution: A positive prospect in sustainable manufacturing. *Procedia Manufacturing*, 21:671–678.

Colli, M., Madsen, O., Berger, U., Møller, C., Wæhrens, B. V., and Bockholt, M. (2018). Contextualizing the outcome of a maturity assessment for industry 4.0. *IFAC-PapersOnLine*, 51(11):1347–1352.

Crnjac, M., Veža, I., and Banduka, N. (2017). From concept to the introduction of industry 4.0. *International Journal of Idustrial Engineering and Management*, 8:21.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, pages 319–340.

De Carolis, A., Macchi, M., Negri, E., and Terzi, S. (2017). A maturity model for assessing the digital readiness of manufacturing companies. *Advances in Production Management Systems. The Path to Intelligent, Collaborative and Sustainable Manufacturing*, pages 13–20.

Duffy, J. (2001). Maturity models. *Strategy Leadership*, 29(6):19–26.

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

Eğilmez, Ö. and Gözde, K. (2018). Gelişmekte olan ekonomilerde sürdürülebilir tedarik zinciri için endüstri 4.0 girişimlerine yönelik güçlüklerin değerlendirilmesi. *Süleyman*

Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 23(Endüstri 4.0 ve Örgütsel Değişim Özel Sayısı):1521–1536.

Felch, V., Asdecker, B., and Sucky, E. (2019). Maturity models in the age of industry 4.0–do the available models correspond to the needs of business practice?

Fornell, C. and Larcker, D. F. (2018). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1):39–50.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., and Tatham, R. L. (1998). *Multivariate data analysis*, volume 5. Prentice hall Upper Saddle River, NJ.

Hayduk, L. A. (1987). *Structural equation modeling with LISREL: Essentials and advances*. Jhu Press.

Iyer, A. (2018). Moving from industry 2.0 to industry 4.0: A case study from india on leapfrogging in smart manufacturing. *Procedia Manufacturing*, 21:663–670.

Kagermann, H., Wahlster, W., and Helbig, J. (2013). Recommendations for implementing the strategic initiative industrie 4.0: Final report of the industrie 4.0 working group. *Forschungsunion: Berlin, Germany.*

Kaplan, D. (2000). Evaluating and modifying structural equation models. *Structural equation modeling, foundations and extensions. Thousand Oaks: Sage Publications*, pages 106–29.

Kiraz, A., Canpolat, O., Erkan, E. F., and Uygun, Ö. (2019). Impuls kriterleri ile endüstri 4.0 eğiliminin değerlendirilmesi: Bir bulanık bilişsel harita uygulaması. *Academic Platform Journal of Engineering and Science*, 7(1):1–1.

Lichtblau, K., Stich, V., Bertenrath, R., Blum, M., Bleider, M., Millack, A., Schmitt, K., Schmitz, E., and Schröter, M. (2015). Industrie 4.0 readiness. impuls-stiftung for mechanical engineering, plant engineering, and information technology.

Lin, C.-Y., Wu, C.-Y., Wu, C.-Y., Tseng, T.-Y., and Hu, C. (2007). Modified resistive switching behavior of zr o 2 memory films based on the interface layer formed by using ti top electrode. *Journal of Applied Physics*, 102(9):1–5.

Masood, T. and Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for smes. *Computers in Industry*, 121:103261.

Mettler, T. (2011). Maturity assessment models: a design science research approach. *International Journal of Society Systems Science*, 3(1/2):81.

Mrugalska, B. and Wyrwicka, M. K. (2017). Towards lean production in industry 4.0. *Procedia Engineering*, 182:466–473.

Nazlıcan, B. D. and Meçik, O. (2018). Türkiye'de endüstri 4.0'in İşgücü piyasasina etkileri: Firma beklentileri. *Süleyman Demirel Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 23(Endüstri 4.0 ve Örgütsel Değişim Özel Sayısı):1581–1606.

Nikkhou, S., Taghizadeh, K., and Hajiyakhchali, S. (2016). Designing a portfolio management maturity model (elena). *Procedia - Social and Behavioral Sciences*, 226:318–325.

Nuroğlu, E. and Nuroğlu, H. H. (2018). Türkiye ve almanya'nin sanayide dijital dönüşümü: Yol haritalari ve Şirketlerin karşilaştirmasi. *Süleyman Demirel Üniver-*

sitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, 23(Endüstri 4.0 ve Örgütsel Değişim Özel Sayısı):1537–1560.

Odası, A. T. (2018). Antalya firmalarına yönelik endüstri 4.0 durum tespiti ölçeğin geliştirilmesi ve pilot uygulama projesi.

Paravizo, E., Chaim, O. C., Braatz, D., Muschard, B., and Rozenfeld, H. (2018). Exploring gamification to support manufacturing education on industry 4.0 as an enabler for innovation and sustainability. *Procedia Manufacturing*, 21:438–445.

Pereira, T., Barreto, L., and Amaral, A. (2017). Network and information security challenges within industry 4.0 paradigm. *Procedia Manufacturing*, 13:1253–1260.

Prause, M. (2019). Challenges of industry 4.0 technology adoption for smes: the case of japan. *Sustainability*, 11(20):1–13.

Proença, D. and Borbinha, J. (2016). Maturity models for information systems - a state of the art. *Procedia Computer Science*, 100:1042–1049.

Raj, A., Dwivedi, G., Sharma, A., de Sousa Jabbour, A. B. L., and Rajak, S. (2020). Barriers to the adoption of industry 4.0 technologies in the manufacturing sector: An inter-country comparative perspective. *International Journal of Production Economics*, 224:107546.

Raykov, T. and Marcoulides, G. A. (2012). *A first course in structural equation modeling*. Routledge.

Ronaghi, M. H. and Forouharfar, A. (2020). A contextualized study of the usage of the internet of things (iots) in smart farming in a typical middle eastern country within the context of unified theory of acceptance and use of technology model (utaut). *Technology in Society*, 63:101415.

Schermelleh-Engel, K., Moosbrugger, H., Müller, H., et al. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of psychological research online*, 8(2):23–74.

Schumacher, A., Erol, S., and Sihn, W. (2016). A maturity model for assessing industry 4.0 readiness and maturity of manufacturing enterprises. *Procedia CIRP*, 52:161–166.

Sharma, S. and Sharma, S. (1996). Applied multivariate techniques.

Tarhan, A., Turetken, O., and Reijers, H. A. (2016). Business process maturity models: A systematic literature review. *Information and Software Technology*, 75:122–134.

Tjahjono, B., Esplugues, C., Ares, E., and Pelaez, G. (2017). What does industry 4.0 mean to supply chain? *Procedia Manufacturing*, 13:1175–1182.

TÜSİAD, SAMSUNG Electronics Türkiye Deloitte Türkiye, GfK (2016). Türkiye'deki dijital değişime ceo bakışı.

TÜSİAD, R. (2016). Türkiye'nin küresel rekabetçiliği için bir gereklilik olarak sanayi 4.0. *Retrieved September*, 18:2018.

Vaidya, S., Ambad, P., and Bhosle, S. (2018). Industry 4.0 – a glimpse. *Procedia Manufacturing*, 20:233–238.

Winberg, E. and Ahrén, J. (2018). Industry 4.0 from a technology adoption perspective: A case study at sandvik coromant.

Yilmaz, V. and Çelik, H. E. (2009). *LISREL ile yapısal eşitlik modellemesi-I: temel kavramlar, uygulamalar, proglamlama*. Pegem Akademi.

Yıldız, A. (2018). Endüstri 4.0 ve akıllı fabrikalar. *Sakarya Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 22(2):546–556.

Zhong, R. Y., Xu, X., Klotz, E., and Newman, S. T. (2017). Intelligent manufacturing in the context of industry 4.0: A review. *Engineering*, 3(5):616–630.

Zhou, K., Liu, T., and Zhou, L. (2015). Industry 4.0: Towards future industrial opportunities and challenges. In *2015 12th International conference on fuzzy systems and knowledge discovery (FSKD)*, pages 2147–2152. IEEE.

Ünlü, F. and Atik, H. (2019). Türkiye'deki İşletmelerin endüstri 4.0'a geçiş performansı: Avrupa birliği Ülkeleri ile karşılaştırmalı ampirik analiz. *Ankara Avrupa Calismalari Dergisi*, 17(2):431–463.