IJTE, Vol.9, No. 1, Summer 2021, pp. 415-438

Research Paper

A Maturity Model for Digital Transformation in Transportation Activities

Elham Asadamraji[1], Ali Rajabzadeh GHatari[2], Maryam Shoar[3]

Received: 2021.01.02 *Accepted: 2021.05.03*

Abstract

Today, one of the important frameworks in understanding and recognizing digital transformation in all activities is the digital transformation maturity model. Understanding the dimensions and stages of maturity is important for transportation decision makers because in this way they can make appropriate management decisions by understanding the position of their organization in the maturity of digital transformation. The main purpose of this study is to present the maturity model of digital transformation capability, determine its stages, and investigate the use of Intelligent Transportation Systems and the maturity of transportation-related activities. In this paper, meta-synthesis is used to study the different models and stages of digital transformation maturity in various scientific databases on the Internet and provide a comprehensive summary of the dimensions and stages of maturity. After evaluation, 30 transportation companies in Tehran and their main activities were selected. By analysing the dimensions and stages of maturity in previous papers, the maturity model presented in this paper includes five stages and 10 dimensions in transportation area. These dimensions include digital management, information technology, manpower, operations and processes, culture, organizational structure, innovation and change, new strategies, intelligent products and services and customer orientation .Therefore, the maturity of 14 transportation activities was measured. The results showed that most transportation activities are at level three of the maturity model. Also, dimensions that scored the most are, respectively, digital process and operations of transportation, digital innovation in transportation, structure and governance, and digital management in transportation.

Keywords: Digital Transformation, Transportation, Meta-Synthesis, Maturity Model, Intelligent Transportation Systems

* Corresponding author E-mail: e.asadamraji@gmail.com
[1] IT Management, Management, Azad University of Tehran Shomal, Tehran, Iran.
[2] Associate Professor, Industrial Management Department, Faculty of Management, Tarbiat Modares University, Tehran, Iran.
[3] Assistant Professor, Industrial Management Department, Faculty of Management, Azad University of Tehran Shomal, Tehran, Iran.

1. introduction

In recent years, the number of papers and scientific research in the field of digital transformation and intelligent transportation systems (ITS) has increased. Various organizations and businesses have also made progress in the field of digital transformation. Modern technologies such as big data, cloud computing, Internet of things (IOT) social networks, smart sensors, and 3D printing are employed [Kempegowda and Chaczko, 2016] . Digital transformation is the profound transformation of business activities, processes, technologies, and models for full penetration and exploitation of opportunities and change through a combination of digital technologies [Berghaus and Back, 2016]. Digital transformation is driving the emergence of a new breed of organisations able to scale quickly, innovate throughout their processes, and lead industries and markets[Elia and Margherita, 2021].Also in today's world, ITS are one of the solutions to overcome transportation problems and developing and developed countries such as the United States, the European Union, and Japan have invested heavily in technology research and development as a basis for implementing ITS within cities and between cities. The age we are in now is the age of industry 4.0, i.e. the age that changes the business model and value proposition offered to customers by organizations. Utilizing technological requirements in this industry requires senior management support for projects and investments. It also requires a broad view of strategy, organization, operations, and products [Akdil, Ustundag, and Cevikcan, 2018]. Some of the characteristics of industry 4.0 are: 1) Digitization and integration of vertical and horizontal value chain, 2) Digitization of products and services, 3) Digital business models and digital customer access [Gollhardt et al, 2020].

When we talk about digital transformation, we mean industry 4.0 because the issues related to technology change, processes, products, business models, and others are similar in both fields [Ustundag and Cevilkan, 2018]. The digital transformation maturity model is a technical technique suitable for companies to transform their business and operations into industry 4.0.For companies looking to evaluate processes, products, and organizations and understand their maturity, this technique is a very important approach for industry 4.0 [Akdil, Ustundag, and Cevikcan, 2018].The maturity models presented in the field of industry 4.0 can be somehow the maturity models used in the field of digital transformationbecause one of the most important keywords in industry 4.0 is digital transformation [Ustundag and Cevilkan, 2018, 55]. Therefore, understanding the comprehensive maturity model in the field of digital transformation can have both richness and theoretical value for researchers in this field and practical value for organizations looking to implement and apply digital transformation technologies in their organization. Understanding the maturity of the transportation industry companies can also help managers of these organizations choose the current and future strategies in the field of ITS within cities and between cities. Companies that seek to evaluate processes, products, and organizations and understand their maturity, this technique is a very important method for industry 4.0 [Akdil, Ustundag, and Cevikcan,

2018]. In recent years, the number of researches in the field of digital transformation has greatly increased;unfortunately, little research has been done in this field inside the country. So, it is relatively novel in this respect. Some industries, such as the banking industry, have sought to provide digital transformation roadmap[4]. As the first step in implementing digital transformation is to assess the maturity of digital transformation, The main purpose of this study is to present the maturity model of digital transformation capability, determine its stages, and investigate the use of ITS and the maturity of transportation-related activities. Since the researcher has used several papers in this research and analyses them qualitatively, it is scientifically sound and has remarkable results. This interdisciplinary research in the field of information technology and transportation is very important, because today, information technology is used in all areas, including transportation. Intelligent transportation systems are effective in collecting transportation data [Asdamarji et al 2019] and [Amiri et al,2020]. For example, data related to drivers [Nadimi et al 2020] can be collected using a driving simulator [Asdamarji et al 2019] In fact, since the use of intelligent systems in the field of transportation in different countries, we have witnessed the growth and development of digital transformation in different countries in the field of transportation.The digital transformation maturity in the field of transportation means the use of digital technologies and ITS in companies and activities in the field of transportation, which changes the performance of business and the use of up-to-date technologies such as Internet of Things, cloud computing. , Mobile applications, social media, virtual and augmented reality, data analytics, artificial intelligence and block chain in the field of transportation. Some use of digital transformation in transportation in resent year papers are pattern detection using topic modelling for speed cameras based on big data abstraction that showing traffic management systems with digital transformation tools [Gholampour, Mirzahossein, and Chiu, 2020]. Analyzing automatic number-plate recognition data and image processing of real-time traffic maps for investigation [Mirzahossein et al, 2021]. Digital Supply chain is one the area that important in this field, so study Literature Review on Maturity Models for Digital Supply Chains is good for understanding this area [Hellweg et al, 2021].

But the fundamental question is at what level of digital transformation maturity is the transportation activity in Iran? To answer this question, it is first necessary to present an up-to-date digital transformation model based on papers in the field of digital transformation maturity model. Then, based on its dimensions and components and examining them through a case study in transportation companies, we can identify at what level of maturity the activities of these companies are and to what level of maturity they can progress in this field.

2. Research background

The present paper consists of three parts with respect to research background: empirical background, theoretical background of research in the field of digital transformation and information technology (IT), and the background of ITS, each of which is briefly explained below.

[4] http://www.ibena.ir/news

2.1. Empirical background of the research

In the empirical background, a number of papers in the field of IT are reviewed, which used the meta-synthesis and survey method to develop the model or framework. In a study entitled "framework for measuring the value of IT business", the meta-synthesis method was used to develop a scientific framework in the research [Faizi, et al. 2017).In the research entitled "systematic mapping of e-commerce research", researchers used the meta-synthesis method to provide a framework for e-commerce researches [Asdamarji, Nemati, and Mohammadian 2016]. In the research entitled "presenting the maturity model of innovation capability based on customer knowledge and the meta-synthesis method", the meta-synthesis method was used to present maturity model in the field of customer knowledge [Pour Saeed Bonab et al., 2018]. Also, in the research entitled "providing a comprehensive framework for implementing Internet marketing using the meta-synthesis method", the researcher presented a comprehensive framework in the field of marketing using the meta-synthesis method [Manian and Ronaghi 2015]. In another study entitled "designing a good e-governance model in the field of e-learning in Iran", the model was designed through the meta-synthesis method and survey [Moghadasi et al. 2016]. The paper "presenting a roadmap for strategic alignment of knowledge management in Iranian government organizations (case study: Tehran regional electricity company)" polled experts on roadmap architecture of alignment knowledge management using a survey approach. It shows the application of roadmap in Tehran Regional Electricity Company via evaluation approach [Jamipour, Yazdani and Sadeghi, 2015].

2.2. Theoretical background of the research

Today, with the growth and development of the use of the Internet in organizations and businesses' willing to digitalize businesses, we are witnessing the emergence and increase of e-commerce and e-business worldwide.Numerous models of maturity have been proposed by researchers in recent years in the field of digital transformation.The focus of each of these models is on one area of digital evolutionand each has different stages of maturity.The MIS Quarterly defines the effective dimensions of digital transformation including strategy, technology, digital diversity, organizational position, operational change, digital competence, financial issues, and investment [Hess et al., 2016].The maturity model considers other dimensions such as culture, organization, technical issues, and insight challenges as the main dimensions of digital transformation in the organization [Reisetal, 2018] .The stages of digital transformation in the DX model are mentioned as IT, supporting business needs, separation from other activities, coordinated, strategic, integrated, and agile business [Geschke, 2017].The focus of the maturity model is on processes, and the levels of maturity of digital transformation as processes are poorly controlled or uncontrolled, processes temporarily planned and implemented, planning process and implementation of management methods, integration, interoperability, and exchange of information, digital process based on a stable technology infrastructure, and an organization with growth potential [Carolis, 2017].Stages of digital transformation maturity in another research include business before transformation, experimentation and learning, the necessity of

strategy, adaptation or destruction, transformed or being transformed, and created or destroyed.Effective dimensions in digital transformation based on another research are defined as process and technology [Solis, 2016].The stages of maturity in the industry 4.0 maturity model consist of digital novice, vertical alliance, horizontal alliance, and digital champion [Gollhardt et al, 2020]. Dimensions of maturity include digital business models and digital access of customers, digital products and services, digitization and integration of vertical and horizontal value chains, data and analysis as key features, agile IT architecture, digital compatibility, digital security, legal issues and taxes, organizations, employees, and digital culture.According to another study, the connected organizational maturity model owns the stages of evaluation maturity, controls and a secure and up-to-date network, data definition and organization, analysis, and collaboration.Effective dimensions in this maturity model involve information infrastructure (hardware and software), controls and devices (sensors, actuators, motor controls, switches, etc.) that receive and feed the data, networks that drive all this information, and security policies (perception, organization, implementation) [Gottschalk and Solli-Sæther,2006].The maturity model of industry 4.0 has a shortage range of industry 4.0 support features to meeting the requirements of industry 4.0.Dimensions affecting maturity in this research are digital strategy, digital leadership, customers, digital products, digital operations, digital culture, people, and technology governance framework [Schumacher, Erol, and Sihn, 2016].Another maturity model is model of maturity and industry 4.0 strategy readiness that has four levels: lack of digital transformation, digital transformation, and the survival of digital and mature transformation; the dimensions affecting maturity in this research include smart products and services, smart business process, digital strategy and digital organization [Akdil, Ustundag, and Cevikcan, 2018].

In some of the models reviewed in the literature review, only the dimensions were presented, and in others, only the stages of maturity were mentioned.Based on the explanations provided in the review of research theory and literature, various researches have been presented so far in the field of digital transformation maturity model,but the focus of each of these maturity models is on one area.Some focus on process, some on innovation, some on industry 4.0, some on strategy, some on hardware, and some on infrastructure issues; however, no comprehensive research has been done in this area so far,which clearly states what the most important dimensions of maturity are in the field of digital transformation.So far, no comprehensive review research has been conducted to evaluate all maturity models of digital transformation and present a comprehensive maturity model based on it.Therefore, the present study is a novel research in the field of digital transformation.This type of meta-research is very important among the disciplines.

2.3. Application of IT in transportation

The increasing use of ITS reflects the growth and development of transportation companies in the field of digital transformation. Here is a review of the research literature in the field of intelligent transportation systems. At the end, the maturity of transportation activities in the field of digital transformation has been investigated according to the maturity model presented in the present study.

ITSs are innovative tools based on information and communication technology (ICT) in the transportation sector. ITSs significantly contribute to a cleaner, safer, and more efficient transportation system [EC, 2011]. Research plays an important role in removing barriers to effective ITS absorption and penetration in the market [EC, 2012; EC, 2009]. Data from various systems in the field of transportation is increasing, the acquisition and processing of which can upgrade and improve ITS [Veres Matthew and Medhat Moussa, 2020].

Traffic monitoring system is an integral part of ITS and one of the important transportation infrastructures that transport activities use a lot of capital to collect and analyze traffic data and use them. Recent advances such as machine learning and wireless communication technologies have created a number of innovative traffic monitoring systems. This paper provides an overview of the most advanced traffic monitoring systems [WON, 2020].

For example, the next paper states that the next generation of ITS will use machine learning. It also states that ITS includes a variety of services and applications such as road traffic management, passenger information systems, public transportation system management, and autonomous vehicles. ITS is expected to be an integral part of future urban planning because it will help improve road and traffic safety, transportation and transit efficiency, increase energy efficiency, and reduce environmental pollution. On the other hand, ITS poses various challenges due to scalability and diverse service quality needs as well as the huge amount of data it generates [Yuan et al., 2020].

In the next paper, machine learning (ML) is mentioned as the main element of ITS. In recent years, deep learning has emerged and become popular, triggering a storm in ITS. As a result, traditional ML models have been replaced in many applications by new learning techniques, and the ITS space is changing. This research tries to provide a clear picture of how different models of deep learning are used in several transportation applications [Wang et al., 2019].

Safety is one of the most important transportation activities in which intelligent transportation systems are used in various stages of data collection [sheikhfard, A & haghighi, F,2019], scenario making [Shikholeslami et al,2020], data analysis and systems evaluation [Asadamraji et al,2017].

ITS are an important factor in the intelligent cities' model. At present, such systems produce large amounts of bulk data that can be analyzed to better understand the dynamics of individuals [Sobral, Galvao, and Borges, 2019].

Intelligent transportation systems are used in transportation economics studies and before and after studies and simulation of transportation and infrastructure projects [Akbari,A & Haghighi, F,2020]

ITSs are one of the components of the intelligent cities of the future. Understanding the true potential of ITS requires extremely low delay and reliable solutions for real-time data analysis. Such data analysis capabilities cannot be provided by conventional cloud-based data processing methods with high communication and computational delay. Instead, there must be solutions tailored to the unique ITS environment in which data is processed at the level of an intelligent roadside or car sensor to overcome ITS delay and reliability challenges.

With a higher capability in passenger compartments and in-vehicle processors, such a distributed computing architecture uses in-depth learning techniques to reliably measure mobile phones in ITS. Preliminary results show

that the introduced analysis architecture, combined with the power of deep learning algorithms, provides a reliable, safe, and truly intelligent transportation environment [Ferdowsi, Challita, and Saad 2019].

In another paper, a number of transportation activities such as walking, running, cycling, buses, cars, trains, and subways use the pressure sensor and inertia of smart mobile data [Wang et al., 2018].

This paper examines the application of ICT in transportation. Various applications are examined under the headings of: network operation and management (all modes), information and guides for users (transportation systems), and exploitation and management of freight systems. For each of these, a brief and critical review is provided about various technologies that are in their final stages today. Applications consist of systems for collecting and disseminating traffic information, network control and traffic management, strategies, vehicle control and driver assistance, and charge collection systems (electronic or others); specifically for transportation, they consist of transportation resource management, communication systems and terminals and ports, cargo tracking and tracking of vehicles, and logistics systems "front or behind the office" [Giannopoulos, 2004].

Dynamic and uncertain demand forces organizations to provide flexible services in order to meet customer demands. Freight transport, as a key component of businesses, requires the adoption of efficient ICT that can induce transparent and flexible services. The findings of this study showed the aspects of development, customer services and technology, as well as data transparency, reliability, and organizational culture as the most important factors and sub-factors, respectively. The proposed model guides freight managers to formulate their strategies about acceptance [Shardeo, Patil, and Madaan, 2020].

For example, according to a research in the field of transportation, an accident may occur due to three factors: human, road and environment and vehicle, each of which alone or in common with other factors contribute to its occurrence. The use of information technology in cars and on the road can play an important role in reducing accidents. Therefore, digital technology in transportation can be a vital factor in the maturity model of digital transformation [Asadamraji et al, 2017] and [Asadamraji, M & Yarahmadi, A].

3. Research methodology

Research method is one of the most important and basic stages in any research and is mainly derived from the worldview or the researcher paradigm [Hashemi, Alvadari, and Daraei 2016]. The method used in the present study is fundemental-applied in terms of purpose and mixed (qualitative-quantitative) in terms of data collection method. The present study consists of three main stages, and in each stage, a research method is used (Figure 1).

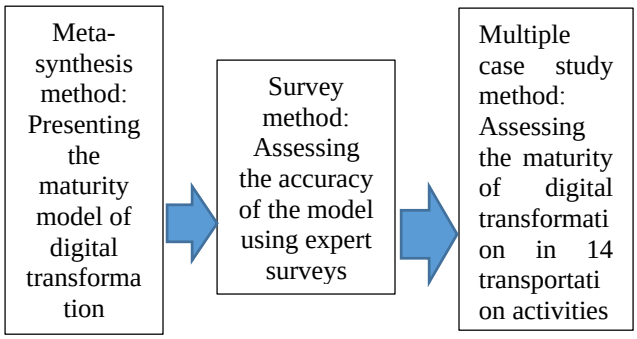

Figure 1. Research steps and methods usedineach step

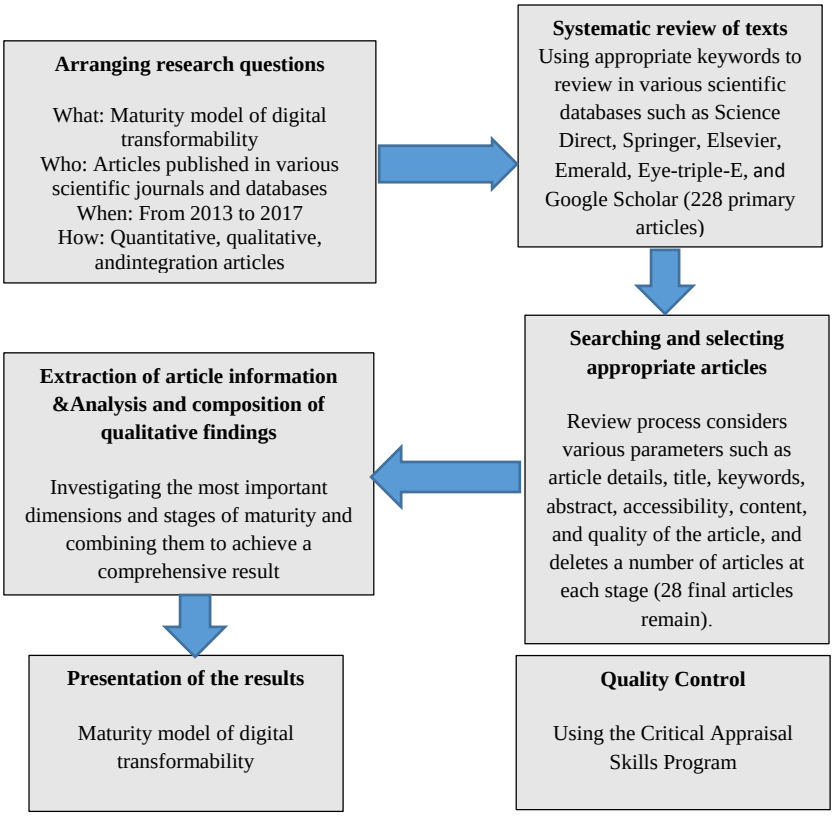

Figure 2. Details of conducting research base on the meta-synthesis method

The main method used in the present study is meta-synthesis research method [Asdamarji, Nemati, and Mohammadian, 2016]; the details of its steps are shown in Figure 2.

The number of initially found papers was 228, which increased to 145 papers after reviewing the titles; after reviewing the keywords, the number of papers decreased to 123, and after reading the abstract, the number of papers was reduced to 98. After reviewing the full text of the papers, 63 papers remained, and finally, after using the business tool looker, 28 papers were used to evaluate and present the maturity model.

Critical Appraisal Skills Programme (CASP) tool was used to assess the quality of qualitative studies extracted from the meta-synthesis process. The results of the review of the 28 final papers obtained by applying the research method are provided in Appendix A.

3.1. Evaluation of the validity and reliability

The inter-coder agreement method was used to evaluate the reliability of the codes extracted from the papers. Thus, in addition to the coder who has done the initial coding another coder encoded the same text that the researcher himself encoded separately without knowing his codes. If the researcher's codes are close to each other, it indicates a high consistency between them, indicating reliability. Kappa was used to calculate the inter-coder agreement. The calculation procedure is as follows (Table 1):

Table 1. Values of inter-coder agreement between the two coders 1 and 2

	Coder 2			
Total Coder 1	**yes**	**no**		
5	1	4	no	Coder 1
10	9	1	yes	
15	10	5		Total Coder 2

$$\text{Observed agreement} = \frac{4+9}{15} = 0.86$$

$$\text{Chance agreement} = \left(\frac{4+1}{15} \times \frac{4+1}{15}\right) + \left(\frac{1+9}{15} \times \frac{1+9}{15}\right) = 0.54$$

$$\text{Agreement percentage} = \frac{0/86 - 0/54}{1 - 0/54} = 0.69$$

The significant value obtained from the index is less than 0.05, so the assumption of independence of extractive codes is rejected and the interdependence of extracted codes is confirmed. Therefore, it can be claimed that the codes were sufficiently reliable.

3.2. Survey research method

Survey research method was used to study the distribution of characteristics of a statistical population. This research can be used to answer research questions of types A and B.

A) What is the nature of the existing conditions? B) What is the current situation? Survey is one of the main and old research methods in various branches of knowledge, especially in the social sciences, where regular and standard methods are used to gather information about individuals, families, or larger activities. Data collection is done by asking people who are regularly selected and categorized into sample groups. By collecting quantitative data, it studies the characteristics or opinions of a particular group (population) [Sarmad, Bazargan, and Hejazi, 2008].The orientation of the study is developmental,because the study purpose is to improve the dimensions and components of the digital transformation maturity model.In the second part of the paper, the survey research method is used to evaluate the accuracy of the dimensions and components of the digital transformation maturity model.In this section, the acceptability of the proposed model has been tested through a survey of experts.Expert opinion survey was used to examine the consensus of experts on a particular topic.Hence, several meetings were held with the presence of elites and university experts, including professors and Ph.D. students in IT at Azad and state universities familiar with the subject of the research.This session was conducted by introducing the extracted dimensions and components. Finally, some of the dimensions, components, and stages of maturity in the present research model were altered based on their opinions.

3.3. Binomial distribution test

The present study can be considered descriptive because describes in detail the dimensions of the digital transformation maturity model so that other researchers who want to do research in this field may gain a comprehensive view on this issue. The binomial distribution test was used to confirm or reject the experts' opinion on the proposed components. The experts who participated in the research are professors and Ph.D. students in the field of IT who are aware of the subject. The statistical samples were more than 30, Because we had access to 30 knowledgeable professors in this field and the variance of the population was unknown.The questionnaire was based on the Likert scale and

was administered to test each of the proposed components of the binomial distribution test.

3.4. Multiple-case study

In a case study, the researcher selects a case and examines it from countless aspects. This case be a unit or system with definite boundaries and consisting of numerous and related elements and factors [Sarmad, Bazargan, and Hejazi, 2008]; in the multiple-case study, more cases are selected and examined.

To assess the level of maturity of a number of Iranian companies based on the presented model, a case study of transportation systems, traffic engineering and studies, traffic organization, law enforcement, dual degree program in 14 transportation activities (ITS, public transportation, transportation management and comprehensive plans, safety, freight transportation, transportation economy, passenger transportation, traffic education and culture building, clean transportation, geometric plan of passages and roads, inter-organ interactions) was used. The reason for choosing these 14 activities is the availability and involvement in the field of digital and the use of different and diverse digital technologies.Also, considering the importance of IT in transportation activities and increasing the use of IT in the organizations and the development of ITS around the world, the researcher conducted this case study on transportation activities. Therefore, a questionnaire was designed and distributed about 14 transportation activities.

A questionnaire was designed for this purpose including 40 questions; five experts were used to evaluate the questionnaire; based on their opinion, some parts of the questionnaire were changed accordingly. Before sending it to five experts to evaluate its face validity through a questionnaire, it was evaluated through interview with four supervisors, consultants, and one Ph.D. student. The questions were given to the IT managers of the organizations or informed managers on the organization's digital field. They answered each question based on the Likert scale (very low (1), low (2), medium (3), high (4), very high (5)).

4. Analysis of results

The most important dimensions of maturity (the first 10 dimensions that are mostly used in papers in the field of digital transformation) used in papers on digital transformation that have the most frequency in literature in this field are listed in Table 2 along with the titles used.

Table 2. 10 important maturity dimensions with the most frequent papers on digital transformation

Dimensions	Titles and resources
Digital leadership and management in transportation	Digital management [Ashurst and Hodges, 2010], digital business management [Carcary, Doherty, and Thornley 2015], digital leadership [Gollhardt et al, 2020], digital programs' management [Gökalp, Şener, and Eren 2017], digital planning, monitoring and digital control, digital change management, digital work planning, digital portfolio management, ad-hoc leadership [Valenti, 2017], digital skills management [Becker et al., 2017], digital content management [Ifenthaler and Egloffstein,2020], digital insight[Reis et al, 2018] digital leadership [Boström and Celik, 2017], digital leadership [Ravarini, Locoro, and Martinez, 2019], digital insight, digital leadership [Aguiar et al, 2019], transformation in digital leadership [Komninos et al, 2020].

Dimensions	Titles and resources
Digital technologies in transportation	IT architecture [Lanza et al., 2016], digital technologies[Gollhardt et al, 2020] digital IT scale, digital IT management [Valenti, 2017], digital technology [Leyh et al., 2017], digital technology [Carolis, 2017], digital complementary IT system [Klötzer and Pflaum, 2017], digital technology architecture [Becker et al., 2017], digital IT [Berghaus and Back, 2016], digital technology [AG, Sharma and Marschner, 2018], digital technology [Ravarini, Locoro, and Martinez, 2019], digital technology [Reisetal, 2018] , digital technology [Boström and Celik, 2017], digital technology [Hamidi et al, 2018], digital IT excellence [Kozina and Kirinić, 2018], digital technology [Mulpuru and Gill, 2015], digital technology team [Solis, 2016]
Digital talents in transportation	Digital competence of individuals [Ashurst and Hodges, 2010], employees [Schumacher, Erol, and Sihn 2016], people [Gollhardt et al, 2020]digital skills, learning [Becker et al., 2017], absorption capacity, measurement of digital learning [Becker et al., 2017], employees [AG, Sharma, and Marschner, 2018], people and digital culture, digital talent and skill [Aguiar et al, 2019], people [Carolis, 2017], digital skills [Boström and Celik, 2017], efficient employee in digital [Kozina and Kirinić, 2018], human resources [Solis, 2016]
Digital processes and operations in transportation	Intelligent digital operations [Schumacher, Erol, and Sihn 2016], digital operations [Gollhardt et al, 2020], digital processes [Lanza et al., 2016], input and output logistics [Zhu, 2017], digital operations, automation, and digital delivery methods [Valenti, 2017], digital process [Carolis 2017], digital organizational process [Klötzer and Pflaum, 2017], process digitalization [Berghaus and Back, 2016], digital processes [Ravarini, Locoro, and Martinez, 2019], digital operations excellence [Kozina and Kirinić, 2018], transformation in digital operation model [Komninos et al, 2020].
Digital culture and transportation	Digital culture [Lanza et al., 2016], digital culture [Gollhardt et al, 2020], digital culture [Zhu, 2017], digital innovation culture [Klötzer and Pflaum, 2017], digital organization culture [Becker et al., 2017], digital culture and expertise [Berghaus and Back, 2016], digital organizational culture [AG, Sharma, and Marschner, 2018], digital culture [Ravarini, Locoro, and Martinez, 2019], digital innovation culture [Aguiar et al, 2019], digital culture[Reis et al, 2018], digital culture [Hamidi et al, 2018], digital culture [Mulpuru and Gill, 2015]
Digital structure and governance in transportation	Digital organizational structure [Schumacher, Erol, and Sihn 2016], digital governance [Gollhardt et al, 2020], digital organizational structure [Zhu, 2017], digital organizational structure [Carolis, 2017], digital organizational structure [Klötzer and Pflaum, 2017], digital organization [Berghaus and Back, 2016], digital organizational structure [Klötzer and Pflaum, 2017], digital structure [Aguiar et al, 2019], digital governance [Aguiar et al, 2019], digital organizational structure [Reis et al, 2018] , digital organization [Mulpuru and Gill, 2015]
Digital innovation in transportation	Digital changes [Ashurst and Hodges, 2010], digital change [Gökalp, Şener, and Eren, 2017], digital change management [Berghaus and Back, 2016], digital innovation [Ravarini, Locoro, and Martinez, 2019], digital innovation, digital innovation capability [Kozina and Kirinić, 2018], digital conversion capability [Kozina and Kirinić, 2018], change and transformation in digital information [Komninos et al, 2020], digital change management [Becker et al., 2017]

Dimensions	Titles and resources
Novel strategy in transportation	Digital strategy [Schumacher, Erol, and Sihn, 2016], digital strategy[Gollhardt et al, 2020], digital policy and strategy, digital IT strategy [Valenti, 2017], digital strategy development [Kl, 2017], digital strategy [Berghaus and Back, 2016], digital strategy [Ifenthaler and Egloffstein,2020], digital strategy [Anderson and Ellerby, 2018], digital strategy [Aguiar et al, 2019]
Intelligent transportation services and products	Intelligent digital products [Schumacher, Erol, and Sihn, 2016], digital products and services [Lanza et al., 2016], digital products [Gollhardt et al, 2020], digital services [Zhu, 2017], digital product development [Leyh et al., 2017], intelligent product realization [Carolis, 2017], intelligent factory [Klötzer and Pflaum, 2017], product innovation [Berghaus and Back, 2016]
Customer digital experience in transportation	Digital delivery to customer [Klötzer and Pflaum, 2017], digital customer experience [Becker et al., 2017], digital personalization of customer talk [Ifenthaler and Egloffstein,2020], digital omni-channel experience [Ifenthaler and Egloffstein,2020]customers [AG, Sharma, and Marschner, 2018], customer [Anderson and Ellerby, 2018], design of customer digital experience [Aguiar et al, 2019], customer relationship management [Solis, 2016], transformation in versatile digital channel experiences [Komninos et al, 2020].

Therefore, the maturity model presented includes 10 dimensions of maturity that had the most frequency in the papers in this field and five stages that were among the most important steps mentioned in most papers. The proposed maturity model (Digital Maturity Model Development, (DMMD)) is presented in Table 3; to better understand each of the dimensions of digital transformation maturity, some explainations are provided.

Digital leadership and management in transportation: The leaders of a transportation organization must have the necessary ability to understand and realize the opportunities of economic growth and value creation through the use of digital technologies in the field of transportation.

Digital technologies in transportation: The use and acceptance of transportation organizations of emerging technology, including modern technologies, the use of mobile devices, the use of machine to machinecommunications and other modern technologies to improve and upgrade organizations in the field of transportation.

Digital talents in transportation: Features of this dimension include employee ICT competence, employees' use of new technologies, and employee independence in transportation.

Digital processes and operations in transportation: This dimension has the features of process decentralization, interdisciplinary modeling and simulation, cooperation between different departments in transportation organizations.

Digital culture and transportation: The company's approach to digital innovation and how they work with digital technologies and activities are common assumptions in the organization that determine how employees understand, think, and react to the environment.

Structure and digital governance in transportation: The degree of coordination of transportation companies in supporting digital strategy, governance, and implementation.

Digital innovation in transportation: The exploitation of data to make decisions through digital technologies. It stimulates digital options for the future by investing in digital opportunities.

Novel strategy in transportation: It includes implementing the digital transformation roadmap, resources available to achieve the adaptation of business models.

Intelligent transportation services and products: Personalization, digitization, and integration of products into other systems in transportation.

Customer digital experience in transportation: The use of customer data, digitalization of sales/services, competition in the field of digital media of customers in transportation collections.

Table 3. Development of digital maturity model (DMMD) and dimensions of digital maturity

Complete transformation	Transformed	Transforming	Familiarity with digital transformation	Before digital transformation	Sub-dimensions (components)	Maturity levels / Dimensions of maturity model
Leadership fully supports technology development management and digital capability	Leadership supports management in technology development and digital capability	Leadership has maximum support for management in technology development and digital capability	Leadership partially supports digital development management and technology capability	There is no leadership in the development and and digital technology capability	Digital leadership Digital management	Digital leadership and management
IT strategy and performance are fully in line with the organization's goals and affect it.	Perfect alliance between IT architecture and business architecture	High level of integration between different levels of IT architecture	Limited integration between different levels of IT architecture	Lack of integration between different levels of IT architecture	Digital data architecture Technology architecture	Digital technology
There is completely ICT competency, training in the use of modern technology, and employees' independence	There is ICT competency, training in the use of modern technology, and employees' independence.	There is mainly ICT competency, training in the use of modern technology, and employees' independence.	There is ICT competency, training in the use of modern technology, and employees' independence to some extent.	There is no ICT competency, training in the use of modern technology, and employees' independence.	Digital education Digital competence	Digital talent
Automated and real-time decision making and fully integrated processes implemented to deliver digital services	Intelligent and integrated process has been created to develop productivity and reduce the cost of designing and	Usual process for integration as documented and defined, and old intelligent and interconnected processes	Taking the initiative for smartization of business and low integration between processes	The operation is performed in a non-integrated, non-intelligent manner and out of coordination with the development team	Integration between processes Intelligent process	Digital process and operations

Complete transformation	Transformed	Transforming	Familiarity with digital transformation	Before digital transformation	Sub-dimensions (components)	Maturity levels Dimensions of maturity model
	supporting digital services.					
Awareness and innovative digital work environment are fully recognized; its progress is constantly measured, reviewed, and improved.	Creating awareness and innovative digital work is recognized, but stakeholders do not understand.	Creating awareness and innovative digital work is often recognized.	Creating awareness and innovative digital work environment is somewhat recognized.	Creating awareness and innovative digital work environment are undefined.	Digital work environment Creating digital awareness	Digital culture and work environment
Organizing and monitoring are done through a combination of innovation projects and efficient use of available resources. The framework for measuring the quantitative and qualitative benefits of innovation project is created.	Organizing and montoring the innovation project are carried out. Innovative project's implementation index is defined, for example, indices related to project implementation (quality, time, and cost)	Organizing and supervising innovation projects are mainly carried out.	Organizing and supervising innovation projects are partially carried out.	Organizing and supervising innovation projects are not carried out.	Monitoring and control Organizing different sections	Digital structure and governance
Evaluation and improvement of experiences with innovative methods and solutions to produce more	Pure and intelligent methods have been used for agile development of high-speed	New relationships with customer are formed through digital channel, and innovation is	Some new products and services are created sparsely and without understanding	Lack of desire to use the new method of creativity and better use of	Creativity and idea generation Agility in implementing digital innovation	Digital innovation

Complete transformation	Transformed	Transforming	Familiarity with digital transformation	Before digital transformation	Sub-dimensions (components)	Maturity levels Dimensions of maturity model
innovative products and customers.	digital innovations.	created based on them.	the needs of customers.	agile models for implementation		
The strategy of the organization is the same as the digital strategy and the portfolio of the digital business model created in the organization.	Digital strategy integrated with the planning process affects the overall strategy of the organization.	There is a formal digital strategy in the company's outlook and business model.	In some parts of the organization, new digital business models have been used.	There is no innovation in the company's outlook and business model.	Digital outlook Digital business model	Digital strategy
Personalization, digitization, integration of products into other systems have been done completely.	Personalization, digitization, integration of products into other systems have been done.	Personalization, digitization, integration of products into other systems have been mainly done.	Personalization, digitization, integration of products into other systems have been done to some extent.	Personalization, digitization, integration of products into other systems have not been done.	Smart products and services Personalization of products	Digital services and products
Machine learning tools for new unique customer experience, desirerecognition, development of new services of pricing strategy	Data analysis is widely used to improve the customer experience and offer new services, advertising, and branding.	Data are collected and used to analyze customer participation.	New tools are provided for a better level of customer experience.	Customer participation and data analysis is very limited.	Customer participation Customer data analysis	

The results of the binomial distribution test showed that 10 proposed dimensions of the model and 20 components (sub-dimension) of the business have been approved by experts with 95% confidence. In order to rank the accepted components, it was first determined by performing χ^2 test that the proposed components for digital transformation do not have identical rankings. Then, based on Friedman analysis of variance, the ranking of

the proposed components was obtained according to the following figure.

Table 4. Ranking of proposed components of digital transformation maturity model based on expert opinion

Components of digital transformation maturity model	Rank	Rank mean
Digital leadership in transportation	8	7.25
Digital management in transportation	13	6.95
Data architecture and digital information in transportation	5	8.23
Technology architecture in transportation	6	8.25
Digital training in transportation	9	7.45
Digital competence in transportation	10	7.46
Integration between transport processes	17	6.42
Intelligent transportation processes	18	6.21
Digital work environment in transportation	20	5.95
Creating digital awareness in transportation	19	6.01
Supervision and control in transportation	16	6.53
Digital organization in transportation	15	6.66
Creativity and digital ideation in transportation	12	7.25
Agility in implementing digital innovation in transportation	3	8.34
Digital outlook in transportation	4	8.35
Digital business model in transportation	1	10.50
Intelligent products and services in transportation	2	10.22
Personalization of products in transportation	14	6.82
Customer participation in transportation	11	7.26
Analysis of customer data in transportation	7	7.53

Figure 3 shows the rank and position of each component of the model in terms of importance. The results of the multiple-case study in pharmaceutical companies indicate the maturity of each company. Based on the score obtained from each questionnaire, if users give a very low score (1) to all questions, the total score is 40, which is a sign of maturity level one. If all the questions are given a very high score (5), the total score is 200, which indicates the maturity level of five. Other levels are shown in Table 6 based on the mean of other scores.

Table 5. Score range of the questionnaire and the maturity level equal to it

Maturity level	Score range
1	0-40
2	41-80
3	81-120
4	121-160
5	161-200

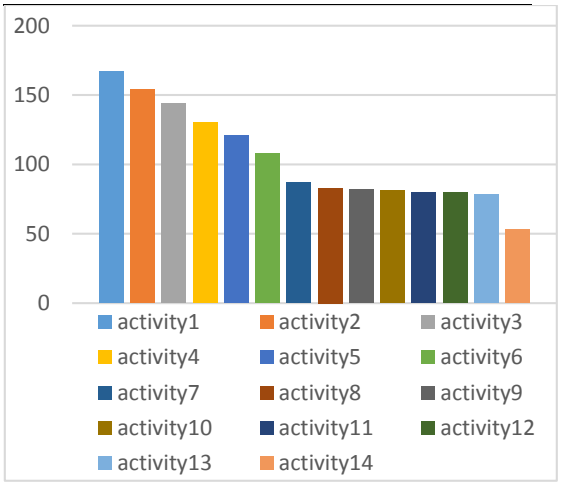

Figure 3. Maturity chart of digital transformation of 14 transportation activities in Iran (column: total score obtained from the survey, which indicates the maturity of each activity)

Activities studied in the present study are as follows:

- Intelligent transportation systems
- Public transportation
- Transportation systems management
- Traffic engineering and traffic organization studies
- Law enforcement
- Transportation planning and comprehensive plans
- Safety
- Freight transportation
- Transportation economy
- Passenger transportation
- Traffic education and culture
- Clean transportation
- Geometric plan of passages and roads
- Inter-organ interactions

In total, after the calculations, a score range was assigned to each level of maturity as shown in Table 4.

According to the results of the questionnaire, there are a total of five activities at level three (transforming), four activities at level two (familiarity with digital transformation), four activities at level four (transformed), and one activity at level five (complete maturity); none of the activities are at level one (prior to maturity). Dimensions that received the lowest score in the questionnaires are digital culture = digital services and products, digital strategy, and digital technologies, and the following dimensions gained the highest scores such as digital process and operation, digital innovation, structure and governance, digital leadership and management, digital talent = customer digital experience. Therefore, transportation organizations should make more efforts in the field of digital transformation maturity. They should pay more attention to the latest technologies in the world and invest more in these technologies .They should also pay special attention to aspects such as culture, digital services and products, digital technology, and digital strategy.

5. Conclusion

In the present study, meta-synthesis method was used to extract papers about digital transformation maturity and develop a maturity model, and effective dimensions in this field were summarized. Dimensions affecting the digital transformation maturity are categorized in terms of maximum frequency in papers. The maturity model presented includes 10 maturity dimensions, 20 sub-dimensions, and six stages of maturity. The dimensions and sub-

dimensions presented in the maturity model were confirmed by experts at 95% confidence level through reviewing the top papers in the field of digital transformation and using the binomial distribution test method including 10 proposed dimensions of the model and 20 components (sub-dimensions) of the business. Finally, the maturity model presented was used to examine the maturity of 14 Iranian transportation activities. The results of the present study are important for both organizations and researchers who want to do research in the field of digital transformation maturity. The importance of the present study for organizations is that they can perceive the stages of digital transformation maturity, recognize what stage of maturity their organization is at and what steps they have to take to develop their maturity in the field of digital transformation, achieve more in the future planning of their organization according to the understanding they find of their maturity position in the organization, and apply appropriate management requirements according to the level at which they are. Also, the most important aspects in digital transformation should be considered that conrtribute to their success in this field by focusing more on these factors and giving higher priority to them in their organization. This can be a beacon, especially for Asian countries and countries with lower levels of digital maturity so that pay more attention to the factors and features that are more important if they seek to enter the age of industry 4.0, which according to the Alp book is digital transformation management [Akdil, Ustundag, and Cevikcan, 2018], and succeed in this field. Transportation companies are suggested to pay more attention to aspects such as digital culture, services, and products, digital technology, and digital strategy to reach higher stages of maturity in the field of digital transformation. The innovation of the present study is that no research has been done in Iran so far to provide a comprehensive maturity model in the field of digital transformation and evaluate it in the transportation industry. It is also recommended to conduct further studies in Iran and in various industries, and further separate researches should be done on different dimensions of digital transformation in transportation industry, to witness the growth of digital transformation and increasing use of new technologies in this field.The present study was conducted in 30 transportation companies in Tehran and 14 activities in this field and the results can be useful for the success of all transportation companies in the field of digital transformation maturity in Iran.

6. Reference

- Aguiar, Tomas; Bogea Gomes, Silvia; Rupino da Cunha, Paulo and Mira da Silva, Miguel (2019), "Digital Transformation Capability Maturity Model Framework", IEEE,Vol.54, No.15, December 2019, PP.110-118.

- Akdil, kartal; Ustundag, Alp and Cevikcan, Erme (2018) "Maturity and Readiness Model for Industry 4.0 Strategy", Springer International Publishing. Vol.16, No.1, Winter 2018, PP. 61-94.

- Anderson, Christine and Ellerby. William (2018) "Digital Maturity Model achieving digital maturity to drive growth", Journal of Deloitte development, vol .10, NO.4, Spring 2018, PP.1-24.

- Asdamarji Elham; Nemati, Hasan Ali and Mohammadian, Ayoub (2016) "Systematic mapping of research methodology in the field of e-commerce", Information Technology Management, Vol .8, No.3, Autumn 2016, PP. 435-455.

- Asadamraji, M., Saffarzadeh, M., Sherafatipour, S., Borujerdian, A., & Mirzayi, M. Hazard perception as a function of Iranian driver's personality,RSS conference,2017.

- Asadamraji, M., & Yar Ahmadi, A. (2020). Structural equations model for assessing drivers' risk perception in 5 driving simulator using driver psychological characteristics. *Traffic Law Enforcement Research Studies*, *1399*(34),PP. 9-32.

- Ashurst, Colin; and Hodges, Julie (2010) "Exploring Business Transformation: The Challenges of Developing a Benefits Realization Capability", Journal of Change Management, Vol.10, No.2, Autumn 2010, PP.217–237.

- Becker J., Monhof M., Barann B., and Dr. Bernd Welz. (2017) "Maturity Model and Best Practice Skill Development for Digital Transformation". SAP SE or an SAP affiliate Technical University of Munich, pp. 1-21.

- Berghaus, Sabine and Back, Andrea (2016) "Stages in Digital Business Transformation: Results of an Empirical Maturity Study", Tenth Mediterranean Conference on Information Systems, PP.1-8.

- Boström Erik. and Can Celik O. (2017). "Towards a Maturity Model for Digital Strategizing", Department of informatics IT Management Master Thesis, university UMEA, PP.1-36.

- Amiri, A. M., Nadimi, N., & Yousefian, A. (2020). Comparing the efficiency of different computation intelligence techniques in predicting accident frequency. *IATSS Research, 44*(4),pp. 285-292.

- Carcary, Martin; Doherty, Eileen and Thornley, Clare (2015) "Business Innovation and Differentiation Maturing the IT Capability", IT professional journal, Vol.4, No.3, Autumn 2015, PP.46-53.

- Asadamraji, M., Saffarzadeh, M., Ross, V., Borujerdian, A., Ferdosi, T., & Sheikholeslami, S. (2019). A novel driver hazard perception sensitivity model based on drivers' characteristics: A simulator study. *Traffic injury prevention, 20*(5), pp.492-497.

- Carolis, Anna (2017) "A Maturity Model for Assessing the Digital Readiness of Manufacturing Companies", International Federation for Information Processing, Published by Springer International

Publishing, Vol.10, No.3, Spring 2017, PP.13-20.

- Asadamraji, M., Saffarzadeh, M., Borujerdian, A., & Ferdousi, T. (2018). Hazard detection prediction model for rural roads based on hazard and environment properties. Promet-Traffic&Transportation, 30(6), pp.683-692.

- Nadimi, N., NaserAlavi, S. S., & Asadamraji, M. (2020, June). Calculating dynamic thresholds for critical time to collision as a safety measure. In *Proceedings of the Institution of Civil Engineers-Transport* (pp. 1-10). Thomas Telford Ltd.

- Elia, Gianluca and Margherita, Alessandro (2021) "A conceptual framework for the cognitive enterprise: pillars, maturity, value drivers" Technology Analysis & Strategic Management , Vol. 33, No. 4, 18 Mar 2021, PP.320-335.

- Faizi, K., Taghavifard, M. T., Raisi Vanani, I., and Salehi, Mohammad (2017) "IT framework for measuring business value", Journal of Management Research, VOL.10, NO. 3, Autumn 2017, PP. 35-62.

- Ferdowsi, Aidin; Ursula, Challita and Walid, Saad (2019) "Deep Learning for Reliable Mobile Edge Analytics in Intelligent Transportation Systems: An Overview", IEEE journal, Vol. 14, NO. 1, Spring 2019, PP.201-212.

- Gholampour, Iman; Mirzahossein, Hamid and Chiu, Yi-Chang (2020) "Traffic pattern detection using topic modeling for speed cameras based on big data abstraction", The International Journal of Transportation Research Latest Papers, Vol.13, No. 3, March 2020, PP. 149-160.

- Gökalp, Ebru; Umut, Şener and Erhan, Eren (2017) "Development of an Assessment Model for Industry 4.0: Industry 4.0-MM". Software Process Improvement and Capability Determination, Vol.15, No.2, Summer 2017, PP. 128–142.

- Gollhardt, Torsten; Halsbenning, Sebastian; Hermann, Andreas; Karsakova, Aleksandra and Becker, Jörg (2020) "Development of a Digital Transformation Maturity Model for IT Companies", IEEE, VOL212, NO4, July 2020, PP115-125.

- Gottschalk, Petter and Solli-Sæther, Hans (2006) "Maturity model for IT outsourcing relationships", Industrial Management & Data Systems, Vol. 106, No.2, February 2006, pp. 200-212.

- Hamidi, Saidatul Rahah; Abdul Aziz, Azara; Shuhidan, Shuhaida Mohammed; Abdul Aziz, Azhar;

- Mokhsin, Mudiana (2018) "SMEs Maturity Model Assessment of IR4.0 Digital Transformation", Advances in Intelligent Systems and Computing, Vol 739, March 2018, pp. 721–732.

- Hashemi, S. A., Al-Wadari, H. and Daraei, M. R. (2017) "Designing a model to evaluate the development of organizational dashboard with business intelligence logic in organizations", Journal of Smart Business Management Studies, Vol. 6, No.3, Autumn 2017, PP. 95-133.

- Hess, Thomas; Christian, Mat; Alexander Benlian, and Florian Wiesböck (2016) "Options for formulating a digital transformation strategy". MIS Quarterly Executive. Vol.20, No.1, Spring 2016, PP.123-139.

- Hellweg, Frauke; Lechtenberg, Bernd, and Márcio Tavares Thomé, Antonio (2021) "Literature Review on Maturity Models for Digital Supply Chains", Brazilian Journal of operations & production management, Vol.18,No.3, PP.1-12.

- Ifenthaler, D. and Egloffstein, M. (2020) "Development and Implementation of a Maturity Model of Digital Transformation", Organizational Training and Performance, Vol. 22, No. 64, November 2019, PP. 302–309.

- Jamipour, M., Yazdani, H. R., and Sadeghi, F. (2015) "Presenting a roadmap for strategic alignment of knowledge management in Iranian government organizations", Journal of Information Technology Management, VOL.8, NO.2, Summer 2015, PP.231- 252.

- Kempegowda, Sunil and Zenon, Chaczko (2016) "Adoption of Emerging Technologies established on Comprehensive Capability Maturity Model Framework: A new practical model". 27th International Business Information Management Association Conference. PP.1-15.

- Klötzer, Christoph and Pflaum, Alexander (2017) "Toward the Development of a Maturity Model for Digitalization within the Manufacturing Industry's Supply Chain", 50th Hawaii International Conference on System Sciences, PP.4210-4219.

- Komninos, Nicos; Kakderi, Christina; Collado, Antonio, Papadaki Ilektra and Panori, Anastasia (2020), "Digital Transformation of City Ecosystems: Platforms Shaping Engagement and Externalities across Vertical Markets", Journal of Urban Technology ,Vol. 15, No.5 Sep 2020.PP. 51-73.

- Kozina, Melita and Valentina Kirinić (2018) "Measuring Digital Capabilities of the Higher Education Institution Using Digital Capability Maturity Model", Maribor Press, VOL.10, NO.3, Autumn 2018, PP. 461- 480.

- Lanza, Gisela; Nyhuis, Peter; Majid Ansari, Sarah; Kuprat, Thorben and Liebrecht, Christoph (2016) "Empowerment and implementation

strategies for industry 4.0", Hanser-elibary, VOL.11, NO.1-2, Spring 2016, PP. 76-79.

- Leyh, Christian; Schäffer, Thomaas; Bley, Katja and Lennart, Bay (2017) "Assessing the IT and Software Landscapes of Industry 4.0-Enterprises: The Maturity Model SIMMI 4.0", Springer International Publishing, Vol 14, No 1, Spring 2017, PP. 1-10.

- Manian, A. and Ronaghi, M. H. (2015) "Providing a comprehensive framework for implementing Internet marketing using the meta-synthesis method", Journal of Business Management, Vol.7, No.4, Autumn 2015, PP. 901-920.

- Mirzahossein, Hamid; Gholampour, Iman, Sedghi, Maryam and Zhu, Lei (2021) "How realistic is static traffic assignment? Analyzing automatic number-plate recognition data and image processing of real-time traffic maps for investigation", Transportation Research Interdisciplinary Perspectives, Vol. 9, No.100320, 17 February 2021, PP.1-11.

- Moghaddasi, A., Manian, A. Gholipour, R.A., and Hassanzadeh, A. (2016) "Designing a good e-governance model in the field of e-learning in Iran". Journal of Information Technology Management, VOL.8, NO.3, Autumn 2016, PP. 591- 620.

- Mupuru, Sucharita, and Martin Gill (2015) "Rank Yourself with The Digital Maturity Model", Busyness and Channel Strategy Professionals, Vol.10, No.3, Autumn, PP.1-12.

- Poor Saeed, Z., Mohammad Khani, M., Arab Sorkhi, A., and Mohammadian, A. (2018) "Presenting the maturity model of innovation capability based on customer knowledge and meta-synthetic method", Journal of Information Management, VOL.4, NO. 2, Summer 2018, PP. 89-109.

- Ravarini, Aurelio; Locoro, Angela and Martinez, Marcello (2019) "Digital Transformation Projects Maturity and Managerial Competences: A Model and Its Preliminary Assessment", Exploring Digital Ecosystems, Vol.33, No. 2, July 2019, pp 261-272.

- Reis J., Amorim M., Melão N., Matos P. (2018) "Digital Transformation: A Literature Review and Guidelines for Future Research", Trends and Advances in Information Systems and Technologies, vol. 745, pp. 411-421.

- Sarmad, Z., Bazargan, A., and Hejazi, E. (2008). "Research methods in behavioural sciences". Tehran: Aagah Publications Institute.

- Schumacher, Andreas; Selim, Erol, and Wilfried, Sihn.(2016) "A Maturity Model for Assessing Industry 4.0 Readiness and Maturity of Manufacturing", Procedia CIRP, Vol.52, No.10, Autumn 2016, PP.161-166.

- Sheykhfard, A., & Haghighi, F. (2019). Performance analysis of urban drivers encountering pedestrian. *Transportation research part F: traffic psychology and behaviour*, *62*,pp. 160-174.

- Sheikholeslami, S., Boroujerdian, A. M., & Asadamraji, M. (2020). A rural road accident probability model based on single-vehicle hazard properties including hazard color and mobility: a driving simulator study. *Journal of advanced transportation*, *2020*.

- Asadamraji, M., Saffarzadeh, M., & Mirzaee Tayeghani, M. (2017). Modeling driver's hazard perception using driver's personality characteristics. *International Journal of Transportation Engineering*, *5*(2),pp. 167-182.

- Sobral, T., Galvão, T. and Borges, J. (2019) "Visualization of Urban Mobility Data from Intelligent Transportation Systems". Vol.19, No.2, Summer 2019, PP.332-340.

- Akbari, A., & Haghighi, F. (2020). Traffic calming measures: an evaluation of four low-cost TCMs' effect on driving speed and lateral distance. IATSS research, 44(1), 67-74.

- Solis, B. (2016). "the six stages of digital transformation maturity", elasticwebcast, Vol.10, No. 3, PP. 17- 26.

- 0Ustundag, Alp and Cevilkan, Emre (2018). "Industry 4.0: Managing the Digital Transformation". Switzerland: Springer international publishing, 2020 Springer Nature Switzerland AG. Part of Springer Nature.

- Veres, Matthew and Medhat, Moussa (2020) "Deep Learning for Intelligent Transportation Systems: A Survey of Emerging Trends", IEEE Transactions on Intelligent Transportation Systems, Vol. 21, NO. 8, Autumn 2020, PP.315-3168.

- Wang Yuan, Dongxiang; Zhang, Ying; Liu, BoDai; Loo and Hay,Lee (2019) "Enhancing transportation systems via deep learning: A survey", Transportation Research Part C: Emerging Technologies,Vol. 99, NO.10, Spring 2019, PP.144-163.

- Won, Myounggyu. (2020). "Intelligent Traffic Monitoring Systems for Vehicle Classification: A Survey". IEEE Journal, Vol. 8, NO.10, Summer 2020, PP. 73340 – 73358.

- Yuan, Tingting; Wilson, Borba da; Rocha Neto; Christian, Rothenberg; Katia, Obraczka; Chadi, Barakat and Thierry, Turletti (2020) "Harnessing Machine Learning for Next-Generation Intelligent Transportation Systems: A Survey". Version1, Hal-Inria, Vol.2, Winter 2020, PP. 1-10.