Int. J. Nonlinear Anal. Appl. In Press, 1–16
ISSN: 2008-6822 (electronic)
http://dx.doi.org/10.22075/ijnaa.2022.26942.3456

Designing and explaining the IoT commercialization model in Iranian organizations (Telecommunication Company of Iran): An interpretive structural modeling (ISM) approach

Davood Adib[a], Hossein Safarzadeh[a,*], Mahmood Mohammadi[b]

[a] *Department of Entrepreneurship Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran*
[b] *Department of Industrial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran*

(Communicated by Majid Eshaghi Gordji)

Abstract

The present study aimed to design and explain the IoT commercialization model in Iranian organizations (Telecommunication Company of Iran). A mixed-methods approach with the exploratory design method was used in the study. In the qualitative phase, the content qualitative analysis method was used by interviewing 21 telecommunications managers as well as IT professors and experts. In the quantitative phase, a questionnaire with a statistical sample of 400 individuals was used using the Interpretive Structural Modeling (ISM) approach. In the qualitative phase, the paradigm model of IoT commercialisation is detected in the roles of causal, contextual, intervening conditions, strategies, main phenomena and consequences, design and development of the country's telecommunication infrastructure, full utilization of all communication power with real and legal customers, increasing the power of analysis in the dimensions of telecommunication business, moving towards integration of telecommunication services, strengthening the understanding of customers and their needs, collecting data, transmitting the selected data through communication networks, evaluating and estimating data, and responding to access information for the main phenomenon and were confirmed in the quantitative phase.

Keywords: the internet of things (IoT), IoT commercialization, grounded theory, Interpretive Structural Modeling (ISM)
2020 MSC: 00A71, 65D17

---

1 Introduction

There are about 13.5 billion devices to connect to the Internet via mobiles, tablets, and laptops in the world. In other words, there are smart communication devices about twice the population of the world. It is forecasted that this number will increase to 50 billion devices in the next four years [16]. The vast business opportunities in the field of IoT are constantly increasing the number of smart devices in IoT networks. Furthermore, the dependence of IoT devices on cloud infrastructures for data transmission, storage, and analysis leads to the development of IoT networks

---

[*] Corresponding author

Email addresses: `davood.adib@ava.ir` (Davood Adib), `Hr.safarzadeh@gmail.com` (Hossein Safarzadeh), `mah.mohammadi@iauctb.ac.ir` (Mahmood Mohammadi)

Received: November 2021 *Accepted:* February 2022

active in the cloud [10]. The Internet of Things is a different technology that will become more widespread shortly and will become an important tool of the Internet. The Internet of Things (IoT) is an Internet-based model consisting of a large number of nodes and things connected, and its purpose is to create useful information. This technology needs a complementary technology to save and process its data, namely cloud computing [19].

The Internet of Things is a world of heterogeneous things that, in addition to physical and virtual properties, also have identities and are seamlessly and safely integrated with the Internet infrastructure using standard communication protocols. This view is based on advances in fields such as radio frequency identification, machine-to-machine communications, wireless sensors, ubiquitous computing, and the Web of Things (WoT). Internet-enabled things offer many benefits to organizations and individuals by facilitating or simplifying environmental sensors, automated sensors, and actuators that can be used in a variety of applications, from smart home appliances to smart networks, and product management [3]. The IoT represents a tremendous opportunity for various organizations, including IoT service providers and applications, IoT platform providers and integrators, telecommunication operators, and software vendors [5]. The Internet of Things represents the future of the Internet, where all gadgets and devices are interconnected and can understand their surroundings and communicate with other gadgets. To establish this connection, there is a need for communication contracts so that the devices can communicate with the Internet and other devices [26]. All the world's things are available in the Internet of Things design. Things do not become computers, but have limited computer capabilities and are more intelligent in nature [18]. The top ten countries in IoT technology are mostly developed countries; hence, it can be concluded that the spread of IoT is more in developed countries than in developing countries and this issue increases the information gap between countries [21]. No society can expect success and continued presence in competitive markets, regardless of technological developments. The proper use of information and communication technology (ICT) is an emerging phenomenon in modern business and commerce, and despite its short history, it has caused a concerning gap between our society and the international in this field due to the lack of real awareness and the lack of appropriate basis, both legally and administratively for the proper use of these new technologies [6]. The present study sought to answer the question of how to design and explain the IoT commercialization model in Iranian organizations (Telecommunication Company of Iran) with an Interpretive Structural Modeling (ISM) approach?

Research literature

The term "Internet of Things" was first introduced by the MIT Press in 1999, describing a world in which everything, including inanimate objects, has a digital identity, allowing computers to organize and manage them. The concept of the Internet of Things was coined by a committee member through RFID in 2000. He pointed out the location of information about a tagged thing by searching a specific Internet address or the content of a database. Since then, the term IoT has become synonymous with everyday things that can be detected, located, addressed, and controlled via the Internet [20]. Many definitions of the Internet of Things have been presented by various research associations based on their attitudes toward the strengths of this idea. The IoT is an integrated ecosystem of things equipped with sensors, processors, software, and communication technologies. The goal of the Internet of Things is to provide uninterrupted service to anything anywhere and anytime [14]. The Internet of Things is not just a network for the exchange of information, but as an ecosystem with unique protocols, standards, events, and processing methods that require the least human intervention to provide their services (Omar Said et al., 2020). Latent system technologies, wireless sensor networks, artificial intelligence, machine learning, control systems, automation, etc. help to grow and use the Internet of Things as much as possible [13].

The reason for this multifaceted concept goes back to the naming of this idea, i.e. the "Internet of Things". The name consists of two words; the first emphasizes the networking perspective of the concept, while the second emphasizes the public things that are placed in a common package [25]. The Internet of Things also refers to a network in which each physical thing is identified by a tag and, with other objects, forms a network in which these things can exchange data independently while communicating with each other [8].

Comercialization is the process of turning new technologies into successful commercial products. In other words, commercialization involves various arrays of important technical, commercial, and financial processes that transform a new technology into useful products or services. This process includes activities such as market evaluation, product design, production engineering, intellectual property rights management, marketing strategy development, capital raising, and worker training [15]. Commercialization is an attempt to profit from innovation by transforming new technologies into new products, processes, and services, and selling them in markets. For many new technologies, commercialization means increasing the scale from prototype to mass production and access to more resources. Commercialization strategies include different ways of utilizing technologies and research that researchers and start-ups need to transfer knowledge from concept to market. Furthermore, the decision to commercialize a new technology is closely related to the characteristics of the innovation system in which the company operates. Choosing the right model and strategy is inevitable to successfully commercialize [1].

In an article titled “Healthcare service evolution towards the Internet of Things: An end-user perspective”, Martdnez-Caro et al.[11] examine the benefits of the Internet of Things for users in the healthcare industry. Furthermore, in an article titled “Analyzing challenges to the Internet of Things (IoT) adoption and diffusion: An Indian context”, Luthra et al. [9] examine the adoption of this technology and its diffusion in India. Shakeel et al. [17] conducted a study titled “Commercialization of renewable energy technologies” to find how to effectively commercialize renewable energy technologies in Finland. Mital et al. [12] conducted a study titled “Adoption of Internet of Things in India: A test of competing models using a structured equation modeling approach” to examine the factors affecting the adoption of this technology among individuals, using the technology acceptance model (TAM) and the theory of planned behavior (TPB). Temkar et al. [24] conducted an article titled “Internet of Things for Smart Classrooms”. In a study titled “New Architecture of the Future: An Innovative Model for Business in the Context of Cloud Computing and IoT Integration”, Zarrin et al. [26] examined the IoT from a business perspective and its integration with cloud computing technology with a focus on theoretical and practical aspects. In a study titled “The technology commercialization process model in Iran’s public research institutes” and by conducting six case studies in two public research institutes, Goodarzi et al. [7] provided a model for technology commercialization in public research institutes.

2 Research method

A mixed-methods research approach with an exploratory design was utilized to design the IoT commercialization model and achieve the research objectives. The exploratory design is a two-step approach, also called sequential exploration [4]. In terms of method, the grounded theory of Strauss and Corbin [22] model was used in the qualitative phase of the research. The quantitative phase had a descriptive-survey type. Interpretive Structural Modeling (ISM) was also utilized in the research.

The statistical population of the study consisted of senior managers of the Telecommunication Company of Iran and managers of the Ministry of Communications and Information Technology. Sampling was purposive according to the research purpose.

The data collection tools included interviews and questionnaires. To this end, the sample group was first interviewed. In the quantitative phase, a researcher-made questionnaire was used and it was based on the results of the qualitative phase. Therefore, two types of questionnaires were developed, one with a 5-point Likert scale and another based on pairwise comparisons between research elements, including 13 questions.

Nonlinear structural equation model

The traditional linear structural equation model is typically made up of two parts: the measurement model describing the relationships between the observed and latent variables and the structural model describing the relationships between the latent variables. Given a vector of p observed variables $\mathbf{Z}_i$ for the ith individual in a sample of size n and a vector of q latent variables f_i, the linear structural equation model system can be written:

$$\mathbf{Z}_i = \mu + \Lambda f_i + \varepsilon_i, \tag{2.1}$$

$$b_0 + \mathbf{B}_0 f_i = \delta_{0i}, \tag{2.2}$$

where in the measurement model, the matrices $\mu(p \times 1)$ and $\Lambda(p \times q)$ contain fixed or unknown scalars describing the linear relation between the observations $\mathbf{Z}_i$ and the common latent factors f_i, and ε_i represents the $(p \times 1)$ vector of random measurement error independent of f_i such that $E(\varepsilon_i) = 0$ and $Var(\varepsilon_i) = \Psi$ with fixed and unknown scalars in Ψ; and in the structural model, the matrices $\mathbf{b}_0(d \times 1)$ and $\mathbf{B}_0(d \times q)$ contain fixed or unknown scalars defining d different additive linear simultaneous structural equations relating the factors to one anther plus the $(d \times 1)$ vector of random equation error δ_{0i}, where $E(\delta_{0i}) = 0$ and $Var(\delta_{0i}) = \Delta_0$ with fixed and unknown scalars in Δ_0.

The simultaneous linear structural model as written in (2.2) is very general. For many practical research questions which can be addressed by simultaneous structural models, itis useful to model specific variables in terms of the rest of the variables, i.e., it is useful to consider some of the latent variables as endogenous and others as exogenous, where endogenous variables are those that are functions of otherendogenous and exogenous variables. Let $f_i = (\eta_i', \xi_i')'$ where η_i are the d endogenous latent variables and $_i$ are the $q - d$ exogenous latent variables. Then a commonly used form for the structural model (2.2) becomes:

$$\eta_i = \mathbf{b} + \mathbf{B}\eta_i + \Gamma\xi_i + \delta_i, \tag{2.3}$$

where it is assumed the equation errors δ_i have $E(\delta_i) = 0$, $Var(\delta_i) = \Delta$ and are independent of the ξ_i as well as independent of ε_i in (2.1), and the matrices $b(d \times 1), \mathbf{B}(d \times d), \gamma(d \times (q-d))$, and $\Delta(d \times d)$ are fixed or unknown scalars. The structural model (2.3) is said to be in implicit form, implicit because it has endogenous variables on both sides of the equations, i.e., it is not " solved" for the endogenous variables. it is assumed that thediagonal of $\mathbf{B}$ is zero so that no element of η_i is a function of it self. A sufficient condition for solving (2.3) is that $(I - B)$ is invertible, then (2.3) can be solved for the endogenous variables and written as

$$\eta_i = \mathbf{b}^* + \Gamma^* \xi_i + \delta_i^*, \tag{2.4}$$

where $b^* = (I-B)^{-1}b, \gamma^* = (I-B)^{-1}\gamma$, and $Var(\delta_i^*) = (I-B)^{-1}\delta(I-B)^{-1'}$.

The structural model (2.4) is said to be in reduced form as the η_i now appears only on the left-hand side of the equation. It is important to note the assumption that the equation errors δ_i where additive and independent of the ξ_i in the implicit form (2.3) results in the equation errors δ_i^* in the reduced form (2.4) also being additive and independent of the η_i.

Given p, q and d, additional restrictions must be placed on $\boldsymbol{\mu}, \boldsymbol{\Lambda}, \boldsymbol{\Psi}, \boldsymbol{b}_0, \boldsymbol{B}_0$, and $\boldsymbol{\Delta_0}$ in (2.1)-(2.2) in order to make all the unknown parameters identifiable. The assumption that (2.2) can be written in reduced form (2.4) is the typical restriction placed on the structural model.

Additionally, a common restriction placed on the measurement model (2.1) is the errors-in-variables parameterization where q of the observed variables are each fixed to be equal to one of the q different latent variables plus measurement error. For a thorough discussion of identifiability in linear structural equation models see, e.g.. Finally, it should be noted that there is no inherent distributional assumptions needed for $\boldsymbol{\varepsilon}_i, \boldsymbol{\delta}_{0i}$, nor $\boldsymbol{f}_i$ at this point of model specification although distributional assumptions may be added eventually to perform estimation.

A mixture SEMs for a $p \times 1$ random vector $\boldsymbol{y}_i$ is defined as follows:

$$f(y_i) = \sum_{k=1}^{K} \pi_k f_k(y_i | \mu_k, \sum_k), \qquad i = 1, \cdots, n, \tag{2.5}$$

where $\boldsymbol{K}$ is the number of components which can be unknown, π_k's are component probabilities which are nonnegative and sum to 1.0, $f_k(\boldsymbol{y}|\boldsymbol{\mu_k}, \sum_{\boldsymbol{k}})$ is a multivariate normal density function with an unknown mean vector $\boldsymbol{\mu_k}$ and a covariance matrix $\sum_{\boldsymbol{k}}$. Conditional on the kth component, suppose that y satisfies the following measurement model:

$$y = \mu_k + \Lambda_k \omega_k + \varepsilon_k, \tag{2.6}$$

where $\boldsymbol{\mu_k}$ is an $\boldsymbol{p \times 1}$ intercept vector, $\boldsymbol{Y_k}$ is a $p \times q$ factor loading matrix, $\boldsymbol{\omega_k}$ is a $q \times \mathbf{1}$ random vector of latent variables, and $\boldsymbol{\varepsilon_k}$ is a $p \times \mathbf{1}$ random vector of error measurements with distribution $\boldsymbol{N(0, \Psi_k)}$, which is independent of $\boldsymbol{\omega_k}$, and $\boldsymbol{\Psi_k}$ is a diagonal matrix. Let $\boldsymbol{\omega_k}$ be partitioned into $(\eta_n^T, \xi_k^T)^T$, where $\boldsymbol{\eta_k}$ is a $q1 \times 1$ vector, $\boldsymbol{\xi_k}$ is a $q2 \times 1$ vector, and $q1 + q2 = q$. The structural equation is defined as

$$\eta_k = B_k \eta_k + \Gamma_k \xi_k + \delta_k, \tag{2.7}$$

where $\boldsymbol{B_k}$ and $\boldsymbol{Y_k}$ are $q1 \times q1$ and $q1 \times q2$ matrices of unknown parameters; and random vectors $\boldsymbol{\xi_k \lambda_k}$ are independently distributed as $N\boldsymbol{(0, \Phi_k)}$ and $N(0, \boldsymbol{\Phi_{\lambda k}})$, respectively; and $\boldsymbol{\Phi_k}$ is a diagonal matrix.
We assume that $\boldsymbol{B}_{0k} = (\boldsymbol{I}_{q1} - \boldsymbol{B_k})$ is nonsingular and $(\boldsymbol{I}_{q1}$ is independent of any elements in $\boldsymbol{B_k}$. One specific form of $\boldsymbol{B_k}$ that satisfies this assumption is the lower or upper triangular matrix. As the mixture model defined in (2.5) is invariant with respect to permutation of labels $k = 1, \cdots, K$, adoption of an unique labeling for identifiability is important. Roeder and Wasserman (1997), and Zhu and Lee (2001) proposed to impose the ordering $\mu_{1,1} < \cdots < \mu_{k,1}$ for eliminating the label switching (jumping between the various labeling subspace), where $\mu_{k,1}$ is the first element of the mean vector $\boldsymbol{\mu}_k$. This method works fineif $\mu_{1,1}, \cdots, \mu_{k,1}$ are well separated.

However, if $\mu_{1,1}, \cdots, \mu_{k,1}$ are close to each other, it may not be able to eliminate the label switching, and may introduce incorrect results. Hence, it is necessary to find a sensible identifiability constraint. In this chapter, the random permutation sampler developed by Frühwirth-Schnatter (2001) will be applied for finding the suitable identifiability constraints. See the following sections for more details.

Moreover, for each $k = 1, \cdots, K$, structural parameters in the covariance matrix $\sum_k$ corresponding to the model defined by (2.6) and (2.7) are not identified. A common method in structural equation modeling for identifying the model is to fix appropriate elements in $\boldsymbol{A}_k, \boldsymbol{B}_k$, and /or $\boldsymbol{Y}_k$ at preassigned values. The positions of thepreassigned values of the fixed elements in these matrices of regression coefficients can be chosen on a problem-by-problem basis, as long as each $\sum_k$ is identified. In practice, most manifest variables are usually clear indicators of their corresponding latent variables are usually clear indicators of their corresponding latent variables. This give rather clear prior information to specify the zero values to appropriate elements in these parameter matrices. See the illustrative example in section 5 for a more concrete example. For clear discussion of the proposed method, we let $\mathbf{\Pi} = (\Pi_1, \cdots, \Pi_k)$, and $\boldsymbol{\theta}$ be the vector which contains all unknown parameters in the covariance matrices that defines an identified model.

3 Results

The following three main steps are necessary to design the model, each of which is described below [2].

1. Detecting the IoT commercialization dimensions;
2. Detecting the conceptual relationship between these dimensions using Interpretive Structural Modeling (ISM);
3. Drawing the network of interactions between IoT commercialization dimensions

Step 1: Detecting the IoT commercialization dimensions. Data analysis of this stage was performed at three stages, namely open coding, axial coding (detection of axial category, causal conditions, intervening conditions, basic conditions, and consequences), and selective coding (theory creation).

4 Open coding

Open coding is a part of the analysis that is done by careful analysis of data, naming, and classifying data. For accurate classification of concepts into categories, each concept was conceptualized after separating the labeled and raw data by careful examination of the text of interviews and background notes to more easily detect similarities and differences. MAXQDA software was used for coding. Table 1 presents examples of interview analysis and initial coding.

5 Axial coding

purpose of this step is to establish a relationship between the classes produced in the open coding step. At this stage, the indices extracted from the interview texts are categorized by screening, removing duplicate codes, and integrating synonymous codes [22]. Therefore, the categories were determined and 9 main categories and 44 subcategories were obtained at this stage from all indices obtained from the open coding stage. The above-mentioned cases are presented in separate tables.

6 Provision of the research model

The Interpretive Structural Modeling (ISM) was used to design the IoT commercialization model.

7 Formation of the structural self-interaction matrix

The formation of a structural self-interaction matrix is the first step in interpretive structural modeling. This matrix is used to detect the internal relationships of indices. Expert perspectives are commonly used to reflect the internal relationships between indices.

The matrix obtained in this step indicates which variable affects another variable and is affected by which variable. The structural self-interaction matrix consists of research dimensions and indices, and their comparison is performed using four modes of conceptual relationships. The obtained information is summarized based on Interpretive Structural Modeling and forms the final structural self-interaction matrix [2]. Table 4 presents the structural self-interaction matrix.

8 Formation of the reachability matrix

The reachability matrix is obtained by converting the interactive structural matrix into a Zero-One matrix. In the reachability matrix, the main diagonal elements are equal to one. Secondary relationships must also be controlled. In other words, if A leads to B, and B leads to C, then A must lead to C. Therefore, if direct effects should be considered based on the secondary relationship, but this has not happened in practice, the table should be corrected and the secondary relationships should also be shown [2]. Table 5 presents the reachability matrix.

Table 1: An example of initial extracted coding

Row	Initial concept	Open coding	Sample text
1	Improving Iran's telecommunication infrastructure	Need to change Investing in capacity building building Ability to detect changes by organizations Establishment of training in the telecommunication company IoT infrastructures Platform as a service	... Specifically, the Internet of Things changes constantly with changes in technology and infrastructures. Telecommunication company needs to invest in capacity building and agility because of these changes; hence, they can adapt to the circumstances. The ability to detect these changes by organizations has become an integral part and core of all business activities. If the telecommunication company could train itself as soon as possible, it can respond quickly and flexibly to technological changes, and thus improve the telecommunications infrastructure. It provides the IoT infrastructures to various businesses through the "platform as a service method."
2	Full utilization of the whole power of communication with real and legal customers	IoT platform in the telecommunications company Managing and collecting data from various sensors Application, collection, storage, and retrieval Ability to communicate with customers	"The IoT platform in the telecommunication company provides the necessary facilities such as data collection and management from various devices and sensors, independent of the type of application, collection, storage, and retrieval and provides them for customers. Emphasizing it and protecting the rights of the Internet of Things is important to customers' financial and intellectual property."
3	Increasing the power of analysis in dimensions of the telecommunication business	Providing convenient, accessible, and personalized services for customers Analytical power of online telecommunication company Telecommunication company applications Maintaining organizational survival as the ultimate and important goal of all organizations Ensuring the authenticity of customer registration	"Today, customers demand available services some of which can be seen in the analysis power of the online telecommunication company, the applications of the telecommunication company, and contactless payment technology."

9 Formation of the final reachability matrix

After obtaining the initial reachability matrix, the final reachability matrix is obtained by entering transitivity in the relationships of the variables. This is a square matrix in which each entry is equal to 1 when the element has access to the element of any length, otherwise, it is zero. The reachability matrix can be obtained using Euler's theory in which we add the adjacency matrix to the unit matrix. Then, we exponentiate this matrix to n if the matrix entries do not change. The following equation shows how to determine reachability using the adjacency matrix:

Table 2: Main and sub-categories of research

Main categories	**Sub-categories**
Developing the managerial strategies	√ Improving Iran's telecommunications infrastructure
	√ Full use of all communication power with real and legal customers
	√ Increasing the analytical power in the telecommunication business dimensions
	√ Moving toward the integration of telecommunication services
	√ Strengthening the understanding of customers and their needs
IoT commercialization in telecommunication companies	√ Providing services without the physical presence of people
	√ Increasing the efficiency of human resources in the company
	√ Service improvement system using the rapid feedback of customers
	√ Remote service monitoring and control system
	√ Analyzing bulk information and understanding customer behavior patterns
	√ Predicting future trends in the telecommunication industry by the Internet of Things
IoT implementation infrastructure	√ Data collection
	√ Transfer of selected data through communication networks
	√ Evaluating and estimating data
	√ Responding to available information
Ensuring privacy	√ Ensuring the privacy
	√ Communication with customers
	√ Commitment to existing agreements or policies
	√ Identifiable and reliable
Change management in the Internet of Things	√ Extensive scalability of IoT applications
	√ Challenges of data management
	√ Challenges of data mining
	√ Challenge of confidentiality and security as technical components of the system
Securing the interests of the main IoT stakeholders	√ Telecommunication operators
	√ Customers and applicants
	√ Service providers
	√ Software and hardware suppliers
	√ People as the end-users
Confidentiality, Communication infrastructures integrity, and accessibility of information	
	√ Wireless network bandwidth
	√ Integration of user data
	√ Authentication credentials
IoT profitability	√ Development of social, economic, and welfare activities
	√ Making money from IoT
	√ Increasing the GDP
	√ Gaining global credibility for Iran's Telecommunication
	√ Improving Iran's global indices
	√ Job creation and involvement of manufacturing companies in √ the implementation of the Internet of Things
Quality of service for users	√ Quick access to convenient, timely, and cost-effective information
	√ Reduction of risk and possible risks
	√ Preventing the possible consequences of accidents
	√ Increasing the efficiency, quickness in action, and decision making
	√ Increasing the security
	√ Increasing the public quality of life

Table 3: Modes and symbols used to express the relationship between variables

Symbol	**V**	**A**	**X**	**O**
Relationships	Variable i affects variable j.	Variable j affects variable i.	Mutual relationship	No relationship

Equation (9.1): Determining the final reachability matrix

$$A + I$$

$$M = (A + I)^n \tag{9.1}$$

Matrix A is the initial reachability matrix of the unit matrix and the final reachability matrix. The matrix exponentiation operation is performed according to the Boolean rule (9.2).

Equation (9.2): Boolean rule

$$1 \times 1 = 1; 1 + 1 = 1. \tag{9.2}$$

Therefore, secondary relationships must be controlled to ensure. To this end, if A leads to B and B leads to C, then A must lead to C. In other words, if direct effects should be considered based on the secondary relationships

Table 4: Structural self-interaction matrix

X	**IoT**	**UQ**	**CM**	**PS**	**IF**	**IS**	**SH**	**SM**	**PA**
IoT		A	A	A	A	O	O	A	A
UQ			A	A	A	A	A	A	X
CM				A	A	A	X	A	V
PS					X	A	V	A	O
IF						A	V	A	V
IS							V	X	V
SH								A	V
PA									O
PA									

Table 5: Reachability matrix of IoT commercialization variables

RM	**IoT**	**UQ**	**CM**	**PS**	**IF**	**IS**	**SH**	**SM**	**PA**
IoT	1	0	0	0	0	0	0	0	0
UQ	1	1	0	0	0	0	0	0	1
CM	1	1	1	0	0	0	1	0	1
PS	1	1	1	1	1	0	1	0	0
IF	1	1	1	1	1	0	1	0	1
IS	0	1	1	1	1	1	1	1	1
SH	0	1	1	0	0	0	1	0	1
SM	1	1	1	1	1	1	1	1	0
PA	1	1	0	0	0	0	0	0	1

but it does not occur in practice, the table should be corrected and the secondary relationship should also be shown. Table 6 presents the total reachability matrix of the research variables.

Table 6: Total reachability matrix of research variables

TM	**IoT**	**UQ**	**CM**	**PS**	**IF**	**IS**	**SH**	**SM**	**PA**
IoT	1	0	0	0	0	0	0	0	0
UQ	1	1	0	0	0	0	0	0	1
CM	1	1	1	0	0	0	1	0	1
PS	1	1	1	1	1	0	1	0	1*
IF	1	1	1	1	1	0	1	0	1
IS	1	1	1	1	1	1	1	1	1
SH	1*	1	1	0	0	0	1	0	1
SM	1	1	1	1	1	1	1	1	1*
PA	1	1	0	0	0	0	0	0	1

10 Determining relationships and leveling dimensions and indices

A set of outputs and a set of inputs for each criterion must be extracted from the reachability matrix to determine the relationships and level the criteria.

- √ Reachability set (row elements, output, or influence): variables that can be reached through this variable.
- √ Prerequisite set (column elements, inputs, or dependence): Variables through which this variable can be reached.

The set of outputs includes the criterion and criteria that are affected by it. The set of inputs includes the criterion and criteria that affect it. The set of mutual relations of criteria is then determined.

For variable C_i, the reachability set (output or influence) includes variables that can be reached through the variable C_i. The set of prerequisites (inputs or dependence) includes the variables through which the variable C_i can be reached.

The commonality of the two sets is calculated after determining the reachability and prerequisite sets. The first variable, in which the commonality of the two sets is equal to the reachability set (outputs), is the first level. Therefore, the first level elements have the highest dependence in the model. After determining the level, the criterion, in which the level is determined, is removed from the whole set and again forms the set of inputs and outputs, and the next variable level is obtained (Asgharpour, 2013).

Table 7: Determining the levels of IoT commercialization variables

Variables	Output: Influence	Input: Dependence	Commonalities	Level
IOT	IOT	IOT,UQ,CM,PS,IF,IS,SH,SM,PA	IOT	1
UQ	IOT,UQ,PA	UQ,CM,PS,IF,IS,SH,SM,PA	UQ,PA	2
CM	IOT,UQ,CM,SH,PA	CM,PS,IF,IS,SM	CM	4
PS	IOT,UQ,CM,PS,IF,SH,PA	PS,IF,IS,SM	PS,IF	5
IF	IOT,UQ,CM,PS,IF,SH,PA	PS,IF,IS,SM	PS,IF	5
IS	IOT,UQ,CM,PS,IF,IS,SH,SM,PA	IS,SM	IS,SM	6
SH	IOT,UQ,SH,PA	CM,PS,IF,IS,SH,SM	SH	3
SM	IOT,UQ,CM,PS,IF,IS,SH,SM,PA	IS,SM	IS,SM	6
PA	IOT,UQ,PA	UQ,CM,PS,IF,IS,SH,SM,PA	UQ,PA	2

Based on the results of interpretive structural modeling, the IoT commercialization (IoT) in the Telecommunication Company is the first-level element and a dependent variable. The variables, namely the user quality (UQ), and the profitability of the Internet of Things (PA) are at the second level. Providing the main IoT stakeholders' interests (SH) is at the third level. The Internet of Things change management (CM) variable is at the fourth level. The privacy (PS), and confidentiality, integrity, and reachability of information (IF) are at the fifth level. Finally, the development of strategic management (SM), and the implementation of the Internet of Things infrastructure (IS) are at the sixth level and the most basic elements of the model. The following figure shows the final model of the levels of the detected variables. Only the significant relations of the elements of each level on the elements of the lower level as well as the significant internal relations of the elements of each row are considered in this figure.

The variables, namely the development of strategic management (SM), and the implementation of the Internet of Things infrastructure (IS) have high influence and low dependence and are considered independent variables. The variables, namely providing the main IoT stakeholders' interests (SH), the Internet of Things change management (CM), the privacy (PS), and confidentiality, integrity, reachability of information (IF) also have high influence and dependency; hence, they are linkage variables. The IoT commercialization in the Telecommunication Company (IoT), the user quality (UQ), and the IoT profitability (PA) are also highly dependent, but have lower influence; hence, they are considered dependent variables.

MICMAC analysis: In ISM, the interrelationships and effectiveness between criteria and the relationship of criteria at different levels are well shown, leading to a better understanding of the decision-making space by managers. The total access matrix is formed to determine the key criteria of influence power and dependence of the criteria. The figure shows the influence power-dependency diagram for the variables.

Table 8: Influence power and dependence of IoT commercialization variables

Research variables	Dependence	Influence	Level
IoT commercialization (IoT) in the Telecommunication Company	9	1	1
User quality (UQ)	8	3	2
Internet of Things change management (CM)	6	5	4
Privacy (PS)	4	7	5
Confidentiality, integrity, reachability of information (IF)	4	7	5
The Internet of Things infrastructure (IS)	2	9	6
Providing the main IoT stakeholders' interests(SH)	6	5	3
Development of strategic management (SM)	2	9	6
Profitability of the Internet of Things (PA)	8	3	2

Based on the influence power and dependence of variables, a coordinate system can be defined and divided into four equal parts. In the study, a group of variables were placed in the "actuators" subgroup. These variables have high influence power and low dependence. Dependent variables are in the next category and they are the results of the

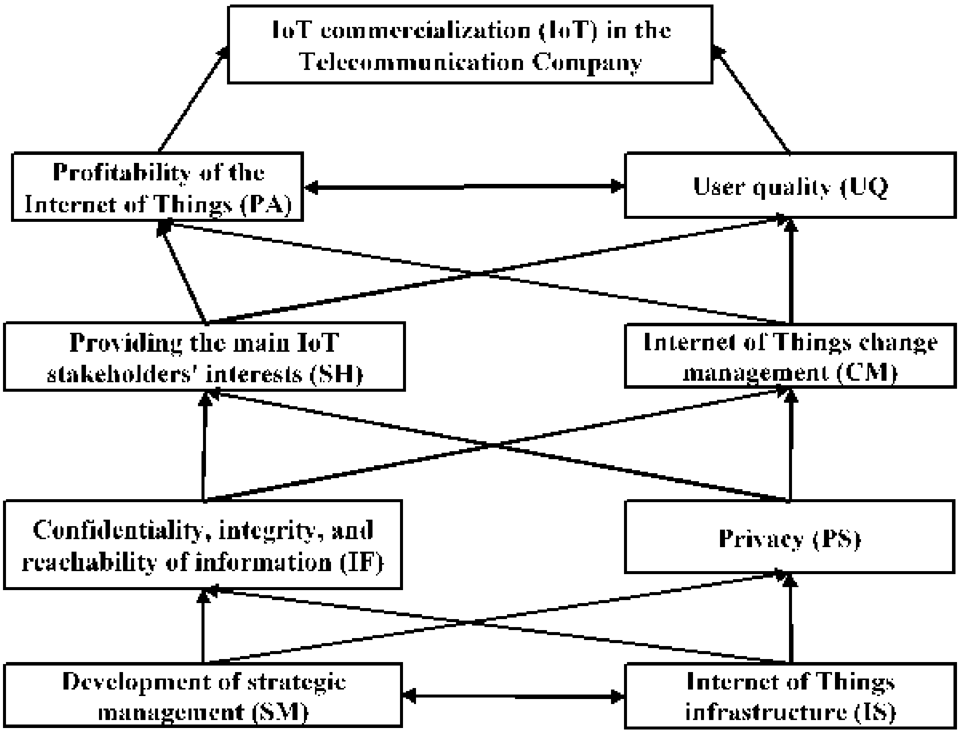

Figure 1: The basic model of IoT commercialization

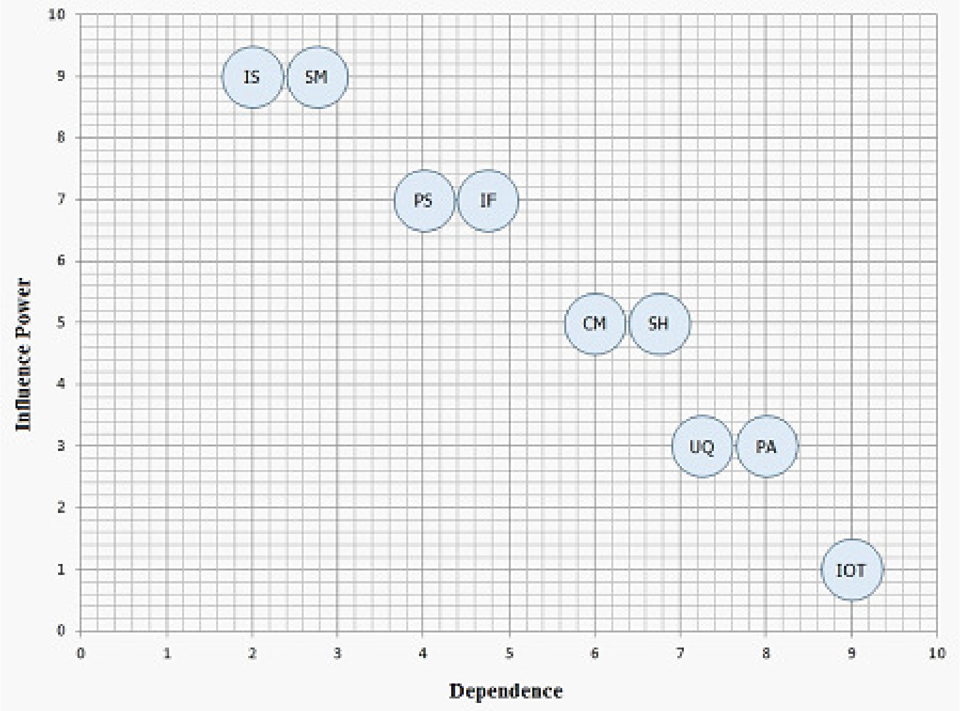

Figure 2: Diagram of influence power and dependence level (MICMAC output)

product development process and can less be the basis for other variables. In this analysis, the variables are divided into four groups: Autonomous, dependent, linkage, and independent.

Autonomous variables: These variables have low dependence and conductivity. They are generally separated from the system because they have poor connections to the system. A change in these variables does not cause a serious change in the system.

Dependent variables: These variables have strong dependence and poor conductivity. They generally have high dependence and low influence on the system.

Independent variables: These variables have low dependence and high conductivity, in other words, high influence and low dependence are the characteristics of these variables.

Linkage variables: These variables have high dependence and high conductivity. In other words, the influence of these criteria is very high and any small change in these variables causes fundamental changes in the system. They are at the second level according to the influence-dependence diagram.

11 Research model validation

Structural equation modeling and LISREL software were utilized to validate the IoT commercialization model. The following table presents the research constructs and distribution of questions.

Table 9: Research constructs and distribution of their questions

Main categories	Symbol	Number of items	Number
Providing the main IoT stakeholders' interests	SM	5	1-5
IoT commercialization in the Telecommunication Company	IoT	6	6-11
The Internet of Things infrastructure	IS	4	12-15
Privacy	PS	4	16-19
Internet of Things change management	CM	4	20-23
Providing the main IoT stakeholders' interests	SH	5	24-28
Confidentiality, integrity, reachability of information	IF	4	29-32
Profitability of Internet of Things	PA	6	33-38
User quality	UQ	6	39-44

Confirmatory factor analysis was used to ensure the accuracy of the selected items. The following figure shows the output of confirmatory factor analysis in non-standardized estimation.

The factor loading of all cases is above 0.6, indicating that the selected items are highly correlated with the latent variables. The RMSEA fit index value is equal to 0.036 and less than 0.08. The normal chi-square value is less than 2. Therefore, the confirmatory factor analysis fit is also appropriate. T-statistic is used to evaluate the significance of the effects. The following figure shows the confirmatory factor analysis at a significance level.

The following figure shows the final validation results of the research.

The following cases are found based on the results:

The standard factor loading of the effect of IoT implementation infrastructure on the provision of privacy was equal to 0.45. Furthermore, the t-statistic value was 5.69; hence, it can be claimed at a 95% confidence level: IoT implementation infrastructure had a positive and significant effect on privacy.

The standard factor loading of the effect of formulating management strategies on confidentiality, integrity, and reachability of information was equal to 0.35. Furthermore, the t-statistic value was equal to 4.32. Therefore, it can be claimed with 95% confidence that the development of management strategies had a positive and significant effect on the confidentiality, integrity, and reachability of information.

The standard factor loading of the effect of formulating management strategies on providing privacy was equal to 0.48. Furthermore, the t-statistic value was equal to 5.77. Therefore, it can be claimed with 95% confidence that the development of management strategies had a positive and significant effect on the provision of privacy.

The standard factor loading of the effect of the provision of privacy on confidentiality, integrity, and reachability of information was equal to 0.56. Furthermore, the *t*-statistic value was equal to 6.46. Therefore, it can be claimed with 95% confidence that the provision of privacy had a positive and significant effect on the confidentiality, integrity, and reachability of information.

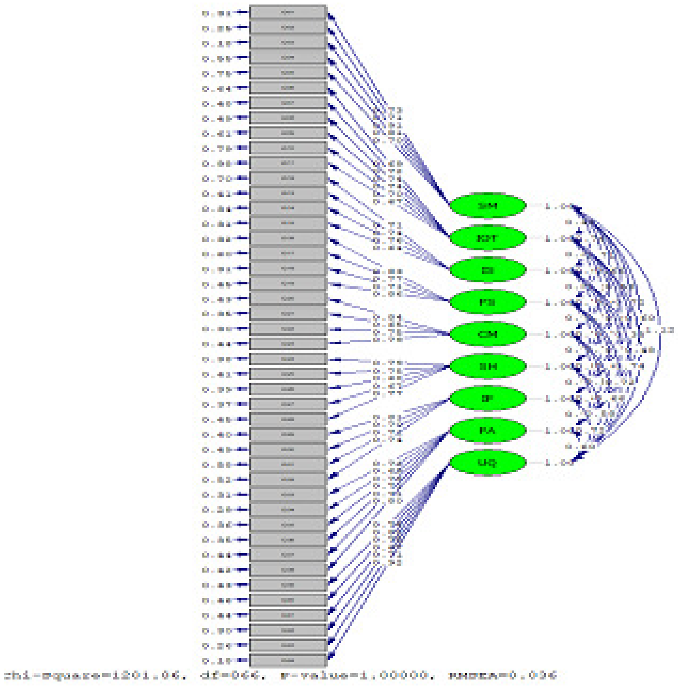

Figure 3: Output of standardized coefficients

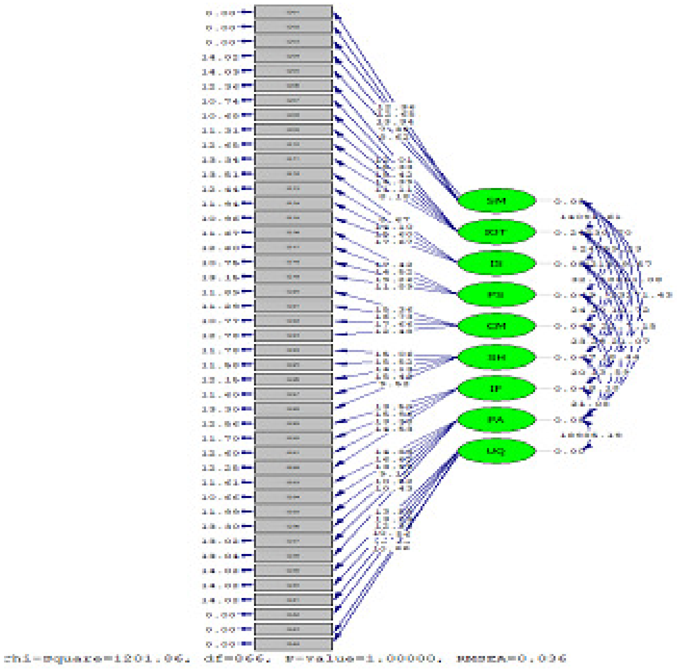

Figure 4: T-value output

The standard factor loading of the effect of the provision of privacy on the Internet of Things change management was equal to 0.65. Furthermore, the t-statistic value was equal to 7.32. Therefore, it can be claimed with 95% confidence that the provision of privacy had a positive and significant effect on the Internet of Things change management.

The standard factor loading of the effect of confidentiality, integrity, and reachability of information on providing the main IoT stakeholders' interests was equal to 0.37. Furthermore, the t-statistic value was equal to 3.44. Therefore,

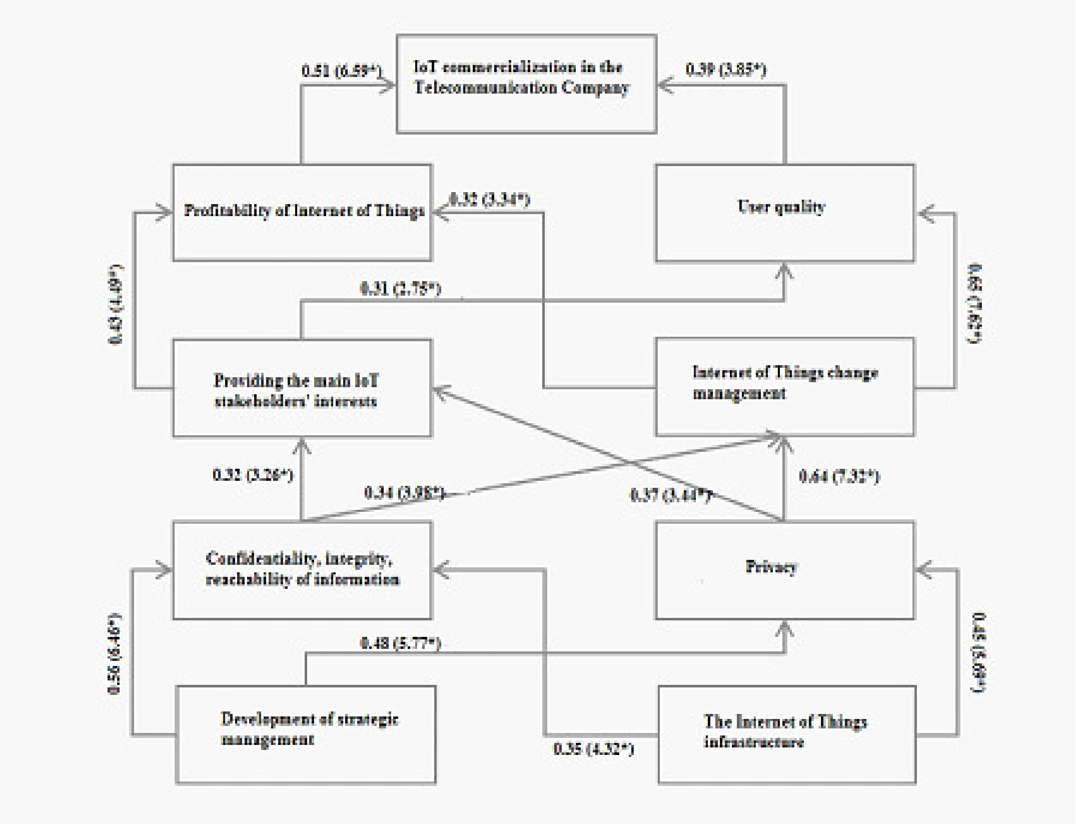

Figure 5: Validation of the structural model of research

it can be claimed with 95% confidence that the confidentiality, integrity, and reachability of information had a positive and significant effect on providing the main IoT stakeholders' interests.

The standard factor loading of the effect of confidentiality, integrity, and reachability of information on the Internet of Things change management was equal to 0.32. Furthermore, the *t*-statistic value was equal to 3.26. Therefore, it can be claimed with 95% confidence that confidentiality, integrity, and reachability of information had a positive and significant effect on the Internet of Things change management.

The standard factor loading of the effect of the Internet of Things change management on the main IoT stakeholders' interests was equal to 0.34. Furthermore, the *t*-statistic value was 3.98. Therefore, it can be claimed with 95% confidence that the Internet of Things change management had a positive and significant effect on the main IoT stakeholders' interests.

The standard factor loading of the effect of the Internet of Things change management on the user service quality was equal to 0.65. Furthermore, the t-statistic value was 7.62. Therefore, it can be claimed with 95% confidence that the Internet of Things change management had a positive and significant effect on the user service quality.

The standard factor loading of the effect of providing the main IoT stakeholders' interests on the profitability of the Internet of Things was equal to 0.32. Furthermore, the *t*-statistic value was 3.34. Therefore, it can be claimed with 95% confidence that providing the main IoT stakeholders' interests had a positive and significant effect on the profitability of Internet of Things.

The standard factor loading of the effect of providing the main IoT stakeholders' interests on the user service quality was equal to 0.31. Furthermore, the t-statistic value was 2.75. Therefore, it can be claimed with 95% confidence that providing the main IoT stakeholders' interests had a positive and significant effect on the user service quality.

The standard factor loading of the effect of user service quality on the profitability of the Internet of Things was equal to 0.43. Furthermore, the t-statistic value was 4.49. Therefore, it can be claimed with 95% confidence that the user service quality had a positive and significant effect on the profitability of the Internet of Things.

The standard factor loading of the effect of the profitability of the Internet of Things on the IoT commercialization in the telecommunication company was equal to 0.39. Furthermore, the t-statistic value was 3.85. Therefore, it can be claimed with 95% confidence that the profitability of the Internet of Things had a positive and significant effect on the IoT commercialization in the telecommunication company.

The structural model of the research was saturated at two stages. The value of normal chi-square was also equal to 1.60, which was in the acceptable range of 1 to 5. The RSMEA and SRMR fit indices were respectively 0.033 and 0.036 that were less than 0.05. The goodness of fit index (GFI), the normed fit index (NFI), and the Tucker Lewis index (TLI) were also greater than 0.9 and were in the acceptable range.

$$\frac{\chi^2}{df}=\frac{1417.43}{887}=1.60;;RMSEA=0.033;;SRMR=0.036;;GFI=0.92;;NFI=0.94;;TLI=0.92 \tag{11.1}$$

Therefore, the research model had a good fit and we could rely on the results.

12 Discussion and conclusion

The research results indicated that the cost of telecommunication measures to commercialize such technology increased due to the economic pressures and sanctions of the current situation in Iran, and thus needs paying attention to the quality of this technology. Furthermore, the competition between telecommunications and other organizations for the implementation and commercialization of the Internet of Things caused these organizations to compete with each other for the implementation and commercialization of such technology. According to the results, the causal factors, which caused the commercialization of the Internet of Things in Iran's telecommunications, were as follows: Communication infrastructure, wireless network bandwidth, user data integrity, and authentication credentials because the IoT platform in the telecommunications company collected, stored, and retrieved the necessary facilities such as data management and collection from various devices and sensors, independent of the type of application, and provided them for businesses. It provided the IoT infrastructures as the "platform as a service" method for various businesses.

The intervening conditions, which lead to the commercialization of the Internet of Things in telecommunications, are as follows: the large scalability of IoT applications, the challenge of data management, the challenges of data mining, and the challenge of confidentiality and security as technical components of the system because our daily activities depend on equipment or systems that can connect to the Internet. Many manufacturers also offer their products the ability to connect to the Internet. Therefore, IoT equipment is needed for essential services day by day, and the security of this equipment becomes more prominent. This level of dependence on IoT equipment and Internet services increases the hackers' access to equipment. We may easily turn off an Internet-connected TV in a cyberattack, but turning off a smart electricity meter is not easy because the security of IoT equipment and its services is a key issue in this field. It should be noted that when it comes to IoT equipment, the security of this equipment will not be absolute. Security is not a zero-one concept (secure and insecure equipment), but a range of security vulnerabilities need to be considered. This range is from unprotected equipment (without security features) to highly secure systems (with multiple layers of security features). In other words, there are always new security threats and network equipment manufacturers and operators are constantly looking for new solutions to respond to these threats. IoT security is a function of the way of managing security risks. The equipment security is a function of the risk that it faces, the damage by this risk, and the time and resources required to achieve an acceptable level of protection.

The present study considered the improvement of the telecommunications infrastructure, making full use of all communication power with real and legal customers, increasing the analytical power in telecommunication business dimensions, moving towards integration of telecommunication services, strengthening the customers' knowledge and needs, data collection, the transmission of selected data via communication networks, evaluation and estimation of data, and response to available information as an axial phenomenon category in the IoT commercialization model. Customers want convenient, accessible, and personalized services. Some of these services can be found in online telecommunication companies, telecommunication company applications, and contactless payment technology. They also want the highest level of digital security in their telecommunication companies. Machine-to-machine connectivity, which enables the collection and exchange of data from sensors and things, also provides numerous opportunities for telecommunications companies to track and analyze their customers' behaviours, desires, and demands. It allows the telecommunications company to provide customers with much more personal experiences, targeted advice, and informed suggestions. Therefore, the telecommunications company can achieve a new level of understanding of customer needs and closer communication with customers.

References

[1] N. Allahyari Fard and R. Abbasi, *Suitable organizational structure for knowledge-based companies*, Roshd-e-Fanavari **8** (2011), no. 29, 1–10.

[2] A. Azar, *Modeling agility of supply chain, using interpretive structural modeling approach- Structural*, J. Human. Teacher-Manag. Res. Iran **14** (2010), no. 4.

[3] Y. Cheng, L. Huang, R. Ramlogan and X. Li, *Forecasting of potential impacts of disruptive technology in promising technological areas: elaborating the SIRS epidemic model in RFID technology*, Technol. Forecast. Soc. Chang. **117** (2017), 170–183.

[4] J.W. Creswell and V.L. Plano Clark, *Designing and conducting mixed-methods research*, First edition, Thousand Oaks, Sage Publication, 2007.

[5] Gartner, *Gartner says it's the beginning of a new era: The digital industrial economy,* Retrieved from `http://www.gartner.com/newsroom/id/2602817`, 2013.

[6] M. Gheysari, A.K. Tajfar and M. Keshavarz-Deyhim, *A study on the role of new technology of internet of things in improving the performance of E-commerce*, The Second . Conf. Manag. Entrepreneur. Emphasis Resistance Economy Conditions, 2016.

[7] M. Goodarzi, J. Bamdad Soufi, S.M. Arabi and M. Amiri, *The technology commercialization process model in Iranian government research institutes*, Sci. Technol. Policy **4** (2011), no. 2, 41–56.

[8] ITU Strategy and Policy Unit (SPU) *ITU internet Rreports 2005: The internet of things, Geneva: International Telecommunication Union (ITU)*, Retrieved from `http://www.itu.int/wsis/tunis/newsroom/stats/The-Internet-of-Things-2005.pdf.(Accessedon02.11.2014)`, 2005.

[9] S. Luthra, D. Garg, S.K. Mangla and Y. Berwal, *Analyzing challenges to the internet of things (IoT) adoption and diffusion: An Indian context*, Procedia Comput. Sci. **125** (2018), 733–739.

[10] V. Mai and I. Khalil, *Design and implementation of a secure cloud-based billing model for smart meters as an Internet of Things using homomorphic cryptography*, Future Gener. Comput. Syst. **72** (2017), 327–338.

[11] E. Martdnez-Caro, J.G. Cegarra-Navarro, A. Garcta-Pérez and M. Fait, *Healthcare service evolution towards the Internet of Things: An end-user perspective*, Technol. Forecast. Soc. Change **136** (2018), 268–276.

[12] M. Mital, V. Chang, P. Choudhary, A. Papa and A.K. Pani, *Adoption of internet of things in India: A test of competing models using a structured equation modeling approach*, Technol. Forecast. Soc. Change **136** (2018), 339–346.

[13] A.R. Montazerolghaem and M. H. Yaghmaee, *Load-Balanced and QoS-Aware software-defined iInternet of things*, IEEE Internet Things J. **7** (2020), no. 4, 3323–3337.

[14] S. Narasimha and S.R. Kota, *An empirical study on system level aspects of internet of things (IoT)*, IEEE Access **8** (2020).

[15] A. Reamer, *Technology transfer and commercialization their role in economic development*, Economic Ddevelopment Administration, U.S. Ddepartment of Commerce, 2003.

[16] M. Sariolghalam, *The implications of the fourth generation of technology*, World Economy Nnewspaper, 2016.

[17] S.R. Shakeel, J. Takala and L.D. Zhu, *Commercialization of renewable energy technologies: A ladder building approach*, Renew. Sustain. Energy Rev. **78** (2017), 855–867.

[18] S. Shane and N. Nicolaou, *Creative personality, opportunity recognition and the tendency to start businesses: A study of their genetic predispositions*, J. Bus. Ventur. **30** (2015), 407–419.

[19] M.K. Sharifabadi, M. Gerami and A.A. Yazdanpanah, *Identifying the effective factors in IoT adoption from the users' point of view using the complementary TAM presented in Gao and Bai model, Case study: Customers of Mobile Telecommunication Company of Iran (MCI)- Hamrah e Aval.*, Quart. Technol. Growth **15** (2019), no. 58, 1–12.

[20] G. Shen and B. Liu, *Research on application of internet of things in electronic commerce*, Electron. Commerce Secur., Third Int. Symp. IEEE, 2010, pp. 13–16.

[21] J. Short, D. Ketchen, C. Shook and R. Ireland, *The concept of "opportunity" in entrepreneurship research: Past accomplishments and future challenges*, J. Manag. **36** (2010), 40–65.

[22] A.L. Strauss and J. Corbin, *Basics of qualitative research: Techniques and procedures for developing grounded theory*, 2nd Ed., Sage, 1998.

[23] A.L. Strauss and J. Corbin, *Basics of qualitative research: Techniques and procedures for developing grounded theory*, Thousand Oaks, CA: Sage, 2008.

[24] R. Temkar, M. Gupte and S. Kalgaonkar, *Internet of things for sSmart classrooms*, Int. Res. J. Engin. Technol. **3** (2016), 204–207.

[25] D. Uckelmann, M. Harrison and F. Michahelles, *An architectural approach towards the future internet of things*, Architecting the Internet of Things, Springer Berlin Heidelberg, 2011.

[26] S. Zarrin, M. Alimohammadi and S.H. Siadat, *New aArchitecture of the Ffuture: An innovative model for business in the Ccontext of cloud computing and IoT integration*, Quart. Technol. Dev. **14** (2018), no. 54, 26–35.