Journal of Information Technology Management

Print ISSN: 2008-5893

Online ISSN: 2423-5059

IoT-Based Services in Banking Industry Using a Business Continuity Management Approach

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Abstract

Background: The Internet of things (IoT) is a new technology that expanding rapidly and has led to the emergence of new services in the banking industry. Although IoT is an emerging technology in Iran, it is expected to become a paradigm in the future. IoT applications in banking have helped to provide high quality and fast responses to customers anytime, anywhere.

Purpose: This research aims to identify and prioritize IoT applications in the Iranian banking industry based on business continuity indicators.

Methods: First, based on the comprehensive literature review and practical experiences, IoT applications in the banking industry are identified. Then, each indicator's weight was calculated using the Grey Decision-making trial and evaluation laboratory (DEMATEL). Finally, IoT-based applications in the Iranian banking industry have prioritized using the multi-attribute utility theory (MAUT). Due to the unstable economic conditions for the financial sector, business continuity indicators are employed in this study. Also, the reason for using MAUT is to consider the utility of banking experts for performing IoT banking services.

Findings: According to results, IoT-based services in the banking industry, including Transmit instant reports, smart ATMs, non-contact electronic payments, and electronic checks, are identified for Iranian banks. Then, These appropriate services are prioritized with the capabilities of Iranian banks.

Keywords: Internet of Things, Smart Banking, Business Continuity Management, DEMATEL, MAUT.

DOI: http:// 10.22059/JITM.2021.314908.2666 Document Type: Research Paper

Received: December 06, 2020 Accept: October 17, 2021

Introduction

To move from an efficiency-driven economy to an innovation-driven, it is very important to pay attention to new technologies (Vares et al., 2011). Industry 4.0 is a revolutionary concept that integrated smart technologies, IoT, and artificial intelligence to improve communications, business efficiency, and business smartness. Almost all business functions may be adapted to the internet of things and create new business opportunities. Industry 4.0 technologies open up new opportunities for businesses to collect, analyze, and utilize data to improve their efficiency and productivity. These innovative technologies help businesses by reducing defective products, time and cost. Industry 4.0 technologies have vastly been used to improve productivity and efficiency, which are employed in the production process and are used in services processes such as banking and accounting (Yilmaz & Hazar, 2019).

Successful organizations provide better customer service to achieve a competitive advantage (Safari, Abdollahi & Ghasemi, 2012). IoT is one of the newest and most accepted ideas that, if implemented, provide the basis for ideas, implement ideas, facilitate existing affairs, and change past ineffective ways (Jeschke et al., 2017; Dijkman et al., 2015).

In today's world, the IoT, a reasonably new technology, has become a popular topic for discussion (Zadtootaghaj, Mohammadian, Mahbanooei, & Ghasemi, 2019: 102). The Internet of Things is a driver for the sustainable development of countries (Zarei, Mohammadian, & Ghasemi, 2016). In the sustainability approach, economic, social and environmental dimensions are considered simultaneously (Talebzadehhosseini, 2015; Haghighi, Torabi & Ghasemi, 2016; Jamalian et al., 2018).

However, the implementation of the Internet of Things in Iran faces technical and regulatory and educational challenges that should not be ignored (Mohammadzadeh et al., 2018). Also, the effect of the macroeconomic environment, labour market and infrastructure on technology readiness should not be ignored (Rastegar, Mahbanooei, & Ghasemi, 2012; Jafarnejad, A., Ghasemi, R., Abdollahi, B., & Esmailzadeh, 2013; Ghasemi, Hashemi–Petroudi, Mahbanooei, &

Mousavi–Kiasari, 2013). The Internet of Things also empowers human resources (Venkatesh, 2017), and labor market efficiency leads to innovation (Ghasemi, Mahbanooei & Beigi, 2018).

However, The Internet of Things has moved on from its infancy and has provided innovative applications and services to businesses, individuals and governments. Which can not be ignored (Ghasemi, Mohaghar, Safari, & Akbari Jokar, 2016). So that it can affect the cooperative strategy of companies (Razavi, Abdi, Amirnequiee, & Ghasemi, 2016); and IoT affect their relationships with their suppliers (Botea, B., & Marinescu, 2017); So, better relationships with them lead to improved quality, reduced delivery time, increased flexibility and reduced costs (Mohaghar et al., 2011; Mohaghar & Ghasemi, 2011:a; Mohaghar & Ghasemi, 2011:b); and this contributes to the excellence of the organization (Zade, Safari, Abdollahi, & Ghasemi, 2011).

Many researchers have been done on IoT-based technologies application in various business. However, few studies study IoT technology impact on service-oriented business models (Marco Paiola, Heiko Gebauer, 2020). The Internet of Things has provided useful applications in a variety of industries, and the banking industry has been no exception (Khanboubi, F., Boulmakoul, A., & Tabaa, 2019; Zamani, Ghorchibeigi, Ghasemi, 2018).

The banking industry has experienced many significant changes that evolve its operations and actions in the last few decades. Nowadays, banks worldwide have effectively deployed smart technologies such as artificial intelligence, IoT, and Information and Communications Technology as strategic resources for improving speed, productivity, competitive advantage, decreasing costs (Boumlik & Bahaj, 2017; Lande, R. S., Meshram, S. A., & Deshmukh, 2018; Ammirato, Sofo, Felicetti & Raso, 2019:a).

This study is the first attempt to evaluating IoT applications in the Iranian banking industry. Since the banking industry is one of the essential pillars of the country's economy, and Iran's economic situation has special conditions and undergoes various changes in different periods, business continuity indicators were created. In other words, Due to the instability of economic conditions, business continuity management indicators are utilized as a guideline for the orientation of policymakers and managers of the banking industry.

Therefore, this study seeks to answer the following questions:

1. What are the most common IoT applications in banking?

2.What are the indicators of business continuity management to evaluate these applications?

3. What are the cause-and-effect relationships between IoT-influenced business continuity indicators?

4. What is the priority of IoT applications based on business continuity indicators in Iran?

For this research, first, by reviewing the literature, IoT applications were identified. Then, business continuity indicators were provided to banking experts and the most important ones were selected to evaluate IoT applications. Then, the cause-and-effect relationships of these indices were evaluated by the gray DEMATEL method and the weight of the indices was used. Finally, IoT applications in banking were prioritized based on business continuity indicators with the MAUT method.

Literature review

Internet of Things

The concept of the Internet of Things was coined by Kevin Ashton, a member of the Radio Frequency Identification (RFID) Society in 1999, and described a world in which everything, including inanimate objects, had a digital identity itself and allowed computers. Organize and manage them. However, in the short term, it has achieved great success. With mobile devices' growth, communication and computing and data analytics have become more and more popular. Since then, many thinkers on the term "Internet of Things" have come to refer to the general idea of objects, in particular, everyday objects that were readable, recognizable, locatable, addressable, and controllable via the internet regardless of type. Communications) via RFID, Wireless, WAN, etc. "Everyday objects are not just electronic devices that we face or technology-developed products such as vehicles and ... that we usually use we don't consider e.lectronics like food and clothing" (Perera, C., Zaslavsky, A., Christen, P., & Georgakopoulos, D. 2013).

The Internet of Things has received a great deal of attention from businesses and has led to the development of e-business

IoT applications have potential futures markets in the telecommunications services and industry (Vermesan & Friess, 2014). Vermesan et al., (2011) described IoT as an integral part of the future Internet with self-structuring capability. Atzori, Luigi, Iera, Antonio, Morabito, Giacomo (2010) defined IoT as an object-oriented technology comprising a set of wired and wireless devices and smart devices (Uckelmann, Harrison, & Michahelles, 2011), and in many cases, customer relationship management is facilitated through this information technology (Xiaocong, Q., & Jidong, 2010).

Also, IoT should be viewed as a new paradigm of network and physical and virtual communication with minimal human intervention, and they believe that this paradigm pursues two main goals: 1) connecting the physical world and virtual social networks with the creation of intelligent systems The main physical - Cyber socio-2) Smart Power stage of resource allocation to automatic operation (Wu et al., 2014; Zarei, Jamalian, Ghasemi, 2017).

In IoT, billions of smart objects are interconnected with each other such that these objects can take an independent decision concerning event detection and data transmission without human interventions (Rajanpreet Kaur Chahal, Neeraj Kumar, Shalini Batra, 2019).

You can connect physical objects to the internet, access remote sensor data, and control the physical world remotely. The Internet of Things is based on seeing the vision. IoT expressing what it can do beyond social meaning, empowerment and consultation (Atzori, L., Iera, A., & Morabito, 2010). The now-restricted emerging market in March 2010 and following the constraints available to you, you can quickly access and use your industry in November 2010 with Make use of your internet and international services and provide your position as a consultant (Chen, Xu, Liu, Hu, Wang, 2014). As a possible indication of Internet use and Internet use, you can use the refrigerator of the British and recreational valves. The sensors embedded in the refrigerator can use it to penalize the remainder of the milk through the penalties you can use. If so, you can be summarized using these resources. With these resources, summarize and present yourself more quickly and submit your proposals using financial plans and management. IoT expressing what it can do beyond social meaning, empowerment and consultation (Atzori, L., Iera, A., & Morabito, 2010).

The now-restricted emerging market in March 2010 and following the constraints available to you, you can quickly access and use your industry in November 2010 by Make use of your internet and international services and provide your position as a consultant. Iodine" (Chen, Xu, Liu, Hu, Wang, 2014). You can see now, you can find it by referring to the official on the internet and the jobs available between objects, services, and applications and is emerging" (Wu et al., 2014).

There are three main demand-side IoT options. First, camera networks are high-throughput IoT devices designed for in-store use. The second demand-side IoT option relies on customers and employees' smartphones to connect via a wireless network as a mobile payment method and (optionally) to track shopper paths during a store operation. The third option on the demand side is for customers to carry a smart card, in the form of a loyalty or credit card, scanned at the point of sale (PoS) or near an entrance to the store (Caro & Sadr, 2018).

The Internet of Things is composed of three layers. The first layer is the perception layer, the second layer is the network transmission layer, and the third layer is the application layer. The acquired data and related information can be intelligently processed and applied based on the first two layers. The Internet of Things is widely used in intelligent monitoring, smart grid, smart home, environmental monitoring, and other aspects (Ahmed Abbasi, Wang, Zhou, & Hassan, 2019).

RFID is a non-contact automatic identification system that automatically recognizes a target object through radio frequency wireless signals and realizes acquiring relevant data. The system mainly includes electronic tags, readers, and computer networks. The electronic tag comprises a chip and an antenna and mainly identifies the target object by attaching it to the object. The electronic tag has a unique electronic code for storing relevant information of the target object (Waseem Ahmed Abbasi, ZongrunWang, Yanju Zhou and Shahzad Hassan, 2019).

Building on the performance and strategic development, and onboard capital literature streams, we construe prior economic performance as a proxy of the firm's motivation and human and social board capital as proxies of the firm's ability, analyzing their effect on adding emerging digital technologies, such as Internet of Things solutions, to the firm's resource base (Ceipek, Hautz, Petruzzelli, De Massis, Matzler, 2020).

IoT devices exchange data with millions of other devices around the globe. Such type of open large-scale communication makes them especially inviting for users with illegal intentions. Only in 2017, there was a 600 percent increase in attacks against IoT devices. Due to its volatile nature, digital evidence has to be acquired and analyzed using validated tools and techniques that ensure the maintenance of the Chain of Custody (Stoyanova, Nikoloudakis, Panagiotakis, Pallis, & Markakis, 2020). The adoption of IoT technologies within enterprises needs an effective technology management approach to exploit all the benefits possible to improve process performance (Ammirato, Sofo, Felicetti & Raso, 2019:a).

Business continuity indicators

Business continuity management and risk management are very close concepts, and many see them as two distinct concepts, or at best as different aspects of a function. Some argue that risk management is, in fact, part of the broader concept of business continuity management. In the 5BS standard, business continuity management is a complement to the risk management framework. Although the views differ, there is an agreement that risk management responds to specific identified risks, while business continuity management develops methods to rank undetected risks **(**Blyth, 2009; Hiles, 2010; Herbane, 2010). Risk management seeks to manage risk around the essential products and services that an organization offers. However, the delivery of products and services can be hampered by a wide range of events that can be difficult to predict or analyze for a cause. Business continuity management identifies the products and services on which the organization's survival depends and identifies what is needed to continue fulfilling its obligations. Through business continuity management, the organization can identify what needs to be done before disasters to protect people, technology, information, supply chain, stakeholders and credit. With this recognition, the organization can then have a realistic view of the responses that will be needed when the disorder occurs. Therefore, it can be confident that it will manage any consequences without unacceptable delay in delivering products or services (BS) **(**Elliott, 2002, Hiles, 2010; Gibb, & Buchanan, 2006).

Therefore, a company that considers the risk of hurricane damage to the warehouse does risk management. When the company decides what to do if the warehouse goes out of business, it does business continuity management. When analyzing the bankruptcy risk of a key provider, it performs risk management, and the organization performs business continuity management, the organization that plans its actions to lose a provider. Any organization with acceptable business management practices may be able to take advantage of high-risk opportunities. It should be noted that the reason for the creation and utilization of business continuity indicators is the fissionable economic situation of Iran. Based on the literature available in business continuity management, it can be understood that this field examines strategies in times of crisis (Herbane, Elliott, & Swartz, 2004; Hiles, 2010; Estall, 2012; Tammineedi, 2010).

IoT in the Banking industry

There are bounded studies on IoT in the banking industry. Nevertheless, it could be observed more researches in this field in future's studies. The following Examples of IoT studies in banking are given (Khanboubi, Boulmakoul, & Tabaa, 2019). Classified digital trends consisted of Mobile banking, Crowd-based financing, M-banking, Big data and IT analytics, Cyber criminality, Virtual money, and High-frequency trading firm in banking to 2 groups and six classes. In the proposed card-less multi-banking Transaction ATM system replaces the traditional ATM system. It has advantages such as saves manufacturing cost of cards and overcomes drawbacks of the traditional system like carrying multiple cards, losing the card, losing PINs, remembering multiple PINs, fraud calls related to ATM cards, etc. (Jagtap.S, Shedji. G, Revanna. Sh & Shinde.K., 2018).

Denis, Kumar, Karthikeyan & Sasipriya (2020) considered the challenges of securing the passwords on the internet and shown some equivalent effort in this field and discussed how to secure OTP (One-touch multi-banking) passwords generated by the server. The advanced system reduced the difficulties of old PIN entry methods and introduced a new PIN-entry technique that has proposed security against the old method. This is feasible by successfully enlarging the part of memory

Methdology

All industries are looking for Providing useful, simple, and inexpensive services. IoT, as an expanding platform, has many ideas for Increasing productivity in various industries. The banking industry has infinite potential to use new technologies, but It has not been long since IoT entered banking.

Although there are many opportunities for banks to improve their services, approaching the considerable capacity of IoT needs some studies. The present study proposes a priority of IoT-based banking services concerning business continuity management. The steps of the study are summarized in Table 1:

Table 1. Steps of Research

steps	description
1	IoT-based banking services were identified from the modern banking industry and various worldwide references.
2	The Business continuity indicators were extracted from business continuity management literature regarding ISO 22301.
3	Business continuity indicators were weighted using two different processes. Firstly, four Banking Experts, Including Senior Managers, evaluated indicators Based on each indicator's Likert scale. Secondly, Ei=R-J (it was concluded in the DEMATEL method) shows the impact of the system's indicators.
4	The services offered in the Iranian banking industry were prioritized with the MAUT method.

In this study, by exploring IoT services in the banking industry, IoT applications were extracted. Also, indicators for evaluating services were listed. Bank experts were interviewed using the snowball method. Inappropriate indicators were eliminated, and suitable indicators were identified. Some bank experts evaluated indicators. The experts were selected for their experience of using technologies in the banking industry.

On the other hand, using the grey DEMATEL method, the relationship between indicators and the importance of the business continuity indicators was determined. Two methods were used to calculate the indicators' weights: the first was the average of the expert's evaluating scores, which was extracted in the interview form (pairwise matrix) based on the Likert spectrum. Second, the Ei parameter value for all factors, which shows the most effect on the whole system (system includes all other factors). The final weights were calculated related to the above two ways. In the next section, considering the different weights of the indicators and after completing the utility decision matrix, the nonlinear function parameters for each indicator were determined. After forming the function for each service, each service's total utility was calculated, and according to this rating, IoT services were prioritized in banking.

Grey DEMATEL Method

DEMATEL's technique was introduced in 1971. The technique was developed to identify and design models for complex economic, political, and social problems with a systematic approach. (Li, Hu, Zhang, & Deng, & Mahadevan 2014). This technique aims to structure information and identify the severity of the relationships between variables using numerical values and a map of causal relationships. In recent years, numerous applications have been made to this method (Deng, 1989). Deng first developed this concept and then developed it by other researchers (Orr, & McKenzie, 1992). Grey theory is an effective way to solve uncertainty problems using discrete data and incomplete information (Zhang, Wu & Olson, 2005). Grey system theory is used to solve uncertainty problems for discrete data and incomplete information (Fu, Zhu & Sarkis, 2012). In this study, the grey approach has been used in the DEMATEL method.

A grey number is a number whose exact value is unknown, but the interval that contains the value is known (Bai & Sarkis, 2013). Grey numbers are displayed in three forms: "from infinite to high", "from infinite to the bottom", and "from bottom to top":

$$G\in[\overline{a},\underline{a}],G\in(\infty,\overline{a}],G\in[\underline{a},\infty) \quad (1)$$

The fundamental difference between grey numbers and fuzzy numbers is that in grey numbers, an integer's exact value is unknown, but the interval it contains is determined (Bai, & Sarkis, 2013). In fuzzy numbers, while the number is defined in a range, the exact value of the left and right wings of the interval is unknown. Deng (1989) claims that grey numbers are more flexible and more comfortable than fuzzy numbers.

These numbers have been used in multiple criteria decision making (Wang, Qi, Chen, Tang, & Jiang, 2014). The implementation steps of this technique are as follows (Chang, Chang, & Wu, 2011; Zhou, Huang, & Zhang, 2011, Hsu, 2012):

Step 1: Factors affecting the system are extracted using methods such as brainstorming, library studies, writing, Delphi, etc.

Step 2: Concerning the experts' opinions, the matrix of influence of the members is obtained. This matrix is as follows where Zij denotes the intensity of factor I over factor j. Each member of this matrix is equal to the average of expert opinions.

$$Z=\begin{bmatrix} z_{11} & z_{12} & \cdots & z_{1n} \\ z_{21} & z_{22} & \cdots & z_{1n} \\ \vdots & \vdots & \ddots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ z_{m1} & z_{m2} & \cdots & z_{mn} \end{bmatrix} \quad (2)$$

Step 3: According to experts, matrix values that are less than a certain amount will be eliminated (considered zero).

Step 4: The sum of the matrix layers' rows is calculated, and the maximum is selected and multiplied by the inverse of the matrix layers.

Step 5: The infinite sequence set of direct and indirect effects (together with all possible feedback) is calculated from the following formula.

$$S=M+M^2+\ldots+M^t=\frac{M(I-M^t)}{I-M}=M(I-M)^{-1}$$

$$\lim_{t\to\infty}M^t=0 \quad (3)$$

The S-matrix represents the intensity of the relative effect of the direct and indirect relationships in the system.

Step 6: Ri is the sum of the rows I of the matrix S and denotes the intensity of the total factor I on the system, and Ji equals the sum of the j matrix S column and denotes the magnitude of the total factor i of the system. R + J represents the superiority vector for each component of the system and its operating weight in the system and represents the sum of the operating system's effectiveness and effectiveness in question. R-J Determines the final amount of effect an agent will have. If this value is positive, the "effective" factor is identified and cited as the "cause". Otherwise, the "effective" factor is identified and referred to as the "disabled".

Step 7: Draw a Cartesian coordinate machine and consider "R + J, R-J" for each coordinate agent.

Multi-attribute utility theory

Customer satisfaction with the consumption of goods and services given to the consumer is called "utility" (Mehregan, 2008). To maximize the expected utility, the utility of a target or an indicator indicates the highest degree of satisfaction with that target with the decision-maker indicator (Asgharpour, 2007).

The utility theory was first proposed by (Neumann, Morgenstern, 1947). Three decades later, they restored utility theory by extensive work on mathematical modelling of value theory, one-dimensional utility, and multi-attribute utility. Their efforts are the essential work done in quantifying utility values to express the decision-maker preferred structure.

In general, the calculation of utility in multi-attribute utility theory can be summarized as follows:

- Problem description and purpose of decision-making need to be implemented along with the relative importance of services to Iranian banks' potential.
- Determining the form of the utility function and the conditions of independence.
- Evaluation and calculation of conditional utility functions.
- Evaluation and calculation of scaling coefficients.
- Evaluate and calculate the final utility for each decision-maker.
- Evaluating and calculating group utility (Dyer, 2005; Dyer, 2016; Alinezhad & Khalili, 2019; Farmer, 1987).

Utility functions can be used as a basis for describing a decision maker's views on risk (Georgy, Chang, & Zhang, 2005). People's attitude to risk is deduced from their utility function (Barry, 1987). Risk is applied to both the uncertainty of the consequences of a specified future action and the concept of risk.

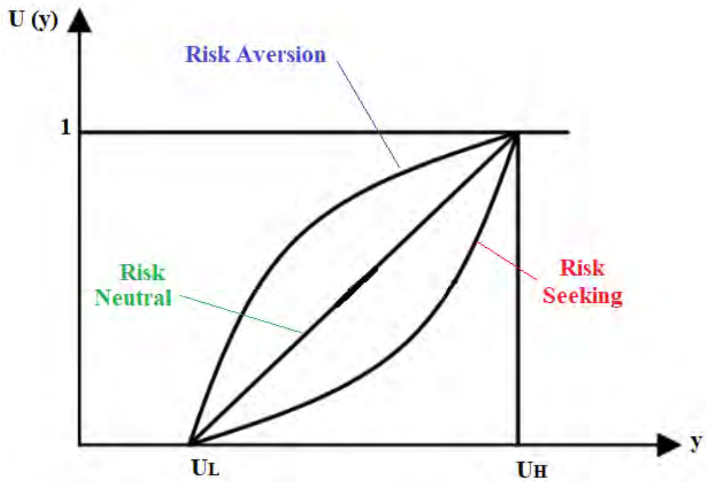

Figure 1. Risk utility function (adopted: Georgy, M.E., Chang, L.M. and Zhang, L., 2005).

Figure 1 illustrates the utility function based on the type of decision-maker risk perspective. The risk perspective is divided into three categories: risk-averse, risk-averse, and neutral risk and each of the functions based on the three above approaches has its form (Georgy, Chang, & Zhang, 2005). All of the above utility functions show that the utility must also increase as the preference or decision maker's preference increases. This reflects the basic assumption of utility theory that utility or preference increases. Therefore, results with more downloads are preferred over other results. In general, the utility function for money can be used as a basis for explaining one's views on risk

Results

Based on related literature on business continuity management, six indicators and 24 indicators are identified. Six general indicators related to business continuity management, specifically ISO 22301, are extracted. Also, Based on a comprehensive literature review, 100 sub-indicators are identified, and most related ones are selected. Twenty-four selected sub-indicators are categorized into six leading indicators that resulted in table 2.

Table 2. Primary list of Indicators for analysing and prioritizing the IoT banking services (adopted: IOS, 2015)

indicators	Sub-Indicators
Costs and Resources	1. Equipment costs
	2. Launch time
	3. Setup cost
	4. Human resources training
	5. required human resources
Match strategic goals	6. customer cost reduction
	7. customer's time saving
	8. coordinating cost
	9. after-sales service
Help to stabilize	10. Length of service

	11. regulatory time delays
	12. regulatory costs
Performance	13. potential customers
	14. domestic potential customers
	15. service profit
	16. brand image promotion
	17. innovations
Feedback	18. The number of outputs
	19. responsivity
Continuous improvement	20. investment
	21. Quality Improvement
	22. Employee capabilities
	23. operating expenses
	24. employee learning

Five experts in the banking industry are evaluated sub-indicators using the snowball method based on the Likert scale. The sub-indicators with a low score (less than cutpoint) are eliminated, and the final sub-indicators are selected, as shown in table 3.

Table 3 Final Indicators for choosing IOT Bank Services

Symbol	Indicator
C1	equipment cost
C2	Launch time
C3	required human resources
C4	customer cost reduction
C5	customer's time saving
C6	coordinating cost
C7	regulatory time delays
C8	potential customers
C9	service profit
C10	brand image promotion
C11	responsivity
C12	Quality Improvement

Based on literature and pioneer banks experiences in IoT services, five IoT-based banking applications are extracted, presented in table 4. Due to the IoT platform properties, thousands of other ideas can be added to the list in future studies.

Table 4. Internet of Things Bank Services (Alternatives)

Alternative(s)	IOT Banking Services	References
A1	Use in bank headquarters to track, transmit instant reports, and provide more security for money machines	Giripunje, Sudke, Wadkar & Ambure (2017); M.Padmavathi, 2017; Kumar, (2019); Del Giudice, Campanella, & Dezi (2016); Ammirato, Sofo, Felicetti, & Raso (2019:a); Ammirato, Sofo, Felicetti, & Raso (2019:b); (Khanboubi, Boulmakoul, & Tabaa, 2019); Chen, Liang, & Zhang (2021)
A2	Use in Bank Branches to identify customers, diverse and useful information to tailor customer service (identify, message service advice and improve customer service in the branches)	
A3	Provide a safe and secure environment for issuing electronic checks and cashing checks without the need to attend branches	
A4	Creating the necessary platforms for diverse non-contact electronic payments such as electronic payment without credit cards	
A5	Applications related to smart ATMs and their ease of use include reporting the nearest ATM and using ATMs with a defined digital identity for easy and fast service	

Also, each of the applications is described as follow:

- **A1** indicates machines equipped with IoT devices and sensors to monitor the machines' geographical and physical information dynamically and instantly. These devices also benefit headquarters to track, transfer instant reports, and save money.
- **A2** represents a capability to identify detailed data of customers' services in bank branches. Banks could use these data to analyze and evaluate customers behaviour to provide appropriate customized services based on each customer's needs. Customers' demanding services can be collected from various sources such as banks, websites, apps, and in-person services.
- **A3** describes specific circumstances for monitoring electronic checks and transactions.
- **A4** indicates established platforms for non-contact electronic payments such as Electronic Payments without Credit Cards.
- **A5** represents smart ATMs' IoT applications, including reporting the nearest ATM and ATMs defined digital Identification.

Descussion

The use of research methods in operations, including multi-criteria decision making, is effective in improving the productivity of managers' decisions (Amoli, Talebzadehhosseini, & Salehi, 2012). DEMATEL is a valuable managerial tool to evaluate indicators in a dilemma, and a popular MADM method that extended form of it, integrated with grey logic, have been used in many studies. For example, Hsu (2012), in a research paper, evaluated criteria related to the web-designing field using Grey-DEMATEL.

(Fu, Zhu & Sarkis, 2012) analyzed criteria in the context of green supplier selection problem using integrated Grey and DEMATEL model in the telecommunication industry.

The paired matrix shows the relationship between the indicators in pairs. This matrix has been filled by four banking experts, including top managers of the Iranian banking industry, using the snowball method. Each of the experts comprised factors that affect overall each other to form an initial paired matrix using a qualitative spectrum (VH: Very High, H: High, L: Low, VL: Very Low, N: Non-effective, as shown in Table 5).

Table 5. Linguistic greyscales for the importance weight of evaluators.

Efficacy	Very High	High	Low	Very Low	Non-effective
Mathematical symbol	VH	H	L	VL	N
Grey numbers	[0.75, 1]	[0.5, 0.75]	[0.25, 0.5]	[0, 0.25]	[0, 0]

One of the experts' preferences towards the effect of the factors on each other has presented in table 6.

Table 6. Early Grey Paired Matrix of a Banking Expert (Example)

Z matrix	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}
C_1	-	VL	L	VL	VL	N	VL	L	VH	L	N	VL
C_2	VL	-	H	H	H	L	VH	VL	L	H	VL	VL
C_3	N	L	-	VL	VL	H	VL	L	VH	N	H	H
C_4	H	VL	N	-	VL	VL	N	VH	VL	H	VH	H
C_5	N	L	N	H	-	VL	N	H	L	H	VH	VL
C_6	VL	VH	VH	H	H	-	VL	L	VH	VL	VL	VL
C_7	L	VH	VL	VL	H	VL	-	N	VL	VL	VL	VL
C_8	N	VL	VL	VH	VH	VL	N	-	H	VH	H	N
C_9	VH	L	VH	L	L	VH	H	H	-	H	H	H
C_{10}	H	H	L	L	L	N	H	VH	VH	-	VH	H
C_{11}	N	VL	H	VH	VH	N	H	VH	H	VH	-	VH
C_{12}	VL	VL	L	L	L	L	VL	VH	H	VH	H	-

Linguistic terms are converted into quntitive grey values (VH: [0.75, 1], H: [0.5, 0.75], L: [0.25, 0.5], VL: [0, 0.25], N: [0, 0]). Linear Normalazation method have used to forming normalized decision matrix. According to following fourmola, the final matrix (matrix T) are calculated as shown in table 7.

$$\text{Matrix T} = \text{Matrix N} * (\text{Matrix I} - \text{Matrix N})^{-1} \quad (4)$$

Table 7. General T-matrix assuming the same weight of expert opinion

T matrix	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	Ri
C_1	0.0828	0.1236	0.1864	0.1588	0.1840	0.1201	0.1669	0.2178	0.3061	0.2506	0.1892	0.1460	2.1321
C_2	0.1163	0.1497	0.2009	0.2322	0.2428	0.1750	0.2898	0.2174	0.2223	0.2709	0.2266	0.1928	2.5367
C_3	0.1199	0.2099	0.1818	0.2400	0.2139	0.2780	0.2014	0.2566	0.3235	0.2518	0.2968	0.2404	2.8139
C_4	0.1756	0.1838	0.2176	0.1981	0.2382	0.1921	0.1780	0.3539	0.2836	0.3975	0.2910	0.2594	2.9689
C_5	0.1121	0.1744	0.1819	0.2871	0.2049	0.1576	0.1871	0.3676	0.2908	0.3803	0.3256	0.1939	2.8631
C_6	0.1129	0.2975	0.2939	0.2559	0.2365	0.1605	0.2108	0.2525	0.3372	0.2528	0.2259	0.2131	2.8494
C_7	0.1058	0.2379	0.1662	0.1326	0.2033	0.1357	0.1218	0.1500	0.1809	0.1823	0.1563	0.1772	1.9498
C_8	0.1333	0.1943	0.2077	0.3150	0.3331	0.1582	0.1807	0.2538	0.3344	0.3882	0.2991	0.1973	2.9952
C_9	0.2244	0.2593	0.3995	0.3136	0.3670	0.3585	0.3388	0.4241	0.3582	0.4044	0.3840	0.3679	4.1998
C_{10}	0.2174	0.3436	0.3711	0.2931	0.3463	0.2398	0.3791	0.4082	0.4703	0.3436	0.3957	0.3597	4.1680
C_{11}	0.1851	0.2548	0.3200	0.4362	0.4075	0.2235	0.3318	0.5019	0.4699	0.4810	0.3160	0.3811	4.3087
C_{12}	0.2051	0.2587	0.2693	0.3005	0.2738	0.2693	0.2637	0.3792	0.4677	0.4597	0.3284	0.2365	3.7119
Dj	1.7907	2.9652	3.4345	4.0631	4.0449	3.7829	2.8499	2.4684	3.2512	3.1631	2.9962	2.6873	-

The sum of the row (Ri) and the sum of the column (Dj) values was calculated for each criterion, which is presented in matrix T where Ri represent the direct and indirect effect of factor I on other factors and Dj indicate the direct and indirect effect of all factors on the factor j.

P is calculated by the sum of R and D values, which indicates the factor I effects on the elements of the system:

$$P_i = R_i + D_j \quad D_j \tag{5}$$

E is calculated by subtraction the factor R and D values, which represents the factor I effects on all system elements. E equitation is presented as follow:

$$E_i = R_i - D_j \tag{6}$$

The value of P1 (the effect of the first factor on the system's elements) is calculated as **P1=R1 +D1** and is equivalent to **3.9228**. Also, the value of E1 (the final value of the first factor's effect on the elements of the system) is calculated as **P1=R1-D1** and is equal to **0.3414**.

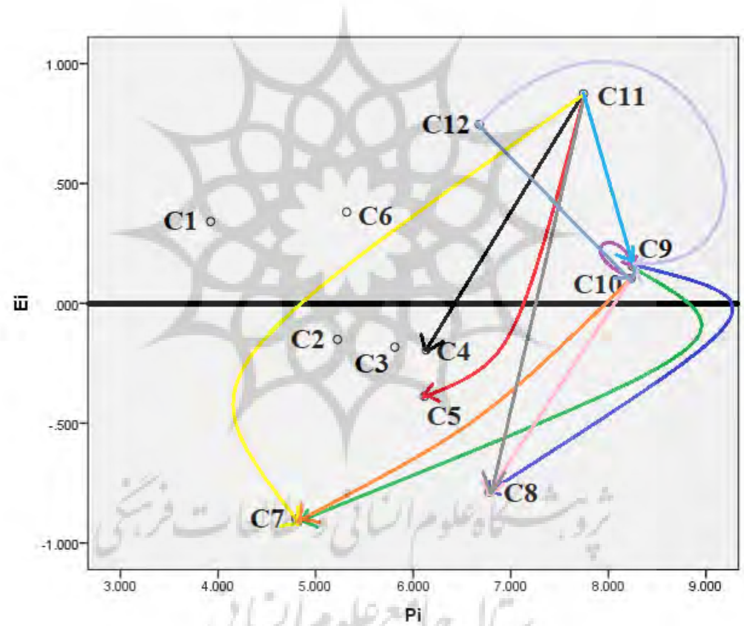

Figure 2. Causal Relationship Diagram of Business Continuity Indicators in Selecting IoT-based Banking Services

As shown in Figure 2, a diagram for Indicators of the issue is drawn for the more straightforward and more comprehensible graph. Here tried to use of the mean and variance of the numbers within the Table (mean plus three standard deviations considered) is an appropriate estimate, and the significant causal relationships are plotted in Figure 2).

If the value of Ei is more significant than zero, the indicator is influencing other factors. If the value of Ei is less than zero, indicator I am a dependent factor and not affecting other factors. Also, factor Ei which is the result of grey DEMATEL was used for weighting the indicators.

There are two forms of functions that use in utility theory, including linear and nonlinear functions. The former one presents risk-neutral 31ehavior, and nonlinear functions show risk-averse and risk-seek managers. In this study, the nonlinear function in the context of utility theory is used and formulated as follow:

$$U(X) = a + b.\, e^{(-cx)} \quad (7)$$

e=2.71828…. (Euler's number)

Experts interview forms and available documents in Iranian Banks are considered for Quantification selected indicators. These twelve indicators values are shown in Table 8.

Table 8. Values and levels assigned to the selected indicators

Attributes (nature)	C1 (+)	C2 (-)	C3 (-)	C4 (+)	C5 (+)	C6 (+)	C7 (-)	C8 (+)	C9 (+)	C10 (+)	C1 1 (+)	C12 (+)
Unit of measure ment	Milli on Rial	Da y	Pers on	Percent age	Percent age	Percent age	Da y	Per 1000 Pers on	Milli on rial	Percent age	Da y	Percent age
A1	200	12 0	20	3	1	8	60	800	50	4	1	2
A2	400	60	30	15	35	10	30	1000	100	10	6	15
A3	3000	15 0	40	10	30	10	24 0	1500 0	400	65	10	20
A4	1000	21 0	30	20	55	28	45	5000	150	15	12	45
A5	500	30	15	12	45	4	2	3000	65	10	20	15

The decision-makers evaluate the impact of each other's criteria using pairwise comparisons, just like the 1st step, subsequently, the weight of indicators is calculated as shown in Table 9.

Table 9. Weight of indicators according to experts

Attribut es (nature)	C1 (+)	C2 (-)	C3 (-)	C4 (+)	C5 (+)	C6 (+)	C7 (-)	C8 (+)	C9 (+)	C10 (+)	C11 (+)	C12 (+)
Weights	1.362 %	3.270 %	4.087 %	9.537 %	8.174 %	5.450 %	2.180 %	12.262 %	16.349 %	14.986 %	13.624 %	8.719 %

In this section, Due to the defined utility function, indicators' coefficients values are determined. Parameters a and b show upper and lower limits of indicators and parameter c demonstrates the interval's utility coefficients average.

Table 10. Parameters (a, b and c)

parameters	C1 (+)	C2 (-)	C3 (-)	C4 (+)	C5 (+)	C6 (+)	C7 (-)	C8 (+)	C9 (+)	C10 (+)	C11 (+)	C12 (+)
a	0.07	0.14	0.38	0.15	0.02	0.14	0.01	0.05	0.13	0.06	0.05	0.04
b	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
(-c)	-0.4	-0.5	-0.6	-0.4	-0.6	-0.5	-0.4	-0.5	-0.5	-0.4	-0.6	-0.5

The formulated table of the nonlinear function is calculated concerning coefficients as in table 11.

Table 11. Determine the utility of each service in each indicator

Applications	C1 (+)	C2 (-)	C3 (-)	C4 (+)	C5 (+)	C6 (+)	C7 (-)	C8 (+)	C9 (+)	C10 (+)	C11 (+)	C12 (+)
A1	0.7370	1.0254	1.0126	1.0777	1.0073	1.0097	0.9951	1.0270	1.0644	1.0312	1.0204	1.0225
A2	0.8854	0.9217	1.1158	0.8373	0.7008	0.9793	0.9820	1.0205	1.0075	0.9875	0.8853	0.8909
A3	1.0404	1.0477	1.1735	0.9288	0.7391	0.9793	1.0050	0.6599	0.7315	0.6681	0.7908	0.8452
A4	0.9898	1.0739	1.1158	0.7565	0.5670	0.7494	0.9907	0.8998	0.9540	0.9526	0.7477	0.6510
A5	0.9188	0.7494	0.9238	0.8908	0.6303	1.0739	0.6787	0.9582	1.0470	0.9875	0.5988	0.8909

At the right side of table 12, a column is calculated for services scores according to utility level.

Table 12. Determine the weighted utility of each service based on each indicator

Applications	C1 (+)	C2 (-)	C3 (-)	C4 (+)	C5 (+)	C6 (+)	C7 (-)	C8 (+)	C9 (+)	C10 (+)	C11 (+)	C12 (+)	score of services	Services Utilities
A1	0.01	0.0335	0.0414	0.1028	0.0823	0.055	0.0217	0.1259	0.174	0.1545	0.1390	0.0892	1.0295	22.92%
A2	0.0121	0.0301	0.0456	0.0799	0.0573	0.0534	0.0214	0.1251	0.1647	0.1480	0.1206	0.0777	0.9358	20.84%
A3	0.0142	0.0343	0.0480	0.0886	0.0604	0.0534	0.0219	0.0809	0.1196	0.1001	0.1077	0.0737	0.8027	17.87%
A4	0.0135	0.0351	0.0456	0.0721	0.0463	0.0408	0.0216	0.1103	0.1560	0.1428	0.1019	0.0568	0.8428	18.77%
A5	0.0125	0.0245	0.0378	0.085	0.0515	0.0585	0.0148	0.1175	0.1712	0.148	0.0816	0.0777	0.8805	19.60%
												Sum	4.4913	100%

At the end of the MAUT procedure and after prioritizing the services based on the higher scores of IoT-based banking services in Table 13, it was proposed to be integrated into the Banks for the first time in Iran. At the end of the MAUT procedure and after prioritizing the services based on the higher scores of IoT-based banking services in Table 13, it was proposed to be integrated into the Banks for the first time in Iran.

Table 13. Prioritize IoT-based banking services at Iranian Banks with MAUT

Priority	Applications	Services Utilities	IoT-based banking services in order of priority
1	A1	22.92%	Use in bank headquarters to track, transmit instant reports, and provide more security for money machines
2	A2	20.84%	Use in Bank Branches to identify customers, diverse and useful information to tailor customer service (identify, message service advice and improve customer service in the branches)
3	A5	19.60%	Applications related to smart ATMs and their ease of use include reporting the nearest ATM and using ATMs with a defined digital identity for easy and fast service.
4	A4	18.77%	Creating the necessary platforms for diverse non-contact electronic payments such as electronic payment without credit cards
5	A3	17.87%	Provide a safe and secure environment for issuing electronic checks and cashing checks without the need to attend branches

Conclusion

Increasing countries' technological readiness leads to promoting their innovation & business sophistication (Razavi et al., 2011; Razavi et al., 2012). This study's findings show that the Iranian banking industry has some opportunities in terms of business continuity management. New technologies could help the banking industry improve its efficiency and bring prosperity to the economy. This study has investigated IoT-based banking services in the Iranian banking industry. In this regard, a nonlinear utility function has been used for prioritizing IoT-based banking services. Multi-attribute utility theory (MAUT) has been employed to evaluate IoT applications in the Iranian banking industry in business continuity management. Although this study has practical and academic contributions for banking industry managers and researchers, we identified some limitations to this approach. Due to the novelty of IoT-based banking applications in developing countries, such as Iran, few experts are familiar with both banking and IoT fields. This situation limited the data-gathering phase with the lack of adequate experts. It is suggested in future research to identify the implementation requirements of IoT services in the banking industry.

Conflict of interest

The authors declare no potential conflict of interest regarding the publication of this work. In addition, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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Bibliographic information of this paper for citing:

Mohaghar, A., Sadeghi Moghadam, M. R., Ghourchi Beigi, R. & Ghasemi, R., (2021). IoT-Based Services in Banking Industry Using a Business Continuity Management Approach. *Journal of Information Technology Management*, 13(4), 16-38.