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Research Paper

Prioritizing policy tools to support development of IoT technologies in Iran

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ABSTRACT

The Internet of Things is a new perspective on the information technology industry that encompasses all technical, social and economic concepts. Identifying priority application areas for this technology is one of the key points for its effective use. Governments also have a variety of tools for policy-making to support the development of this technology. Therefore, knowing which tool has a higher priority for support is a very important point that can not only prevent the loss of resources but also improve the speed of development. In this research, using the opinion of experts and using the TOPSIS method, an attempt has been made to identify the priority of IoT application areas as well as the priority of government support policy tools in these areas. The results of this research have shown that the important areas in this field respectively are Smart cities, Factories and industries, Shipping, Healthcare, Supply chain management, Buildings and houses and finally Agriculture and animal husbandry. Also Government policy tools respectively, in order of priority, are Financial and Investment Incentives, Flexible regulatory, Tax Exemption, Deploying IOT applications in E-government, Standards and Accreditation, Technology Infrastructure, Macro Policies, Application Infrastructure, Cybersecurity Regulation, Privacy Regulation.

1. Introduction

The Internet of Things has a high potential to change the way we interact with our surroundings. The ability to monitor and manage objects in the physical world electronically can transform data-driven decision-making into new areas of human activity, optimizing the performance of systems and processes, saving time for individuals and businesses, and improving the quality of life (Schianchi, 2023) (Vermesan et al., 2014). IoT-based sensors can help companies in areas such as factory-level machine monitoring or even tracking the progress of ships at sea, to go beyond their physical capital and extend machine performance and their

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life, and even learn to redesign them to achieve a higher level of efficiency and effectiveness (Bayanati, 2023a).

The concept of the Internet of Things was first used by Kevin Ashton in 1999 at Procter & Gamble to describe a world in which everything, including inanimate objects, has a digital identity of its own and computers are allowed to organize and manage them. The idea of the Internet of Things was a link between the new RFID technology and the hot topic of the Internet in the company's supply chain, which caught the attention of executives (Suresh et al., 2014). Later, the MIT Auto-ID Center presented its IoT Outlook in 2001, and then the International Telecommunication Union officially introduced the technology in 2005 in a report.

The Internet of Things is a new perspective on the information technology industry that encompasses all technical, social and economic concepts. In this view, products, consumer goods, cars and trucks, industrial and industrial equipment (electricity, telephone, etc.), sensors and other components; With Internet connections as well as powerful analytical capabilities of data are combined to transform the way we work and live (Ghahremani-Nahr et al., 2022).

IoT projects have had a significant impact on the Internet and the economy, as forecasts showing that by 2025 there will be around 100 billion IoT-connected objects, which will have more than $ 11 trillion impact on the world economy. The growth of IoT usage is such that Microsoft, in one of its latest market analysis, stated that by the end of 2021, more than 94% of US businesses will use IoT, and Currently 84% of businesses have planned to use the Internet of Things (Iran-IoT-Research-Center, 2020).

According to the Iranian Digital Economy Database (2020), the registration of IoT patents in the world is in the third place among digital technologies, after cloud computing and artificial intelligence, with a share of about 14% (Iran-Digital-Economy-Database, 2020). This technology has always been one of the most important technologies in the digital field since 2010. With the entry of cloud computing technology in the ranking of the best technologies in the digital field in 2015, the Internet of Things, cloud computing and artificial intelligence as complementary technologies have always been among the top three technologies in the ranking of the best digital technologies in terms of Have been patent registration (M. Mousakhani et al., 2020) (Ghahremani nahr et al., 2021a) (Sabet, 2021).

But the Internet of Things is a complex phenomenon that is formed at different levels of different fields of technology. It also has a variety of applications in various fields (fallah et al., 2021). Harnesing IoT technology is one of the signs of economic development and growth in countries (Aliahmadi et al., 2022a). Given the importance of this technology and the global trend towards it, the need for government support for the development of the Internet of Things is quite obvious. Also, like other technologies, it is not possible to enter all levels of technology and applications available for the Internet of Things, due to limited government resources and facilities. So it seems to identify priority areas of IoT application as well as the most effective government policy tools to support this technological field. This is a significant topic that will be addressed in this article.

Given the above, the key questions that this paper tries to answer are:

- What is the prioritization of IoT applications in Iran?
- What is the prioritization of policy tools to support the development of IoT-related technologies?

2. Related Work

2-1. IoT Definition

According to the IERC definition, the Internet of Things (IoT) is a dynamic worldwide network infrastructure with self-configuring functionality based on standard and integrated communication protocols in which physical and virtual "items" have characters, physical features, and virtual personalities, use smart interfaces, and are seamlessly integrated into the information network (IERC, 2013). The Internet of Things may be defined as a collection of interconnected gadgets that can be detected using existing Near Field Communication (NFC) technologies (ETSI, 2013) (Ghahremani Nahr et al., 2021b). The main notion behind this concept is the pervasiveness of all types of things or items around us that may communicate with each other through unique addressing systems, such as radio frequency identification (RFID) tags, sensors, actuators, mobile phones, and so on. To attain mutual goals, they must work together and with their neighbors (Giusto et al., 2010) (Nozari, Ghahremani-Nahr, et al., 2022). The terms "Internet" and "Things" refer to a global network that is interconnected and based on sensory, communication, networking, and information processing technologies, and might represent the next generation of information and communications technology (ICT) (Li et al., 2015) (Bayanati, 2023b).

In “Fig. 1”, the main concepts, technologies, and standards are highlighted and categorized with reference to the IoT perspectives that are best identified. From such a picture, it is clear that the IoT pattern is the result of the convergence of the three main insights (Atzori et al., 2010).

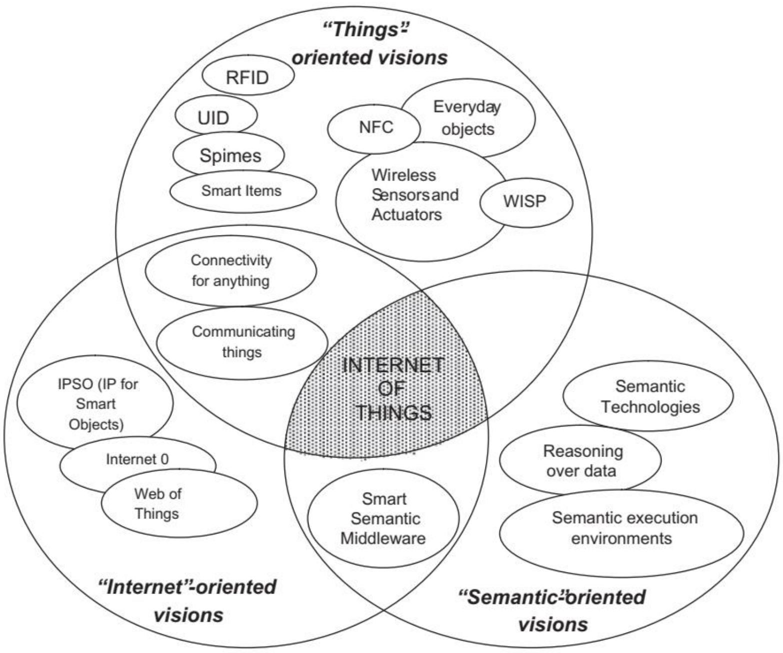

Figure 1. The "Internet of Things" paradigm

2-2. IoT Architecture

The use of the Internet of Things, like other technological phenomena, requires the use of various technologies. This part of the article tries to provide a brief explanation of the key technologies that are involved in the development and use of the Internet of Things. The International Telecommunication Union (ITU), one of the world's leading communications authorities, has designed the IoT architecture. This architecture has four layers of application, support, network and device, which, with the help of management and security capabilities, realizes IoT applications such as smart city, smart transportation, smart building, smart energy, smart industry, smart health and smart life (Iran-IoT-Research-Center, 2020). Also, Atzori (2010) classifies the technologies involved in the Internet of Things into two levels: Basic technologies including Identification, sensing and communication technologies, and Middleware (Atzori et al., 2010).

Basic technologies are mainly based on sensors and telecommunication communication networks. But the middleware consists of a 5-layer architecture, which are: 1- Security and privacy management, 2- Object abstraction, 3- Service management, 4- Service composition, 5- Applications (Atzori et al., 2010). Voas (2016) considers the IoT architecture to consist of 5 layers, which are the Sensor, Aggregator, Communication Channel, External Utility, Decision Trigger. Table 1 shows the definitions and functions of each of these layers (Voas, 2016).

Table 1- IoT architecture

layer	Function	Definition
Sensor	receiving information	An electronic instrument that measures physical properties
Aggregator	Computing	Software that converts raw data into compact data
Communication Channel	communicate	Communication intermediaries
External Utility	Computing	Software or hardware that processes or stores data on the network
Decision Trigger	Setup	Creates the final results needed to meet the purpose, specifications and requirements of the network

2-3. IoT Applications

Due to the nature of IoT technology, many applications can be expected. Most of these applications are based on changing the current living and environmental conditions. This means that some of these are new to us and some are not. Activities and events that are currently normal in people's daily lives can be directed and performed quite intelligently with the help of the IoT. Given the potential of this technology, various researchers have proposed a variety of applications, some of which are common and some of which are not. The point is that a number of applications have been realized so far and some are in the early stages of design and have not yet been commercialized.

Capital management, factory automation, smart grids, office automation, and smart cities are the five areas that Holler separates IoT applications under (Höller et al., 2014). Bandyopadhyay and Sen (2011) also stated that in the future, IoT will be used to create many applications for more intelligent homes and offices, transportation systems, healthcare facilities, organizations, and factories, and they divided IoT applications into fifteen categories: space systems and aircraft industry, automotive sector, telecom sector, medical and healthcare industry, independent living, pharmaceutics, banking, logistics and supply chain management, manufacturing industry, Process Industries, Environmental Monitoring, Transportation Industries, Agriculture and Breeding Industries, Media, Entertainment Industries, Insurance Industries, and Recycling Industries (Bandyopadhyay & Sen, 2011). In 2015, the McKinsey Global Institute listed the environments in which the Internet of Things will be impacted. Accordingly, 9 work environments of this technology have been identified, which are explained in the table 2 (McKinsey-Global-Institute, 2015).

Table 2 – IoT work environments

Situation	Sample
Human	Devices for human health control, disease treatment, and fitness enhancement
Location	Devices for home control and security;
Business environments	Shops, banks and restaurants;
Office environments	Improved energy and security management in office; enhancing Productivity;
Service environments	Operational productivity, equipment usage, and inventory optimization are all important factors in places with repeated work patterns, such as hospitals and farms.
Operating environments	Construction, mining, and oil and gas; Health and safety, as well as operational efficiency
Vehicles	Maintenance, performance analysis, and use-based design
Urban environments	In urban regions, public spaces and infrastructure; Smart order, environmental monitoring, and resource management are some of the terms used to describe adaptive traffic control.
Outdoor environment	Routes for trains, self-propelled vehicles (outside of cities), and aircraft direction; Routing supplies in a timely manner

In this regard, we listed 7 main uses of the IoT, which are smart buildings, smart transportation, IoT-based agriculture and animal husbandry, smart industries, medical technology and health, smart cities as well as the Internet of Things supply chain (fallah et al., 2021) (Aliahmadi et al., 2022c) (Rahmaty, 2023) (Sadeghi, 2022) (Nozari & Ghahremani Nahr, 2022) (Wang & bayanati, 2023) (Aliahmadi et al., 2022b) (Sadeghi & Jafari, 2021) (Kian, 2022) (Nozari, Sadeghi, & Najafi, 2022) (Uver, 2023).

Table 3-The main areas of IoT application

IoT application context	Application examples
Buildings and houses	• Control of smart devices; • Home control and security; • Intelligent maintenance systems; • intelligent heating and cooling systems and ventilation; • Control and monitoring of energy consumption (water, electricity, gas);
Shipping	• Intelligence of the transport fleet; • Intelligent traffic control systems; • Intelligent road maintenance systems (land, air and sea); • Intelligent parking systems;
Agriculture and animal husbandry	• Application of sensors and detectors in farms, pastures, crops and livestock; • Automation of ordering, delivery and payment processes (elimination of intermediaries);
Factories and industries	• Upgrading and growth in the sectors of production, warehousing, quality control of equipment and products, safety, maintenance and repair, sales and support;
Healthcare	• Improving the quality of life of patients; • Reducing hospitalization and hospitalization costs, increasing patients' independence; • Hospital equipment tracking; • Exercising control and monitoring of treatment and care processes; • Increase the safety and security of hospital centers;
Smart cities	• Optimizing the use of urban physical infrastructure (such as road networks, power grids, etc.); • Advanced traffic control systems; • Traffic monitoring in cities and highways; • Intelligent parking system based on sensor technology and RFID; • Identify the level of air pollution and available chemical gases; • Detect violations and transfer data related to law enforcement agencies;
Supply chain management	• Data management • Track and track orders • Transportation and movement of goods • Analysis and forecasting of competitive markets • Production automation

3. Policy tools to support IoT development

Technological transformation constantly creates new challenges and opportunities. These opportunities must be evaluated through effective and dynamic technology management (Golmohammadi & Kazerooni, 2021). Developing high technologies need special policy framework and tools (Mohammad Mousakhani et al., 2020). In this article, the study of countries' experiences was used to identify policy tools and government support for the development of the Internet of Things. Referring to the applications of technology in the IoT Research Center of Iran (2020), different countries, according to the needs of the market and their industrial approach, each have targeted specific areas of IoT application (Iran-IoT-Research-Center, 2020). In the table below, the intended applications of the study samples are collected.

Table 4- IoT application areas in leading countries (author's conclusion)

Field of application \ Country	US	China	Germany	South Korea	Malaysia	India	Saudi Arabia
Buildings and houses	✓	✓		✓	✓		✓
Shipping	✓	✓	✓	✓		✓	✓
Agriculture and animal husbandry		✓			✓		
Factories and industries	✓	✓	✓	✓			
Healthcare		✓	✓	✓	✓		✓
Smart cities	✓	✓	✓		✓	✓	✓
Supply chain management		✓	✓	✓	✓	✓	

The development of the Internet of Things in the countries under study has been influenced by broad supportive, infrastructural and incentive policies, which can be summarized as follows:

Attention to technology development infrastructure: The IoT, as one of the top three technologies in the field of digital technologies, requires the development of infrastructure commensurate with the implementation of technology in countries. Countries have taken different steps to develop the infrastructure needed for IoT technology. To this end, in the United States, the expansion of the sixth-generation Internet Protocol, in China, the expansion of IoT clusters (Chen, 2018), in Germany, the creation of the Gigabit fiber-optic network (European-Commission, 2017), and in South Korea, the expansion of the fifth-generation mobile network infrastructure has been considered (MSIP, 2014).

Develop and upgrade technology development standards: In order to counter the obstacles of the technology and innovation development, it is important to pay attention to flexible standards with the cooperation of domestic and foreign stakeholders, public and private. Accordingly, the United States has developed low-up standards based on a public-private partnership network (Chen, 2018). The establishment of a National Expert Committee for the Development and Adaptation of Standards across India is another example of government action to develop constructive standards for digital technology development (Government-of-India, 2016).

Financial and tax incentives in the development of innovation: Specifically China with the establishment of the Innovation Support Fund (Chen, 2018), Germany with long-term and low-interest loans, grants and tax exemptions for the development of the Internet of Things (European-Commission, 2017), and India with the implementation of the M-SIPS scheme[2] in this area provide the most effective Support measures (Government-of-India, 2016).

Increase government cooperation with the private sector: Establishment of national innovation centers to facilitate public-private partnerships in China (Chen, 2018), launch startups and encourage collaboration between established companies and start-ups with government subsidies from the German federal government (European-Commission, 2017), and Open Innovation ecosystem development strategy (the government be as a client of private corporates) in South Korea (MSIP, 2014) and Malaysia (Berhad, 2014) are examples of selected countries' actions to increase public-private partnerships in the development of the Internet of Things.

Encourage research and development and fostering international business: Examples of these policies include granting tax exemptions to companies active in technology research and development in Germany (European-Commission, 2017), developing government-sponsored pilot projects in Malaysia (Berhad, 2014), and paying attention to holding international technology development fairs in Saudi Arabia (IDC, 2019).

[2] The Modified Special Incentive Package Scheme (M-SIPS) is a plan that encouraged manufacturing and electronics industry projects between 2012 and 2018. Under the scheme, companies active in the production of electronic products, in addition to benefiting from tax exemptions, received 20 to 25 percent of the subsidy.

Also, in studying the development of the Internet of Things in study samples, according to the economic, political and industrial status of countries, two main approaches are observed; In industrialized countries such as the United States and Germany, the development of the Internet of Things is at the service of industry, and it is observed that the government in these countries sometimes does not have a specific policy on the development of such technologies and leaves it to related industries. In contrast, less developed countries such as Saudi Arabia have used technology development to provide solutions to their current problems. Of course, it should be acknowledged that there is a third approach that takes into account both of these considerations and in addition to technology-based industrial development, they have extensive use of technology in their country.

Table 5- policy tools for supporting IoT development in leading countries (author's conclusion)

Policy Tools \ Country	US	China	Germany	South Korea	Malaysia	India	Saudi Arabia
Macro policies (supporting the development of industrial clusters and startups, etc.)		✓		✓	✓	✓	
Development of IoT application infrastructure	✓	✓		✓		✓	✓
Development of IoT technology development infrastructures (live and research laboratories, etc.)	✓			✓	✓	✓	
Cybersecurity regulations	✓		✓	✓		✓	
Privacy Regulation	✓					✓	
Standards and Accreditation	✓		✓	✓	✓	✓	✓
Development of IoT deployment in government	✓	✓	✓	✓		✓	✓
Tax Exemption		✓					
Financial incentives for technology development at various levels in the form of loans, grants, technology development funds, venture capital, etc.		✓	✓		✓		✓
Flexible regulatory frameworks for innovation (including labor, environmental and competition laws and the expansion of digital technology free zones)			✓	✓	✓		

4. PROPOSED METHOD

In terms of purpose, this study is applied, and the data gathering technique is quantitative survey. In this study, the criteria were weighed using the Simple Weighted Mean technique, and policy instruments were prioritized using the TOPSIS method. To prioritize applications, the Simple Weighted Mean was also employed.

To establish the relative importance of the factors for prioritizing IoT development policy tools, three expert panel meetings (in November and December 2020) were held with the presence of 28 relevant and specialized IoT experts in the government, especially the Ministry of ICT and the Ministry of Jihad Agriculture, academic researchers and business managers. The criteria for prioritizing the tools were extracted from the background and literature, which was modified and finally approved by the experts present in the panel.

After determining the ranking criteria, to determine their weight, the experts were asked to assign a score from 0 to 100 to their importance based on Iran's political and technological conditions. The scores of 28 experts on the criteria were scaled and their average was used as the weight of each criterion in the ranking.

In the next step, to rate the tools based on the extracted criteria, the members of the panel of experts were again asked to prioritize each tool in the 5 criteria, a numerical score between 1 and 5 (from very low to very high). The final summary and consensus of experts (numerically in the Likert scale 1 to 5) was used for ranking in the TOPSIS method. Similarly, in order to prioritize IoT applications, the panel of experts was asked to rate the importance of applications based on Iran's conditions and circumstances.

4-1. TOPSIS method

Hwang and Yoon proposed the TOPSIS algorithm in 1981. This approach is one of the most effective interdisciplinary decision-making systems available, and it has a wide range of applications (Hwang & Yoon, 1981) (Nozari et al., 2012) (Sadeghi et al., 2021). In this strategy, n indicators assess m options. The foundation of this strategy is that the chosen option should have the shortest distance to the positive ideal solution (A +: best possible state) and the longest distance to the negative ideal solution (B – worst possible state) (A-: worst possible state). Each index's desirability is considered to be consistently growing or decreasing (Momeni & Sharifi salim, 2011).

Solving the problem with TOPSIS is Proposed in six steps (Opricovic & Tzeng, 2004):

Step 1: The normalized decision matrix is calculated. The following formula should be used to calculate the normalized value r_{ij}:

$$r_{ij} = x_{ij}\sqrt{\sum_{i-1}^{m} x_{ij}^2} \qquad \text{i =1, 2, ..., m and j = 1, 2, ..., n.}$$

Step 2: The weighted normalized decision matrix is calculated. The following formula should be used to calculate the weighted normalized value v_{ij}:

$$v_{ij} = r_{ij} \times w_j \qquad \text{i =1, 2,..., m and j = 1, 2, ..., n.} \quad (1)$$

where w_j is the weight of the j^{th} criterion or attribute and $\sum_{j=1}^{n} w_j = 1$.

Step 3: Finding the ideal (A^*) and negative ideal (A^-) solutions.

$$A^* = \{(\max_i v_{ij} \mid j \in C_b), (\min_i v_{ij} \mid j \in C_c)\} = \{v_j^* \mid j = 1,2,...,m\} \quad (2)$$

$$A^- = \{(\min_i v_{ij} \mid j \in C_b), (\max_i v_{ij} \mid j \in C_c)\} = \{v_j^- \mid j = 1,2,...,m\} \quad (3)$$

Step 4: Using the m-dimensional Euclidean distance to calculate separation metrics. The following are the separation metrics between each alternative and the positive and negative ideal solutions, respectively.

$$S_i^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^*)^2}, \; j = 1,2,..., m \quad (4)$$

$$S_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}, \; j = 1,2,..., m \quad (5)$$

Step 5: Calculating the distance from the optimal solution. The following is a definition of the A_i alternative's relative proximity to A^*.

$$RC_i^* = \frac{S_i^-}{S_i^* + S_i^-}, i = 1,2,..., m \quad (6)$$

Step 6: The option with the highest RC receives a higher rating and is ranked based on the final RCs.

5. RESULTS

In this part of the article, the calculations related to the implementation of the TOPSIS method are shown. Table 7 shows the weight of each of the policy tools for the development of IOT.

Table 6- Weights of Indicators

Indicators	weights
X1: Ease of implementation and assessment	*0.24*
X2: Considering supply side of innovation	*0.11*
X3: Considering demand side of innovation	*0.17*
X4: Supporting capability creation in firms	*0.3*
X5: Supporting international competitiveness of IoT firms	*0.18*

Table 7- Decision matrix for ranking IoT development policy tools

	Type: + OR - ?	+	+	+	+	+
		X1	X2	X3	X4	X5
Macro Policies	A1	4	2	4	2	5
Application Infrastructure	A2	3	4	3	2	3
Technology Infrastructure	A3	4	3	3	3	3
Cybersecurity Regulation	A4	3	3	3	2	4
Privacy Regulation	A5	3	3	3	2	3
Standards and Accreditation	A6	3	3	4	4	5
Deploying IOT applications in E-government	A7	4	3	4	4	4
Tax Exemption	A8	3	4	5	4	4
Financial and Investment Incentives	A9	4	5	5	5	5
Flexible regulatory	A10	3	3	5	5	5
	Wj	0.24	0.11	0.17	0.3	0.18

Then the normalized decision matrix is calculated (Table 8).

Table 8- Normalized decision matrix (N)

Matrix Nd

0.368	0.187	0.317	0.18	0.378
0.276	0.373	0.238	0.18	0.227
0.368	0.28	0.238	0.271	0.227
0.276	0.28	0.238	0.18	0.302
0.276	0.28	0.238	0.18	0.227
0.276	0.28	0.317	0.361	0.378
0.368	0.28	0.317	0.361	0.302
0.276	0.373	0.397	0.361	0.302
0.368	0.466	0.397	0.451	0.378
0.276	0.28	0.397	0.451	0.378

After that, the Diagonal decision matrix was calculated for the 5 specified criteria. The result of this calculation is shown in Table 9.

Table 9: Diagonal decision matrix Wn×n

Matrix Wn*n

0.24	0	0	0	0
0	0.11	0	0	0
0	0	0.17	0	0
0	0	0	0.3	0
0	0	0	0	0.18

Also, Table 10 shows the normalized decision table.

Table 10- normalized decision matrix (V)

Matrix V=Nd*W

	0.088	0.021	0.054	0.054	0.068
	0.066	0.041	0.04	0.054	0.041
	0.088	0.031	0.04	0.081	0.041
	0.066	0.031	0.04	0.054	0.054
	0.066	0.031	0.04	0.054	0.041
	0.066	0.031	0.054	0.108	0.068
	0.088	0.031	0.054	0.108	0.054
	0.066	0.041	0.067	0.108	0.054
	0.088	0.051	0.067	0.135	0.068
	0.066	0.031	0.067	0.135	0.068
+A =	0.088	0.051	0.067	0.135	0.068
-A =	0.066	0.021	0.04	0.054	0.041

Table 11 shows the distance from positive and negative ideals.

Table 11: Matrix of distance from positive and negative ideals

di+		*di-*	
d1+=	*0.088*	*d1-=*	*0.038*
d2+=	*0.093*	*d2-=*	*0.021*
d3+=	*0.069*	*d3-=*	*0.036*
d4+=	*0.092*	*d4-=*	*0.017*
d5+=	*0.095*	*d5-=*	*0.01*
d6+=	*0.043*	*d6-=*	*0.063*
d7+=	*0.039*	*d7-=*	*0.062*
d8+=	*0.039*	*d8-=*	*0.065*
d9+=	*0*	*d9-=*	*0.097*
d10+=	*0.03*	*d10-=*	*0.09*

Table 12 shows the distance of the options from the optimal solution. In fact, this table is the ranking of political tools.

Table 12: IoT Development Policy Tools Ranking Results

	RCi
A9	RC9= 1
A10	RC10= 0.75
A8	RC8= 0.627
A7	RC7= 0.615
A6	RC6= 0.596
A3	RC3= 0.344
A1	RC1= 0.3
A2	RC2= 0.181
A4	RC4= 0.157
A5	RC5= 0.098

Table 13 also shows the ranking of IOT applications in Iran and its comparison with other countries.

Table 13- Result of the IoT Applications Ranking for Iran

Country / Field of application	weight	US	China	Germany	South Korea	Malaysia	India	Saudi Arabia
Buildings and houses	0.07	✓	✓		✓	✓		✓
Shipping	0.17	✓	✓	✓	✓		✓	✓
Agriculture and animal husbandry	0.03		✓			✓		
Factories and industries	0.22	✓	✓	✓	✓			
Healthcare	0.14		✓	✓	✓	✓		✓
Smart cities	0.26	✓	✓	✓		✓	✓	✓
Supply chain management	0.11		✓	✓	✓	✓	✓	

6. DISCUSSION AND CONCLUSION

In response to the first question of this research, determining the priority of IoT application areas in Iran, it can be said, the results show that according to the experts participating in this study the most important applications respectively are Smart cities, Factories and industries, Shipping, Healthcare, Supply chain management, Buildings and houses and finally Agriculture and animal husbandry.

This result is largely consistent with global studies. As shown in Table 13, the field of smart cities has been among the practical priorities of 6 countries. The four major industrialized countries, the United States, China, Germany, and South Korea, have prioritized IoT applications in industry. The use of the Internet of Things in shipping was also identified as the third priority in this study, which has received much attention in other countries and 6 countries have paid much attention to it.

In this study, the lowest priority was given to the use of the Internet of Things in the field of agriculture. This result is also in line with studies from other countries. Only 2 out of 7 countries studied have identified agriculture as their priority.

In response to the second question of this research, using the TOPSIS method, according to experts, the most important policy tools of the government for supporting the development of IoT technology respectively are: Financial and Investment Incentives, Flexible regulatory, Tax Exemption, Deploying IOT applications in E-government, Standards and Accreditation, Technology Infrastructure, Macro Policies, Application Infrastructure, Cybersecurity Regulation, Privacy Regulation.

As the results show, the experts in the first stage have considered the highest priority for financial support. This may be because IoT technology is still in the early stages of its life cycle, and at such stages policymakers need to focus more on supply-side support and technology companies so that they can quickly develop the necessary technologies and introduce them to the market.

Flexible regulatory were also identified as the second most important tool to support technology development in this area. This could also be due to the fact that most of the companies active in the field of digital technologies in the country are startups and small and medium sized companies that do not have enough organizational ability to deal with strict regulations and must focus their limited resources on technology development.

The difference between this article and others is that despite the development of IoT in the country and even at the international level, government policy tools in support of IoT technology have not been studied. Although IoT applications have been studied in various fields, the TOPSIS method has not been used to prioritize policy tools in these areas.

Adopting such an approach helps policymakers to allocate limited government resources to effective tools and, in addition to preventing the waste of resources, shorten the effectiveness of policies. Therefore, using this method with more experts is recommended to policymakers.

Authors Contributions

Mostafa Mohseni Kiasari: Conceptualization, Methodology, Writing-Original Draft.

Kiarash Fartash: Validation, Investigation, Writing-Review & Editing.

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The authors declare no conflict of interest related to this publication.

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