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Analysis of Factors Influencing Adoption of Internet of Things: A System Dynamics Approach

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Abstract

The Internet of things (IoT) has become an interesting topic of research as it assimilates several sensors and objects to communicate directly with one another without human interference. IoT helps businesses and society in many ways such as it improves public safety, transportation, and healthcare by providing better information and faster communications. The adoption of IoT is going to create a persistent impact on society and business. This paper develops a model based on system dynamics and identifies the factors influencing IoT adoption. The dominant factors of IoT adoption are communication, control and automation, efficient business processes, self-configuration, and cost savings. IoT adoption is also affected by negative factors including privacy risks and security risks, interoperability, reliability, poor infrastructure, less skilled IT professionals, etc. Businesses can reap the potential benefits of IoT by solving the issues related to their adoption. Besides, this paper attempts to derive a framework for the successful adoption of IoT in organizations. This study is, therefore, a significant contribution towards understanding the factors that influence the adoption of IoT in businesses.

Keywords

Internet of Things, Reliability, System Dynamics, Self-Configuration, Control and Automation

1. Introduction

IoT is an amalgamation of devices, software, sensors, and networks to work jointly to extract significant and usable data or information generated from it [1]. IoT benefits the organization in various ways from improving the efficiency of the organization to increase customer satisfaction but the major benefit of IoT that will impact every business is communication, control, and automation, cost savings [2]. IoT helps communicate between the humans and the systems and reduces personnel as well as equipment failure cost [3]. IoT helps in reducing maintenance costs of the plant facilities and increasing production output in a manufacturing firm with the accessibility of real-time data. Transportation and shipping companies are also able to reduce maintenance costs and improve delivery service using IoT [4]. Currently, IoT consists of more desirable sensors, satisfactory computing capability and preferable wireless networks that allow the distribution of IoT application across many sectors of the organization including manufacturing, telecommunication, agriculture, power and energy, health care, supply chain, logistics, data filtering, security and defense industries. The most widely used IoT applications are inter-connected security systems, regulators, cars, electronic machines, electric lights used in houses and commercial places, alarm clocks, speaker systems, vending machines, etc. IoT becomes more powerful when data is generated from various devices and sensors store all in a single location and analyzed statistically and offer new insights and services in real-time. This can be done when IoT integrates with other technologies such as fog computing, edge computing, cloud computing, big data, data mining and machine learning [5]. Fog computing and edge computing help in communicating data in real-time generated by IoT with the help of many communication technologies and protocols. This helps the managers in making real-time decisions in the firms. Cloud computing provides global infrastructure to store this real-time data and data analysis is done using big data technologies such as Hadoop, NoSQL, and cloud-based Database as a Service (DaaS). Data mining and machine learning or artificial intelligence techniques are used to find out new patterns inside the data. Application developers can utilize this data to create new business applications. In this way, IoT brings business value to a firm by generating a new pattern or insights. IoT also allows firms to enter new markets, enhance the production, streamline their business processes, and satisfies the customer's needs more effectively and efficiently [5].

Various market research firms such as AT & T emphasized that 30 billion IoT devices will get connected to the Internet by 2020. Similarly, IDC predicted that several IoT devices for operational usage will be 28.1 billion by 2020 with a CAGR growth of 17.5% between 2016 and 2020 [6]. Gartner's report predicted that the number of devices connected with IoT will preferably reach by 40 billion and the economic growth of IoT will overreach $1.9 billion with 26 billion units by 2020 [7] [8]. A recent study done by Deloitte predicted that, by 2010, IoT devices in India are expected to grow 31 times to 1.9 billion units [9]. Likewise, the NASSCOM report predicted that by 2020, the Indian market accounted for 5% of the global market of IoT and expected to grow $15 billion [10].

IoT is still in a nascent stage in India and the percentage of organizations with more than fifty thousand connected devices active has been increased two-fold in the last year [11]. 81% of Indian organizations felt that digital transformation occurs due to the evolution of IoT [11]. In India, Industries like manufacturing, logistics, automotive and transportation, and utilities are expected to be the highest adopter of IoT, whereas healthcare, retail, and agriculture industries are predicted to have significant contributions in IoT adoption [12]. The government of India is planned to invest one billion dollars for developing smart cities that influence IoT adoption across the industries. Various big global firms have already adopted IoT like Intel, Microsoft, Samsung, DHL, General Electric, Rolls Royce, Bosch, etc. Some Indian firms have also adopted IoT like HCL Technologies, Infosys, Ramco Systems, and Secure Meters, etc. [12].

Very few studies such as Caro *et al.* [13]; Hu *et al.* [14]; Mital *et al.* [15]; and Mengru Tu [16] have examined IoT adoption in the organization. Prior studies related to IoT adoption highlighted only the factors like perceived usefulness, perceived ease of use, attitude towards adoption, adoption intention, perceived behavioral control, and perceived risks like security/privacy risks. Therefore, the motivation of this study is to identify the other dominant factors that influence IoT adoption by understanding the dynamic behavior of IoT in the organization using a system dynamics model.

This study contributes to the literature by providing a system dynamics model and framework to analyze the factors that influence IoT adoption in the organization. This study fills the gap by introducing other relevant positive and negative factors that influence IoT adoption in the organization. This paper proposes the conceptual model and framework for IoT adoption, therefore future research will be based on formulating hypotheses and data collection. In the future, the proposed model will be tested using advanced econometrical methods like exploratory factor analysis and structural equation modeling.

The paper initiate with the introduction of IoT followed by the purpose and motivation of the study. The literature review of IoT is done in the next section. The conceptual model and framework are discussed in the latter part of the paper. Lastly, the conclusion and implications are discussed in the paper.

2. Literature Review

Caro *et al.* [13] highlighted that IoT plays a vital role in connecting the supply and demand and can act as a retaliatory measure to fill a space between information and fulfillment in the retail industry. IoT adoption generates value by increasing capabilities at a point where supply and demand intersect. Hu *et al.* [14] articulated and presented IoT in the context of the online retailer's decisions. They throw some light on the positive and negative parts of IoT in the retail industry based on IoT. The retailers could gather various types of information about the customers and analyse the market demand through IoT as well as from other new technologies like big data, Cloud computing. They also highlighted that people are still concerned about personal privacy and (or) health risk caused by the IoT environment.

Mital *et al.* [15] explored the intention to adopt IoT in Indian organizations with the help of various theories like Theory of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), and Technology Acceptance Model (TAM). The empirical validation of this model was performed using Structural Equation Modeling. Mengru Tu [16] identified the determinants of IoT adoption intention in logistics and supply chain management using a mixed-method research approach. To understand the impact of IoT on logistics and supply chain management, qualitative analysis was done using the grounded theory methodology. The result showed that perceived benefits, perceived costs, and external pressure are significant factors of IoT adoption intention. The insignificant factors were technology trust.

Olivier *et al.* [17] developed a security architecture for the Internet of Things (IoT) based on software-defined networking (SDN). SDN was used to achieve network security in an IoT environment. Tarabasz [18] presented the innovative approaches of IoT idea, enumerate association to its opportunities and threats as well as to indicate the inner potential of IoT which is been dominated. With the upcoming opportunities, there are many threats associated with them in the field of information security which requires continuous research and development of new approaches to ensure safety, security, and privacy. Roy *et al.* [19] validated the underlying factors for the easy adoption of IoT based innovations. They performed the study in four different stages of literature review, survey, interviews with experts and a usability test to develop a model for IoT adoption by the urban poor. The findings showed that IoT based innovation can be in the area of nutrition, healthcare, employment, education, and finances. Kim et al, [20] applied a Value-based model and TAM to analyse the factors that influence the adoption of IoT based smart home service. The findings revealed that perceived value was influenced by both perceived benefit and perceived sacrifice. The study showed that perceived benefit had a stronger positive effect on perceived value than perceived sacrifice.

Tedeschi *et al.* [21] developed a safe remote monitoring system for machine tools through IoT devices and examines the serious issues focusing on the manufacturing environment. Glória *et al.* [22] enlightened about the practical implementation of IoT gateway which is dedicated to real-time monitoring and remote control of the swimming pool. Raspberry Pi acts as an aggregate node, Arduino with a set of sensors acts as a sensor node and a web platform to control and maintain the network. A secure system using encrypted communication and an SSL protocol and certificate on a web server-side were developed. Stietencron [23] proposed IoT in the field of marine services to manage the two devices that are automatic identification systems and product embedded information devices to save time and reduce manual efforts. Rahman *et al.* [24] explained IoT systems as a combination of IoT Device, IoT Service and IoT Application along with the generic life cycle approach model for each of them. They highlighted the development of IoT systems and implementation of generic model into a specific IoT system for any specific domain. Boyes *et al.* [14] reviewed the definition of Industrial IoT. They developed the definition of the Industrial Internet of Things (IIoT) and examined IoT taxonomies. They also developed a framework for IIoT analysis which can be used to compute and describe IIoT devices while reviewing different system architecture. This framework also helped in evaluating security risks and vulnerabilities associated with IIoT. Mir *et al.* [25] examined the physical and the virtual resource management in IoT systems and highlighted that the basic functioning of IoT includes sensing and data aggradations, processing of the data, storing data and then communication of this data to the virtual environment.

Ray [26] emphasis area-specific architecture of IoT applications and focuses on the challenges and possible research opportunities in the area of defense, military, robotics intelligence services, etc. The author highlighted that IoT may not be adopted by the organization due to its challenges related to flexibility, interoperability, concurrency, scalability, and addressability. Ammar *et al.* [27] provide a picture of a present state of IoT platforms and identify the trends of different IoT platforms. All the security issues of the IoT framework were considered in terms of authentication, authorization and access control and secure communication.

Chatfield and Reddick [28] have developed a new conceptual framework for IoT enabled smart government. The U.S. federal government's IoT case was examined in four domains: Transportation, Energy, Smart cities and Defence. The finding showed that the strategic usage of IoT is still in the nascent stage in government across the globe. Li *et al.* [29] review the present research state-of-the-art of 5G IoT, key enabling technologies, and main research trends and challenges in IoT. Pauget and Dammak [30] addressed the organizational implementation of IoT in the case of senior care with three aspects. The first one discusses the patient's independence with the introduction of the Internet of Things; the second one opposes the contradictory image of senior care and the third one confirms endurance among homecare services and institutionalization.

IoT related literature review and a theoretical framework and conceptual model were developed by Nord *et al.* [31]. The framework highlighted the factors that influence IoT adoption by firms. These studies also highlighted various applications of IoT and found privacy, security, and trust as IoT challenges. Mountrouidou *et al.* [32] constructed an IoT taxonomy based on generic building blocks for a wider understanding of large pool of IoT devices that are used in home appliances and health care, such as smart plugs, digital assistants, and web cameras, smart meters and robots. They showed that their taxonomy is broad and robust having a simple and effective algorithm that makes it complete, timely, and accurate. **Appendix 1** shows the literature review table.

3. System Dynamics Model

System dynamics (SD) is a mathematical modeling technique to frame, understand, and discuss complex issues related to systems [33]. SD is a method to understand the dynamic behaviour of complex systems. Researchers have used SD to design the structure of statistically vigorous systems that put up common dynamics [34]. System dynamics modeling lies in determining the dynamics of a system. The dynamics arise from the interaction of two types of feedback loops positive and negative feedback loops. Positive loops are self-reinforcing that have the capability to amplify whatever happening in the system. Negative loops are self-correcting and have the capability of counteracting and oppose changes in the system. In this study, the causal loop diagram in SD Model is used to identify the positive and negative feedback processes that stimulate IoT adoption. The positive (+) sign at the arrowheads indicates that the effect is positively related to the cause. On the contrary, the negative (−) sign at the arrowheads indicate the effect is negatively related to the cause. The dynamics of the system arise from interactions of networks of these two types of feedback loops.

The system dynamics model was developed and shown in **Figure 1**. **Figure 1** depicts the positive and negative feedback loops in the form of factors that affect IoT adoption in the organization. These factors can be divided into three types: technical, personal and organizational. Personal factor such as privacy risks is negatively influencing IoT adoption. The variables of organization aspects such as cost savings and efficient business processes are positively influencing IoT adoption. The variables of technical aspects such as security, control and automation, communication and self-configuration of IoT devices are also positively influencing IoT adoption. Other technical factors such as reliability, interoperability, poor infrastructure are also negatively influencing IoT adoption. Other organizational factors such as less vendor credibility and less skilled IT professionals also negatively influencing IoT adoption.

The positive factors are communication, control, and automation, cost-saving,

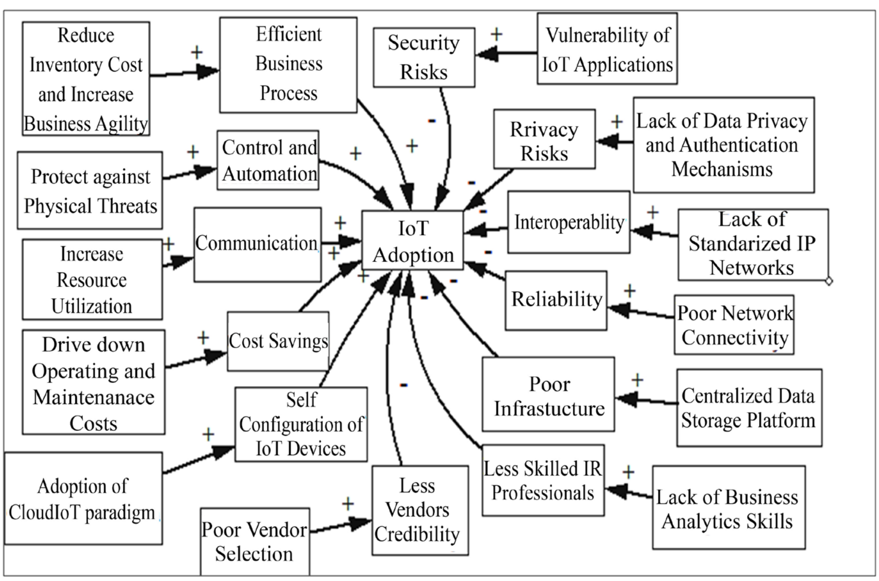

Figure 1. System dynamics model for IoT adoption.

efficient business processes, and self-configuration of IoT devices. The negative factors are security risks and privacy risks, interoperability, reliability, poor infrastructure, less skilled IT professionals, and less vendor credibility.

3.1. Analysis of Factors That Positively Influence the Adoption of IoT

3.1.1. Communication

Tracking of assets (such as equipment, machinery, tools, etc.) using sensors and connectivity will be more convenient with IoT, which in turn helps organizations to easily locate issues in the assets and run preventive maintenance to improve asset utilization [2].

Proper resource utilization helps to communicate data and information to people and systems [3]. It also tracks current location and movement like locating items and people within the organisation through sensors like RFID [23]. In this way communication influences IoT adoption in the firm.

3.1.2. Control and Automation

IoT also helps the business to provide visibility to send alerts for anomalies and delivered an automated response from the remote device [2]. IoT services assimilated with sensors and video cameras help in ensuring equipment safety and give protection against physical threats in a workplace [2]. In this way control and automation in IoT services synchronize multiple teams to resolve problems on time and encourages IoT adoption.

Caro *et al.* [13] explained the impact of control and automation in IoT adoption and explained that IoT can be used in three different ways in the demand side of the retail supply chain. First, it can be used as a camera network to analyse customer and employee behaviour and also for inventory management. The second demand-side IoT device used by retailers is smartphones carried by customer and employee to track payment during a store operation. On the demand side, the third option is the usage of the smart cards as loyalty or credit card by the consumers. Finally, on the supply side, IoT is used to track and monitor the inventory on the floor [13].

3.1.3. Cost Saving

IoT helps a company to save cost by minimizing equipment failure and allow the business to perform planned maintenance with the help of new sensor information. The return on investment for IoT applications can be easily gained back within a year by enabling capabilities of IoT [13]. IoT also helps to improve resource utilization, business productivity, and increase business process efficiency which in turn cut down operating and maintenance costs [2]. For example, IoT applications such as predictive analytics and real-time diagnostics reduce maintenance costs. In this way, cost-saving promotes IoT adoption in the organization.

3.1.4. Efficient Business Processes

Business agility and inventory reduction take place with IoT as it deals with real-time operational data [3]. For example, concurrent data collected from logistics network, factory floor, and supply chain will help reduce inventory, time to market and downtime due to inter-connectivity of the maximum number of devices to the internet in IoT platform. Adoption of IoT in manufacturing sector helps to increase business efficiency in its day to day operations and assist them to improve their production quality with high-end safety [3]. Therefore, business process efficiency leads to IoT adoption in the organization.

3.1.5. Self-Configuration of IoT Devices

Stergiou *et al.* [23] suggested that integration of IoT with cloud solutions is required to connect with existing enterprise and operational systems *i.e.* on public clouds or in private data centers. Maintenance and management of IoT service become easier when IoT service deployed on the cloud platform. IoT platform vendors who are offering a multi-cloud strategy are more responsive to customer and regional requirements. Integration of Cloud with IoT allows IoT devices to integrate with current systems and other IoT devices [35]. This is called the CloudIoT paradigm [35]. Cloud helps IoT to integrate the data collected from its devices with the information exist in current business applications. For example, in a manufacturing company, data collected from sensors on machines can be linked with shipping logs to recognize the influence of machine downtime on delivery times. The cloud plays a major role in the development or improvement of IoT devices because it helps in the automatic configuration of IoT devices securely. Hence, the cloud is an important part of a successful IoT environment. The amalgamation of IoT and Cloud computing provides new prospects of data-sharing and internet-enabled services. This would also lead to a vigorous global network system along with self-configuring capabilities which are based on standard and interoperable communication protocols. According to Distefano *et al.* [36], IoT devices can securely self-configured and interact with the cloud to customize its behavior. IoT devices can also download the required features from the Cloud. Thus, this integration of cloud platform with IoT would further lead to IoT adoption in the organization.

3.2. Analysis of Factors That Need to Be Controlled in the Adoption of IoT

A successful IoT deployment takes place when negative factors are also analysed with the drivers. The main challenges in IoT adoption are security and privacy threats, reliability or poor network connectivity, less skilled IT professionals, infrastructure for storing and analysing data generated by IoT and choosing the right IoT vendor [37].

3.2.1. Security Risks

IoT comes with various security issues, such as authorization, verification, access control, system configuration, information storage, and management [16]. According to Voas *et al.* [38], the security implications of IoT are creating hurdles for its wider adoption. IoT is at high-security risks for several reasons. Firstly, IoT systems do not have well-defined standards and are extremely dynamic, unsteady because of mobility. Besides, IoT systems are vastly diverse concerning communication mediums and protocols, platforms, and devices. Furthermore, there can be portability issues as IoT connected devices may not portable to the Internet. Lastly, IoT systems may not be secured [39]. The major IoT security risks involve software attacks that can make use of entire systems, loss of data or information, modify data, refuse service and compromise or spoil devices. According to a survey done by Gartner [4], 32% of IT leaders highlighted security as a top obstacle to IoT success. Past studies highlight that 70% of the commonly used IoT devices are at risk because of the lack of software protection, transport encryption, insufficient authorization, and inadequate web interface insecurity [40]. Therefore, there is a need for well-defined policies and a steady legal framework for IoT adoption in the organization [33].

3.2.2. Privacy Risks

Kolias *et al.* [41] focused on privacy threats caused by IoT such as leakage of personally identifiable information (PII) and sensitive user information, and unauthorized execution of functions. Internet of things includes an enormous number of applications that are at present part of people's lives. IoT includes devices in the form of smart objects (SO) that communicate with each other through the Internet. These devices are aggressively delivering the services of IoT applications. This brings privacy concerns to IoT applications because there is a constant increase of involvements of people and devices in these applications.

IoT applications can provide a person's identity and location information to others which may raise privacy concerns. These privacy risks can be simple user irritation in the form of violent advertising such as personalized spam at point-of-sale locations, tracking user routes and constructing user habit profiles and even serious criminal activities [1].

3.2.3. Interoperability

Noura *et al.* [42] highlighted the interoperability as a challenge in IoT adoption in the industry. This challenge can be overcome by connecting IoT devices with standards-based IP networks. The lack of protocols and standards from the governing bodies and the absence of the latest technologies would slow down the adoption of IoT. Furthermore, the integration of IoT and cloud computing would also help in data-sharing and services like self-configuration capabilities based on standard and interoperable communication protocols.

3.2.4. Infrastructure

With the incremental growth in real-time data, companies need to opt for a sustainable solution for data storage. The real-time data are stored centrally which is unsustainable. Hence, companies should switch to a distributed cloud platform from centralized data storage [37]. Also, companies should ensure that they have the right infrastructure that manages IoT connected devices, sensors, and data generating in real-time.

3.2.5. Network Connectivity/Reliability

The successful IoT adoption can be ensured by powerful and reliable network connectivity [37]. Instead of establishing proprietary networks, IoT devices should be connected with standards-based IP networks. IoT service can be delivered with performance with an IP-based network without the issues of reliability and interoperability.

3.2.6. Less Skilled IT Professionals

IoT is a very extensive area and generates a huge volume of data collected from several sources using devices and sensors. Therefore companies require IT professionals with big data analytical skills to make quick and reliable business decisions. An IT professional should have sufficient analytical skills in business intelligence areas such as data center management, sensor data analysis, predictive analytics, with programming knowledge of NoSQL distributed databases and Hadoop file system that are required to manage huge and fast-growing data sets. Therefore, there is a need for a team of IT professionals with business analytical skills for successful IoT adoption in the organization [37].

3.2.7. Vendors Credibility

Today, organizations outsource IoT solutions to the third-party vendor. The selection of IoT vendor is one of the most crucial decisions which businesses take. IoT platforms that offer the right infrastructure, high scalability, optimized results, and disaster recovery, without compromising on precision and efficiency are required [37]. Therefore, the challenge is to find out the appropriate IoT vendor that provides the best IoT solution.

Table 1 shows the factors that need to control along with the remedies in the successful adoption of IoT in the organization.

4. The Framework of Adoption of IoT in an Organization

The framework was developed and shown in Figure 2. The framework shows

Table 1. Factors to be controlled along with their measures to control in IoT adoption.

Factors to be controlled	Measures to control
Privacy Risks	Identity and authentication structures need to be updated time to time.
Security Risks	Security procedures such as hardware encryption, physical building security and network security need to be implemented.
Infrastructure	Sustainable solutions for data storage need to be implemented like Cloud Computing.
Reliability/Network Connectivity	Establish powerful and reliable network connectivity.
Interoperability	Connect IoT devices with standards-based IP networks.
Less skilled IT professionals	A team of IT professional with knowledge of business analytics tools.
Choose the right vendor	Find the best IoT vendor that provide right IoT infrastructure with scalability, disaster recovery, precision and efficiency.

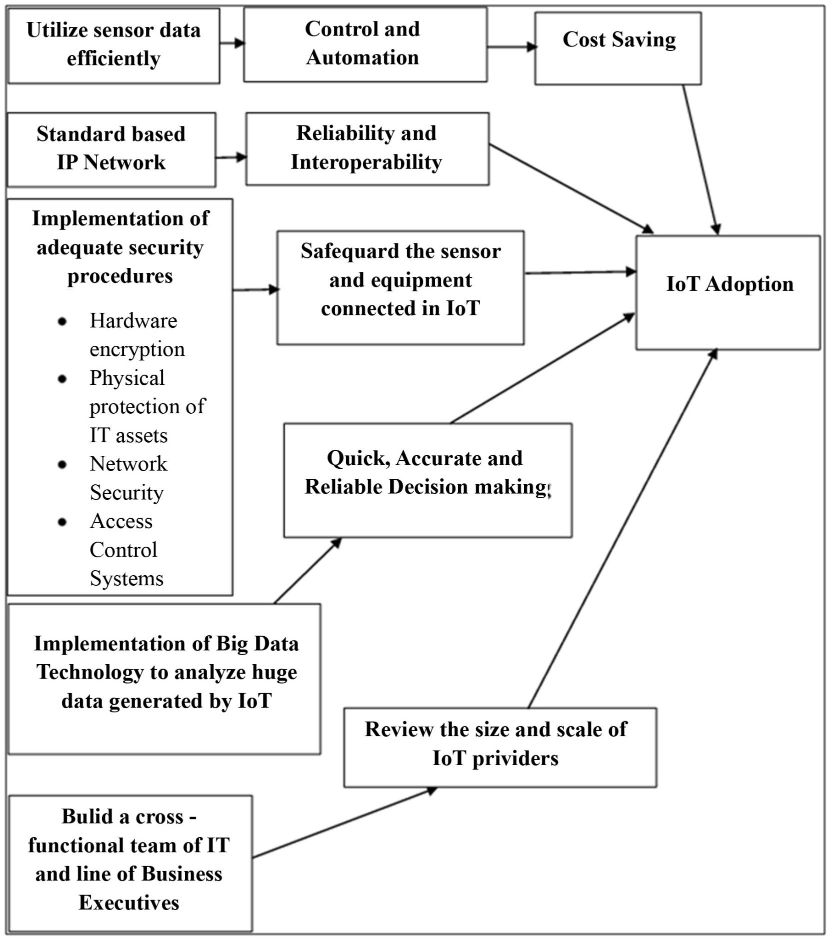

Figure 2. A framework of adoption of IoT in an organization.

the different factors and sub-factors that influence IoT adoption. In case of cost saving, with new sensor information, IoT can help a company, save money by minimizing equipment failure and allowing the business to perform planned maintenance. IoT will improve tracking of assets (equipment, machinery, tools, etc.) using sensors and connectivity, which helps organizations benefit from real-time insights. With the help of IoT, organizations could more easily find problems in the assets and execute preventive maintenance to get better asset utilization. IoT helps in reducing operating costs by providing real-time operational insights to the organization. For example, in a manufacturing firm, IoT collects data from the logistics network, factory floor, and supply chain. This will help the firm to reduce inventory, time to market and downtime due to maintenance. The improved asset utilization, productivity, and process efficiencies can save operating and maintenance costs.

Implementation of security procedures such as hardware encryption, physical building security, and network security are needed to safeguard the sensor and equipment connected in IoT. Identity and authentication structures will also need to be updated to minimize the privacy risks associated with IoT in the organization. According to Nord *et al.* [31], security decisions maker is unknown in IoT area because there are many partners involved in IoT including designing a device, supplies software component, operation of a network where devices are embedded, deployment of the device. There is a need for comprehensive, international norms Successful IoT adoption only occurs when security and privacy risks are minimized.

Successful IoT adoption takes place when IoT devices are connected with standards-based IP networks instead of using proprietary networks for communication. Interoperability and reliability are required to support global IoT networks and connections with partner ecosystems.

Organizations must build a data collection and analytics strategy that supports the new and large amount of information in a scalable and cost-effective manner, generated by IoT. Cloud computing provides an IoT infrastructure for data storage. Big data technology, such as Hadoop and NoSQL, can give companies the ability to rapidly collect, store and analyze large volumes of disparate IoT data. Cloud computing and big data technologies help the managers to make quick, accurate and reliable decisions in the business. This leads to the successful adoption of IoT.

IoT is a complex landscape with numerous categories and many vendors within each category. The four main categories of an IoT solution are sensors or radios that fit inside the device, an M2M device management platform, a solution delivery platform and applications that enable IoT devices to act on data, generated by sensors. This landscape requires many vendors for IoT because no single vendor offers a complete solution without building partnerships. This requires a cross-functional team of IT professionals and business executives to evaluate the financial position of the vendors, their industry knowledge, partnerships and their range of offerings, which in turn helps in IoT adoption in an organization.

5. Conclusions and Implications

This study portrays the positive and negative factors of IoT adoption with the help of the system dynamics model. The model gives a clear picture of technical, personal and organizational factors of IoT adoption. Personal factor consists of privacy risks that negatively influence IoT adoption. Cost savings and efficient business processes are the organizational factors that positively influence IoT adoption. Technical factors such as control and automation, communication and self-configuration of IoT devices are positively influencing IoT adoption. Other technical factors such as security, reliability, interoperability, poor infrastructure are negatively influencing IoT adoption. Less skilled IT professionals and vendor credibility are other organizational factors that have a negative impact on IoT adoption.

Although IoT offers immense potential value, organizations must find solutions for some significant challenges related to IoT adoption such as data and information management issues, lack of interoperable technologies, security and privacy concerns, and the skills to manage a growing and complex landscape of IoT. Conversely, a professional IoT vendor can overcome these challenges and increase return on investment of the companies. This study is, therefore, a significant contribution towards understanding the factors that influence the adoption of innovations like IoT in businesses. To implement IoT successfully and to analyse the hindrances, companies should make use of modern technologies like fog/edge computing, cloud computing, big data technology, data mining and machine learning with the help of highly skilled IT professionals. Currently, IoT is used to connect several devices in a network for commercial and domestic purposes. Therefore, there is a major influence of IoT on society and business.

A review of the literature showed that IoT is still an emerging area of research. Based on the literature review of available research papers and white papers, a system dynamics model of IoT adoption and conceptual framework are proposed. Analysis of the positive and negative factors that influence IoT adoption in the organization was done with the help of the system dynamics model. This study contributes to the literature by exploring additional factors of IoT adoption and also by proposing the framework of successful IoT adoption in the organization. This study fills the gap by introducing other relevant positive and negative factors that influence IoT adoption in the organization. Future research will be the focus on empirically testing of the conceptual model by collecting data using a questionnaire. Advanced statistical analytical tools like SPSS Statistics Version 26 will be used to validate the model.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix 1. Literature Review Table

Title/Journal	Author	Year	Model	Objective
The implementation of the Internet of Things: What impact on organizations?	Bertrand Pauget, Ahmed Dammak	2019	Literature Review	This study proposed a model to understand the impact of implementation of IoT technology in the organization like senior care sector.
Internet of Things (IoT) in retail: Bridging supply and demand	Felipe Caro, Ramin Sadr	2019	Literature Review	This study classified IoT initiatives on an opportunity map and presented a strategic framework that distinguishes initiatives by the value they create and by their major area of impact on retail firms.
5G Internet of Things: A survey	Shancang Li, Li Da Xu, ShanshanZhaof	2018	Literature Review	This paper reviews the current research state-of-the-art of 5G IoT, key enabling technologies, and main research trends and challenges in 5G IoT.
A framework for Internet of Things-enabled smart government: A case of IoT cybersecurity policies and use cases in U.S. federal government	Akemi Takeoka Chatfield, Christopher G. Reddick	2018	Literature Review	This paper developed a framework for IoT-enabled smart government performance. This study applied the framework to conduct case study analyses of digital technology policy, IoT cybersecurity policy, and IoT use in major application domains at the U.S. federal government level.
A survey on Internet of Things architectures	P.P. Ray	2018	Organizational theory	In this article, firstly the background and definition of IoT are given. Secondly, thorough discussions on fundamentals behind IoT architectures are elaborated.
The industrial internet of things (IIoT): An analysis framework	Hugh Boyes, BilHallaq, Joe Cunningham, Tim Watson	2018	Literature Review	This paper reviews what is meant by Industrial IoT (IIoT) and relationships to concepts such as cyber-physical systems and Industry 4.0. The paper develops a definition of IIoT and analyses related partial IoT taxonomies.
Understanding IoT Systems: A Life Cycle Approach	Leila Fatmasari Rahmana, Tanir Ozcelebia, Johan Lukkien	2018	Literature Review	This study defined a generic life cycle model for IoT, which is specified by observations on life cycles of existing IoT solutions and generalization.
Success of IoT in Smart Cities of India: An empirical analysis	Sheshadri Chatterjee, Arpan Kumar Kar, M.P. Gupta	2018	Updated information system success model	The study identifies key factors affecting successful implementation of information system in Smart Cities of India (SCI). This study also highlights successful implementation of IoT policy in Smart Cities of India coupled with Artificial Intelligence.
Internet of Things: A survey on the security of IoT frameworks	Mahmoud Ammar, Giovanni Russello, Bruno Crispo	2018	Literature Review	This study gave a high overview of the current state of the art IoT platforms. This study also provided a high level comparison between the different security architectures of the various frameworks.
A Survey of How to Use Blockchain to Secure Internet of Things and the Stalker Attack	Emanuel Ferreira Jesus, Vanessa R. L. Chicarino, Célio V. N. de Albuquerque, and Antônio A. de A. Rocha	2018	Literature Review	The paper goal is to provide the concepts about the structure and operation of Blockchain and, mainly, analyse how the use of this technology can be used to provide security and privacy in IoT.
Resource management in pervasive Internet of Things: A survey	Saniya Zahoor, RoohieNaaz Mir	2018	Literature Review	This paper presents a survey of physical and virtual resource management in IoT systems. The main focus of the paper is on resource management in pervasive IoT environment with limited resources.
Internet of Things: A systematic review of the business literature from the user and organisational perspectives	Yang Lu, SavvasPapagiannidis, EleftheriosAlamanos	2018	Literature Review	The study followed a systematic approach to reviewing the relevant literature following a number of steps, such as planning the review, selecting and reviewing the papers, synthesising the results, and reporting the findings.

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Understanding business model in the Internet of Things industry	ConcettaMetalloa, Rocco Agrifoglio, Francesco Schiavone, Jens Mueller	2018	Multiple case study	Using an explorative sequential approach through the multiple-case study method, we apply the "Canvas Business Model" framework to explore the business model of three companies operating in IoT industry, namely Intel, Solair, and Apio.
Intertwining the internet of things and consumers' behaviour science: Future promises for businesses	Caputo Francescoa, Scuotto Veronica, Carayannis Elias, Cillo Valentina	2018	Empirical paper (motivation theory)	The objective of this study is to offer an explorative, quantitative study on the IoTs to enhance the existing knowledge and support business in the process of engaging more users and creating new personalised products.
An experimental study of a reliable IoT gateway	Byungseok Kang Hyunseung Choo	2018	Conceptual Paper	This paper introduced an experimental study of a reliable and self-configurable IoT gateway that is developed in a laboratory testbed by using the IoTivity framework.
IoT Data Provenance Implementation Challenges	Adel Alkhalil, Rabie A. Ramadan	2017	Literature Review	This paper aims to establish a starting point towards addressing security and privacy challenges of IoT by suggesting the implementation of data provenance in IoT.
Secure IoT Devices for the Maintenance of Machine Tools	Stefano Tedeschia, Jörn Mehnena, Nikolaos Tapogloua, Rajkumar Roya	2017	Literature Review	This paper introduced a global strategy for secure Design for IoT which includes: safe solutions for environments with rich information, guarantee that the devices are functioning as intended by the manufacturer and are not damaged, life cycle security across devices, networks and data centers, support for industry standards and interoperability of devices, ability to solve the challenges of the information link, secure clouds for traditional systems.
Design and implementation of an IoT gateway to create smart environments	Andr'eGl'oria, Francisco Cercas, NunoSouto	2017	Conceptual paper	The paper presents a proposal of a practical implementation for an IoT gateway dedicated to real-time monitoring and remote control of a swimming pool. Based on a Raspberry Pi, the gateway allows bidirectional communication and data exchange between the user and the sensor network implemented on the environment using an Arduino.
The Internet of Things: Are you ready for what's coming?	Ted Saarikko, Ulrika H. Westergren, Tomas Blomquist	2017	Literature Review	This study reviewed the complexity of the IoT, the complexities of an increasingly interconnected environment, and the increasing need to develop partnerships in order to create IoT based innovative solutions.
Utilising the Internet of Things for the Management of Through-life Engineering Services on Marine Auxiliaries	Moritz von Stietencron, Carl Christian Røstad, Bjørnar Henriksen, Klaus-Dieter Thoben	2017	Literature Review	This paper presents a solution approach and its prototypical implementation utilising the Internet of Things (IoT) to aid the marine auxiliaries' producers in the process of managing the product usage phase and its services.
Adoption of Internet of Things in India: A test of competing models using a structured equation modeling approach	Monika Mital, Victor Chang, Praveen Choudhary, Armando Papa, Ashis K. Pani	2017	Empirical Paper-Structured Equation Modeling	This study explored the adoption of Internet of Things from a multiple theory perspective, namely, The Theory of Reasoned Action (TRA), The Theory of Planned Behavior (TPB) and The Technology Acceptance Model (TAM).

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The Framework of Business Model in the Context of Industrial Internet of Things	Sylwia Gierej	2017	Conceptual paper	The purpose of this article is an attempt to develop the concept of a business model dedicated to companies implementing technologies of the Industrial Internet of Things.
The Internet of Things and new business opportunities	Vlad Krotov	2017	Literature Review	This study elaborated the business opportunities provided by IoT by covering various elements within the technological, physical, and socioeconomic environments that comprise IoT.
The Internet of Things—Chance and challenge in industrial business relationships	Christine Falkenrecka, Ralf Wagner	2017	Multi-method research approach	This study developed and discussed a conceptual frame of organizational networks, trust, and technology acceptance in the context of the IoT. The empirical data provide evidence of how IoT transactions affect trust in buyer-manufacturer relationships.
The influence of the Industrial Internet of Things on business models of established manufacturing companies—A business level perspective	Daniel Kiel, Christian Arnold, Kai-Ingo Voigt	2017	Qualitative empirical approach (Semi-structured expert interviews)	This study aims at analysing the influence of the Industrial Internet of Things (IIoT) on established business models of manufacturing companies.
Challenges and Solutions for Applications and Technologies in the Internet of Things	SaadAlbishi Ben Soh AzmatUllah Fahad Algarni	2017	Literature Review	The aim of this paper is to study the literature review of electronics applications in the context of the Internet of Things' challenges and solutions for emerging sensors and electronics applications.
Disruption of Things: A Model to Facilitate Adoption of IoT-based Innovations by the Urban Poor	Abhimanyu Roy, Ali M.S.Zalzala, Alok Kumar	2016	Literature Review, Interviews and Usability test	This study examines the adoption of the Internet of Things (IoT) based innovations by urban poor communities.
The Internet of Things—Digital Revolution in Offline Market. Opportunity or Threat?	Anna Tarabasz	2016	Literature Review	The main aim of this article is to present the innovative approach of the IoT idea, enumerate juxtaposition of its opportunities and threats as well as to indicate its inner potential still being dormant.
Prototyping Business Models for IoT Service	Jaehyeon Jua, Mi-Seon Kima, Jae-Hyeon Ahn	2016	Case study	The aim of this research is to develop a generic business model framework for IoT business through literature analysis and interviews. To test the proposed business model framework, case studies of current IoT companies had done.
Management and Internet of Things	Mayra Samaniego, Ralph Deters	2016	Conceptual paper	This work addressed the management of resources in the Internet of Things. This is achieved by proposing a virtual-resource edge layer, which enables access and configuration to constrained physical resources.
New Security Architecture for IoT Network	Flauzac Olivier, Gonzalez Carlos, Nolot Florent	2015	Literature Review	This study explained the notion of security architecture for Internet of Things (IoT) based on software-defined networking (SDN).
An Integrated Approach to Common Problems in the Internet of Things	Sergey Efremov, Nikolay Pilipenko, Leonid Voskov	2015	Literature Review	The study investigated the topic and point out several problems that need to be efficiently solved for the Internet of Things to work on large scale numbers.

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Business models for the Internet of Things	R.M. Dijkmana, B. Sprenkels, T. Peeters, A. Janssen	2015	Literature Review	This paper presented a framework for developing business models for IoT applications. The framework is created based on a literature survey into existing business model frameworks and subsequently adapting these frameworks based on interviews in 11 companies that develop IoT applications.
A distributed and flexible architecture for Internet of Things	Ghofrane Fersi	2015	Conceptual paper	This article presented a new approach for use in the Internet of Things. It includes a complete architecture that integrates things identifiers assignment, routing, churn and mobility management.
Business Models for the Internet of Things Environment	Jozef Glova, Tomáš Sabol, ViliamVajda	2014	Conceptual Paper	This paper provides an overview of business models for Internet of Things, Services and People applications.