A Systematic Review of Internet of Things Adoption in Organizations: Taxonomy, Benefits, Challenges and Critical Factors

Sehnaz Ahmetoglu 1,*, Zaihisma Che Cob 2,3 and Nor’Ashikin Ali 1

1 College of Graduate Studies, Universiti Tenaga Nasional (UNITEN), Kajang 43000, Malaysia; shikin@uniten.edu.my
2 College of Computing and Informatics, Universiti Tenaga Nasional (UNITEN), Kajang 43000, Malaysia; zaihisma@uniten.edu.my
3 Institute of Informatics and Computing in Energy, Universiti Tenaga Nasional (UNITEN), Kajang 43000, Malaysia
* Correspondence: sehnaz.ahmetoglu@gmail.com

Abstract: Despite the evident growth of the Internet of Things (IoT) applications, IoT deployments in organizations remain in their early stages. This paper aims to systematically review and analyze the existing literature on IoT adoption in organizations. The extant literature was identified using five electronic databases from 2015 to July 2021. Seventy-seven articles have met the eligibility criteria and were analyzed to answer the research questions. This study produced a coherent taxonomy that can serve as a framework for future research on IoT adoption in organizations. This paper presents an overview of the essential features of this emerging technology in terms of IoT adoption benefits and challenges in organizations. Existing theoretical models have been analyzed to identify the factors that influence IoT adoption and to understand the future requirements for widespread IoT adoption in organizations. Six critical factors affecting and playing a key role in IoT adoption in organizations were identified based on the critical review findings: technological, organizational, environmental, human, benefit, and value. Decision-makers and developers can prioritize these critical factors and progressively improve their development to enhance IoT adoption efficiency. This review also includes an in-depth analysis to bridge gaps and provide a comprehensive overview to further understand this research field.

Keywords: adoption factors; IoT benefits; IoT challenges; organizations; systematic review; technology adoption

1. Introduction

The Internet of Things (IoT) ushered in a new industrial revolution, the fourth industrial revolution (Industry 4.0), resulting in radical changes across all industries [1]. IoT has differentiated itself from other technologies by incorporating smart features that enable it to sense, collect, communicate, and analyze massive amounts of data from various internal and external sources across a global network [2]. These features have attracted various sectors to adopt IoT, including healthcare, agriculture, transportation, oil and gas, manufacturing, supply chains, and logistics [3,4]. By 2025, the economic influence of IoT is expected to reach between $3.9 and $11.1 trillion; at that point, the value of such influence will equal approximately 11% of the global economy [5]. Thus, IoT technology enables all sectors to shift from traditional to smart business environments.

IoT can be described as a network comprising several connected nodes that depend on sensory, transmission, and information processing technology that communicate with each other as smart components to achieve a specific goal using the Internet as a communication medium with no time and space constraints [2,6,7]. According to the International...
Telecommunication Union (ITU-T), IoT is “a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies [8]”.

Disruptive technology allows businesses to exchange real-time data with numerous facilities, operators, customers, supply chains, and other connected devices using Internet network infrastructure. Moreover, it directly integrates computer-based systems with the physical world through remote control and sensing, improving efficiency, accuracy, and economic benefits [7,9]. IoT offers promising opportunities for organizations to build vital applications and services, such as facility management, production flow monitoring, plant safety and security, energy management, asset management, quality control, and logistics and supply chains [10]. These IoT applications generate a new pattern that enables organizations to explore new markets, enhance production, streamline business operations, and more effectively and efficiently satisfy customer requirements while maintaining competitive advantages [3,11].

IoT adopters saw IoT as critical to business success in the coming years [12] and believed companies that do not embrace IoT will fall behind their competitors within five years [13,14]. Competitors who adopt IoT can produce goods faster and more efficiently and conquer market shares even as new competitors emerge [11,15]. Thus, the IoT will become a necessity rather than an option for competitive market success [11,12]. Furthermore, IoT can play a strategic role in preserving organizations and protecting them from collapse during crisis times, such as the COVID-19 pandemic outbreak that devastatingly affected human lives and the global economy [16,17]. Besides assisting in recovery from pandemic impacts, remote work and increased reliance on technology can also keep employees safe [16,18]. Consequently, organizations are increasingly looking toward emerging technologies for operational support in the wake of extreme disruption [12,19].

Despite the importance of IoT deployments within organizations, IoT remains in the early adoption phase [20–25]. Adoption is the process by which a decision-making unit (adopter) considers a new technology [26]. This process concludes with an outcome or decision to accept or reject the technology based on the organization’s evaluation of the new technology [26]. Several studies have been conducted on IoT adoption in organizations in the existing literature [2,4,27–31]. However, some of these studies have focused on studying IoT adoption in a particular sector, restricting their findings to that sector [4,27–30]. Previous studies have attempted to synthesize and analyze the literature without providing a coherent taxonomy to help future researchers map the research directions and relevant issues [2,27–29,31]. Furthermore, these studies were often focused on IoT adoption challenges and neglected to discuss the benefits [4,27,29,30]. IoT adoption benefits require special attention due to their impact on the IoT adoption decision. Finally, previous studies have not provided a sufficient analysis to understand the main factors influencing IoT adoption in organizations, except the study [31] that attempted to determine the factors based on UTAUT constructs, as seen in Table 1. Therefore, this review aims to bridge the current literature gap regarding IoT adoption in organizations and offers a recent picture of its current status through the following steps:

1. Analyzing and building on existing research to provide a coherent taxonomy and landscape for future IoT research in organizations.
2. Surveying the IoT adoption benefits and challenges to provide insight into the future requirements of IoT adoption and deployment in organizations.
3. Identifying the critical factors that influence IoT adoption in organizations.

This paper is organized as follows: Section 2 details the methodology of the review. Section 3 summarizes the literature landscape and outlines the coherent taxonomy. Section 4 presents and classifies IoT benefits for organizations. Section 5 discusses the challenges that hinder IoT adoption in organizations. Section 6 presents the theoretical models used in prior studies and identifies the critical factors of IoT adoption. Section 7 discusses the findings and limitations of the study. The final section presents the conclusions of this study.
Table 1. Comparison between existing systematic reviews and this study.

| Author and Year                        | Organization Type         | Time Range         | Taxonomy | IoT Benefits | IoT Challenges | Adoption Factors |
|----------------------------------------|---------------------------|--------------------|----------|--------------|----------------|-----------------|
| [2] Lu, Papagiannidis, and Alamanos 2018 | General                   | 2010–Feb 2017      |          | /            | Security and ethical issues |                  |
| [4] Wanasinghe et al., 2020            | Oil & gas                 | No lower bound–Aug 2019 |          | /            |                |                  |
| [27] Birkel and Hartmann 2019          | Supply Chain Management   | 2008–2018          |          | /            |                |                  |
| [28] Rejeb et al., 2021                | Halal food supply chain   | 2008–2020          |          | /            |                |                  |
| [29] Aamer et al. 2021                 | Food supply chain         | 2010–2020          |          | /            |                |                  |
| [30] Almansour, and Saeed 2019         | Healthcare                | 2005–Not specified |          | /            |                | Limited to UTAUT constructs |
| [31] Carcary et al., 2018              | General                   | 2016–July 2021     |          | /            |                |                  |
| This SLR                               | General                   | 2016–July 2021     |          | /            |                |                  |

2. Systematic Review Protocol

This study conducted a systematic literature review (SLR) to compile all available research in the IoT adoption field following the PRISMA guidelines [32]. This type of review provides policymakers and future researchers with an in-depth analysis and significant insights into the topic. According to the purpose of this review, the following research questions were identified:

RQ1: What research evidence indicates IoT adoption in organizations?
RQ2: What are the benefits of adopting IoT in organizations?
RQ3: What are the challenges of adopting IoT in organizations?
RQ4: What are the key factors that influence IoT adoption in organizations?

2.1. Study Selection and Eligibility Criteria

Articles were searched and selected from five scholarly literature databases: Web of Science (WOS), IEEE Xplore, Science Direct (SD), Emerald (EI), and Google Scholar (GS). The following search query was used: (Adopt OR Accept OR Diffuse) AND (“Internet of things” OR IoT), focusing exclusively on proceedings of conferences, reviews, and journal articles as the most appropriate sources of the latest proper scientific articles related to the research area. However, books, chapters, and reports have been excluded to make the results in each database readable and able to be filtered in a short period.

In addition, all articles that were dedicated to the individual level or studied the adoption of IoT in conjunction with the adoption of other technologies in the organizations were removed; due to the different characteristics of each technology and various challenges it may encounter during adoption and to not affect the analysis results. Furthermore, the eligibility criteria were applied independently to all articles to prevent the risk of selection bias (see Table 2). Ultimately, 77 articles were included in the final set of this study. All selected articles were read in-depth to obtain the relevant data to answer the research questions. Then, the synthesized data into groups, where each group represented an answer to each research question. Figure 1 presents the PRISMA flow diagram for the systematic review and results.
Table 2. Inclusion and exclusion criteria.

| Inclusion Criteria | Exclusion Criteria |
|--------------------|-------------------|
| The articles must be in the English language. | The articles are published in other languages. |
| The published year before 2015. | The published year between 2015 and July 2021. |
| Articles published in journals and conferences. | Technical articles and periodic articles published by news websites, trade journals, magazines, and unreliable resources. |
| Articles dedicated to an organizational perspective. | Articles dedicated to an individual perspective. |
| Articles that are study IoT adoption only. | Articles that are study IoT adoption with the adoption of other technologies such as blockchain, digital twin, etc. |

Figure 1. PRISMA flow diagram for the systematic reviews.

2.2. Demographic Statistics
2.2.1. Publications by Year and Industry

Figure 2 shows a breakdown of the selected articles by year. Most articles were published in 2019, followed by 2020 and 2018, with the lowest number published in 2015. Over the years, the number of articles investigating IoT adoption in organizations has steadily increased. This upward trend may be attributed to the deployment of IoT applications in industries such as oil and gas [4,11,24,25,33], manufacturing [1,10,13,34–39], supply chains and logistics [20,22,23,27–29,40–45], construction [46–50], healthcare [30,51–55], agriculture [56–60], smart cities [21,61–63], hospitality [15,64], retail [65], education [17], and banking [66] (see Figure 3).
2.2.2. Publications by Country and Continents

The adoption of the IoT in organizations has been studied in different countries. Indian researchers have shown a keen interest in this area of research, with 11 studies [3,6,11,22,35,37,57,62,67,68], followed by the USA [9,21,38,41,46,65,69–72] and Malaysia [7,24,25,33,39,48,51,73] with 10 and 8 studies, respectively. Nigeria [49,50,74,75] and the UK [2,15,43,47] both ranked fourth in terms of publication, with each country producing a total of four studies. Three studies originated from Australia [44,53,58], Canada [4,10,29], Germany [1,13,27], Italy [45,66,76], and Pakistan [54,55,60]. China [20,40], Colombia [77,78], Indonesia [36,79], Ireland [31,34], Netherlands [61,63], Saudi Arabia [30,52], South Korea [80,81], and Taiwan [23,42] each contributed two studies. As depicted in Figure 4, Austria [64], France [82], Hungary [28], Iran [83], Kosovo [84], Portugal [85], Romania [17], Singapore [36], and the UAE [86] each contributed one study to the literature.

Additionally, among researchers from different continents, Asian scholars contributed the most to IoT adoption research, with 45.4% of publications, followed by European scholars (25.9%) and North America (16.8%), as seen in Figure 5.
3. Taxonomy

This section organizes the research findings into a coherent taxonomy to provide a concise overview of existing research relevant to the first question. After the filtering and full-text reading phases were completed, all the articles were grouped into three major categories and different sub-categories. As depicted in Figure 6, the first category of articles is the review studies (29/77), divided into general and specialty-based reviews. The second category represents the smallest group related to the conceptual studies (4/77). Finally, the last category is empirical studies (44/77), divided into five sub-categories: theoretical, multi-criteria decision-making, case study, survey, and other.

However, not all studies were clearly defined, and some overlapped into different categories, which were then classified according to the author’s viewpoint. An overview of the included studies can be found in Appendix A, Table A1. In general, the findings of the first question indicate that there is a limited number of studies, and further studies are still needed to address all aspects of IoT adoption and bridge the gap between academic research and real-world applications to reach full adoption among practitioners.
3.1. Review Studies

The main objective of reviewing articles on IoT adoption in organizations is to assess the current situation and justify future research on related subjects. Of the 77 selected articles, 30 were review studies (37.6%). This category is divided into two subcategories: general reviews (10/29) and specialty-based reviews (19/29) on IoT adoption in a specific sector.

General review studies offer an overview of IoT technology in organizations, highlighting numerous benefits, challenges, applications, and visions [2,7,9,31,73,86]. Despite the generality of these articles, several contained specific elements, including an ecosystem and business model for IoT implementation in organizations [71], IoT system requirements for sustainable deployment [75], implementation tools, and industrial sectors affected by IoT adoption [79], and bibliometric and network analysis of IoT in organizations [67].

On the other hand, specialty-based review studies focus on IoT adoption in a particular sector. Examples include, manufacturing [10,34], smart buildings [46], healthcare [30,52,53], agriculture [57,58,60], oil and gas industry [4], supply chains [27–29,43], small and medium enterprises (SME) [77,78,84], retail [65], and high-risk environment, health and safety (EHS) industries [82].

3.2. Conceptual Studies

Four articles (5.1%) were included in the conceptual studies category. This category aimed to offer suggestive frameworks or models without examining the results. One study provided a system dynamics model that identifies the positive and negative factors that affect IoT adoption [3]. Another study offered a model that discusses the impact of IoT adoption on organizational buying behavior [69], while the study [70] developed a model that identifies IoT priority areas and challenges that guide leaders of IoT initiatives. Finally, the last study proposed a conceptual model for IoT adoption in the oil and gas industry [24].

3.3. Empirical Studies

The final and largest category was empirical studies, with 44 articles (57.1%) grouped into five sub-categories based on the methodology used. In the theoretical studies sub-category, there were 17 articles identified, in which the IoT adoption factors were empirically investigated based on theories and hypothesis testing. Several studies have examined IoT adoption factors...
based on a single theory, such as the technology-organization-environment (TOE) framework [13,23,33,35,40,42], the technology acceptance model (TAM) [68], complexity theory [15], and the poly social reality (PoSR) framework [11]. In contrast, others have integrated more than one theory in their models, such as TOE and human-organization-technology (HOT-fit) [56], TOE and diffusion of innovation (DOI) [38], TOE, DOI, and oil and gas value (OGV) framework [25], and DOI, TAM, and theory of reasoned action (TRA) [39]. Furthermore, three studies developed hypotheses and identified factors based on the literature to determine the factors affecting IoT adoption [45], short-term impacts of IoT adoption [36], and IoT impact on higher education [17]. Lastly, the authors of [21] used path-dependence theory to explain government IoT adoption behavior. Table 3 shows the theoretical models used in IoT adoption studies at the organizational level. Studying various models helps to better understand IoT adoption and the development of more unified models. However, the TOE framework is the most frequently used theory for this purpose.

Table 3. The theoretical model used in IoT adoption at the organizational level.

| Abbreviation | Theory Name | Reference |
|--------------|-------------|-----------|
| CT           | Complexity Theory | [15] |
| DOI          | Diffusion of Innovation | [25,38,39] |
| HOT-fit      | Human-Organization-Technology | [56] |
| OGV          | Oil and Gas Value Framework | [25] |
| PoSR         | Poly Social Reality Framework | [11] |
| TAM          | Technology Acceptance Model | [39,68] |
| TOE          | Technology-Organization-Environment Framework | [13,23,33,35,38,40,42,56] |
| TRA          | Theory of Reasoned Action | [39] |
| PD           | Path-Dependence | [21] |

Eleven articles were identified in the multi-criteria decision-making sub-category. These studies highlighted different multi-criteria decision-making methods for analyzing and identifying the relationships between IoT adoption factors. Several studies adopted a single method, such as the fuzzy analytic hierarchy process (FAHP) method [51] or the analytical hierarchy process (AHP) [80]. Others combined multiple methods in their studies, such as the combination of grey relational analysis (GRA) and analytical hierarchy process (AHP) [6], interpretive structural modeling (ISM) integrated with matrice d’impacts croisés multiplication appliqués à un classement (MICMAC) [20,61,81], modified total interpretive structural modeling (m-TISM) and MICMAC methods [59], ISM and decision making trial and evaluation laboratory (DEMATEL) [22], techniques for ordering preference by similarity to ideal solution (TOPSIS) and AHP [54], DEMATEL method, maximum mean de-entropy (MMDE), and ISM [37], and total interpretative structural modeling (TISM) approach, Fuzzy-MICMAC, and DEMATEL method [62]. As shown in Table 4, ISM and MICMAC are the most frequently used methods.

Table 4. Multicriteria decision-making methods are used in determining IoT adoption factors.

| Abbreviation | Method Name | Reference |
|--------------|-------------|-----------|
| AHP          | Analytical Hierarchy Process | [6,54,80] |
| DEMATEL      | Decision Making Trial and Evaluation Laboratory | [22,37,62] |
| FAHP         | Fuzzy Analytic Hierarchy Process method | [51] |
| Fuzzy-MICMAC | Fuzzy Matrice d’Impacts Croisés Multiplication Appliqués à un Classement | [62] |
| GRA          | Grey Relational Analysis | [6] |
| ISM          | Interpretive Structural Modeling | [20,22,37,61,81] |
| MICMAC       | Matrice d’Impacts Croisés Multiplication Appliqués à un Classement | [20,59,61,81] |
| MMDE         | Maximum Mean De-Entropy | [37] |
| m-TISM       | Modified Total Interpretive Structural Modeling | [59] |
| TISM         | Total Interpretative Structural Modeling Approach | [62] |
| TOPSIS       | Technique for Order of Preference by Similarity to Ideal Solution | [54] |
The third sub-category comprised **survey studies** (seven articles) that evaluated IoT adoption in different sectors. These studies used questionnaire surveys to evaluate IoT adoption in hospitals [55], the public relations sector [74], IoT benefits and challenges in supply chains [41], IoT implementation in industries [83], IoT challenges in the construction sector [48,50], and the positive and negative effects of IoT on construction projects [49].

The fourth sub-category was **case studies** (four articles). These studies used a multiple case study method in their research to analyze IoT benefits and risks [63], identify the requirements for successful IoT adoption [66], identify the drivers for sustainability through IoT [64], and sustainable value [1].

The last sub-category included **other studies** (five articles). However, these studies were not related to any of the previous subcategories. For example, two studies focused on the role of governments in spreading IoT. One study recommended promoting the government’s role in IoT deployments based on analyzing 177 documents and developing general policy principles, specific policies to accelerate IoT adoption, governance, and process approaches [72]. Another study defined IT governance enablers to assist IoT implementation by using the Delphi method [85]. In contrast, the authors of [76] used a secondary database for 523 IoT projects to outline a taxonomy that allows the organization of IoT projects based on their technological novelty, IoT capabilities, and applications. Finally, the last two studies used interviews to investigate the opportunities and challenges of IoT use in the supply chains [44] and assess IoT’s critical success factors in construction projects [47].

### 4. IoT Adoption Benefits

This section highlights the benefits that motivate organizations to adopt IoT, corresponding to the second research question. In this study, the term “benefits” refers to the advantages that IoT provides, which result in positive outcomes for an organization [45]. Many experts and researchers have mentioned the potential benefits of IoT technology in their research. A summary of IoT benefits can be found in Appendix A, Table A2. Figure 7 illustrates the benefits of IoT adoption for organizations. According to Iacovou et al. [87], technology’s benefits can be grouped into two dimensions: direct and indirect benefits.

![IoT Benefits](image)

**Figure 7.** IoT benefits for organizations.

#### 4.1. Direct Benefits

The first dimension of IoT benefits is the direct benefits observed directly and is mainly related to an organization’s operational and internal efficiency [87]. These benefits refer to the enhancements introduced to the activities of the organization’s internal functions using IoT technology [36].

#### 4.1.1. Data Availability and Accuracy

IoT sensors enable seamless real-time data collection from all organizational sectors, processing, and analysis periodically and continuously [1,43,69,82]. Furthermore, these
data are unique and valuable because of their high quality, accuracy, and accessibility from anywhere and at any time [21,33,35,42,66]. Autonomous data collection, analysis, and visualization are critical to the organization’s digital transformation [4,15,36,47]. In addition, IoT allows the collection of large amounts of data [74], displaying [44], and sharing [31], not only from the internal sources of the organization but also from external sources that feed the facility, such as suppliers and customers who are served after receiving the products or services owing to the interconnectivity of things [9,37,83]. The ability of IoT to transmit real-time information leads to more transparency [27], visibility [28], improved quality [59], and an appropriate level of intelligence [41,79,83].

4.1.2. Better Decision-Making

IoT allows organizations to make decisions, plan, and schedule activities based on real-time data-driven choices rather than consequential information processing [38,39,45,48,53,55,56,59,73]. By using data from IoT systems, decision-makers can gain new insights into the value proposition, increase value creation, enhance customer relationships [11], adopt more effective policies and practices [21], and mitigate uncertainty [22,76]. Accordingly, IoT reduces complexity [31], conflict [69], and the decision-making cycle through the availability of related information to all decision-makers [33,36,66]. Furthermore, IoT enables objects to make automated decisions by communicating information about themselves without human intervention and increasing self-awareness capability among different systems, enabling them to react quickly to events [7,31,37,41,49], such as sending purchase orders for raw materials when stocks are low [69]. These ideal decisions are generated automatically using a large amount of multi-source data and intelligent algorithms (e.g., machine-learning algorithms), which increases the automation level [10].

4.1.3. Operation Process Efficiency

IoT device interconnections improve operations and communications management [22], increase agility [82], and enhance performance by combining systems that run the business with controllers, sensors, and data storage to support business operations [73]. This connectivity helps to increase efficiency [63], performance [28], and optimization in the organization’s day-to-day operations and assists in improving quality with high-end safety [3,24]. For example, Mercedes-Benz has improved the quality and increased auto production’s operational efficiency and flexibility by integrating IoT technology in assembly lines and materials handling in their factories [88].

In addition, IoT sensors are used to perform remote monitoring [52] and automate workflows/processes without human intervention [58,68], thereby reducing human error [31,39,51]. Such a process can enhance autonomy and manage various interruptions [1]. Furthermore, wireless connectivity, low-cost sensors, and big data techniques may offer valuable data to examine the equipment’s status and performance [11]. Historical and real-time data can be modeled, correlated, analyzed, and visualized to investigate the performance status of the equipment, allowing predictive maintenance and cost reduction [3,34], unplanned downtime [35,36], and unanticipated interruptions [43]. This process promotes early diagnostics and part replacement according to the prediction without compromising the company’s profit because of extended shutdowns [76]. As a result, IoT can reduce overall operational costs by enhancing predictive maintenance [41], minimizing equipment failure [33], reducing waste [59], and improving energy efficiency [15,31].

4.1.4. Assets Management Efficiency

Effective resource utilization requires communication and information exchange between assets and the organization [1,3,24,52]. The connected sensors embedded in all equipment and tools allow the direct tracking of assets directly [39,42,79], whether localized or geographically distributed [76], as well as the acquisition of more precise information regarding the equipment’s health [63], and improve the speed and accuracy of the equipment [36], through a set of algorithms for investigating the equipment’s performance status.
over time [34]. Such a process provides visibility into asset status [63], allows remote diagnostics, easily locates issues [45], and improves asset utilization [46]. IoT data can also help companies track products condition “from the floor to store” and beyond [41], including the time spent in cargo and the time it took to fly off the shelf, and even the temperature at which it was stored [43]. Furthermore, IoT allows for more accessible information sharing for live inventory levels and captures internal and external movements to help manage stock [43,59]. This process leads to inventory and raw material reductions and better purchasing decisions [11].

4.1.5. Improved Safety and Security

IoT has enormous potential in high-risk EHS industries [82,83], where human lives are at risk from incidents, such as collisions with heavy objects, falls, and electrocutions [49]. IoT applications are prepared to offer safe, reliable, and practical solutions to improve safety conditions in the working environment [34] because of their capability to facilitate remote operation, enable collaboration between human workers and robots, and provide rich low-level data, such as high or low-level temperatures [1]. Additionally, IoT technology offers an innovative design for an autonomous system that localizes, monitors, and cautions site workers who work in danger zones [48], especially in remote and hostile locations, where the challenges and risks associated with these facilities are elevated [4]. The IoT also provides alerts for anomalies or any actions that threaten the organization, ensuring security and protection against physical dangers, such as like fire accidents in the working environment [33,46]. In addition, the IoT enables the preservation of workstations against physical threats and ensures equipment safety [3]. The unique capabilities of these systems allow the organization to maintain situational awareness, respond effectively to incidents and threats, and comply with occupational safety and health [4,24].

4.1.6. Improved Supply Chains and Transportation

IoT systems can enable unparalleled visibility along the supply chain by connecting supply chains with the organization and effectively tracking export and import activities [33,45,76,83]. With this feature, production activities can be scheduled and planned through the supplied data in response to demand and other market dynamics [7,65,67], bringing transparency to the processes [22], retrieving demand and supply [37,38], and feedback information in real-time for all concerned parties [10]. Concurrently, IoT technology can aid organizations in fleet management [41]. Sensor networks can monitor field personnel, field vehicles, mobile equipment, and product transportation systems (e.g., planes, ships, trucks, and trains) in real-time [4,41]. However, manually coordinating an entire fleet is challenging for one fleet management operator [4]. Therefore, using IoT geo-positioning sensors’ location data, automated fleet management can be implemented using data-driven systems to track equipment operator and driver performance, identify hassle-free delivery routes, assess field personnel, and assist facility managers and supervisors in optimizing fleet deployments [4,49]. Amazon is a good example of improving fleet management by applying IoT technology. By geo-positioning sensors, Amazon can track their vehicles along with the drivers assigned to them at any time. This feature allowed them to ensure safety compliance with the drivers, track the shipments locations vehicles’ health, and enhance the overall visibility of the supply chains [89].

4.2. Indirect Benefits

The second dimension for IoT benefits is indirect benefits that need some time to be observed and is related to the development observed in organizational strategies and competitive and economic advantages [36,87].

4.2.1. Competitive Advantage

Companies today need to be equipped with new technologies to remain competitive in the market [13,20,84]. Today, businesses depend on gathering people, technology, processes,
data, and things together to create new value and predict market needs, as most value creation occurs outside the focal company [43]. The IoT can help organizations capture new value through its ability to gather and analyze real-time data from all parties [2,76]. Improved customer and user experiences [74], marketing and advertising benefits [71], productivity improvements [35], market expansion [1,74], and competitiveness [11] are all examples of value creation. Thus, organizations that adopt the IoT may gain a sustained competitive advantage over their competitors [7,15,38,44,83].

4.2.2. Business and Network Integration

Researchers have considered the potential ability of IoT to foster deep and integrated relationships with stakeholders [51,69] through the enabled IoT devices to link and integrate all stakeholders and the business ecosystem in one network [17], including shareholders, partners, customers, suppliers, employees, as well as activities and resources [2,43,44]. This process can help all parties become aware of interdependencies, the flow of materials/parts, new product and service updates, and the integration of responsiveness when a problem arises [39,83]. Furthermore, ecosystem integration is considered important for improving business performance [41], synchronizing data, enabling the strategic redesign of business operations, and extending stakeholders’ experience [22], all of which result in increased stakeholder loyalty and the development of long-term sustainable relationships [11].

4.2.3. Sustainability

Organizations prioritize the triple bottom line of sustainability, which includes profit, people, and the planet, to meet their future needs [71]. Therefore, today’s organizations incorporate sustainability into their business models to achieve financial success [73] and profitability while also fulfilling their social and environmental responsibilities [71]. IoT applications consider the impact on the aforementioned three sustainability dimensions and help achieve socially responsible business practices, less waste production, and a cleaner environment [1]. Moreover, IoT enables effective resource allocation, including water, raw materials, and others, based on real-time data [58,59]. These data can provide complete knowledge to draw a future map for businesses regarding inventory, raw materials, and energy consumption reduction, leading to green procedures, waste reduction, and natural resource conservation [49,67]. Additionally, monitoring industrial pollution using IoT can help reduce pollution, save the planet, and reduce human interference, leading to a healthy working environment for employees [24,36]. In addition, the IoT can help organizations increase revenue by improving production and operational efficiency, product and service development, and inventory reduction [3], ensuring their competitiveness and business sustainability [56,64].

4.2.4. Customer Satisfaction

Customers are the best data source for evaluating customer satisfaction [74]. The IoT has tremendous potential to enhance an organization’s processes and leverage the next level of achievement by connecting things with embedded smart devices or unique identifiers [37,77]. This approach enables the creation of substantial business value through data gathering with the assistance of customers and analysis of changes in customer behavior, thus improving the performance and services based on customer experience and expectations [11,15,49] and responding to their requirements faster and more flexibly [1,67]. IoT technology centers on developing an integrated model for designing services with the customers’ involvement as a critical component of creating a new dimension of services and products [2,36]. This supports adopting the quality function deployment approach for customer-focused processes and is managed through a virtual model that enables the continuous improvement of new products through sensors that collect real-time data [27]. Thus, this will lead to a higher standard of customer engagement and satisfaction [24,41,47,51].
4.2.5. Products and Services Innovation

The IoT has great potential for transforming existing business processes and unlocking economic and market value [37]. The future economy is driven by the knowledge that predicts the market needs and innovates new products and value-added services [2,36]. The IoT is a catalyst for deploying innovative solutions that help companies shorten their innovation cycles, bringing highly customized products [13]. The IoT enables process innovation in various companies’ operations through embedded machines and equipment [76]. Previous studies have found a positive relationship between product and service innovation and IoT [1,34]. Because of IoT’s capability to collect valuable information throughout the product lifecycle, continuously monitor operations, and make decisions based on reliable and real-time data, better product and service configurations are generated, and the overall performance improves [11,41]. Such a process could be crucial in enhancing financial and competitive advantages, as well as economic sustainability [71].

4.2.6. New Revenue Stream

Businesses will gain insights into previously unexpected product and service lines by leveraging IoT, thereby creating new revenue opportunities [63,83]. IoT can derive business value by linking data from different sources and monitoring what happens in the real world in real time [2,24,60], analyzing market status [65], communicating with customers more effectively, and increasing their loyalty [11,28,76]. Furthermore, real-time data insights increase service flexibility and product effectiveness [9], decrease production waste and pollution [58], and save energy, which frequently results in new revenue streams [7,84]. According to previous studies, organizations that adopt IoT see an increase in revenue and a reduction in production costs [1,36]. This uniqueness gives many organizations a strategic advantage over competitors and enables them to survive for years to come [49].

5. IoT Adoption Challenges

Despite the potential benefits of IoT implementation, the technology is still nascent [31], and several implementation challenges must be overcome before a large-scale rollout [61]. These challenges highly contribute to the minimum adoption rate and hinder the attainability of IoT’s extreme benefits [70]. The challenges in this study refer to IoT’s negative impacts [3], including concerns, risks, and barriers that cost firms money and disturb or prevent successful IoT implementation [27] (see Appendix A, Table A3). As IoT challenges may include several aspects other than technological ones, they were categorized into three dimensions that apply to organizations through the lens of the TOE framework [90], including technological challenges [41], organizational challenges [27,41], and environmental challenges [27]. Moreover, this classification enabled the research to consider the barriers to adoption that could discourage organizations from adopting this technology [13]. Figure 8 summarizes the challenges of IoT adoption reported in previous studies.
5.1. Technological Challenges

The technological challenges are those associated with the technology innovation’s characteristics, such as security, compatibility, complexity, implementation cost, scalability, and energy consumption and are considered to have a significant influence on innovation adoption [24]. Most studies have highlighted security and privacy as one of the biggest challenges to IoT adoption. Several technical and non-technical issues exist; however, they are less prevalent than security and privacy concerns.

5.1.1. Security and Privacy

While IoT improves an organization’s productivity and performance, it introduces various security and privacy issues [4,27,43,45,54,65,78,82,84], as an increasing number and variety of connected devices are being integrated into organizations [17,48,71,73]. The privacy threats associated with IoT are manifested by unauthorized function execution and the leakage of personal data and sensitive user information [1,3,7,33,70,72]. Simultaneously, IoT security risks involve different attacks on the software, hardware, and networks [39,41,60], such as denial of service [31], compromised or spoiled devices [23], and data or information modification/loss [22,59]. In addition, IoT implementation requires cooperation between several partners, raising concerns regarding data ownership and protection [29,36,57]. Consequently, IoT security implications are posing significant barriers to wider adoption within organizations for several reasons. Firstly, the potential security threat escalates due to the lack of common standards and architecture for IoT security [9,46,69,86]. Secondly, IoT networks comprise various devices, platforms, communication mediums, and protocols, leading to the emergence of many layers that require different security systems [70]. Thirdly, most IoT communications are wireless, making an attack relatively easy [52,53,79]. Finally, IoT systems are extremely dynamic [2], resulting in the emergence of new cyberattacks [24,63].

5.1.2. Compatibility

IoT applications combine the capabilities of several sectors that have typically worked differently and without any collaborations. The involvement of cross-functional specialties, legacy systems integration, and the operationalization of a simple, intuitive service model
all contribute to the complexity of IoT implementation [22,29]. Business processes can be internal to an organization or distributed across organizational boundaries, making process integration quite challenging owing to different interfaces, technologies, methods, protocols, and unique characteristics in each organization involved [47]. Furthermore, organizations’ legacy systems have been developed over time [4], with isolated data silos [36] and limited connectivity to external systems, making them highly inflexible and difficult to expand or upgrade their functionality [34]. Thus, these legacy systems are incompatible with IoT systems, which depend on an open, ubiquitously connected IP network [7]. IoT applications require a high-quality Internet connection [22], fixed-broadband [78], and cloud computing for data storage, sensors, controllers, and specialized software. Organizations may have difficulties implementing IoT applications due to the limitation of their IT infrastructure [35,38,48,63,78]. Typically, IT infrastructure has been established since the organization’s inception, which means it is outdated and not subject to upgrade or development [37,71].

5.1.3. Complexity

IoT is a complex technology consisting of a large number of disparate devices connected via a vast network [28,54,61]. Integration of these devices is a complex ongoing issue for IoT applications due to the need to manage a large number of heterogeneous things that run on different platforms [7,39,57,58,86]. When implementing IoT applications, no single vendor can provide all the functions required by the customer [4]. Therefore, a large number of different devices from multiple suppliers must be configured into one network, resulting in protocol, architecture, and configuration heterogeneity [79]. However, IoT devices are still lacking unified standards and protocols [3,37,44,50,82,83], which complicates the interoperability between these devices [25,40,48,73]. Big data techniques require semantic interoperability in IoT devices [53]. Each IoT device generates a massive amount of data, making managing, processing, integrating, and analyzing this heterogeneous data a significant challenge in the absence of unified standards [27,63]. This reduces the significance and value of the collected data, thus losing the opportunity to leverage IoT benefits, such as predictive modeling and decision-making [29].

5.1.4. Implementation Cost

IoT technology implementation in organizations may require a considerable initial investment in technical infrastructure support [3,30,39,44,50,78], hardware [27,42,60], software [7,46], skilled staffing [1], and training due to the interdisciplinary nature and complexity of IoT [48,62], as well as the maintenance and operation costs involved [29,35]. The higher cost of IoT technology is an inhibitor to organizations’ adoption intentions [15], particularly small and medium-sized enterprises (SMEs), which have limited finances [28,35,77]. Furthermore, organizations fear the risks of irreversible financial and investment losses [41], and return on investment (ROI) could take longer than expected [64,82], lengthening the payback period [6,22]. Therefore, implementation costs are critical in the decision-making process surrounding IoT adoption [17,45,47]. When implementation costs are high, IoT adoption is typically lower in organizations [40,56].

5.1.5. Scalability of IoT Infrastructure

An IoT network consists of a wide range of devices connected in an open environment using different technologies and protocols [50]. However, this feature made IoT technology very low in terms of scalability and interoperability due to the heterogeneity of the IoT devices [79,80]. IoT devices will generate exponentially more big data in the future, requiring more physical devices to be connected [31]. Scalability will be a significant concern as organizations need to keep up with the changing complexity of data collection and processing [22]. The availability of efficient and scalable infrastructure to deal with the complexities of IoT big data is significant for ensuring getting new business value [31].
5.1.6. Energy Consumption

Power consumption is a significant concern for IoT devices [22,62]. IoT sensors work to send and receive data back and forth with the data centers continuously [49]. This process leads to an increased demand for electricity to operate these devices, one of the most critical obstacles to the practical application [79]. Powering these devices using battery technology with power limited is a big challenge [79]. Furthermore, IoT implementation generates vast quantities of data to be processed and analyzed in real-time [49]. There will be a growing energy demand with the increasing number of IoT devices, data centers, and networks [22,37]. Data centers will be faced with additional workloads due to processing large volumes of data, making them face a new challenge in energy-consuming [49]. For IoT implementation to be suitable for organizations, IoT devices must use a self-powered sufficient energy source to be smart and mitigate energy and green computing consumption [50], such as utilizing renewable energy sources from wind and solar to charge batteries [37].

5.2. Organizational Challenges

On the other hand, organizational challenges are internal challenges related to the organization’s operations, such as top management support, organizational readiness, IT skills and knowledge, and employees’ resistance [27].

5.2.1. Top Management Support

Organizational decision makers may lack knowledge or expertise in digital technologies [7,31,44], discouraging them from recognizing the new technology’s opportunities and advantages [62]. Many organization owners and managers are still unaware of IoT and how it can positively impact their business [39,84]. Furthermore, some senior managers tend toward closed thinking and are trapped in standard industry routines and procedures. Throughout the IoT adoption process, top management plays an essential role in determining the level of adoption, securing the required resources, sponsorship, and strategy development [13,23,25,35,41]. However, IoT adoption in organizations is a complex task that requires innovation, knowledge, and previous experience of top management with information and communications technology (ICT) [33,77], as well as the persuasion of internal company stakeholders, such as suppliers, employees, and shareholders [1,47]. Different stakeholders’ perceptions of IoT, such as unwillingness to change, misperceptions about the returns on investment (ROI), and unrealistic expectations about the efforts needed to deal with the new systems, may prevent IoT adoption or be unsuccessful [29].

5.2.2. Organizational Readiness

Prior to adopting any technology, it is critical to assess the organization’s readiness [23,35]. Organizations must assess the adequacy of their resources, such as financial, human, and technological resources, to determine their readiness to adopt IoT technology [15,38,39,61]. IoT implementation requires a large investment, the availability of experts who can work with IoT features, as well as the assessment of the technology readiness level to examine the technology requirements [76]. They will be unable to adopt IoT technology if they lack sufficient resources [38]. Furthermore, IoT is a new technological paradigm that can change businesses and create value [78,84]. One of the challenges to IoT adoption is the inability of the current business model to handle the IoT ecosystem [6,82]. Thus, organizations’ business models must be redefined to accommodate IoT technology and benefit from its unique functions [10,13,33,85]. In general, organizations are afraid to take risks in changing their business models, leading to unexpected disruptions and radical changes in their prevailing work habits [6,27].

5.2.3. IT Skill and Knowledge

Inadequate technical knowledge constrains organizations’ IoT adoption [29,39]. IoT is a complex technology area that deals with a vast volume of data, devices, sensors, and
several sources [3,24,60,77]. Therefore, IoT requires professionals with more knowledge and skills in data analytics and the ability to create value and content analysis using optimization and prediction applications [22,41,58,61,62]. The matter of knowledge gaps in organizations involves the top management’s inability to manage IoT [27,84], the lack of skills among employees [6,20,37,40,44], and the unavailability of experts such as data analysts [30,48,50,79]. Thus, to ensure the success of IoT adoption, organizations must hire experts with IoT expertise [35] and invest in developing digital skills for their employees to take advantage of IoT [1,6,78,82].

5.2.4. Employees Resistance

Introducing new techniques, gadgets, or ways of working into organizations is a significant undertaking. The majority of the workforce is unwilling to learn new technologies or change their routines [27]. Employees feel comfortable and in harmony with the current technology. However, they are concerned about their inability to use emerging technologies such as IoT, prompting them to abandon them [44]. Furthermore, incorporating IoT technology into the workplace leads to increased automation and autonomy [58,68], which instills fear in employees about losing their jobs and causes them to reject IoT technology [49,76]. Therefore, employee attitudes significantly influence IoT adoption’s technical efficiency and failure [56].

5.3. Environmental Challenges

In contrast, environmental challenges are the external challenges occurring from the organization’s interaction with its network and the outside environment [27], such as government regulations, vendors and suppliers issues, collaboration with partners, and uncertainty.

5.3.1. Government Regulations

The lack of policies and regulatory norms leads to the emergence of faulty standards and challenges in security [62], data sharing [61], protection [63], and unclear ownership [1,27]. Governments must consider how to support new technology innovations such as IoT and how to integrate this technology into organizations systematically to strengthen the competitiveness of an economy [22,59,77]. Therefore, governments need to formulate related policies and legislation to help adopt and develop IoT technology to realize its full economic and societal potential, including identifying challenges and proposing solutions [28,71,75], laying the legislation for privacy and liability regulations [29,82,85], supporting technology investment [7], and expanding tax credits for research and development. Accordingly, more effort is required to promote IoT applications by defining national initiatives and policy tools to support the IoT technology development ecosystem [37,72,80,81].

5.3.2. Vendors and Suppliers Issues

Today, organizations’ IoT devices and products from leading vendors are unable to communicate with each other due to their different platform architectures [31]. Unfortunately, competitive relations and market monopolies between IoT vendors and technology suppliers have hampered IoT adoption [46,66]. Each vendor may have served customers with different hardware/software configurations, communication protocols, security protocols, and data structures, making IoT solutions complex and impractical [4]. Moreover, there is insufficient technical support from vendors and suppliers when adopting IoT applications. Since IoT is a new technology with complex features, it requires great vendor support both during and after implementation [35]. Additionally, organizations face issues finding the right vendor and supplier who can deliver high scalability, disaster recovery, and optimized results while maintaining efficiency and precision [3]. Therefore, finding the right IoT vendor capable of providing the best IoT solution and support is difficult [83].
5.3.3. Partners Collaboration

Organizations consist of various partners and stakeholders. Therefore, it is necessary to bring together all partners and stakeholders on a common platform to achieve a common goal and maximize the benefits of IoT implementation [22,85]. IoT implementation requires extending the system’s resources and infrastructures and connecting to the systems of cooperating partners [1,29]. This is a challenging task because most partners have different platforms, procedures, and legacy systems, and they are not always technologically compatible with one another [48]. Besides, they are afraid of sharing their information [44]. Such a challenge may require a cultural shift to obtain greater cross-organizational transparency [29]. Moreover, the lack of standards and compatibility between IoT systems makes it challenging to garner consensus on a single standard [27,42,72]. In addition, the varying interests of stakeholders and their different strategies for adopting new technology and investment policies could conflict with those of other stakeholders [25,37,61,63].

5.3.4. Uncertainty

As with other technologies, IoT technology inherently contains both market and technical uncertainty [10,42]. Technology advances rapidly, which could threaten the IoT via the emergence of an advanced new technology [1,40,44]. Decision-makers are concerned with the uncertainty associated with technology development and the high investment costs of IoT [29], which other emerging technologies may outperform. Furthermore, business is characterized by economic uncertainty, which manifests itself in the form of changeable levels of demand, volatile customer preferences [66], fluctuating prices [13], speedy production processes, and regulations [80], all of which have created an unprecedented set of challenges that may affect IoT adoption [13,66].

6. Factors Influencing IoT Adoption

This section answers the fourth research question, which aims to identify the critical factors that affect IoT adoption in organizations. First, the information was extracted from the empirical studies included in this research and arranged into one table. The method of identifying the factors has been adopted from the study [26]. As illustrated in Table 5, the table was designed with seven columns: reference, organization type, theory, methodology, dependent variable, independent variable, and research findings. The variables were then grouped and categorized according to the specific factors, as shown in Table 6. To accomplish this, the following steps were taken in identifying the factors:

1. All variables identified in Table 5 were extracted and sorted into groups.
2. The variables for each group were filtered to eliminate the duplications because some studies used the same variables but with different names.
3. Some variables were specified for the specific industry, thus removed to ensure that all variables can be applied to all organizations.
4. The groups were named with factors’ names based on the common characteristics of the variables in each group.
Table 5. The empirical studies examining the IoT adoption factors in the organizations.

| Ref. | Organization Type | Theory | Methodology | Dependent Variable | Independent Variable | Research Findings |
|------|-------------------|--------|-------------|---------------------|-----------------------|-------------------|
| [11] | Public sector retail oil outlets | - Extended Polycontextual Reality (PoCR) framework Thing theory | Exploratory mixed methods: - A semi-structured interview - Survey to test the hypotheses logistic regression | IoT adoption | People Factors: - Brand value - Relations with stakeholders - Customer experience - Marketing - Workforce at outlets - Customer expectation - Optimization Technologies Factors: - Efficient new method for task - Customer insights - Increased in-store sales - Cashless transaction - Convenience Processes Factors: - Return on investment - Cost optimization Interoperability Factors: - Connecting customers’ mobile to petrol pumps - Security risks Data Security Factors: - Business value - Faster decision-making - Data protection Competitive Advantage Factors: - Competitive-edge - Gaining new revenue Things Factors: - Sensors - Wearables | “Using the seven factors as predictors, it was found that five factors: people, technologies, processes, data security, and competitive advantage have a higher impact on the adoption of IoT.” |
| [13] | Manufacturing | TOE | Survey | IoT adoption | - Technological Factors: - Relative advantage - Perceived challenges - Compatibility - Organizational Factors: - Firm size - Top management support - Absorptive capacity - Environmental Factors: - Competition - Environmental uncertainty - Perceived outside support - Control Variable: - Industry sector | - “The only exception was compatibility, in which items did not load as expected. Consequently, these items were dropped.” - “Relative advantage, top management support, and competition each have a significant positive effect on IoT adoption. Among these determinants, relative advantage has the strongest impact.” - “Environmental uncertainty shows a negative impact on IoT adoption, therefore opposite the proposed positive correlation.” - “Firm size, perceived challenges, absorptive capacity, and perceived outside support seem not to affect the adoption of IoT, indicating that benefits play a substantially more important role in the adoption decision.” - “The industry sector does not play a role in IoT adoption.” |
| [15] | Hospitality (SMEs) | Complexity theory | Survey | Willingness to adopt IoT | - Operational mode - Perceived benefits - Perceived risks - Perceived barriers - Competition - Innovation - Technology competence | “The adoption decision revolves around three levels of elements respectively benefits, risks, and barriers associated with the integration of IoT in the current offering and its servicescape.” |
| [17] | Higher Education | — | Survey | IoT adoption | - Intra- and extra-university connectivity - Additional resources - Excellence in teaching - Excellence in learning - Challenges in data security and integrity - IoT adoption education policies | “The adoption of IoT in higher education has a positive influence on excellence in teaching, on additional resources, and excellence in learning.” - “The education policies do have an influence on the adoption of IoT in universities, but that influence is relatively low.” - “The adoption of IoT in universities also has a positive influence on intra- and extra-university connectivity and results in challenges related to data security and integrity, but the effect of this influence is rather low.” |
Table 5. Cont.

| Ref. | Organization Type | Theory | Methodology | Dependent Variable | Independent Variable | Research Findings |
|------|-------------------|--------|-------------|--------------------|-----------------------|-------------------|
| [21] | Smart city        | Path dependence | Logistic regression | - Adoption of smart and connected sensors  
- Adoption of integrated sensor network  
- Scope of sensors  
- Sensors on natural resources and energy  
- Sensors for transportation and mobility | - Urban sustainability efforts  
- Data-driven DM practices  
- Digital government progressiveness  
Control Variables: internal/organizational factors:  
- Government operating expenditure  
- Government IT expenditure  
- Form of government  
External/environmental factors:  
- Network infrastructure deployment in the city  
- Member of What Works Cities  
- Political culture  
- Percentage of IT employment  
- Percentage of population with college degree or above  
- Population | - “The local governments’ early adoption of smart sensors is likely to stem from their needs in specific policy domains.”  
- “The local government’s historical paths on urban sustainability and data-driven decision-making practices can predict its trajectory of sensor deployment, in terms of the scope and the integration of smart sensors across different urban domains.”  
- “The local government’s e-government progressiveness is not a significant predictor.”  
- “The local governments’ adoption of sensor technologies differs from traditional e-government development.”  
- “Organizational and environmental factors, such as administrative and IT capacity, leadership support, IT infrastructure, peer effects, and the influence of different constituency groups, are not highly significant.” |
| [22] | Logistics         | Hybrid model - TOE-DEMATEL | DEMATEL to identify the causal relationships among factors | IoT adoption | Technology Dimension:  
- Technology infrastructure  
- Technology integration  
- IT expertise  
Organization Dimension:  
- Expected benefits  
- Top management support  
- Organizational readiness  
Environment Dimension:  
- Government policy  
- Supporting industry  
- Competitive pressure  
Security Dimension:  
- Data security  
- Institution security  
- System security | - “Three critical factors for IoT adoption in the logistics industry are identified. These include two causal (environment, organization) and one effect factor (security) dimensions.”  
- “The indices suggest that the technology dimension has a low impact on the overall framework but is also susceptible to other factors and that an adjustment of the other factors can lead to an improvement in the technology dimension.”  
- “With respect to the technology dimension, IT expertise is the most influential criterion, followed by technology infrastructure and technology integration.”  
- “In the organization dimension, top management support is the most influential criterion, followed by organizational readiness and expected benefits.”  
- “In the environment dimension, competitive pressure is the most influential criterion, followed by government policy and supporting industries.”  
- “In the security dimension, institution security is the most influential criterion, followed by system and data security.” |
| [23] | Oil & Gas         | TOE-DOI-Oil & Gas-Value OGV | Survey to test the hypotheses  
Expert evaluation to the results | IoT Adoption intention | Technology & Innovation:  
- Relative advantage  
- Complexity  
- Compatibility  
- Technology readiness  
- Security concern  
Organization Factors:  
- Top management support  
- Firm size  
Environment Factors:  
- Competitive pressure  
- Trading partner pressure  
- Information intensity  
- Regulatory support  
Industry Factors:  
- Financial performance  
- Customer value  
- Societal value  
- Environmental value | - “Information intensity, security concern, customer value, firm size, financial performance, trading partner pressure, environmental value, and top management support are important factors with significant performance to IoT adoption intention.”  
- “The competitive pressure and regulatory support were found insignificant.” |
| [24] | Oil & Gas         | TOE | Survey | IoT Adoption | Technological Factors:  
- Technology infrastructure  
- Use of technology resources  
- Organizational factors:  
- Top management support  
- Scope of business operation  
Environment Factors:  
- Competitive pressure  
- Governmental policy  
Security Factors:  
- Information security  
- Corporation security | - “The relationship between all factors and the adoption of IoT are significant and positive.” |
### Table 5. Cont.

| Ref.   | Organization Type          | Theory | Methodology                      | Dependent Variable                                                                 | Independent Variable                                                                 | Research Findings                                                                                                                                                                                                 |
|--------|----------------------------|--------|----------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [35]   | Auto-Component Manufacturing SMEs | TOE    | - Extensive discussion with experts to consider the factors. | IoT Adoption intention                                                              | Technological Factors: IoT expertise, IoT infrastructure, Relative advantage, Cost, Compatibility, Security and privacy Organizational Factors: Top management support, Organizational readiness Environmental Factors: Competitive pressure, Support from IoT vendors, Control variable, Organization size | - “The results revealed that all technology, organizational, and environmental factors are significantly influencing the IoT adoption intention.”  
- “IoT is compatible with the existing traditional technology available in SMEs.”  
- “The cost has a significant negative path coefficient on the IoT adoption intention, which means that a higher cost is an inhibitor to the adoption intention of IoT.”  
- “The examination of the influence of the control variable showed that the effect of organization size is not significant.”  

| [36]   | Manufacturing              | —      | Survey                           | Expected outcome via IoT adoption                                                  | - Digitalization, Connectivity, Analytics, Downtime, Cost, Security and interoperability | - “The results found digitalization has a strong influence on analytics.”  
- “The impact of connectivity on the desired outcome via IoT adoption is in the moderately acceptable range.”  
- “Advanced analytics has a significantly strong influence on the desired outcome via the adoption of the IoT.”  
- “Downtime has a strong influence on business decisions.”  
- “The impact of asset and plant performance on the overall expectation outcome from the IoT has a moderate impact.”  
- “The impact of business decisions on the outcome of the key expectations from IoT adoption is strong.”  
- “The impact of security and interoperability on the business decisions is high.”  
- “Security and interoperability has moderate impact on the expected outcome from IoT adoption.”  

| [37]   | Manufacturing              | TOE    | DOI Survey                       | IoT adoption                                                                        | - IT governance, Interoperability, Staff collaboration, IT Infrastructure, IT/OT convergence | - “IT infrastructure, IT governance, and systems interoperability all have a direct and positive relationship with IT/OT convergence.”  
- “No empirical evidence to support a direct effect between staff collaboration and IT/OT convergence.”  
- “Staff collaboration did not play directly into IT/OT convergence and becomes significant when interacted with IT governance.”  

| [38]   | Halal agro-food manufacturing(SMEs) | DOI    | TRA TAM Survey                   | IoT adoption                                                                        | - Perceived ease of use, Perceived usefulness, Knowledge, Firmographic Profiles: Annual sales, Presence of Muslim workers | - “There are significant relationships between perceived ease of use and perceived usefulness and adoption of IoT.”  
- “There are no significant relationships between knowledge level, annual sales, and the presence of Muslim workers with the adoption of IoT.”  

| [39]   | Supply chain               | TOE    | Survey                           | IoT adoption                                                                        | Technical Factors: Complexity, Compatibility, Perceived benefit, Cost  
Organizational Factors: The scale of enterprise, Executing support, Trust among businesses in the supply chain, Technical knowledge, Employee resistance  
Environmental Factors: External pressure, Uncertainty, Government support | - “Resistance from employees and uncertainties are not important factors that influence the IoT adoption.”  
- “Technical factors (complexity, compatibility, perceived benefit, and cost) have a complicated influence on IoT adoption.”  
- “Organizational factors (scale of enterprise, executive support, trust among the businesses in the supply chain, and technical knowledge) and environmental factors (external pressure and government support) all have positive relationships with IoT adoption.”  


| Ref. | Organization Type       | Theory       | Methodology | Dependent Variable | Independent Variable | Research Findings                                                                                                                                                                                                 |
|------|-------------------------|--------------|-------------|--------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [42] | Logistics and Supply chains | Grounded theory | Exploratory mixed methods: - Group interviews and in-depth personal interviews to identify the framework. - Survey to test the hypothesis. | IoT adoption intention | Perceived trustworthiness of technology - Perceived cost - External pressure | Mediator Variable: - Perceived benefits - Technology trust | “The resulting quantitative model shows that perceived benefits, perceived costs, and external pressure are significant determinants of IoT adoption intention, while technology trust is not.” - “Technology trust does indirectly influence IoT adoption intention through perceived benefits.” |
| [45] | Transport and Logistics | -       | Mixed methods research: - Survey to gathered information on firms - OLS regression analysis to determine which factors drive IoT adoption. | IoT adoption | Firm size - Innovation capacity - Absorptive capacity - Perceived benefits - Perceived costs | Control variable: - LnAge (the natural logarithm of firm age in years) | “The results suggested that the level of IoT adoption within firms is positively affected by firm size, the firm’s absorptive capacity, and entrepreneurs’ perception of the benefits of related technologies.” - “Perceived costs was positive and not statistically significant.” - “Innovation capacity variable was not significant and negative.” “The variable LnAge revealed a significant and negative coefficient, it means that young firms are more likely to adopt new technologies because they are more flexible and open.” |
| [56] | Agriculture | TOE | HOT-fit DEMATEL | IoT adoption intention | Human Factors: - Innovation of the leader - Technical skill owned IT staff - Technical skill owned non-IT staff - Previous experience owned IT staff | Organizational Factors: - Centralized decision-making process - Formalization on task codification - Size of organization - Expected relative profit - Adequate human resource - Employee attitudes toward organizational changes | “The human factor is the most important criteria when compared to other main criteria.” - “According to human factor, the innovation attitude of the leaders and technical skills of IT staff are the most important factors when compared to other factors.” - “From the technological perspective, the IS/IT infrastructure as well as data security and privacy factors are the most important factors when compared to other factors.” - “Top management support and perceived technology adoption costs are the most important factors from the perspective of organizational criteria.” - “The perceived mimetic pressure factor and perceived coercive pressure are the most important factors in an environmental perspective.” |
| [68] | Corporate sector | TAM | Exploratory mixed methods: - Interview to propose factors Survey to test hypotheses | Behavioral Intention to use IoT | Perceived usefulness of IoT - External organization variables - Internal organization variables - Perceived ease of use of IoT | | “All four factors have a positive and significant correlation with IoT adoption.” |
According to Table 6, from the SLR, the factors can be categorized into six main factors that influence IoT adoption in organizations: technological, organizational, environmental, human, benefit, and value factors. However, the results revealed that several studies had examined technological, organizational, environmental factors as important factors for IoT adoption with little consideration paid to human, benefit, and value factors. Therefore, these factors must be studied in more detail to identify the factors that significantly affect IoT adoption and enhance its effectiveness. Hence, these factors can be isolated and progressively developed to improve IoT adoption efficiency.

7. Discussion

This study aimed to provide an overview of IoT adoption studies in organizations and evaluate the current research situation. This review could help researchers to identify the key benefits and challenges of IoT adoption, explore the theoretical models used to guide and support IoT adoption studies, and identify critical factors that influence IoT adoption in organizations. The findings of this study can be used as a guide for practical implementation, providing managers with relevant information to promote and support
IoT applications before and during the adoption phase, thereby ensuring the success of IoT solution deployment.

The systematic review technique ensured that the search process was accurate and impartial. A general data analysis of the selected 77 studies was presented, then the four research questions were addressed. The first question provided a coherent taxonomy of existing research to provide a roadmap for future research. Generally, the publication trend denotes an increasing interest in implementing IoT in organizations. However, only 44 empirical studies have been identified, indicating that IoT adoption is still in the early stage and that more research is required in the field.

The second question highlighted IoT benefits to organizations, classified into two groups: direct and indirect. However, there are limited studies that examine the benefits of IoT. Investing in IoT technology is costly, and the potential benefits of IoT are still vague for organizations [29]. Thus, decision-makers in organizations desire clear benefits and returns on investment. Otherwise, they believe IoT is a useless technique and will withhold investment until its benefits are clearly demonstrated. Further empirical studies are required to analyze and examine the potential benefits of IoT in organizations and translate them into profits. In addition, further studies of fully implemented IoT applications in organizational environments are necessary for a comprehensive understanding of the potential benefits of real-world applications. Such studies will encourage organizations to invest in and implement IoT applications.

The third question examined barriers to IoT adoption or failure. This question aimed to define the challenges and solve them according to their priority and impact on adoption in the context of the organization. This study categorized the challenges into technological, organizational, and environmental challenges. Technological challenges, such as security and privacy, complexity, compatibility, implementation cost, scalability, and energy consumption have been identified as the most significant challenges to IoT adoption. IoT technology is still an emerging technology that requires much development in protocol unification, integration with legacy systems, and high implementation costs. Apart from that, security and privacy are the biggest obstacles to adopting IoT technology in organizations. Additionally, it was found that most organizational challenges are related to organizational readiness and human resources. Human resources are critical to the adoption and use of technology. Thus, to keep pace with rapid technological development, organizations must invest in human resources, provide continuous training, and attract human competencies with outstanding skills. Concerning environmental challenges, organizations face four challenges: the absence of government regulations governing IoT, lack of collaboration among partners, insufficient technical support from vendors and suppliers, and uncertainty surrounding IoT technology.

The fourth question investigated theoretical models to identify the critical factors influencing IoT adoption. Determining these factors can provide decision-makers with a better view of IoT technology’s positive and negative effects and enhance its level of adoption. Six critical factors were identified from the previous studies. However, the results indicated that researchers have focused on technological, organizational, and environmental factors as the main factors that influence IoT adoption. Although human, benefit, and value factors significantly affect the technical efficiency and success of IoT adoption, researchers have paid little attention to them. This may be due to the lack of real-life applications in organizations, existing studies’ immaturity on IoT adoption, and the nascent attempts to apply prevalent models. Researchers need to focus on these factors and determine their impact on IoT adoption at each adoption stage: planning, implementing, and using. The expected positive impact of these factors will enhance the IoT adoption level.

However, this study has some limitations, most notably that technology topics are inherently fast-paced. In other words, the findings of this study may be quickly superseded by the new findings. In addition, the literature review was conducted using five electronic databases, focusing only on academic articles and conferences. Future research could include more databases and include books, chapters, and industrial reports to broaden
the body of knowledge. Furthermore, the review period was limited and included specific keywords. Future research could expand the period and add more search keyword combinations. Finally, the findings were based on secondary data analysis. Hence, future research could justify the results using primary data.

8. Conclusions

IoT technology is still in the development phase, and its applications are still growing across different industries. Each industry has specific characteristics and requirements that differ from those of other industries such as manufacturing, healthcare, education, and agriculture. Therefore, future research is needed to investigate emerging IoT applications’ influence in different industries.

Accordingly, several studies have examined IoT adoption factors theoretically, and empirical evidence has provided a solid foundation for future research. However, previous studies have not adequately examined the human, benefit, and value factors. Therefore, this study used a systematic review to analyze and categorize existing research on IoT adoption at the organizational level, classifying the articles into the following themes: review, conceptual, and empirical studies. This classification provides researchers with a general overview of the current state of research. Furthermore, this study highlighted IoT adoption benefits and challenges in organizations. Although some studies have attempted to investigate this, they have tended to focus minimally on IoT benefits and give more attention to challenges. Thus, further studies are required to investigate IoT benefits as an ongoing and emerging subject from organizations’ perspectives, especially quantitative studies, as evidence indicates that awareness of the benefits can affect IoT adoption [45].

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# Appendix A

## Table A1. Summary of the included studies.

| ID | Author | Year | Country | Organization | Article Type | Category |
|----|--------|------|---------|--------------|--------------|----------|
| 1  | Kiel et al. [1] | 2017 | Germany | Manufacturing | Empirical | Case study |
| 2  | Lu, Papagiannidis, and Alamanos [2] | 2018 | UK | - | Review | General review |
| 3  | Tripathi [3] | 2019 | India | - | Conceptual | - |
| 4  | Wanasinghe et al. [4] | 2020 | Canada | Oil and gas | Review | Specialty-based review |
| 5  | Luthra et al. [6] | 2018 | India | - | Empirical | Multi-criteria decision-making |
| 6  | Badarudin et al. [7] | 2018 | Malaysia | - | Review | General review |
| 7  | Lee and Lee [9] | 2015 | USA | - | Review | General review |
| 8  | Yang, Shen, and Wang [10] | 2016 | Canada | Manufacturing | Review | Specialty-based review |
| 9  | Das [11] | 2019 | India | Oil and gas | Empirical | Theoretical |
| 10 | Arnold and Voigt [13] | 2019 | Germany | Manufacturing | Empirical | Theoretical |
| 11 | Pappas et al. [15] | 2021 | UK | Hospitality | Empirical | Theoretical |
| 12 | Mircea, Stoica, and Ghilic-Micu [17] | 2021 | Romania | Education | Empirical | Theoretical |
| 13 | Lin, Lee, and Tai [20] | 2018 | China | Supply chains and logistics | Empirical | Multi-criteria decision-making |
| 14 | Tang and Ho [21] | 2019 | USA | Smart city | Empirical | Theoretical |
| 15 | Kamble et al. [22] | 2019 | India | Supply chains and logistics | Empirical | Multi-criteria decision-making |
| 16 | Hsu and Yeh [23] | 2017 | Taiwan | Supply chains and logistics | Empirical | Theoretical |
| 17 | Satar, Hussin, and Ali [24] | 2018 | Malaysia | Oil and gas | Conceptual | - |
| 18 | Satar, Hussin, and Yusof [25] | 2019 | Malaysia | Oil and gas | Empirical | Theoretical |
| 19 | Birkel and Hartmann [27] | 2019 | Germany | Supply chains and logistics | Review | Specialty-based review |
| 20 | Rejeb et al. [28] | 2021 | Hungary | Supply chains and logistics | Review | Specialty-based review |
| 21 | Aamer et al. [29] | 2021 | Canada | Supply chains and logistics | Review | Specialty-based review |
| 22 | Almansour, and Saeed [30] | 2019 | Saudi Arabia | Healthcare | Review | Specialty-based review |
| 23 | Carecy et al. [31] | 2018 | Ireland | - | Review | General review |
| 24 | Hawash et al. [33] | 2021 | Malaysia | Oil and gas | Empirical | Theoretical |
| 25 | Papakostas, O'Connor, and Byrne [34] | 2017 | Ireland | Manufacturing | Review | Specialty-based review |
| 26 | Sivathanu [35] | 2019 | India | Manufacturing | Empirical | Theoretical |
| 27 | Seetharaman et al. [36] | 2019 | Singapore | Manufacturing | Empirical | Theoretical |
| ID | Author                              | Year | Country      | Organization                      | Article Type | Category                        |
|----|-------------------------------------|------|--------------|-----------------------------------|--------------|---------------------------------|
| 28 | Singh and Bhanot [37]               | 2020 | India        | Manufacturing                     | Empirical    | Multi-criteria decision-making  |
| 29 | Ehie and Chilton [38]               | 2020 | USA          | Manufacturing                     | Empirical    | Theoretical                      |
| 30 | Ahmad Tarmizi et al. [39]           | 2020 | Malaysia     | Manufacturing                     | Empirical    | Theoretical                      |
| 31 | Lin, Lee, and Lin [40]              | 2016 | China        | Supply chains and logistics       | Empirical    | Theoretical                      |
| 32 | Haddud et al. [41]                 | 2017 | USA          | Supply chains and logistics       | Empirical    | Survey                          |
| 33 | Tu [42]                             | 2018 | Taiwan       | Supply chains and logistics       | Empirical    | Theoretical                      |
| 34 | Shah, Bolton, and Menon [43]        | 2020 | UK           | Supply chains and logistics       | Review       | Specialty-based review          |
| 35 | De Vass, Shee, and Miah [44]        | 2021 | Australia    | Supply chains and logistics       | Empirical    | Other studies (Interviews)      |
| 36 | Rey et al. [45]                    | 2021 | Italy        | Supply chains and logistics       | Empirical    | Theoretical                      |
| 37 | Jia et al. [46]                    | 2019 | USA          | Construction                      | Review       | Specialty-based review          |
| 38 | Silverio-Fernandez, Renukappa, and Suresh [47] | 2019 | UK           | Construction                      | Empirical    | Other studies (Interviews)      |
| 39 | Gamil et al. [48]                  | 2020 | Malaysia     | Construction                      | Empirical    | Survey                          |
| 40 | Oke, Arowoiya, and Akomolafe [49]   | 2020 | Nigeria      | Construction                      | Empirical    | Survey                          |
| 41 | Oke, Arowoiya, and Temitope [50]    | 2020 | Nigeria      | Construction                      | Empirical    | Survey                          |
| 42 | Alansari et al. [51]               | 2018 | Malaysia     | Healthcare                        | Empirical    | Multi-criteria decision-making  |
| 43 | Irfan and Ahmad [52]               | 2018 | Saudi Arabia | Healthcare                        | Review       | Specialty-based review          |
| 44 | Kelly et al. [53]                  | 2020 | Australia    | Healthcare                        | Review       | Specialty-based review          |
| 45 | Tariq et al. [54]                  | 2020 | Pakistan     | Healthcare                        | Empirical    | Multi-criteria decision-making  |
| 46 | Pir, Akram and Khan [55]            | 2016 | Pakistan     | Healthcare                        | Empirical    | Survey                          |
| 47 | Ladasi et al. [56]                 | 2019 | Indonesia    | Agriculture                       | Empirical    | Theoretical                      |
| 48 | Khanna and Kaur [57]               | 2019 | India        | Agriculture                       | Review       | Specialty-based review          |
| 49 | Madushanki et al. [58]             | 2019 | Australia    | Agriculture                       | Review       | Specialty-based review          |
| 50 | Singh et al. [59]                  | 2020 | India        | Agriculture                       | Empirical    | Multi-criteria decision-making  |
| 51 | Farooq et al. [60]                 | 2019 | Pakistan     | Agriculture                       | Review       | Specialty-based review          |
| 52 | Janssen et al. [61]                | 2019 | Netherlands  | Smart city                        | Empirical    | Multi-criteria decision-making  |
| 53 | Sharma et al. [62]                 | 2020 | India        | Smart city                        | Empirical    | Multi-criteria decision-making  |
| 54 | Brous, Janssen, and Herder [63]     | 2020 | Netherlands  | Smart city                        | Empirical    | Case study                      |
| 55 | Eskerod et al. [64]                | 2019 | Austria      | Hospitality                       | Empirical    | Case study                      |
| 56 | Caro and Sadr [65]                 | 2019 | USA          | Retail                            | Review       | Specialty-based review          |
Table A1. Cont.

| ID | Author                          | Year | Country   | Organization               | Article Type   | Category            |
|----|---------------------------------|------|-----------|----------------------------|----------------|---------------------|
| 57 | Ammirato et al. [66]            | 2019 | Italy     | Banking                    | Empirical      | Case study          |
| 58 | Deepa et al. [67]               | 2016 | India     | -                          | Review         | General review      |
| 59 | Singh, Gaur, and Ramakrishnan [68] | 2017 | India     | Corporate sector           | Empirical      | Theoretical         |
| 60 | Osmonbekov and Johnston [69]    | 2018 | USA       | -                          | Conceptual     | -                   |
| 61 | Nord, Koohang, and Paliszkiewicz [70] | 2019 | USA       | -                          | Conceptual     | -                   |
| 62 | Lee, I [71]                     | 2019 | USA       | -                          | Review         | General review      |
| 63 | Lee, G [72]                     | 2019 | USA       | -                          | Empirical      | Other studies (Secondary data) |
| 64 | Rad and Ahmad [73]              | 2017 | Malaysia  | -                          | Review         | General review      |
| 65 | Amodu et al. [74]               | 2019 | Nigeria   | Public relations sector    | Empirical      | Survey              |
| 66 | Chukwudebe, Ogu, and Fawei [75] | 2021 | Nigeria   | -                          | Review         | General review      |
| 67 | Ancarani et al. [76]            | 2019 | Italy     | -                          | Empirical      | Other studies (Secondary data) |
| 68 | Parra et al. [77]               | 2021 | Colombia  | Small and medium enterprises (SME) | Review         | Specialty-based review |
| 69 | Parra and Guerrero [78]         | 2020 | Colombia  | Small and medium enterprises (SME) | Review         | Specialty-based review |
| 70 | Dachyar, Zagloel, and Saragih [79] | 2019 | Indonesia | -                          | Review         | General review      |
| 71 | Kim and Kim [80]                | 2016 | South Korea | -                          | Empirical      | Multi-criteria decision-making |
| 72 | Kim, Park, and Song [81]        | 2019 | South Korea | -                          | Empirical      | Multi-criteria decision-making |
| 73 | Thibaud et al. [82]             | 2018 | France    | High-risk environment, health and safety (EHS) industries | Review         | Specialty-based review |
| 74 | Valmohammadi [83]               | 2016 | Iran      | -                          | Empirical      | Survey              |
| 75 | Abazi [84]                      | 2016 | Kosovo    | Small and medium enterprises (SME) | Review         | Specialty-based review |
| 76 | Henriques et al. [85]           | 2020 | Portugal  | -                          | Empirical      | Other studies (Delphi method) |
| 77 | Tubaishat and Paliath [86]      | 2018 | UAE       | -                          | Review         | General review      |
Table A2. Summary of IoT adoption benefits.

| Ref | Data Availability and Accuracy | Better Decision-Making | Operation Process Efficiency | Asset Management Efficiency | Improved Safety and Security | Improved Supply Chains and Transportation | Competitive Advantage | Business and Network Integration | Sustainability | Customer Satisfaction | Products and Services Innovation | New Revenue Stream | Review | Conceptual | Empirical |
|-----|--------------------------------|-------------------------|------------------------------|------------------------------|----------------------------|--------------------------------------|------------------------|---------------------------------|-----------------|-------------------|-----------------------------|-----------------|--------|-----------|----------|
| Kiel et al. [1] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | /
| Lu, Papagiannidis, and Alamanos [2] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Tripathi [3] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Wanasinghe et al. [4] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Badarudin et al. [7] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Lee and Lee [9] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Yang, Shen, and Wang [10] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Das [11] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Arnold and Voigt [13] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Pappas et al. [15] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Mirea, Stoica, and Ghilic-Micu [17] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Lin, Lee, and Tai [20] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Tang and Ho [21] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Kamble et al. [22] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Satar, Hussin, and Ali [24] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Birkel and Hartmann [27] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Rejeb et al. [28] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Carcary et al. [31] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Hawash et al. [33] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Papakostas, O'Connor, and Byrne [34] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Sivathanu [35] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Seetharaman et al. [36] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
Table A2. Cont.

| Ref | Direct Benefits | Indirect Benefits | Research Method |
|-----|-----------------|-------------------|-----------------|
| Singh and Bhanot [37] | / | / | / |
| Echie and Chilton [38] | / | / | / |
| Ahmad Tarmizi et al. [39] | / | / | / |
| Haddud et al. [41] | / | / | / |
| Tu [42] | / | / | / |
| Shah, Bolton, and Menon [43] | / | / | / |
| Alansari et al. [51] | / | / | / |
| Irfan and Ahmad [52] | / | / | / |
| Kelly et al. [53] | / | / | / |
| Pir, Akram and Khan [55] | / | / | / |
| Ladasi et al. [56] | / | / | / |
| Madushanki et al. [58] | / | / | / |
| Singh et al. [59] | / | / | / |
| Farooq et al. [60] | / | / | / |
| Brous, Janssen, and Herder [63] | / | / | / |
| Eskerod et al. [64] | / | / | / |
| Ref | Data Availability | Better Decision-Making | Operation Process Efficiency | Asset Management Efficiency | Improved Safety and Security | Improved Supply Chains and Transportation | Competitive Advantage | Business and Network Integration | Sustainability | Customer Satisfaction | Products and Services Innovation | New Revenue Stream | Research Method |
|-----|------------------|------------------------|------------------------------|-----------------------------|-----------------------------|------------------------------------|-----------------------|-------------------------------|---------------|------------------|-----------------------------|------------------|----------------|
| Caro and Sadr [65] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Ammirato et al. [66] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Deepa et al. [67] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Singh, Gaur, and Ramakrishnan [68] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Osmonbekov and Johnston [69] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Lee, I [71] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Rad and Ahmada [73] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Amodu et al. [74] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Ancarani et al. [76] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Parra et al. [77] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Dachyar, Zagloel, and Saragih [79] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Thibaud et al. [82] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Valmohammadi [83] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Abazi [84] | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Ref                                | Technological Challenges | Organizational Challenges | Environmental Challenges | Research Method |
|------------------------------------|--------------------------|---------------------------|---------------------------|-----------------|
|                                    | Security and Privacy     | Complexity                | Implementation            | Cost            | Scalability of IoT Infrastructure | Top Management Support | Organizational Readiness | IT skill and Knowledge | Employees Resistance | Government Regulations | Vendors and Suppliers Issues | Partners | Collaboration | Uncertainty | Review | Conceptual | Empirical |
| Kiel et al. [1]                    | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Lu, Papagiannidis, and Alamanos [2] | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Tripathi [3]                       | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Wanasinghe et al. [4]              | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Luthra et al. [6]                  | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Badarudin et al. [7]               | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Lee and Lee [9]                    | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Yang, Shen, and Wang [10]          | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Arnold and Voigt [13]              | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Pappas et al. [15]                 | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Mircea, Stoica, and Ghilic-Micu [17]| /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Lin, Lee, and Tai [20]             | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Kamble et al. [22]                 | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Hsu and Yeh [23]                   | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Satar, Hussin, and Ali [24]        | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Satar, Hussin, and Yusof [25]      | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Birkel and Hartmann [27]           | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Rejeb et al. [28]                  | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Aamer et al. [29]                  | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Almansour, and Saeed [30]          | /                        | /                         | /                         | /               | /                          | /                     | /                         | /                   | /                 | /                                      | /                                | /                          | /                          | /                        | /               | /                    | /                     |
| Ref                                                                 | Technological Challenges | Organizational Challenges | Environmental Challenges | Research Method |
|--------------------------------------------------------------------|--------------------------|----------------------------|--------------------------|-----------------|
|                                                                    | Security | Privacy | Compatibility | Complexity | Implementation | Cost | Scalability of IoT Infrastructure | Energy Consumption | Top Management Support | Organizational Readiness | IT skill and Knowledge | Employee Resistance | Government Regulations | Vendors and Suppliers Issues | Partners Collaboration | Uncertainty | Review | Conceptual | Empirical |
| Carcary et al. [31]                                                 | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Hawash et al. [33]                                                 | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Papakostas, O’Connor, and Byrne [34]                               | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Sivathanu [35]                                                     | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Seetharaman et al. [36]                                            | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Singh and Bhanot [37]                                              | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Ehie and Chilton [38]                                              | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Ahmad Tarmizi et al. [39]                                          | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Lin, Lee, and Lin [40]                                             | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Haddud et al. [41]                                                 | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Tu [42]                                                            | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Shah, Bolton, and Menon [43]                                       | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| De Vass, Shee, and Miah [44]                                       | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Rey et al. [45]                                                    | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Jia et al. [46]                                                    | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Silverio-Fernandez, Renukappa, and Suresh [47]                    | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Gamil et al. [48]                                                  | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Oke, Arowoeya, and Akomola [49]                                    | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Oke, Arowoeya, and Temitope [50]                                   | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Irfan and Ahmad [52]                                               | /        |        |               |            |               |      |                               |                    |                            |                        |                            |               |                         |                          |                               |                        |            |        |           |          |
| Ref | Technological Challenges | Organizational Challenges | Environmental Challenges | Research Method |
|-----|---------------------------|---------------------------|--------------------------|------------------|
|     | Security and Privacy | Compatibility | Complexity | Implementation Cost | Scalability of IoT Infrastructure | Energy Consumption | Top Management Support | Organizational Readiness | Top Management Support | Organizational Readiness | IT skill and Knowledge | Employees Resilience | Government Regulations | Vendors and Suppliers Issues | Partners Collaboration | Uncertainty | Review | Conceptual | Empirical |
| Kelly et al. [53] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Tariq et al. [54] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Ladasi et al. [56] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Khanna and Kaur [57] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Madushanki et al. [58] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Singh et al. [59] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Farooq et al. [60] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Janssen et al. [61] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Sharma et al. [62] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Brous, Janssen, and Herder [63] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Eskerod et al. [64] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Caro and Sadr [65] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Ammirato et al. [66] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Singh, Gaur, and Ramakrishnan [68] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Osmontev and Johnston [69] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Nord, Koohang, and Paliszkiwicz [70] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Lee, I [71] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Lee, G [72] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Rad and Ahmada [73] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Ancarani et al. [76] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Ref | Technological Challenges | Organizational Challenges | Environmental Challenges | Research Method |
|-----|--------------------------|---------------------------|--------------------------|-----------------|
|     | Security and Privacy | Compatibility | Complexity | Implementation | Cost | Scalability of IoT Infrastructure | Energy Consumption | Top Management Support | Organizational Readiness | IT skill and Knowledge | Employee Resistance | Government Regulations | Vendors and Suppliers Issues | Partners Collaboration | Uncertainty | Review | Conceptual | Empirical |
| Parra et al. [77] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Parra and Guerrero [78] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Dachyar, Zagloel, and Saragih [79] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Kim and Kim [80] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Kim, Park, and Song [81] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Thibaud et al. [82] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Valmohammadi [83] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Abazi [84] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Henriques et al. [85] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
| Tubaishat and Paliath [86] | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / | / |
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