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Providing a Model of New Public Services with an Emphasis on the Internet of Things in the Mashhad Electricity Distribution Company

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A B S T R A C T

In the era of advanced technologies, transformation in the delivery of public services—especially in infrastructural sectors such as electricity distribution—is an undeniable necessity. Given the rapid development of modern technologies and the need to enhance the efficiency and quality of services, electricity distribution companies must continuously update and optimize their operational processes. This transformation not only contributes to increased customer satisfaction but also leads to overall improvement in energy network performance and cost reduction. In this context, the Internet of Things (IoT), as a key technology, offers new capabilities for data collection and analysis, resource management, and service optimization. This study aims to present a novel model for public services in the Mashhad Electricity Distribution Company with a particular emphasis on the application of the Internet of Things. The present study is applied-developmental in nature and employed a qualitative meta-synthesis approach to achieve the research objective. Subsequently, the reliability of the identified dimensions was examined through the Delphi analysis method. Finally, in the quantitative phase, the most influential components of new public services with an emphasis on IoT were determined using Interpretive Structural Modeling (ISM). The qualitative findings revealed four main categories (enabling factors, service factors, IoT-related factors, and outcomes of public services), twelve key concepts (technical factors, non-technical factors, quality of modern services, remote services, electronic relationship management, data and telemetry systems, security and control systems, integrated management systems, smart distribution, employee quality of life, customer experience enhancement, and productivity of the electricity distribution company), and sixty-nine primary codes. Quantitative results indicated that the components of technical and non-technical factors possess higher driving power compared to other elements of the model. The findings of this research clearly demonstrate that the implementation of new public services—particularly those leveraging advanced technologies such as the Internet of Things—can act as a key driver in transforming the electricity distribution industry.

Keywords: *Internet of Things, new public services, electricity distribution industry, Interpretive Structural Modeling (ISM), smart distribution.*

1. Introduction

Public organizations, as governmental institutions, are obliged to uphold core values such as accountability, justice, equality, transparency, and citizen-centeredness in the delivery of public services. However, the increasing deviation of these organizations from a citizen-centric approach in favor of purely organizational objectives constitutes a major challenge. This gap has led to the emergence of the "New Public Service" paradigm. This paradigm, emphasizing democratic values and citizen orientation, steers public organizations toward achieving social goals (Idoko et al., 2024). Within this framework, new public service emphasizes the establishment of responsive and trustworthy public institutions, where public servants act not as experts and entrepreneurs but as active facilitators. This new role empowers citizens to accurately identify their own needs and to build trust-based relationships with service-providing institutions (Aboelazm et al., 2025).

Nevertheless, there exists a deep gap between the implementation of new public services and the deployment of advanced technologies in developing countries. While developed nations have widely utilized information and communication technologies (ICT) to enhance governmental structures and public service delivery, such advancements remain underutilized in developing contexts. Emerging technologies—particularly the Internet of Things (IoT)—are regarded as key enablers for governments in the 21st century, capable of fostering democracy, reducing costs, and improving the quality of public services (CheSuh et al., 2024). The IoT, with its capability to enable intelligent connectivity and collect precise data, allows governments to deliver services in a transparent, efficient, and citizen-oriented manner. Countries such as Norway, Singapore, and Australia have made significant strides in realizing new public services through the application of IoT (Hu et al., 2020).

In the electricity distribution sector, IoT is recognized as a leading technology playing a vital role in the development of smart grids. It improves the processes of energy generation, transmission, distribution, and consumption, facilitating optimal resource management and sustainable service provision (Pouti & Taghva, 2019; Shahbazi et al., 2022). The neglect of new public services and the underutilization of advanced technologies have detrimental consequences. Inadequate responses to public needs and inefficient public service systems not only lead to a crisis of governmental inefficiency but may also provoke challenges to governmental legitimacy and increase public dissatisfaction (Adejuwon, 2018).

In the electricity distribution sector, the lack of state policies overseeing the power industry—alongside concerns such as the preservation of basic resources, environmental protection, and reforming consumption patterns—has created serious challenges (Yahiapour et al., 2022). Population growth and rising energy consumption underscore the pressing need to deploy technologies such as IoT. This technology enables smart management of energy consumption and distribution, thereby helping to preserve resources for future generations (Chatfield & Reddick, 2019).

Ultimately, the failure to adopt advanced technologies and rethink public service provision jeopardizes economic development, competitiveness, and consumer welfare. Therefore, structural reforms and policy initiatives in the electricity sector—especially those centered on IoT—are essential and unavoidable (Enciso et al., 2018; Bakari et al., 2022).

A review of the related literature highlights the multidimensional nature of public service development in the digital age. Najjarzadeh et al. (2023) examined the opportunities and threats of electronic public services from an administrative law perspective, emphasizing how the 21st-century communications revolution and growing citizen expectations have necessitated a shift toward electronic government services (Najjarzadeh Hanjani & Shamsi Moheb, 2023). Yousfian et al. (2023) proposed a structural strategic model for urban public service development based on spatial justice, finding disparities in service access and offering a budget distribution software solution as a practical output (Yousefi Amiri et al., 2021). These studies underscore the critical role of both structural and technological factors in modernizing and enhancing public service delivery.

It is evident that numerous challenges exist in the areas of electricity supply, distribution, and consumption. High per capita energy consumption, non-strategic allocation of electricity subsidies, unrestrained exploitation of non-renewable resources for power generation, and adverse consequences such as frequent power outages are critical issues within the national electricity domain. According to the new public service approach, such issues can be addressed while fulfilling citizens' expectations. In this context, the application of IoT may provide a viable solution. Specifically, in the field of energy consumption—such as electricity—one can leverage the concept of the "Internet of

Energy," which is a subdomain of the IoT. This includes real-time production and consumption of energy and the intelligent management of consumption patterns.

As an executive arm of the government in delivering public services, the electricity distribution company can employ IoT to ensure effective management of power generation and consumption. At present, there is no clear implementation model in this area, and excessive electricity consumption is an undeniable reality in the country. If a scientifically grounded, applied, and developmental model for the use of IoT in the electricity company is designed, these issues could be systematized, leading to improved services for electricity subscribers and the establishment of mechanisms for optimal consumption. It appears that the capacities and capabilities of the Internet of Things can aptly address the government's challenges in this domain.

Accordingly, this study seeks to fill the existing research gap by proposing a model of new public services with an emphasis on the Internet of Things in the Mashhad Electricity Distribution Company. The present study aims to answer the key question: What is the model of new public services with an emphasis on the Internet of Things in the Mashhad Electricity Distribution Company?

2. Methods and Materials

This study is an applied-developmental research project conducted with the aim of designing and proposing a model of new public services with an emphasis on the Internet of Things (IoT) in the Mashhad Electricity Distribution Company. In this research, the meta-synthesis method was employed as a qualitative and systematic approach to present the model of new public services focusing on IoT in the Mashhad Electricity Distribution Company. Meta-synthesis, as an analytical method, enables the integration and interpretation of findings from previous studies and contributes to the development of deeper understanding and new insights into complex phenomena through the identification, analysis, and synthesis of key concepts.

In this study, through a systematic search in reputable databases, studies related to new public services and IoT were identified, and after assessing their quality, qualitative data were extracted. Subsequently, using coding methods and content analysis, the main concepts and categories were extracted, and ultimately, a conceptual model was developed. This method was selected due to its ability to combine diverse findings and establish a comprehensive framework, making it a suitable approach for addressing the research questions and achieving the model of new public services emphasizing IoT.

The study was carried out in three main steps:

In the first step, the meta-synthesis method was used as a systematic approach to analyze and integrate the findings of previous research. By reviewing scholarly articles, books, and credible resources related to IoT and public services in the electricity distribution industry, relevant data were extracted. Using open, axial, and selective coding, the main concepts and categories were identified. This process led to the development of a conceptual framework that served as the foundation for designing the model in this research. For the identification and review of scholarly works, books, and credible resources related to IoT and public services in the electricity distribution sector, databases such as SID (Scientific Information Database), MAGIRAN, ScienceDirect, Emerald Insight, and Wiley Online Library were utilized.

In the second step, Delphi analysis was used to validate and enhance the reliability of the dimensions identified in the first step. This method involved the participation of 14 experts specialized in IoT, electricity distribution, and public services. These experts included university professors, senior managers from electricity distribution companies, and information technology specialists. Through structured questionnaires and multiple rounds of surveys, expert consensus on the dimensions and components of the model was achieved, thereby strengthening the research framework.

In the final step, Interpretive Structural Modeling (ISM) was employed to determine the relationships and hierarchical influence levels of the identified components. Using specialized software and expert input, a relational map of the components was created, identifying the key elements with the highest driving power.

Through the identification and review of research via the National Library's search system and other library and research institute platforms such as SID, Noor Specialized Journals Database, national scientific conference articles, the National Publications Database, and IranDoc, a total of 34 relevant studies were found using keywords related to the research objective in the title field. In quantitative research methods, various sampling techniques exist, such as random sampling and others. In qualitative research methods, sampling is generally purposeful. Since the meta-synthesis method is classified as a qualitative approach, sampling in this method was also conducted purposefully, based on entry criteria.

The validity of the qualitative section was evaluated and confirmed using Lincoln and Guba's four criteria: credibility, transferability, confirmability, and dependability, based on the judgment of experts. To assess the reliability of the qualitative section and the coding of the conducted interviews, Holsti's method was employed. Coding was performed twice, and the "observed agreement percentage" obtained was 0.712, which exceeds the threshold of 0.60, thereby indicating sufficient reliability for the qualitative analysis.

To identify the categories involved in proposing a model of new public services with an emphasis on IoT in the Mashhad Electricity Distribution Company, meta-synthesis analysis was used. The statistical population in the Interpretive Structural Modeling (ISM) section consisted of experts, scholars, and professionals active in the field of new public services and IoT, from which 16 individuals were selected through purposive sampling. The characteristics of the selected experts were as follows:

- A minimum of 10 years of managerial experience in the Mashhad Electricity Distribution Company
- At least a graduate-level degree (Master's or Doctorate)
- Being key figures in the field, well-known, theoretically knowledgeable, diverse in background, and motivated to participate.

3. Findings and Results

The first step in the meta-synthesis method is the formulation of research questions. These questions are generally structured around four parameters: what, who, when, and how. Table 1 presents the research questions:

Table 1

Research Questions

Parameter	Research Question
What	What are the underlying components of the new public services model with emphasis on IoT in the Mashhad Electricity Distribution Company?
Who	Who are the key actors involved in the new public services model with emphasis on IoT in the Mashhad Electricity Distribution Company?
When	The time range includes studies conducted from 2011 to 2023 (1390 to 1402 in the Persian calendar) and from 2015 to 2024 in the Gregorian calendar.
How	How are the components of the new public services model with emphasis on IoT in the Mashhad Electricity Distribution Company interrelated?

In the following sections of the study, each of these four questions is addressed in a separate subsection. Formulating research questions is one of the most important and initial steps in conducting a meta-synthesis. If this process is properly conducted from the outset, it enables a consistent and error-free progression throughout the study. It must be noted that due to its inherent complexity, the meta-synthesis method is typically applied in specific and critical areas of research.

Step 2: Systematic Literature Review

Globally recognized scientific databases, both Persian and English, were used in this study. Therefore, keywords were searched in both languages. Every study or researcher typically provides a summary at the beginning of the paper, followed by a list of keywords. Table 2 lists the keywords considered for this research.

Table 2

Keywords Used in Step Two of the Meta-Synthesis Method

Key Concepts	English Equivalent
خدمات عمومی نوین	New public services
اینترنت اشیا	Internet of Things
خدمات عمومی نوین با تاکید بر اینترنت اشیا	Modern public services with an emphasis on the Internet of Things
شرکت توزیع برق	Electricity distribution company

In the next stage, after identifying the topic and selecting relevant keywords, the study turned to introducing the scientific databases from which data would be extracted. Unfortunately, no single database within the country encompasses all relevant research. Therefore, it was necessary to refer to multiple national databases.

Step 3: Search and Selection of Relevant Texts

In qualitative research, the researcher enjoys greater flexibility and can employ more creativity. Criteria should be set to ensure inclusion of all findings aligned with the study's topic.

Inclusion criteria:

1. Articles and studies must be published within the relevant subject area.
2. Since meta-synthesis deals only with qualitative data, the selected articles must use qualitative methods (e.g., interviews, observations, systematic literature reviews), or even quantitative methods (e.g., surveys, experiments, correlation studies) that yield qualitative insights and address the subject of this study.
3. Studies must report sufficient data and findings aligned with the research objectives.
4. Studies must have undergone expert peer review and be published as full-text online or in print.
5. Articles must be published between 2011 and 2023 (1390–1402 in Persian calendar) or 2015 to 2024 (Gregorian calendar).
6. Articles must have used scientific methods to examine the study's topic and provide appropriate analytical solutions.

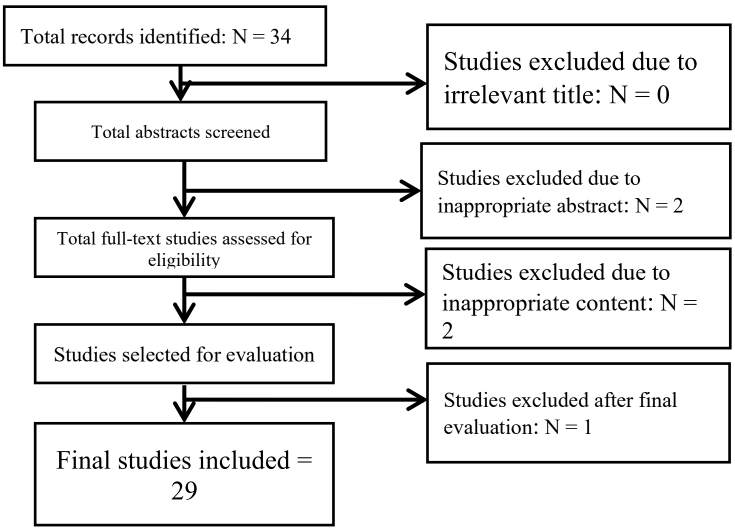
Exclusion criteria:

1. Studies that failed to report sufficient information relevant to the study's objectives.
2. Duplicate studies with identical titles and objectives.
3. Studies lacking appropriate methodological frameworks.
4. Studies not providing adequate data for analysis.
5. Studies lacking scientific quality, such as those published in low-tier journals.

In the search process, parameters such as title, abstract, content, and article details were considered, and papers that did not align with the research questions and objectives were excluded. The process of review and selection is summarized in Figure 1.

Figure 1

Review and Selection Process



Eventually, after four filtration stages, 5 studies were excluded and 29 studies were selected from an initial pool of 34 for data extraction and analysis.

Step 4: Data Extraction from Selected Studies

In this study, information from the selected research articles was categorized in a table that included:

- **Bibliographic Information**: Title, names of authors, year of publication.
- **Methodological Details**: Research method and purpose.
- **Key Findings**: Main results and conclusions of each study.

Step 5: Analysis of Qualitative Findings

During the analysis phase, the researcher searches for recurring themes across the selected studies within the meta-synthesis. This process is referred to as thematic analysis.

Once the themes are identified, the reviewer categorizes them, grouping similar and relevant classifications under a unifying theme that best describes them. These themes serve as the foundation for forming explanations, conceptual models, theories, or hypotheses.

In this study, all extracted factors from the studies were initially treated as identifiers. Then, based on their meaning, the identifiers were redefined under similar concepts. These concepts were further categorized into explanatory themes, thereby identifying the core and sub-components of the research.

Step 6: Quality Control of the Analysis

The Kappa coefficient is a statistical decision-making tool used to evaluate the degree of agreement between two independent raters or sources. The Kappa value ranges between +1 and –1, where values closer to +1 indicate strong agreement, values closer to –1 indicate inverse agreement, and values around 0 suggest a lack of agreement.

To evaluate the reliability of the meta-synthesis, one document was given to an expert for review. After assessment, a Kappa coefficient of 0.611 was calculated. A Kappa value above 0.60 is considered desirable (Landis et al., 1977), indicating that the results of the study are reliable.

Additionally, the following methods were adopted to ensure study quality:

- Clear and transparent explanations of the research choices were provided throughout the study.
- Both electronic and manual search methods were used to retrieve relevant research.

Ultimately, through axial coding, 6 main themes and 37 sub-themes were identified. The themes representing the model of new public services with an emphasis on the Internet of Things in the Mashhad Electricity Distribution Company are presented in Table 3.

Table 3

Themes of the New Public Services Model with an Emphasis on the Internet of Things

Category	Concept	Code	Source
Enabling Factors	Technical Factors	1. Use of up-to-date hardware for service delivery	Ahmadi & Moradi (2023); Aripin et al. (2024)
		2. Appropriate technical equipment for IoT	Najjarzadeh Henjani & Shamsi-Mohabb (2023); Aripin et al. (2024)
		3. Upgrading existing hardware based on IoT	Aripin et al. (2024)
		4. Deployment of new IoT software	Aripin et al. (2024)
		5. Continuous software updates	Najjarzadeh Henjani & Shamsi-Mohabb (2023); Aripin et al. (2024)
		6. Specialized human resources in IoT	Dadsadat & Mostafavi (2021); Welsberg et al. (2020)
		7. Software-hardware compatibility	Welsberg et al. (2020)
		8. Software operability on mobile and public platforms	Welsberg et al. (2020)
	Non-Technical Factors	9. Senior management support for new public services	Abbasi et al. (2020); Chesoh et al. (2024)
		10. Management awareness of IoT capabilities	Chesoh et al. (2024)
		11. Managerial commitment to IoT adoption	Yousefi Amiri et al. (2021); Chesoh et al. (2024)
		12. Flexible and adaptive organizational structure	Dadsadat & Mostafavi (2021); Chesoh et al. (2024)
		13. Innovative and creative management attitude	Chesoh et al. (2024)
		14. Governance of change-accepting culture	Chesoh et al. (2024)
Service Factors	Modern Service Quality	15. Simplicity in using modern, remote services	Lotfollah Hamadani et al. (2023); Chauhan & Hou (2020)
		16. Usefulness of modern public services	Chauhan & Hou (2020)
		17. Service security assurance	Dadsadat & Mostafavi (2021); Chauhan & Hou (2020)
		18. Protection of customer privacy	Lotfollah Hamadani et al. (2023); Chauhan & Hou (2020)
		19. 24/7 online support	Chauhan & Hou (2020)

	Remote Services	20. Remote services to electricity subscribers	Mejvil et al. (2023)
		21. Online electricity usage inquiries	Mejvil et al. (2023)
		22. Remote installment, payment, and debt management	Mejvil et al. (2023)
		23. Professional contracts with businesses	Yousefi Amiri et al. (2021); Mejvil et al. (2023)
		24. Electronic notifications and billing	Mejvil et al. (2023)
		25. Online complaint and issue submission	Abbasi et al. (2020); Mejvil et al. (2023)
		26. Continuous development of remote services	Sharifzadeh et al. (2022); Mejvil et al. (2023)
	Electronic Relationship Management	27. Continuous two-way online interaction	Dadsadat & Mostafavi (2021); Shahbazi et al. (2022); Mejvil et al. (2023)
		28. Specialized services for customers	Wu & Xiao (2024)
		29. Electronic submission of customer requests	Abbasi et al. (2020); Wu & Xiao (2024)
		30. One-on-one digital communication with users	Wu & Xiao (2024)
		31. Monitoring customer voice data	Wu & Xiao (2024)
		32. Continuous improvement of digital communication	Wu & Xiao (2024)
		33. Access through multiple digital platforms	Dadsadat & Mostafavi (2021)
IoT Factors	Data and Remote Communication Systems	34. System reliability	Hou et al. (2022)
		35. Use of HVAC systems	Ebrahimi et al. (2021); Hou et al. (2022)
		36. System cost optimization	Ebrahimi et al. (2021); Hou et al. (2022)
		37. System utility services	Ebrahimi et al. (2021); Hou et al. (2022)
		38. IoT-based control of critical units	Hou et al. (2022)
		39. Internet-based electricity consumption adjustment	Hou et al. (2022)
	Security and Control Systems	40. Integration of security systems	Abbasi et al. (2020); Liu & Chang (2022)
		41. Building information management systems	Liu & Chang (2022)
		42. System compatibility with building infrastructure	Liu & Chang (2022)
		43. Full monitoring of security infrastructure	Liu & Chang (2022)
		44. Scheduled public monitoring	Liu & Chang (2022)
	Integrated Management Systems	45. Operational and maintenance costs	Liu & Chang (2022)
		46. System integration capability	Liu & Chang (2022)
		47. System efficiency	Liu & Chang (2022)
		48. Internal coordination of components and units	Liu & Chang (2022)
		49. Service coherence and integration	Liu & Chang (2022)
	Smart Distribution	50. Smart monitoring of electricity consumption	Boustani et al. (2022)
		51. Electricity usage scheduling capability	Boustani et al. (2022)
		52. Electricity usage warning system	Boustani et al. (2022)
		53. Online monitoring of electricity usage	Boustani et al. (2022)
		54. Automation of electricity hazard control	Boustani et al. (2022)
		55. Remote electricity control	Boustani et al. (2022)
		56. Automated monitoring capabilities	Boustani et al. (2022)
Outcomes of Public Services	Employee Quality of Life	57. Acceleration of daily work tasks	Lotfollah Hamadani et al. (2023); Sidak et al. (2022)
		58. Simplicity in performing job duties	Lotfollah Hamadani et al. (2023); Sidak et al. (2022)
		59. Enjoyment of the work environment	Lotfollah Hamadani et al. (2023); Sidak et al. (2022)

		60. Peace and stability in the workplace	Lotfollah Hamadani et al. (2023); Sidak et al. (2022)
	Customer Experience Improvement	61. Easy access to required services	Sidak et al. (2022)
		62. Reduction in electricity costs	Sidak et al. (2022)
		63. Time management in service-related tasks	Yousefi Amiri et al. (2021); Sidak et al. (2022)
		64. Customer satisfaction and contentment	Sidak et al. (2022)
		65. Sense of pleasure and peace from company services	Sidak et al. (2022)
	Electricity Company Productivity	66. Increased operational efficiency	Welsberg et al. (2020)
		67. Enhanced effectiveness of company activities	Yousefi Amiri et al. (2021); Welsberg et al. (2020)
		68. Improved service quality	Welsberg et al. (2020)
		69. Realization of strategic goals and objectives	Welsberg et al. (2020)

The Delphi analysis serves as the connecting bridge between qualitative and quantitative analyses, as it allows the evaluation of the reliability of the model's identified dimensions and facilitates the interpretation of its components using the research instruments within the target population for the quantitative phase. In this study, Delphi analysis was employed to assess the reliability of the themes derived from the proposed model. This analysis was based on two criteria: agreement coefficient and mean score. For this purpose, the model components were formatted into a seven-point Likert questionnaire and distributed among panel members. Through several iterative rounds, the reliability of the research components was assessed.

Table 4

Delphi Analysis of Identified Themes

Category	Main Concepts	Round 1 Mean	Round 1 Agreement Coefficient	Round 2 Mean	Round 2 Agreement Coefficient	Result
Enabling Factors	Technical Factors	6.22	0.88	5.87	0.91	Confirmed
	Non-Technical Factors	5.39	0.64	5.58	0.77	Confirmed
Service Factors	Quality of Modern Services	5.44	0.90	6.03	0.83	Confirmed
	Remote Services	5.86	0.69	5.71	0.79	Confirmed
	Electronic Communication Mgmt.	5.30	0.65	5.40	0.71	Confirmed
IoT Factors	Data and Telecommunication System	5.25	0.89	6.03	0.90	Confirmed
	Security and Control Systems	5.84	0.67	5.47	0.78	Confirmed
	Integrated Management System	6.03	0.82	5.74	0.84	Confirmed
	Smart Distribution	5.33	0.67	5.40	0.72	Confirmed
Outcomes of Public Service	Employee Quality of Life	5.74	0.66	5.54	0.77	Confirmed
	Customer Experience Improvement	6.11	0.82	5.69	0.83	Confirmed
	Electricity Company Productivity	5.19	0.71	5.40	0.75	Confirmed

Based on the two criteria of mean score and agreement coefficient, it was confirmed that all main concepts related to the new public services model with an emphasis on the Internet of Things were validated. In other words, considering that the mean scores of the main concepts were 5 or higher, and the agreement coefficients exceeded 0.50, it can be stated that all identified themes from the qualitative phase were confirmed. Consequently, the next step involves identifying the most influential concepts using Interpretive Structural Modeling (ISM).

Once the validation of the main components of the research was completed, Interpretive Structural Modeling was used to determine the most influential concepts of the new public services model with an emphasis on IoT.

Table 5

Conceptual Relationships for SSIM Matrix Formation

Symbol	Relationship
V	Component *i* influences component *j*
A	Component *j* influences component *i*
X	Mutual influence exists
O	No relationship

The Structural Self-Interaction Matrix (SSIM) is formed by comparing the model's components using four possible relationship states. The resulting information is synthesized using ISM to produce the SSIM matrix, shown in Table 6.

Table 6

Structural Self-Interaction Matrix (SSIM) for Components of New Public Services Emphasizing IoT

SSIM	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12
C01	-	O	O	A	A	A	O	A	A	A	A	A
C02		-	O	A	A	A	A	A	A	A	A	A
C03			-	A	A	A	A	O	A	A	A	A
C04				-	X	A	X	V	V	A	X	V
C05					-	A	X	V	V	A	X	V
C06						-	V	O	V	X	V	V
C07							-	V	V	A	X	V
C08								-	V	A	A	V
C09									-	A	A	X
C10										-	V	O
C11											-	V
C12												-

The Reachability Matrix (RM) is derived by converting the SSIM into a binary (0/1) matrix. In the reachability matrix, all diagonal elements are set to 1. The resulting matrix forms the basis for analyzing the influence and dependence levels of each component in the model of new public services emphasizing the Internet of Things.

The table below presents the binary Reachability Matrix, derived from the Structural Self-Interaction Matrix (SSIM), by assigning 1s and 0s to indicate direct influence relationships. Diagonal elements are assigned the value 1.

Table 7

Reachability Matrix (RM) for Constructs of New Public Services Emphasizing the Internet of Things

RM	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12
C01	1	0	0	0	0	0	0	0	0	0	0	0
C02	0	1	0	0	0	0	0	0	0	0	0	0
C03	0	0	1	0	0	0	0	0	0	0	0	0
C04	1	1	1	1	1	0	1	1	1	0	1	1
C05	1	1	1	1	1	0	1	1	1	0	1	1
C06	1	1	1	1	1	1	1	0	1	1	1	1
C07	0	1	1	1	1	0	1	1	1	0	1	1
C08	1	1	0	0	0	0	0	1	1	0	0	1
C09	1	1	1	0	0	0	0	0	1	0	0	1
C10	1	1	1	1	1	1	1	1	1	1	1	0
C11	1	1	1	1	1	0	1	1	1	0	1	1
C12	1	1	1	0	0	0	0	0	1	0	0	1

The Transitivity Matrix is constructed by examining secondary relationships in the Reachability Matrix. For example, if A affects B and B affects C, then A should logically affect C. If such transitive links are missing, they are corrected to maintain logical completeness. The corrected final matrix is presented in Table (8).

Table 8

Transitivity Matrix for Constructs of New Public Services Emphasizing the Internet of Things

TM	C01	C02	C03	C04	C05	C06	C07	C08	C09	C10	C11	C12
C01	1	0	0	0	0	0	0	0	0	0	0	0
C02	0	1	0	0	0	0	0	0	0	0	0	0
C03	0	0	1	0	0	0	0	0	0	0	0	0
C04	1	1	1	1	1	0	1	1	1	0	1	1
C05	1	1	1	1	1	0	1	1	1	0	1	1
C06	1	1	1	1	1	1	1	1*	1	1	1	1
C07	1*	1	1	1	1	0	1	1	1	0	1	1
C08	1	1	1*	0	0	0	0	1	1	0	0	1
C09	1	1	1	0	0	0	0	0	1	0	0	1
C10	1	1	1	1	1	1	1	1	1	1	1	1*
C11	1	1	1	1	1	0	1	1	1	0	1	1
C12	1	1	1	0	0	0	0	0	1	0	0	1

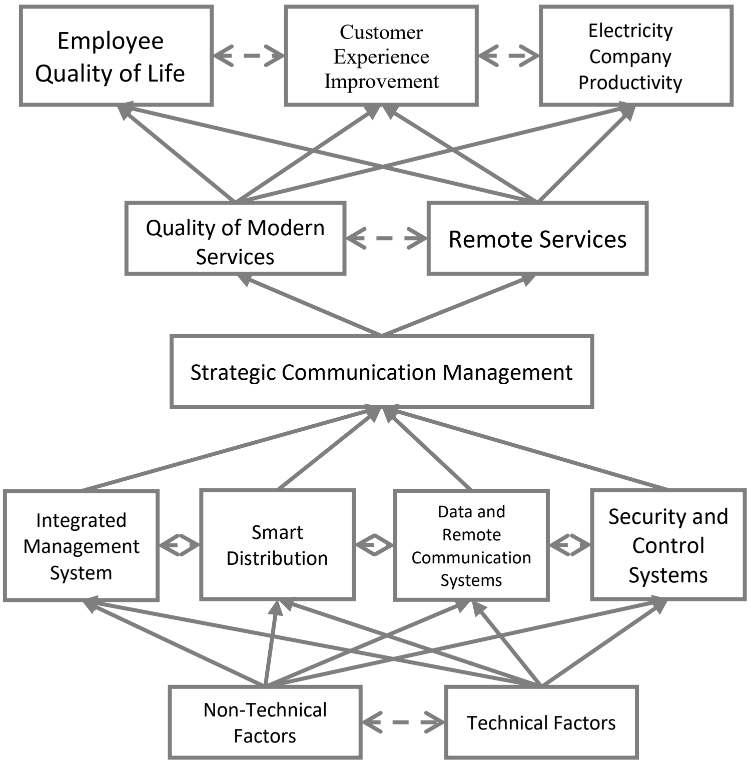
To determine levels, the Reachability Set (row entries: constructs that a given component can reach) and the Antecedent Set (column entries: constructs that can reach a given component) are identified for each component. The intersection of these sets determines the hierarchical level.

The first-level components are those where the reachability set and its intersection with the antecedent set are identical—indicating they are most influenced by others.

This process continues iteratively, removing already-leveled components from the matrix, recalculating sets, and identifying the next levels. The resulting level hierarchy is presented in Figure 2, which shows only meaningful inter-level and intra-level relationships among constructs.

Figure 2

ISM-Based Model of New Public Services Emphasizing IoT



This Interpretive Structural Modeling (ISM) diagram illustrates the interdependencies and influence of constructs, supporting strategic decision-making for managers.

Table 9

Driving Power and Dependence of Constructs of New Public Services Emphasizing IoT

Research Construct	Code	Dependence	Driving Power	Level
Electricity Company Productivity	C01	10	1	1
Customer Experience Improvement	C02	10	1	1
Employee Quality of Life	C03	10	1	1
Security and Control Systems	C04	6	10	4
Data and Remote Communication Systems	C05	6	10	4
Technical Factors	C06	2	12	5
Smart Distribution	C07	6	10	4
Strategic Communication Management	C08	7	6	3
Remote Services	C09	9	5	2
Non-Technical Factors	C10	2	12	5
Quality of Modern Services	C11	6	10	4
Integrated Management System	C12	9	5	2

Based on the power-dependence analysis, a coordinate system is created and divided into four quadrants:

1. Independent Constructs (High Driving Power, Low Dependence): These are the key drivers, such as Security and Control Systems (C04), Data and Communication Systems (C05), Smart Distribution (C07), Quality of Modern Services (C11), Technical Factors (C06), and Non-Technical Factors (C10). These elements influence others significantly and are minimally affected by them.
2. Dependent Constructs (High Dependence, Low Driving Power): These include Electricity

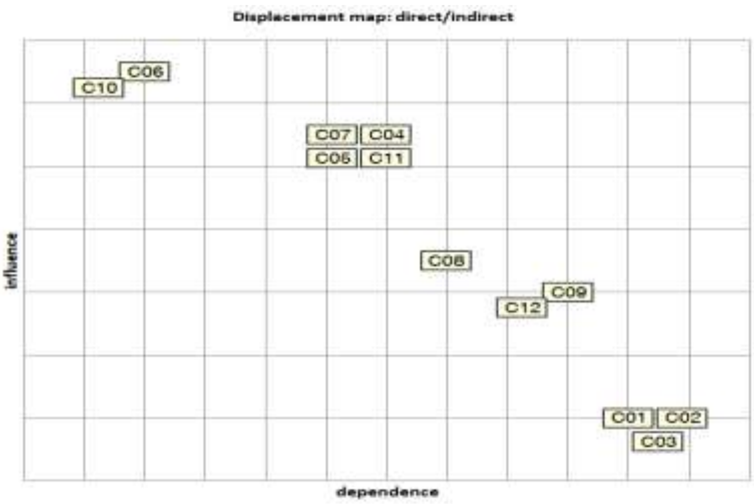
Company Productivity (C01), Customer Experience Improvement (C02), Employee Quality of Life (C03), Remote Services (C09), Integrated Management System (C12), and Strategic Communication Management (C08). They are mostly influenced by changes in other areas and act as outcome indicators.

3. Autonomous Constructs (Low Driving Power and Dependence): None were identified in this study.
4. Linkage Constructs (High Driving Power and High Dependence): None were identified in this study.

This distribution confirms that all constructs are either drivers or dependents, emphasizing the linear and structured nature of the proposed model.

Figure 3

MICMAC Graph of Driving Power and Dependence



4. Discussion and Conclusion

This study was conducted with the aim of proposing a model of new public services with an emphasis on the Internet of Things (IoT) in the Mashhad Electricity Distribution Company. The qualitative findings identified four main categories—enabling factors, service-related factors, IoT-related factors, and public service outcomes—twelve key concepts (technical factors, non-technical factors, quality of modern services, remote services, electronic communication management, data and remote communication systems, security and control systems, integrated management systems, smart distribution, employee quality of life, customer experience improvement, and company productivity), and 69 primary codes. The quantitative findings indicated that the components of technical and non-technical factors possessed the highest driving power among all model elements.

This study confirms that the realization of the proposed model hinges on attention to the four aforementioned dimensions. Each category contains core concepts that are interpreted and discussed from a scientific and professional standpoint. Enabling factors, as the foundation of the model, play a vital role in establishing the necessary infrastructure for implementing IoT in the electricity distribution sector. These factors are divided into technical and non-technical dimensions. Technical factors such as the development of high-speed communication networks, deployment of smart sensors, and creation of data storage systems act as prerequisites for the smartification of electricity networks. Conversely, non-technical factors—such as the formulation of supportive policies, training of human resources, and promotion of an innovative organizational culture—serve as essential complements for successful technological implementation. This study demonstrates that simultaneous attention to both technical and non-technical aspects is the key to achieving smart transformation in electricity distribution.

The findings related to technical factors—such as the use of modern hardware, upgrading technical equipment, and deploying new IoT software—align with (Ahmadi & Moradi, 2023; CheSuh et al., 2024; Memarzadeh Tehran et al., 2021; Najjarzadeh Hanjani, 2019; Najjarzadeh Hanjani & Shamsi Moheb, 2023) who emphasized the role of advanced technical infrastructure and continuous software updates in effective IoT implementation. Similarly, the need for specialized human resources in IoT, identified as a key code in this study, is consistent with findings (Dad Saadat & Mostafavi, 2021) which suggest that even the most advanced technologies are ineffective without skilled personnel.

Regarding non-technical factors, the study's findings—including senior management support, organizational flexibility, and a culture of change acceptance—are in line with (Abbasi et al., 2020; CheSuh et al., 2024; Yousefi Amiri et al., 2021) who emphasized that managerial commitment, innovation-oriented leadership, and an adaptive culture are critical for the success of IoT initiatives.

Service-related factors, as the core of the proposed model, focus on improving the quality of public services in the electricity distribution sector. These include the quality of modern services, remote services, and electronic communication management. High-quality modern services—defined by speed, accuracy, and personalization—are essential to customer satisfaction. Remote services, facilitated by digital platforms, offer unrestricted and convenient access. Electronic communication management enhances user experience and loyalty through integrated customer interaction systems. The study demonstrates that attention to service quality not only elevates public service performance but also creates a competitive advantage in the energy sector.

The study’s findings regarding service quality—such as ease of use, service security, and protection of customer privacy—align with (Chohan & Hu, 2020; Dad Saadat & Mostafavi, 2021; Lotfollah Hamadani et al., 2023) which have shown that delivering secure and user-friendly services significantly enhances customer satisfaction. Similarly, this study’s findings on remote services—such as electricity usage inquiries, remote payments, and online complaint submission—are supported (Sharifzadeh et al., 2022) who observed that such services improve access while reducing costs and increasing operational efficiency.

IoT-related factors, as the technological core of the model, include systems for data and remote communication, security and control, and integrated management. Data and remote communication systems allow for real-time data collection and analysis, improving decision-making and distribution management. Security and control systems protect against cyber threats with advanced security layers. Integrated management systems enable smart, dynamic network coordination. These findings correspond with (Ebrahimi et al., 2021; Hu et al., 2020) which highlighted how advanced data systems optimize network management and reduce operational costs. Similarly, the study’s findings on security and control—such as integrated security systems and comprehensive monitoring—are aligned with Liu and Chang (2022) and Abbasi et al. (2020), emphasizing the necessity of strong cybersecurity infrastructures.

Public service outcomes, as the final category, assess the broader social and environmental effects of transforming electricity distribution. These include smart distribution, employee quality of life, customer experience, and company productivity. Smart distribution contributes to environmental sustainability by reducing energy losses and optimizing network control. Employee quality of life improves through safer, more dynamic workplaces, while customer experience is enhanced through prompt and high-quality service delivery. Improved productivity is achieved through cost reduction and operational efficiency. These findings correspond with (Lotfollah Hamadani et al., 2023) regarding employee well-being, and with (Yousefi Amiri et al., 2021) regarding customer satisfaction. The study’s insights into productivity, such as enhanced operational effectiveness, are consistent with Yousefi Amiri et al. (2021), who highlighted productivity as key to achieving organizational goals (Yousefi Amiri et al., 2021).

The quantitative analysis confirmed that technical and non-technical factors possess greater driving power compared to other components in the model. This clearly demonstrates that the successful implementation of IoT in electricity distribution depends on the synergistic interaction of both. On one hand, technical factors—such as advanced communication infrastructure, smart sensor deployment, and data systems—are foundational for smart transformation. On the other, non-technical factors—like supportive policies, workforce training, cultural innovation, and stakeholder engagement—ensure the organizational embedding of technology. This study emphasizes that only through simultaneous attention to both aspects can digital transformation be achieved effectively.

Based on these findings, it is recommended that policymakers and electricity distribution companies first prioritize the development and updating of technical infrastructure. This includes the installation of smart sensors, creation of data processing systems, and use of advanced IoT software. Investment in the training and empowerment of specialized personnel should also be considered a strategic necessity. At the same time, non-technical elements such as senior management support, innovative organizational culture, and stakeholder engagement must be addressed. Developing supportive policies and flexible structures will help facilitate effective technological integration. Furthermore, improving integrated management systems and service quality will enhance customer satisfaction and user experience. These measures not only boost efficiency and reliability but also serve as a source of competitive advantage.

The proposed model may also serve as a framework for other sectors and regions. Public service providers are encouraged to consider IoT adoption as a pathway to smart networks, service quality improvement, and productivity gains. Local and urban communities can also contribute to the creation of smart and sustainable cities through collaborative energy management, reduced losses, and increased renewable energy use. Universities and research centers should conduct further studies to expand the theoretical and practical understanding of IoT in public services. These efforts may help design innovative models and solutions for complex challenges in energy and other industries. Finally, international collaboration and knowledge sharing can accelerate the digital transformation of electricity distribution and support sustainable development goals.

This study has some limitations. Due to the complexity of human experiences, controlling or limiting variables is inherently difficult. The use of questionnaires is also constrained by potential response biases. Additionally, the generalizability of the findings is limited due to organizational uniqueness and varying target populations. Future researchers are encouraged to replicate this model in different provinces of Iran and compare findings. They may also pursue theoretical conceptualization of the model and investigate practical implementation strategies from both technical and operational perspectives.

Authors' Contributions

Authors contributed equally to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

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Ethics Considerations

In this research, ethical standards including obtaining informed consent, ensuring privacy and confidentiality were considered.

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