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*Article*

# Identifying the Directions of Technology-Driven Government Innovation

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**Abstract:** The world is now strengthening its Information and Communication Technology (ICT) capabilities to secure economic growth and national competitiveness. The role of ICT is important for problems like COVID-19. ICT based innovation is effective in responding to problems for industry, economy, and society. However, we need to understand, not from the perspective of performance or investment, that the use and performance of ICT technology are promoted when each country's ICT related environment, policies, governance, and regulations are effective. We need to share sustainable ICT experiences, successes, and challenges to solve complex problems and reorganize policies. This study proposes a Text Mining methodology from a future-oriented perspective to extract semantic system patterns from International Telecommunication Union (ITU) professional reports. In the text extracted from the report, we found a new relationship pattern and a potential topic. The research results provide insights into a diverse perspective for policymakers to search for successful ICT strategies.

**Keywords:** open innovation; e-government strategy; ICT policy; ego network; topic modelling



**Citation:** Nam, H.; Kim, S.; Nam, T. Identifying the Directions of Technology-Driven Government Innovation. *Information* **2022**, *13*, 208. https://doi.org/10.3390/info13050208

Academic Editor: Dragan Ivanovic

Received: 25 February 2022
Accepted: 15 April 2022
Published: 19 April 2022



## 1. Introduction

The development of Information and Communication Technology (ICT) was observed not only in the environmental changes in information delivery but also in socio-economic development and business patterns. This pattern promotes national growth and the economic activities of institutions [1–3]. Innovation in digital technology is emphasized due to a paradigm of the Fourth Industrial Revolution. The capacity of national innovation is defined as the country's economic and political potential related to institutions, R&D, infrastructure, proliferation, and usage.

The world is now focusing on strengthening ICT innovation capacities to secure economic growth and national competitiveness. Despite human resources and economic problems that occurred due to the COVID-19 epidemic, many countries' governments and institutions have increased their investment in innovation [4,5]. Digital technology such as Cloud computing, Blockchain, Artificial Intelligence (AI), Drone, Internet of Things (IoT), Mobile have caused all industries to change. Such change would have had good performance without COVID-19 because there are many success experiences in the past to prove this similar situation [6]. ICT-based innovation is essential in overcoming common challenges that occurred due to COVID-19 for industries, economies, and society and in rebuilding a better future [7,8].

Countries around the world recognize the importance of the role of ICT. ICT aims to efficiently provide common services and flawless operation among stakeholders [9]. Progress is made in realizing ICT based initiatives that can solve economic problems in various industries and enhance national competitiveness [10]. Galati and Bigliardi [11] assert that it is important to clarify the meaning of industrial development and methods of operation and development. In addition, they emphasize international relations for

cooperation where numerous countries form complex development frameworks and share experiences, successes, challenges, and lessons for sustainable development [12].

The goal of ICT for success emphasizes the effective administration of each government. During the recent crisis of COVID-19, ICT played a major role in maintaining the economy and society [13]. Digital government technology connects governments and people through information sharing or online services [14]. Additionally, rapid policy decisions are made based on real-time data and analysis according to administrative operations. The government is coring on improving digital inclusion policies and enhancing the policy and technology capabilities of public institutions to create an effective ICT environment [15,16].

Several global organizations have studied the goals of ICT for successful strategies [17,18]. By centering on the ICT industry, The World Economic Forum (WEF) provided guidelines for economic development and competitiveness enhancement. Invigorating competitiveness is used to evaluate national competitiveness [19]. International Institute for Management Development (IMD) provides guidance for technology standards such as economic operability, government efficiency, corporate efficiency, and infrastructure [20]. Technological advancement of ICT enables easy understanding and comparison of the level of information and communication in major countries. Economics Intelligence Unit (EIU) guides for improving ICT ability every year [21]. It aims to encourage development through benchmarking by classifying the competitiveness of each country's ICT industry [22,23].

Organizations, such as WEF, IMD, and EIU show relation of cooperation with the International Telecommunications Union (ITU, http://www.itu.int/ accessed 30 December 2021), which is one of the 14 specialized organizations of the United Nations. It is an international telecommunications organization related to international cooperation, regulation, and standardization among member nations in relation to the harmonization of communication policies. Through ITU, many global organizations establish strategies and goals [24]. The UN's ITU plays a role in determining international standards and policies in the field of global information and communication [25]. ITU seeks to maintain and promote international cooperation between countries for telecommunication improvement and rational use. In addition, it is an important telecommunications specialized organization that can determine the current trend and direction of the ICT industry [26].

International organizations publish ICT reports (publications) in diverse fields every year. Futuristic strategies and plans of ICT are established by providing necessary information for each country. The report emphasizes that information may become an important source of insight in inaugurating a country's effective, sustainable economic stability and growth strategy. It clarifies decision-makers and contributes to creating policies to improve ICT performance rules. Furthermore, information on the ICT policy suggests a direction to promote successful national competitiveness [27,28].

The ICT report published by the ITU evaluates many countries in terms of technology, policy, regulation, environment, and governance [29]. It also explores the impact of policy and economic growth development. Reports are published annually to provide insights into complex, future-oriented social responses. ICT report presents causes and solutions for social problems and potential side effects. In some countries, this may contribute to the successful improvement of ICT capabilities. Through ICT technological advancement of countries, changes occur in environmental factors and institutional strategies are provided. However, the conditions for achieving effective ICT goals vary from country to country. Many factors must be considered to encourage sustainable national ICT capabilities [30].

Research demonstrating the causal relationship of economic achievement related to ICT has been proven for a long time. ICT performances are emphasized in these studies. However, studies for examination of the relationships such as ICT-related technologies, regulations, environments, and governance are insufficient. The reason for the lack of research is the limitation of measurement of quantitative methods. We propose a strategic means to identify and understand diverse environments, fields, and characteristics. ITU's documents consist of a large amount of unstructured natural language. This study observes an ICT-related report from 2019, when COVID-19 erupted, to present. The observed report

found 541 documents in a total of 20 fields. A large number of documents consists of a total of 40,627 pages. Many studies have already used text mining as the main method to analyze documents.

A statistical technique that uses an algorithm that considers digitized texts as numerical data for analysis is called text mining [31]. Text mining is useful for processing documents in terms of keyword analysis and structuring [32]. It extracts measurements from the text by converting contextual information into numeric information to extract relevant information with the rapid increase in atypical data [33]. The research involved in text mining identifies useful information, specific issues in the pattern, and a set of objective texts and analyzes them by applying standardized techniques [34,35]. Text mining is used to discover potentially useful information in a variety of atypical data, including business documents, social media, customer feedback, web pages, books, and research materials [36].

By extracting patterns of the system of meaning from this report, we created themes according to the similarity of the topics. Much work is needed to create and solve potential problems by understanding the relationship between words and analysis methods complemented in the existing quantitative approach. It is one of the many methods of gaining insights from a future-oriented perspective that is difficult to predict. The purpose of the proposed approach is to gain relevance and insight from documents that include the role, policy, and environment of governance that correlates to ICT technological progress.

Research related to COVID-19 is like behaviors trying to prevent and ensure the future ahead. It is one of the methods to unfold an unpredictable future in vast ICT documents. Text Mining is unique because it uses an unstructured data-based approach to understand the concept. It is considered general and objective because it selects research reports from international organizations. The report represents the environment, field, and characteristics related to ICT. Such a report differs from previous studies which analyzed subjective papers (body or abstract). This study understands the linguistic context of the report and studies to achieve sustainable ICT development goals. The results of the study help policymakers in making ICT-related decisions and establishing strategies.

This study aims to answer the following research questions. First, what are the main keywords of research related to ICT in ITU? Second, what is the confirmed relationship between words? Third, what is the potential pattern of ICT? This study consisted of the following. Section 2 reviews the relevant literature to explain the fundamental basis of the approach regarding the development of ICT. Section 3 explains the research design in terms of data and methodology. Section 4 presents the results of Text Mining and topic modeling analysis. Finally, Section 5 discusses conclusions and introduces academic and empirical meanings.

## 2. Literature Review

### *2.1. Public ICT Strategy*

ICT policies affect the ICT environment in various fields. In addition, it plays an important role in improving ICT quality, efficiency, security, legality, and ethics. ICT policies authorize many stakeholders. For this reason, ICT policies require ICT environment control and standardization [37,38]. Changes in the technology environment accelerate competition for global companies. Policy support from the government is an essential factor for companies and institutions. Furthermore, ICT policies support the use and development of ICT and effectively respond to problems caused by the ICT [39,40].

According to the ICT literature, ICT policy research is currently conducted in several countries. These studies guide problem-solving skills and insights through policy analysis related to ICT. However, in many countries, there are limitations in formalizing the ICT policy development framework [41]. Many cities recognize the absence of clear strategies or plans when treating ICT policy [42].

ICT differs in policy, strategy, and operation from country to country. In the case of the United States, intensive support is provided in the field of AI in ICT technology. Private companies such as Google and Amazon lead the AI field. The government supports

AI-related policies that companies can quickly apply [43]. Recently, China has established a special AI committee to support human-technology cooperation research. The Chinese government focuses on policies to effectively fulfill ICT convergence [44].

In addition, in the case of the EU, the vision of Europe 2020 is smart growth, sustainable growth, and inclusive growth. It has strong tools to form new economic governance and demands a coordinated response, including economic policy and support [45]. The new vision increases investment in R&D to achieve economic growth through the accumulation of knowledge and innovation [46]. Europe pursues and focuses on the data space where to design, create, and deploy technologies. In particular, it achieves climate-neutral goals and lays the foundation for network construction and policy, which centers on the new ICT industry [47]. This ICT-related policy is important for convergence between industries and productivity improvement. Policymakers need a variety of discussions to create a policy environment to build an effective ICT ecosystem.

To implement a successful e-government, policies should be established by considering many ICT-related environments. It is difficult to understand the complicated multidimensional environment of a country. Moreover, numerous ICT-related social problems should be identified. Problems such as digital gaps, strengthening the ICT-enabled environment, creating value, and strengthening corporate capabilities are tasks that all countries must solve [48]. An effective investigation is possible only when discussed through cooperation and agreement at international conferences rather than individual country-level efforts. Before emphasizing technology and performance, we need to look at various structural relationships such as ICT-related environments, policies, and governance [49].

The International Telecommunications Union (ITU) is a UN ICT agency that leads ICT innovation in 193 countries. ITU performs a wide range of ICT governance functions among international organizations: spreading access to ICT services, forming a future ICT policy and regulatory environment, and establishing global standards and best practices [50,51]. It deals with issues such as standardization of communication network technology and operations, global resource management, policies, regulations, support for developing countries, and ICT applications [52–54]. These functional features focus on developing global networks and improving access to services. ITU works with each government official to discuss ICT-related issues, share insights and best practices, and lay the foundation for long-term industrial growth.

The reports provided by ITU are utilized in many countries in terms of technology, policy, regulation, environment, and governance [55]. ITU explores the impact on policy and economic growth development. It also provides future-oriented insights into complex social responses [56]. Furthermore, it also presents the causes and solutions of ICT-related problems in terms of governance. These data contribute to the successful improvement of ICT capabilities in some countries.

### *2.2. Innovative e-Government Direction*

Existing governments recognize limitations in the early e-government process, information security issues, and traditional government methods [57]. In this respect, e-government brings about a paradigm of using information technology (IT) throughout the economy [58]. In the past, governments focused on performing administrative tasks efficiently using ICT technologies, such as computers and the Internet. However, as e-government advances, it overcomes supplier-centered limitations. Through ICT technology and the Internet, we have strengthened access and delivery of all aspects of the government. To develop information technology and enhance national competitiveness, many countries are targeting ICT investment and technology development [59].

The use of IT provides many possibilities to improve the efficiency of government functions [60,61]. This improved e-government service quality [62,63]. It also contributed to reducing corruption and consolidated the government [64]. Additionally, it has macroscopically changed diverse fields, including politics and government, and microscopically

administrative reengineering [65–67]. The government recognizes the importance of innovation in ICT policy [68].

A country's economy cannot be defined simply by GDP or productivity. Batterbury and Fernando [69] explain that a country must have an environment with an efficient structure, institution, and policy. Balkyte and Tvaronavičiene [70] emphasize that factors involving national competitiveness can maximize the potentiality of the industrial economy. It is necessary to solve environmental pollution or social difficulties and respond to changes in the political, economic, and social environment. Therefore, it demands a high level of e-government innovation through the introduction and utilization of digital technology [71–73].

The government plans and implements ICT-based services prior to effective administrative service operation. The ICT environment, accessibility, and infrastructure are directed to the participation of citizens. Citizen participation improves the maturity of e-government services. Individual development capabilities implement efficient and innovative e-government. Strong ICT capability is a prerequisite for the development of innovative administrative services. It makes the lives of citizens convenient and allows companies to contribute to production for augmenting competitiveness [74,75]. In today's world is difficult to compete without ICT strategies [76,77]. Digital transformation due to the advancement of ICT technology exemplifies the complexity of social problems. Strategies and policies must be in place to supplement complex problems [78]. This is the pathway that e-government should take into account.

## 3. Materials and Methods

*Data Collection*

Text type reports issued by ITU have limitations in objective improvements. Therefore, it is difficult to observe the study. Extracting information in areas where the scientific approach is difficult is an advantage of Text Mining [79]. Most documents consist of unstructured natural language. These documents have the key to solving complex problems that are difficult to access quantitatively. With the study of the relationship of keywords, statistical algorithms were applied to make further progress and the algorithms are useful for tracking and monitoring important information from a large number of documents. Many studies have already suggested insights and directions by utilizing Text Mining techniques [32]. The List of Selected Reports is shown in Table 1.

**Table 1.** List of Selected Reports (http://www.itu.int/hub?s=&post_type=publication, accessed on 31 December 2021).

| Report Category | Number of Reports | Page | Report Category | Number of Reports | Page |
|---|---|---|---|---|---|
| 5G | 21 | 1728 | E·C | 11 | 891 |
| A·I | 17 | 1585 | H·T | 15 | 835 |
| Blockchain | 14 | 698 | Infrastructure | 33 | 2733 |
| C·B | 24 | 1687 | Internet of things | 17 | 1171 |
| Climate change | 18 | 1335 | Network | 12 | 846 |
| Cyber security | 18 | 915 | P&R | 64 | 5782 |
| D·E | 17 | 1216 | Satellite | 13 | 1106 |
| D·FS | 17 | 719 | Smart cities | 29 | 1409 |
| D·T | 73 | 7246 | Social impact | 64 | 4710 |
| D·I | 23 | 1459 | Standards | 41 | 2556 |
| | | | Total | 541 | 40,627 |

* AI: Artificial Intelligence, CB: Capacity building, DE: Digital economy, DFS: Digital financial services, DT: Digital transformation, DI: Diversity inclusion, EC: Emergency communications, HT: Humane technology, NM: Network management, PR: Policy & Regulation.

Text Mining approaches in numerous studies for an unpredictable future. In other words, the ITU reports used in this study contain all the contents of ICT. The reports discover ICT-related information, insights, and directions. Previous studies analyzed subjective research abstracts or results [80,81]. This study, however, understands the linguistic context of the reports and tracks the guidance of sustainable ICT in publications written by experts. It is effective in dealing with diverse topics for policy managers (decision-makers) in a complex ICT environment.

ITU provides documentation for news, publications, and pages related to ICT technology, environment, policy, and governance. The documents cover success cases in various fields. It also deals with technology environments, government roles, policies and regulations, and social issues related to ICT. The documents have reports issued by the ITU organization itself and reports from outside experts. In this study, external expert reports on ICT provided by publications and pages and ICT evaluation reports issued regularly by the ITU are collected. A total of 40,627 pages were collected in 20 fields, each containing 541 documents. To apply the Text Mining technique, a preprocessing of text is required. Prior to text analysis, prerequisites for extracting words are required. For this study, all word classes (adjectives, verbs, numbers, and idioms) except nouns were excluded from the analysis. The selected data extracted a total of 32,952 words from 545 documents. 511,566 keywords, which appeared simultaneously between words, were found. The top 500 words from the extracted words were selected and presented in the research results.

## 4. Analysis

### *4.1. Descriptive Statistics*

Text Mining refines the words in the text through preprocessing and morphological analysis of text type data. It restores the morpheme in places where irregular utilization, abbreviation, or elimination occurred. Words refined in the morpheme are presented according to the word class used for the analysis. The method of calculating the value of the word frequency uses the total frequency of the word appearing in the document. If this value is large, it means that words often appear in the document. The discovery of certain words indicates how frequently they have appeared in several documents.

Nouns were the basis of this study for word extraction. As mentioned earlier, all other types of word classes except nouns were excluded from the analysis. As a result of the analysis, the total number of words is 32,952. ITU-related keywords that most appeared in the collected report are shown in Table 2. The keywords with the highest frequency in the ITU report were "service (27,600), data (21,497), network (14,503), system (11,598), and ITU (11,437)." These words account for about 6% of the total words in the report. Keywords "country (11,209), formation (10,267), technology (9898), cloud (8966), and access (8718)" account for the next highest frequency.

TF-IDF uses the frequency of appearance. It shows a value indicating how important a word is in the document. It is used in several studies to evaluate the importance of documents. More weight is given to documents where certain words appear frequently. Service, data, network, country, ITU, cloud, formation, technology, access, etc., were found in TF-IDF results. The results were similar to the results of word frequency, but a slight difference in the ranking existed. The mentioned words appear intermittently in each document.

In graph theory, centrality is used as a measure of the relative importance of vertices or nodes in a graph or social network [82,83]. The textual analysis uses closeness centrality, degree centrality, eigenvector centrality, and betweenness centrality. Among these analysis techniques, degree centrality identifies the most important vertex by deriving the total amount directly linked to other nodes [84]. It confirms the connection nodes formed between the central words and words in the collected document. The higher the number of connected nodes, the higher the degree of centrality. Therefore, as the result of the analysis, the words are effective in understanding the core connections in the document [85].

**Table 2.** Text mining analysis results.

| Rank | Key Word | Frequency | Key Word | tf-idf | Key Word | Centrality |
|---|---|---|---|---|---|---|
| 1 | service | 27,600 | service | 58,040.37 | data | 0.102 |
| 2 | data | 21,497 | data | 51,653.79 | service | 0.097 |
| 3 | network | 14,503 | network | 39,135.22 | network | 0.086 |
| 4 | system | 11,598 | system | 32,716.45 | system | 0.086 |
| 5 | ITU | 11,437 | country | 32,224.09 | technology | 0.075 |
| 6 | country | 11,209 | ITU | 32,028.02 | formation | 0.072 |
| 7 | formation | 10,267 | cloud | 30,036.35 | country | 0.069 |
| 8 | technology | 9898 | formation | 29,465.04 | time | 0.065 |
| 9 | cloud | 8966 | technology | 29,110.57 | source | 0.064 |
| 10 | access | 8718 | access | 26,525.69 | example | 0.064 |
| 11 | source | 8088 | source | 25,309.20 | use | 0.063 |
| 12 | develop | 7948 | develop | 24,723.23 | apply | 0.058 |
| 13 | use | 7562 | broadband | 24,186.12 | case | 0.057 |
| 14 | broadband | 7191 | use | 23,468.13 | access | 0.057 |
| 15 | policy | 6407 | internet | 21,598.22 | level | 0.055 |
| 16 | apply | 6355 | policy | 21,476.14 | model | 0.055 |
| 17 | internet | 6275 | apply | 21,395.73 | ITU | 0.054 |
| 18 | manage | 6195 | manage | 20,964.94 | develop | 0.054 |
| 19 | time | 6189 | time | 20,744.20 | solute | 0.052 |
| 20 | level | 5728 | model | 19,973.09 | numb | 0.052 |
| 21 | infrastructure | 5690 | infrastructure | 19,656.96 | process | 0.051 |
| 22 | model | 5628 | level | 19,583.43 | area | 0.050 |
| 23 | communicate | 5620 | communicate | 19,560.70 | communicate | 0.049 |
| 24 | case | 5388 | telecom | 18,946.20 | project | 0.049 |
| 25 | telecom * | 5359 | case | 18,533.70 | vice | 0.047 |
| 26 | process | 4800 | area | 17,225.08 | internet | 0.047 |
| 27 | area | 4749 | process | 17,212.74 | work | 0.046 |
| 28 | sector | 4650 | sector | 16,939.61 | port | 0.045 |
| 29 | project | 4552 | project | 16,866.31 | figure | 0.045 |
| 30 | example | 4538 | numb | 16,558.56 | world | 0.045 |

* Telecommunicate.

By observing degree centrality, the ranking difference occurs between the word frequency and TF-IDF results. Data, service, network, system, technology, formation, country, time, source, use, etc., were found. Time, source, use, etc., are new words that have not been found in the existing results and are in the top 10 words with a strong connection.

Since these results are a general and common keyword relationship, limitations in discovering rules or insights for new words exist. It is essential to notice the relationship between words derived through the *n*-gram (The *n*-gram model is a probability language model for predicting the next sequence in the form of an ordinal language model. If used in text modeling, the independent thesis sets each word to depend only on the last $n-1$ word. This assumes that the probability of a word depends only on the previous n-content $x_j-(n-1),\cdots,x_j-1$. The *n*-gram analysis predicts which words may appear in the document through language modeling and shows the importance of the relationship between words [86]). With language modeling, *n*-gram analysis predicts the next word

to appear in each sentence and shows the importance of the relationship between words. The higher the correlation between a specific word and other words, the more consecutive the word-to-word relationship occurs to explain the specific content. In other words, it provides appropriate insight to understand the relationship between connected words in ICT reports.

When analyzing morphemes with only one word, it is difficult to understand the meaning of the word. As parts of speech get analyzed differently with morpheme analysis, examining the appearance state of simultaneous words and the next word to appear provides more appropriate insight than utilizing conventional simple frequency. It is effective in understanding specific events [87]. Simultaneous appearance frequency records the number of times a chain of *n*-words appeared. Yazdani et al. [88] contributed to predicting the following words through *n*-gram, reducing the time and effort while improving text quality. The *n*-gram is used to infer specific content of continuous relationships between words. In addition, it can be interpreted that the higher the correlation between words, the higher the interrelation between words [89,90].

In this study, ego network visualization is used to observe the relationship between words effectively. In the *n*-gram, the value of the connection frequency result between words is expressed as network visualization. Network visualization is effective in identifying the relationship and orientation of words. The arrow direction refers to the direction of the word mentioned after the word appears. The thickness of the node means the frequency between words. The network visualization results are shown in Figure 1. The word displayed in the red circle means a word that has been linked to another word more than three times. Words mentioned the most from existing results, such as device, use, cloud, source, data, technology, network, and access, were used as interconnected words in n-gram. Furthermore, words such as broadcast, Internet, community, infrastructure, operator, and telecommunicate are also related to many other words.

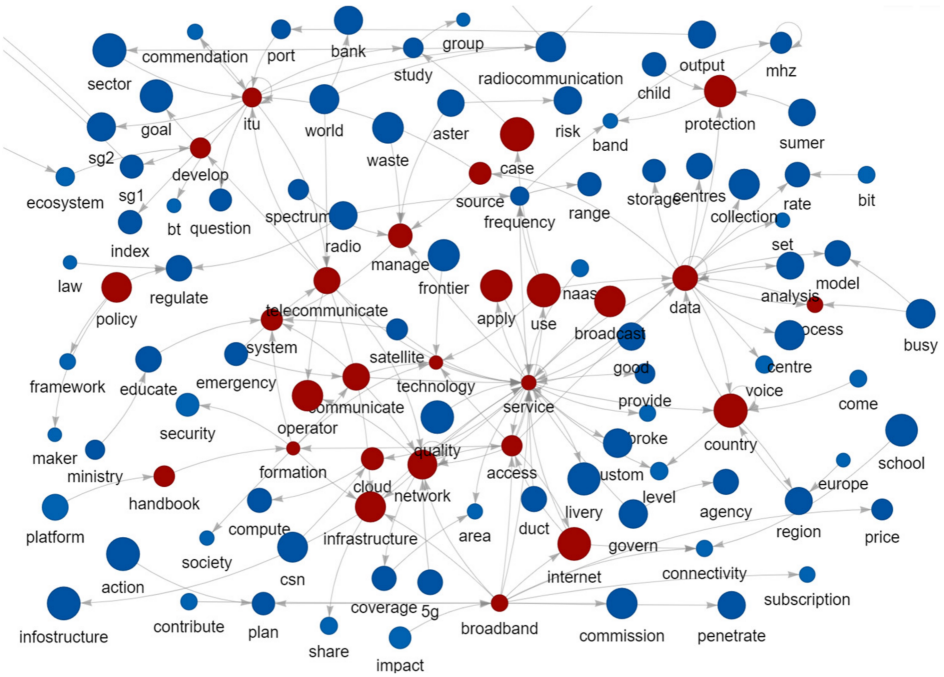


**Figure 1.** Result of ego network visualization.

Specifically, by examining the top relative words extracted from the n-gram, the ICT report is explained by words such as cloud-service (4131), service-provider (2083), cloud-compute (1681), use-case (1431), personal-ability (1111), service-custom (903), and Internet-access (781). Community-technology (664), case-study (660), formation-communicate (651),

telecommunicate-service (646), and policymaker (580), were followed. It contains the meaning of understanding the ICT environment and related cases as well as forming policies.

The study confirmed the connection of many potential words through n-gram. The word-to-word meaning is important, but a phenomenon of inconsistencies among connected words may appear. So the analysis results are important in preparing and predicting the future through this information. The meaning between the connected words also deals with social problems and issues that we have not experienced in the future. We need to be prepared to respond to potential issues in this relationship.

### *4.2. Topic Modeling*

Topic modeling is used to identify potential topics in extracted text documents. It is a method of clustering [91]. It has been used in numerous research fields to identify potential implications and establish strategies or policies to predict uncertain environments. The generation algorithm, Latent Dirichlet Allocation (LDA), infers to topics hidden in the document using mathematical and statistical methods suitable for deducing the semantic structure of text data [92,93].

The main task of topic modeling is to identify parameters that can map known words to unknown topics [94]. Through observed variables of words and literature (coppers), observation for invisible variables is possible. Topic proportions (θ), per word topic assignment (Z), and topic (β) are predicted. Figure 2 is a hyperparameter of α and η, which constitutes the same value in the entire literature set [95].

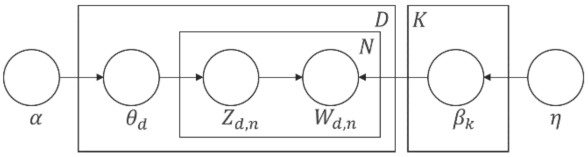


**Figure 2.** Topic modeling structure.

Topic modeling groups specific words with similar meanings within ICT-related reports by utilizing algorithms that automatically extract topics from the literature. Many recent studies utilize LDA techniques based on mathematical algorithms. LDA technique's strength is minimizing the subjective bias of analysis.

In the LDA model, the number of topics derived, the words constituting the topic, the size of the topic, the distance of the topic, and the value of λ confirm the latent topic. The following precautions are needed to interpret the topic. First, the higher the discriminant validity, the clearer the subject is. If the distance between topics is close or intersects, the discriminant validity is poor. This means that the subjects that make up each topic are similar. Second, the larger the size of the circle that makes up the topic, the higher the frequency and the more organized the topics are, which leads to a topic of more importance. Third, the λ value means the conditions for the appearance of the word constituting the topic. If λ is high, it is suitable for observing the composition topic of the words that are significant. On the other hand, when λ is low, it is effective in identifying distinct words that make up each topic. It is necessary to derive the potential number of topics for the study while checking the discriminant validity.

The results of the topic modeling analysis are shown in Table 3. Considering the distance between topics and the size of the topic, the topic is classified into 12 categories. To clearly distinguish keywords by subject, specific words with high λ values were sorted. Specific topic results were categorized into Topic A (6.2%), Topic B (6.7%), Topic C (11%), Topic D (4.6%), Topic E (7.1%), Topic F (10.1%), Topic G (8.5%), Topic H (7.7%), Topic I (11%), Topic J (11%), Topic K (7.4%), and Topic L (9.2%). Topic 3 and Topic 10 consisted of the largest topics among all topics. Topic 6 and Topic 9 were followed by a slight difference. The Distance map between topics is shown in Figure 3.

**Table 3.** Topic modeling analysis result.

| Topic | Key Word | λ | Topic | Key Word | λ | Topic | Key Word | λ |
|---|---|---|---|---|---|---|---|---|
| | bank | 0.040 | | source | 0.056 | | service | 0.147 |
| | group | 0.035 | | radio | 0.042 | | network | 0.037 |
| | standard | 0.035 | | regulate | 0.032 | | access | 0.027 |
| Topic | world | 0.035 | Topic | demand | 0.022 | Topic | custom | 0.018 |
| (A) | commission | 0.022 | (B) | spectrum | 0.022 | (C) | China | 0.018 |
| 6.2% | cycle | 0.020 | 6.7% | broadcast | 0.021 | 11% | control | 0.017 |
| | document | 0.016 | | waste | 0.017 | | apply | 0.016 |
| | website | 0.015 | | policy | 0.016 | | cash | 0.013 |
| | guideline | 0.013 | | objective | 0.012 | | demand | 0.013 |
| | drive | 0.043 | | Internet | 0.047 | | system | 0.031 |
| | value | 0.038 | | telecom | 0.042 | | time | 0.024 |
| | Africa | 0.021 | | access | 0.032 | | apply | 0.020 |
| Topic | question | 0.018 | Topic | change | 0.020 | Topic | message | 0.018 |
| (D) | platform | 0.017 | (E) | household | 0.014 | (F) | component | 0.016 |
| 4.6% | Rwanda | 0.012 | 7.1% | effect | 0.014 | 10.1% | channel | 0.014 |
| | supply | 0.010 | | operator | 0.013 | | value | 0.013 |
| | formation | 0.010 | | phone | 0.012 | | video | 0.013 |
| | biometric | 0.009 | | object | 0.010 | | feature | 0.010 |
| | data | 0.142 | | broadband | 0.054 | | country | 0.038 |
| | security | 0.036 | | develop | 0.033 | | connectivity | 0.027 |
| | formation | 0.026 | | study | 0.033 | | gender | 0.022 |
| Topic | transaction | 0.021 | Topic | build | 0.027 | Topic | develop | 0.022 |
| (G) | system | 0.016 | (H) | country | 0.027 | (I) | risk | 0.021 |
| 8.5% | VMS | 0.016 | 7.7% | children | 0.025 | 10.4% | policy | 0.019 |
| | source | 0.014 | | search | 0.025 | | infra | 0.019 |
| | response | 0.013 | | skill | 0.023 | | framework | 0.015 |
| | process | 0.013 | | capacity | 0.022 | | emergency | 0.014 |
| | technology | 0.030 | | network | 0.055 | | women | 0.058 |
| | formation | 0.025 | | security | 0.041 | | school | 0.030 |
| | educate | 0.024 | | protection | 0.027 | | city | 0.025 |
| Topic | governance | 0.019 | Topic | tent | 0.025 | Topic | innovate | 0.022 |
| (J) | train | 0.018 | (K) | media | 0.020 | (L) | technology | 0.021 |
| 11% | role | 0.017 | 7.4% | program | 0.016 | 9.2% | people | 0.019 |
| | sector | 0.016 | | child | 0.017 | | ecosystem | 0.018 |
| | system | 0.015 | | multimedia | 0.016 | | person | 0.016 |
| | market | 0.014 | | phase | 0.015 | | covid | 0.015 |

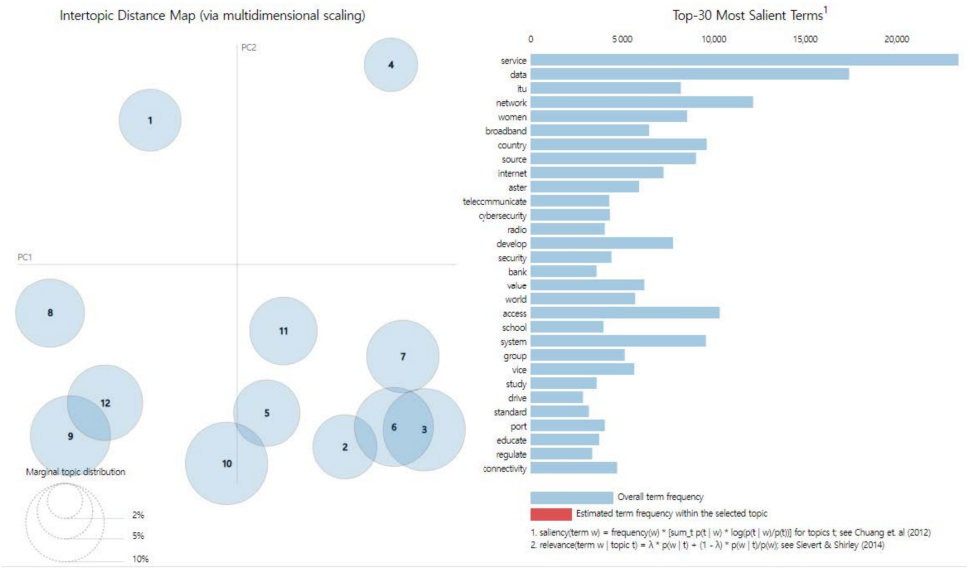


**Figure 3.** Distance map between topics.

Examining the words that make up the specific topic, Topic (A) had words such as bank, group, standard, and world, which are related to ITU. Topic (B) shows that the source word has the largest λ value and suggests words such as radio, regulation, requirement, and spectrum. It deals with topics on ICT-related regulations and the scope of use. Topic (C) has keywords related to building suitable services for the environment. Specifically, network, access, provider, and custom words related to service were represented.

In the case of Topic (D), words that were observed in a specific topic and were difficult to interpret were identified. It is advisable to review the relevant literature to understand the subject of the topic. Topic words with high λ values have a similar crowd with values, bits, Africa, and files, including drive. Topic (E) consists of topic words such as Internet, telecommunicate, access, vice, and use. Potential keywords related to ICT usage emphasize access and use. In the case of Topic (F), problem recognition is required through potential keywords related to the system. Time, application, number, and message were derived as similar meanings corresponding to the system.

In Topic (G), which deals with data transactions and security, "data" was identified as the highest topic word. After that, security, formation, transaction, and method constitute the topic. Topic (H) identified potential topics related to broadband development. The composition of the word is developed, study, port, and build, including broadband. Topic (I) is related to the role of the country. Topic composition words include country, aster, connectivity, and gender.

Included are technology, formation, education, govern, and community. Topic (K) identified potential topics related to security. The word configuration of the latent topic was extracted from network, cyber security, protection, figure, and media. Finally, women came out as the topmost among the topic words that form Topic (L). The keywords school, city, rate, and innovate were identified in relation to women. It is necessary to look specifically at potential topics related to women in ICT.

A total of (12) potential topics were classified through all documents in the ITU. The results from the analysis are common and may be general. However, these studies are needed to focus on specific topics to observe and understand problems. In addition, the words that constitute each topic play as clues for important issues in a particular topic. We need to solve the problems that we haven't experienced through these clues. Preparing for the future further strengthens the ICT environment and related policies.

Among the 12 topics derived, the factors with a topic size of 10% or more are as follows. First, topic (C) has keywords related to establishing the right service for the environment. Specifically, it refers to services, networks, connections, customs, and words related to China. The proliferation of digital networks causes many changes in daily life. Emerging countries are investing largely in ICT-related infrastructure [96]. However, in countries with large populations and weak access to services, such as China, efficient public service delivery and integration are difficult. The Chinese government shares data among various systems that have better social adhesion and that can solve municipal administration and infrastructure management [97]. This is done by taking into account the socio-cultural context that is characterized by diverse users. This will provide solutions to deliver sustainable long-term benefits to public service providers and users [98].

Second, topic (J) was observed as a topic dealing with technology and policy. The words included are technology, formation, education, governance, and community. ICT was used to include technological innovation and convergence, resulting in changes in the social economy, political participation, education, and health. These technologies are effective tools for socio-economic development through new types of government organizations, new relationships between government and citizens, and improved networking within society [99]. However, while the potential of ICT to stimulate socio-economic development and effective governance is well known, differences exist in the ability to utilize ICT between countries [100] effectively. To solve this issue, big data and monitoring tools are used to strengthen the central or local government's information infrastructure [101]. In addition, through ICT, cities empower and educate citizens who participate in discussions about

living conditions [102]. This will affect how central and local governments are organized and managed in response to cooperation, socioeconomic and environmental issues for smooth communication, as well as ICT infrastructure.

Third, topic (I) is related to the role of countries. Topic words include country, connectivity, gender, development, and risk. ICT technology is developed by reflecting the relevant society (country), and the effective use of technology is influenced by the harmonious operation of gender, ethnicity, and social class [103]. Thus, the country allows individuals to participate as a group and provides new opportunities for them to benefit and develop. The growth and absorption of ICT can lead to inequality in certain interest groups or regulations through improved access to information and services [104]. Specifically, the strength of ICT technology generates a large amount of data about the behavior and preferences of users using technology devices and services. Given the ability of these technologies that can deteriorate or improve social realities, the country needs to set the role in how the policy process is done, who is represented, and how the voice of citizens is heard [105].

Fourth, topic (F) requires problem recognition through potential keywords related to the system. Applications, numbers, and messages are derived similarly corresponding to the system. ICT has allowed people to connect and communicate information to bridge the gap between people and messages. For example, the implementation of systems that apply digital technology to prevent accidents that are emerging as social problems, such as automobile accident detection and emergency notification systems, construction safety, and accident prevention, is increasing [106,107]. Through the application of ICT technology, which is closely related to daily life, it is expected that the quality of life may be improved through messages between providers –to-users and users-to-users.

Lastly, "women" placed number one topic word in the topic (L). Keywords related to women were identified, such as school, city, ratio, and innovation. It is necessary to specifically examine potential topics related to women in the ICT field. Today, more than half of society's population accounts for the proportion of women in relation to ICT technology users [100]. It emphasizes that women are inevitable agents of the intelligence community. Mlambo-Ngcuka [108] asserted that ICT has the potential to expand women's economic productivity, increase educational accessibility, and increase political participation. Despite much progress, however, gender gaps still exist in all respects. There are high barriers to digital gaps, especially for women in rural areas [109]. To close this gap, it is beneficial to develop policies that reduce the barriers to women's access to education, employment, political engagement, and communication and provide women's engagement in technology. In other words, ICT may be a tool for increasing women's political and social empowerment and equality [100]. To successfully solve these problems, structural innovation is essential to increase women's participation in the political and social life of the information society.

## 5. Discussion

The importance of countries and ICT networks has been further emphasized by COVID-19. The more rapidly the country deploys and upgrades its ICT network, the greater the economic impact and the stronger the economic resilience to diseases [110]. After COVID-19, ITU discussed the role of the public sector and the government in the future development of the ICT area. In the study, the collection of ITU documents was done during the time of COVID-19 [111]. Many ICT policies and social issues were related to these documents.

ICT is a very important issue for the country. We recognize the importance of ICT technology in infectious diseases such as COVID-19. Along with the Fourth Industrial Revolution, the world has made a lot of efforts and investments in technological progress. As a result, it provides the solution to social problems for industry, economy, and society; it shows a strong preparation for future crises as well. To provide efficient public services, each government is conducting research to search for methods to increase national competitiveness with the purpose of good operation [112].

Today's society forms a very complex structure and network relationship [113]. As such, clarity is needed in the operation and development of ICT [114]. It is vital to solving problems such as policies, governance, and regulations that support this structure and relationship. However, internal development and experience create problems in different aspects [115,116]. There are limitations in solving complex problems of social structures that we have not experienced in the past. We need to share sustainable development, experience, success, challenges, and lessons from many countries through international cooperation. An "Open Innovation" approach using shared resources is required. Sustainable development of each country takes place through experience, success challenges, and lessons [117]. We respond to the future by dealing with the complexes and complex ICT issues.

ICT is covered by numerous global organizations to develop the economy and reinforce competitiveness. ICT contributes to evaluating competitiveness, guiding technology levels, and providing guidelines. Many studies emphasized the use of ICT for investment in economic performance and R&D. However, many factors, such as complex technologies, governance, environment, and regulatory policies, must precede prior to the use of ICT. The problems that impede the ICT environment, such as limitations of technology access and social regulations, and social problems, are actually important factors for establishing ICT strategies.

ITU collaborates with several ICT-related global organizations to determine the flow and direction of the ICT industry. Reports provide important insights into economic stability and selection. It contributes to creating policies to improve ICT performance for decision-makers. Reports are published annually in various fields related to ICT. These reports contribute to improving ICT capabilities. We studied to understand different ICT environments, regulations, policies, and governance aspects from country to country. Scholars emphasize that numerous factors must be considered to find sustainable ICT. However, there is a lack of data necessary for objective and scientific approaches to prove these environmental factors. Text Mining is effective in solving these problems in a quantitative way with a limited approach. We extract text from ITU's reports to effectively achieve ICT strategies and goals. The extracted text includes structures for problem solving and complexity, including abundant environments and characteristics. By analyzing *n*-gram and potential topics in the text, we found a new pattern and relationship.

In addition to ordinary words, we identified words that form connections with external words such as broadcast, Internet, community, infrastructure, operator, and telecommunicate. The harmonization of connected words currently has a complex network format. These central words, which were emphasized for external words, appeared in the report. Conversely, external words are sometimes adopted as important words. We need a strategy to understand and respond to possible problems between words. Through specific latent topics, we have identified problems or improvements to be solved. As a result, we recognized the problem through a total of 12 latent themes. In the list, topics such as "The Role of International Organizations," "Regulation and Scope of Use," "Building Services," "ICT Use and Accessibility," "System Management," "Data Transaction," "Broadband Development," "Technology and Policy," and "Security" are mentioned. These topics are problems that all countries need to solve, so we need an understanding of these topics. In addition, clues dealing with important issues were identified through the words that make up each topic.

Each government should seek national competitiveness by introducing policies and technologies related to its environment. The effective response was made by providing effective administrative services and using ICT technology in crises such as COVID-19. ICT technological progress is needed for the construction of a better future. The government should establish a sustainable ICT strategy that considers various environments, fields, policies, regulations, and governance. Relationships between words and potential topics are challenges that we need to solve in the future. A lot of studies must be conducted to prove such a relationship. For the successful development of ICT, the role of the government in unfolding an unpredictable future is important.

To acquire ideas for social and policy issues, it effectively extracts large interpretable topics from a vast collection of data, such as unstructured documents, reports, survey results, discussions, and statistics. Compared to other topic modeling techniques, LDA techniques readily interpret results and solve overfitting issues, which is advantageous in deriving multiple topics from vast amounts of unstructured data [118].

Nevertheless, if the number of topics was limited while many documents needed to be processed, and if a variety of topics in one document were used, precise specification of the number of topics must be done due to overlapping errors in the topic. In addition, there are some areas where LDA techniques have not been actively utilized. It is necessary to carefully analyze the time series changes and differences in ITU documents to apply the structure of words that appear simultaneously with the year-on-year-based topic factors. Future research must complement text mining approaches such as subject modeling with well-established research methods.

**Author Contributions:** All authors significantly contributed to the scientific study and writing. H.N. contributed to the overall idea, model formulation and analysis, and writing of the manuscript; S.K. contributed the process of refining research ideas. T.N. contributed to the process of detailed writing and discussions on Government Innovation as well as preparation for publishing the paper. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research was supported by the SungKyunKwan University and the BK21 FOUR (Graduate School Innovation) funded by the Ministry of Education (MOE, Korea) and National Research Foundation of Korea (NRF).

**Institutional Review Board Statement:** Not applicable.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** Not applicable.

**Conflicts of Interest:** The authors declare no conflict of interest.

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