Modeling the Policy Portfolio of Systemic Innovations for the Sustainability of the IoT in Manufacturing Industry by Using a Novel MADM Based Integrated Framework

（製造業における IoT の持続可能性に向けた政策ポートフォリオに関する研究）

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Abstract:

The definition of the innovation policy portfolio is critical for technological innovations and industrial sustainability. Due to the fast emergence of the technology for the Internet of Things (IoT), novel applications have evolved rapidly in the past years. In manufacturing industries, the adoptions of the IoT have also increased promptly. For fast catching-up economies such as Taiwan, although the government has proposed policies which include subsidies and financial supports, the diffusions of industrial IoT into manufacturing related applications are relatively slow. To improve such problem, this research attempts to propose a novel multiple attribute decision making (MADM) model and analytical process. The analytical process can be split into several steps. First, this research explores the systemic factors' causality. By the causality result, we can understand influential relationship among factors. Then, this research evaluates the systemic innovation problems in which we can easily understand how to improve different identified systemic problems. Finally, based on different systemic problems, this research attempts to derive the policy portfolios and roadmaps to solve specific problems. An empirical case based on the smart manufacturing industry in Taiwan will be leveraged to validate the proposed analytical framework. The empirical study results based on the novel MADM based integrated framework can offer the innovative insights for policy makers in formulating future policies to develop the IoT industry and support the industrial sustainability.

Keywords: Systemic innovation policy; Bayesian theory, Rough interval number, MADM; Policy portfolio; Policy roadmaps.

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Chpater 1 Introduction

1.1 Research background and motivation

Due to the rapid development in cloud computing, many applications based on internet service have ubiquitously affected the people around the world. Besides, relying on the incremental revolution in information and internet technology, the connection of internet and devices make the communication between machines and people become more complicated. Such interaction is seen as the internet of things (IoT) [1]. Referring to the investigation from IDC, a corporation focusing on market and technology research in the world, the IoT-related spending can scale up to 1.2 trillion US dollars by 2022. In addition, IDC stated that the IoT spending from 2017 to 2020 will have an annual growth rate of approximately 14% [2]. Under such analysis, the next generation of welfare of human beings will be significantly influenced. For instance of IoT applications, countries around the world have started to enter into the 5G generation. In this generation, the real time data will be accessed fast. Depending on the 5G technology, digital twin will be realized. The digital twin stands for the software embedded in object and system, such software relying on 5G technology and collected data from sensor will fast generate the calculation results, including dynamic situation response, check out of potential obstacle factors, and preventive maintenance. In other words, digital twin can serve as a smart/intelligent agent who will effectively manage factories and production line in manufacturing industries and promote the operation efficiency in companies.

Since the rapidly growing in IoT innovations, various innovative technology are gradually changing industrial development. One instance is the unmanned factories where IoT-related technology, such as machine learning and robotic applications, will play a pivotal role. Given the effort of IoT-based systems, the cost in industrial operation will be decreased and resources will also be even more effectively allocated. By such improvements, the sustainability of IoT in industrial development is feasible. Moreover, realization of IoT sustainability will be necessary for both developed economies and emerging economies. The main reason is IoT sustainability will enhance industrial competitiveness and further facilitate the economic growth. In order to follow the trend of IoT development, from the perspective of government, policy intervention is essential. Albeit the important of policy intervention, how to define and adopt the proper policies is not easy. In policy definition and planning, the first task is to understand what kind of factors that are currently influencing industrial development and sustainability. After analyzing the interrelationships between these factors, it is necessary for policy makers to further find out which challenges and difficulties that are hampering industrial sustainability.

Sustainability is a feature that is able to maintain development based on economic, social responsibilities, and environment. Sustainability can be the transition process comprising of industry and technology transition as well as socio-technical transformation. In socio-technical transformation process, technology and social transformations always change simultaneously, and such changes will further influence industrial sustainability. Analysis and explanation above mentioned the transformation process of sustainability is difficult. Many scholars have attempted to propose theoretic framework for such issues. In these theoretic frameworks, a framework of technological innovation system (TIS) has received many concerns. There are seven factors called systemic functions proposed in TIS, these factors can be used to explain and analyze industrial development. In other words, these factors can offer for analysts the foundation to studying industrial development and innovations as well as sustainability.

Besides, many scholars and policy analysts recently have showed the many interests on systemic innovation based policy analyses [14-17]. The analyses of systemic innovation regard the process of formulation of innovation policies as the issues of systemically enhancement. Following such sense of systemic concept, the primary works in defining the innovation policies for government sectors can be split into several parts. First, it is essential to structurally discover which challenges, termed systemic innovation problems, influencing industrial development. Then, government sectors need to conduct a structural evaluation and thereby, providing a solution mechanism. Specifically, systemic innovation issues have to be observed and defined, policy intervention concerning the policy formulation and analysis is subsequently performed, finally the goal such as industrial sustainability can be realized [18].

1.2 Research purposes

The innovation policy formulation is adopted to help the industrial sustainability and technology development through some means, including infrastructure construction, direction of talent cultivation and determination of research budgets [19]. In order to consolidate and improve the industrial competitiveness, the adoption of innovation policies is always approached as the indispensable tools leveraged through public sectors. Since formulation of innovation policy is always associated with various complicated factors, thus the formulating a set of proper innovation policies may not an easy task. Given that, there is a necessity for government to carefully consider how these policies based on systemic improvement should be designed to support technological innovations and industrial development.

However, how to configure or define an appropriate innovation policy portfolio for a specific technology in general, and the IoT technology in special, is not easy. On the one hand, the configuration or reconfiguration of innovation policy portfolios always involve multifaceted factors, which include environmental, demand, and supply ones. On the other hand, IoT technological and its application development may not be analogized to other technological development. That is, if public sectors merely use conventional policy instruments by referring to other technological development trajectory to cope with IoT development, the policy effectiveness will be problematic. Hence customizing a unique policy portfolio for facilitating the IoT development can be a feasible solution.

In pushing the sustainability of socio-technical change, the development process of technological innovation can determine industrial sustainability [4]. Besides, despite scholars have devoted huge efforts in investigating policy portfolios for technical innovations in advanced and fast catching-up economies [16, 17, 20], very few scholars have tried to define innovation policy for the industrial sustainability in both of advanced and fast catching-up countries. Consequently, a research gap exists in accurately evaluate existing systemic challenges which will hamper the industrial sustainability of IoT. Furthermore, define or re-define the proper policy combination for the industrial sustainability of the IoT will be essential for both of the public as well as industrial sectors. Innovations are the systemic activities which associated with a variety of actors within the system, such as industrial development and technological innovations, and their roadmapping have been increasingly leveraged for strategic policy making recently [21]. Given such reason, in addition to policy portfolio configuration for systemic innovation, the systemic innovation policy roadmapping should also be taken into consideration simultaneously.

1.3 Research methods

The aim of this study is to establish a novel MADM based integrated framework for exploring the systemic functions and evaluating systemic innovation problems that affect industrial sustainability of IoT. Finally, based on identified systemic problems, this paper further tries to formulate policy portfolios and plan the roadmap of systemic innovation policies. In order systemic analyze above issues, this research split these issues into several parts in which the proposed analytical method will be introduced to deal with corresponding issues.

First, understanding the factors (systemic functions) and potential obstacles (systemic innovation problems) influencing IoT industrial sustainability are indispensable for policy configuration and formulation. Thus, these factors and obstacles should be identified and confirmed. In other words, through the literature review and experts' interview, the systemic functions and systemic innovation problems can be identified. Subsequently the appropriateness of these systemic functions and systemic innovation problems will be further confirmed based on Random Forest (RF) and modified Delphi method. In short, the first step here is to identify factors and obstacles as well as innovation policies, the subsequent analyses will be conducted by using identified systemic factors, obstacles and innovation policies.

Second, in order for policy makers to effectively formulate policies to motivating IoT industrial sustainability, understanding the relationships between factors influencing sustainability in IoT industries is necessary. Thus, a Bayesian Rough (BR) and Decision Making Trial and Evaluation Laboratory (DEMATEL) will be introduced to explore the causality between these systemic functions. In addition, the influential weights of systemic functions can also be obtained using BR-DEMATEL based Network Process (BR-DNP). Regarding the concept of DEMATEL method, such method aims to derive the causal relationships among identified systemic factors. BR-DNP approach can further calculate the weights of identified factors.

Third, the evaluation of systemic innovations problems can make policy makers easily understand how to improve current challenges in IoT industrial sustainability. In this view, this research proposes a novel hybrid BR based analytical model, termed MBR-VIKOR, incorporating BR method and modified Vlse Kriterijumska Optimizacija I Kompromisno Resenje (modified VIKOR) to evaluate the performance-gap among systemic innovation problems in order to understand how to improve these problems. In other words, gap values of systemic innovation problems can be obtained using VIKOR. The larger the gap values, the inferior the innovation problems' performance.

Fourth, in addition to the assessment of performance-gap in systemic innovation problems, a set of corresponding policy actions, namely systemic innovation policy instruments, will be essential. These policy instruments are customized for enhancing theses systemic problems. Hence, each of systemic problems will require different policy portfolio solutions. To formulate the policy portfolio of systemic innovations, this research utilizes Rough Grey Relational Analysis (R-GRA) approach to derive the systemic innovation policy portfolios versus systemic innovation problems. On the basis of policy portfolios in terms of various systemic innovation problems, the innovation policy roadmaps will be derived by drawing on Rough Competence Set Expansion (R-CSE).

An empirical study that defines the causal relationships among systemic functions, evaluates systemic innovation problems, formulates the policy portfolios for industrial sustainability of IoT. Besides, Taiwanese manufacturing industry is introduced as empirical case for demonstrating the proposed model. Practically, such integrated MADM can offer policy makers the innovative insights in formulating innovation policies with systemic perspectives for supporting industrial sustainable development and technological innovations

1.4 Research contributions

This research aims to explore the IoT sustainability in manufacturing industries. In such issues, this research proposed a novel analytical framework by incorporating many methods, including DEMATEL, DNP, VIKOR, GRA, CSE, rough set theory, and Bayesian theory. In order to analyze comprehensively IoT sustainability, this research used manufacturing industries in Taiwan as empirical case. Taiwan not only has been played the essential role in recent decades in manufacturing industries, but also Taiwan has had the strong manufacturing capability and experiences that can be seen as a modern example. This research contributes the innovation policy fields and research methods with several innovations and ideas.

First, this research proposed an analytical process. In this analytical process, this research initially explores the causal relationship among factors in order to understand how the factors will influence each other. Following this path, this research further discusses what kind of problems which are hampering industrial sustainable development. Based on these problems, called systemic innovation problems, this research calculates the gap values of these problems. This way is to understand how the distance between ideal goal and current problems are, and how to thereby enhance these problems. Finally, this research proposed several important innovation policies that can be adopted to solve existing innovation problems.

Second, this research proposed a novel model. Such model is the first one being proposed for empirical case. The major differences of this model and other models are human judgment problem. This research combined the Rough set theory and Bayesian theory simultaneously to deal with imprecision from human judgment (such as linguistic transformation). Besides, this research also adopted CSE method to derive the policy roadmaps, such application can be the foundation for future analyses.

Finally, this research identified the systemic factors, innovation problems, and innovation policies. The innovation problems being collected from the literature and made a modification for match the situations of manufacturing industries in Taiwan. The innovation policies have also been modified in order to compatible to innovation problems. Future studies can extend and refer to the identified innovation problems and policies.

1.5 Organization of the dissertation

The rest of this paper is organized as follows: the literature review on industrial sustainability, technological innovation system, systemic innovation problems, innovation policy, systemic innovation policy portfolio definition, systemic innovation policy roadmapping, and research gaps will be presented in Section 2. The novel research methods and analytical process regarding to purposed rough integrated framework will be defined in Section 3. The empirical study for illustrating the causal relationship network betwn systemic factors, evaluating systemic innovation policy versus systemic innovation problems, determining the innovation policy portfolios, and deriving the innovation policy roadmap will be presented in Section 4. Section 5 provides the discussions and implications. Finally, Section 6 summarizes the results and concludes the paper.

Chpater 2 Literature review

2.1 TIS framework

The TIS framework, generated from the domains of innovation systems, has been extensively used in many studies, such as emerging technologies, industrial sustainability and innovation polices definition [6, 8, 9, 28-30]. In other words, TIS can be adopted to explore technological innovations, technology diffusion, and sustainable development based on the different levels, comprising of sectors, regions, nations [31].

The main aim of the TIS is to analyze the pros and cons for a specific innovation system based on the both notions of function and structure. The notion of structure being established around the certain technological innovation relying on several structural elements, including actors, networks, and institutions [32]. First, actors can be one of following units, such as university, firms, consumers, public sectors, research institute and interest groups [6]. Second, networks means the cooperation relationship between universities and industries [6]. Eventually, institution can be the routines, regulations, laws, and culture [6]. Moreover, the notion of function being established for studying system performance and potential difficulties through actors, network and institute. Besides, such analytical flow has obtained the huge successes in many research fields [28, 30, 33]. Generally, the analysis of TIS depends on seven key systemic factors (called systemic functions), consisting of knowledge diffusion based on related networks, entrepreneurial and business activities, knowledge development, guidance and direction of search, resource mobilization, market construction and formation, and creation of legitimacy [6, 34].

TIS model's usability in industrial sustainability and systemic innovation is feasible in past few years. For instances, Suurs and Hekkert [35] researched the relations between systemic functions and Netherlands biofuel innovation development by referring to historical papers and events. In addition, they stated that the TIS model is feasible for identifying root causes in biofuel development. Reichardt, Negro [16] analyzed the wind technologies in industrial transitions through a TIS framework. The potential system problems influencing the sustainable development of innovation systems were obtained at first. Next, associated policy suggestions were provided in terms of the notions and opinions of stakeholders and prior literature of related study fields. Edsand [36] assessed the systemic factors (or called systemic functions) of TIS relying on the experts' perspectives and past data of paper for exploring the causations for wind energy diffusion in Colombia. According to research findings, they provided some policy recommendation for those potential systemic challenges versus systemic factors. Haley [37] extended original TIS framework by drawing on an empirical instance concerning renewable electricity in Canada. The extended model used TIS in order to exploring how the technological transformation in focal as well as how policies should be re-configured and planned for facilitating the development of renewable electricity. Above empirical literature of TIS utilization presented for scholars and analysts the foundation and the possibility to analyze industrial sustainability and technological innovations. In the following sub-sections, this research will further introduce seven important factors, termed systemic functions.

2.1.1 Entrepreneurial Experiment

The development Innovation system often needs the support by entrepreneurial activities and experiments [9]. These experiments and activities are to convert the potential of markets, knowledge, and networks into real actions which included entrepreneurial ventures and corporate experiments [16]. In this sense, potential opportunities for business will have a possibility being found. In order to help business activities and experiments, there are some factors that need to be considered, consisting of launching pilot and trial projects, experimentation of applications in technologies, incubation systems, and entry of firms into markets, [6, 16, 31, 34, 38].

2.1.2 Knowledge Development

Knowledge development can be explained by three features including knowledge exchange, knowledge creation, and knowledge facilitation. Based on the past studies, knowledge development is regarded as the crucial role in the initial process of developing a certain technology [6]. Besides, knowledge is able to be converted to feasible applications in commercial settings in terms of two critical types, consisting of learning by doing and learning by searching [39]. Generally, several indicators can be applied to derive knowledge development, such as feasibility study conduction, technology market evaluation and estimation, research cooperation, and complementary technology developement [6, 16, 31, 34, 38].

2.1.3 Knowledge Diffusion through a Network

Knowledge diffusion stands for the knowledge diffusion based on related networks where the information can be shared between actors. The knowledge is diffused and delivered by a kind of meetings, for examples, conference and workshops [7]. Through such diffusion, technological innovations can obtain the well-developed possibility [40]. By the prior TIS literature, knowledge diffusion feature can be composed of implementing business campaigns, training professionals, arranging seminars, demonstrations fields and center, as well as industrial and technological exhibitions [4, 6, 31, 34, 35, 38].

2.1.4 Guidance of Search

Guidance of search represents the organizations' benefits in developing specific technologies or industrial sustainability in terms of expectations of actors [29]. The instance is that public departments offer a series of policies for influencing the direction of industrial and technology development. Given the implementation of policies, firms can be motivated and further use this chance to develop a specific technology. In general, guidance of search can derive different features, comprising of design of favorable rules and regulations, setting a collective development goal, providing directional development, and publicizing expectations (disseminating expectations) [6, 11, 31, 35].

2.1.5 Market Formation

Technological innovations often are facilitated by government procurement programs, regulations, subsidies, and so on. Such reason is that emerging technology can be weak compared to similar technology with incubation help [29]. That is, help of policies by government can create favorable markets for technological innovations [8]. Markets formation can give rise to several criteria, including government procurement, provision of subsidies, technology standards, and regulatory reform [4, 6, 31, 34, 35, 38].

2.1.6 Resource Mobilization

Physical resources, financial and human are the important elements for the development innovation system [9]. Resources mobilization can be composed of features, including education programs of specific technologies, mobilization in human resources, funding projects, and so on. Shortly, the innovation system will be influenced if these useful resources cannot be effectively provided. Specifically, resource mobilization can give rise to several criteria, financial grants and loans, including providing a R&D budget, mobilizing human resources, education program design, and funding on various projects [6, 11, 31, 35].

2.1.7 Creation of Legitimacy

Legitimacy is necessary for stakeholders to commit the investment in technologies and help for development of industry [9]. Such function either represents the technological innovations can be facilitated and influenced by the interactions between the government departments and advocacy coalition [7]. Based on the historical literature, political tools, including interest groups and lobbyists, have tremendously affected expectations of public departments. Hence, legitimacy can be regarded as the useful tools for technological innovation or industrial development (guidance of search), as legitimacy will influence the guidance of search from government sectors [7]. The function of the creation of legitimacy is composed of social acceptability, growth of interest groups, and the strength of lobbying actions [6, 16, 31, 34, 38]. These criteria will be well-explaining for creation of legitimacy [14, 16, 41, 42, 43].

2.2 Industrial sustainability and TIS

Industrial sustainability in the past studies has demonstrated the interrelationship between industrial transformation and technological innovation. In the era of IoT, sustainable development in the industries has become a kind of trend. From the perspective of government sectors, how to motivate the industrial sustainability and technological development by using policy tools will be necessary. In order to develop a sustainability industry, government sectors should identify existing problems influencing industrial development and understand what sort of factors will impact industrial sustainability. Under such setting, TIS framework can be an option of solution. That is because TIS has obtained the many successes in analyzing the definition of innovation policy, sustainability in industries, and technological or industrial transition.

2.3 Innovation policy for systemic innovation

Innovation is defined as new creations of economic and societal significance, primarily carried out by individuals or groups [63]. In general, innovation is involved in many concepts, such as product innovations and process innovations. According to Fuglsang and Sundbo [64], innovation is seen as the combinations of knowledge that result in new products, processes, input and output markets, or organizations. More specifically, innovation is an interactive system comprising of ideas, skills, abilities, and resources [65]. It can be understood as a synthetic process where governments or enterprises find out and define the problems and thereby actively propose new solutions for solving them [66]. Innovation always plays an essential driver that influences the social, environment, and economic development [65, 67, 68].

Technology and industrial policies are two important ways for enhancing national competition ability and stimulating economic growth [14]. The purpose of technology policy is to support companies to invent something new. Conversely, the industrial policy is set to help for companies conducting the commercialization. Based on the advantages from both of two kinds of polices, Rothwell and Zegveld [69] propose a set of innovation policy tools by integrating technology and industrial policies for dealing with these problems. An ideal innovation policy should be designed to not only focus on invention, but also help commercialization [70].

Innovation policy is illustrated as the integral of all state initiatives, including science, education, research, technology policy, and industrial modernization, overlapping also with industrial, environmental, labor and social policies [71]. Likewise, innovation policy can be regarded as a series of activities including the ones being proposed and executed by public sector units and market institutions which can influence technological changes and innovation processes [72], and that goes beyond the scope of science and technology polices. In short, the innovation policy can consist of numerous elements, including the research and development (R&D) policy, technology policy, infrastructure policy, regional policy, education policy, and public actions influencing the demand for innovation [73]. The main objective of innovation policy can be regarded as the supportive means for promoting the usefulness of specific technologies from various aspects in the processes of innovation [9, 17].

2.4 Systemic innovation policy portfolios for technological innovation system

The innovation system has been proved the importance in innovation processes and innovations themselves. In innovation policy formulation, all actions by public sectors will influence the innovation processes as well as innovative products and/or services. In other words, public sectors leverage innovation policies as a kind of intervention way to affect the innovation processes. For emerging technologies, policy interventions can be effective supports to promote the development of specific technologies.

Recently, systemic innovation policy analysis has received considerable attention [14, 74-76]. The core notions of analyzing systemic innovation are to approach the process of developing innovation policy for industrial development and technological innovation as a kind of issues based on systemic enhancement. The systemic innovation policies are expected to realize specific goals such as economic growth, competitiveness, environmental problems, technological innovations and social issues [17, 46, 70, 77, 78]. However, the implementation of policy cannot provide the same weights to each of directions. That is, the policy determination has to be balanced between these goals. In fact, the formulation of innovation policy is always a challenging task. In democratic societies, the formulation of an innovation policy always involves government initiatives, parliamentary discussions, public agencies, the civil society, etc. [63]. In order to simultaneously deal with the different goals of formulating an innovation policy, a combination of various policies will be indispensable. Such a concept of innovation policy combination is similar to the innovation policy mix or innovation policy portfolio. According to Borrás and Edquist [63], an innovation policy combination refers to “a set of different and complementary policy instruments to address the problems being identified” in a national or regional innovation system. According to Reichardt, Negro [79] and Flanagan, Uyarra [80], a policy portfolio encompasses both the combination of innovation policy instruments and the processes by which such instruments emerge and interact [81].

Based on the previous definitions of innovation policy portfolio, three primary features can be concluded as follows: First, the “ultimate purpose” of innovation policy portfolio is often discussed [63, 65]. Since the ultimate purpose for configuring or reconfiguring an innovation policy portfolio will drive policy makers to pursue such a policy portfolio. Second, “interaction” is the central feature of the existing definitions of portfolios for policy instrument [81]. Third, some of the definitions point to the dynamic nature of the innovation policy portfolio, which includes the notions of “evolution” and “developed incrementally over many years” [81]. Such features reflect that innovation policy instruments and their implications may change over time and further, result in interactions and coordination between these policy instruments [82].

Although the application of innovation policy portfolio to the technological innovation system is very recent [63, 79-81], the understandings of the meanings of innovation policy portfolios on the design, implementation and evaluation of innovation policies still need to be developed and explored. Thus, there will be research gaps that can be further filled up. However, innovation policy evaluation and formulating a set of innovation policy tools portfolios are not easy. The formulations of innovation portfolios entailed three important factors [63]. Initially, the selection of the certain policy tools is the most proper among the wide range of different probable tools. Next, the policy instruments shall be operated based on customization. Lastly, designing a set of various policies or combining different policies have to rely on the understanding for identified problems.

On the basis of systemic innovation policy formulation, Bergek, Jacobsson [6] and Wieczorek and Hekkert [9] presented an systemic analytical procedure to dissect the potential problems, or the so-called systemic innovation problems. These systemic innovation problems are seen as obstacles that will hamper industrial development and technological innovation. In this analytical process, systemic innovation problems can be identified based on experts’ opinions and past literature. The corresponding innovation policies will be subsequently designed for facilitating specific technological development. That is, based on such analytical steps, each systemic innovation problem will be further treated by adopting a certain policy portfolio. Such a process of analysis can effectively deal with systemic innovation problems influencing the industrial development and technological innovations by using customized systemic innovation policies.

Based on above literature review, the identification of current systemic innovation problems and the derivation of suitable innovation policy portfolio are essential for technological innovations and sustainable development of industries. Conventional systemic innovation policy analyses would largely use the literature in policy events as basis for policy formulation. However, the literature regarding policy evaluation is still scarce, especially regarding the systemic innovation policy evaluation versus systemic innovation problems. To fill up the research gaps, this research aims to propose a systemic analytical framework for evaluating systemic innovation policies towards systemic innovation problems and, deriving systemic innovation policy portfolios accordingly. In addition, this research will also define the dynamic roadmaps of innovation policies based on every derived systemic innovation policy portfolio.

2.5 Systemic innovation policy roadmapping

In many research fields, the R&D practices are regarded as important feature for framing industrial and technological policies [83]. Due to lots of efforts in policy definition and technological innovation development, the policy analyses have been constantly enhanced. With such trajectory development, the innovation policies emerge accordingly. the task of innovation policy definition has gradually been involved in many sides, including education, finance, technology and science, for specific technological and industrial development [19]. In recent, some scholars considered innovation policy needs to be seriously and carefully defined by several elements, such as actors and institutions [9, 17, 46, 70, 78, 79]. Besides, innovation policy should also be formulated by using multi-level structure. Such multi-level structure consists of the analysis of technological innovation system functions, systemic innovation problems identification, and systemic innovation policies derivations [9].

Systemic innovation policy analyses in recent have been received many attentions, since such analyses can effectively and systemically explore and exploit the challenges of specific technological and industrial development and further, proving the insights for policy makers or policy analysts. In such policy analyses, policy definition or policy portfolio formulation always neglect the dynamic development among various policies. The dynamic development means priority of different policies. Given these reasons, a systemic innovation policy roadmapping can be a solution for dealing with dynamic policy development. More specifically, the systemic innovation policy roadmapping can be used to derive the priority in innovation policy portfolios, which will offer policy makers the different insights for industrial sustainability.

The roadmapping of systemic innovation policy is developed in terms of technology roadmapping and strategy roadmapping [83]. In technology roadmapping, roadmapping is leveraged to identify relevant technologies and make the clear action plans for them [83]. In strategy roadmapping, roadmapping can be seen more as a dynamic and iterative process, which will be involved in a variety of visions, such as long-term visions and short- to medium-term visions [83]. In the field of foresight, the systemic innovation policy roadmapping can be foresight method and stimulates two capacities in technological and industrial development. First, the potential problems and opportunities can be discovered by the roadmapping method. In other words, foresight methods will offer actors the related information to tackle with market failure. Second, the systemic innovation policy roadmapping will facilitate social structure and linkage that could be useful in fostering the circulation of information in the system [84].

The systemic innovation policy roadmapping can also be utilized in policy planning in multiple ways. Firstly, establishing a common vision can encourage the commitment of the long-term goals, consisting of technological innovations and industrial sustainability. For instance, technology commercialization is usually dependent on investments and development activities realized by multiple actors [83]. Secondly, a roadmapping can be a solution for potential problems in technological innovations and industrial developments. That is, by the roadmapping method, potential problems can be articulated more explicitly. Thirdly, the roadmapping can also make a foresight and expectation in novel technological innovations. When a roadmapping analysis executed well, a roadmap will be depicted well and will let policy makers understand the future societal and market needs. Fourthly, the roadmapping method should be visionary and strategizing. For example, defining a roadmapping should consider various factors in a certain timeframe [83]. Finally, an innovation target is essential for roadmapping analysis. The target can be either a technology or logical temporal sequence such as industrial sustainable development [83].

2.6 MADM in innovation policy evaluation

In recent years, the configurations and reconfigurations of innovation policy based on the analytical results of innovation systems are receiving increasing attentions. Such model of innovation policy has demonstrated the usefulness for motivating the industrial sustainability and technological innovations [9]. The policy portfolio for systemic innovation usually encompasses numerous policy tools for solving current problems of innovation problems and facilitating developments of industrial technology. In the modeling process of portfolios for innovation policy, policy evaluations play a central role that will influence the adaption and feedback of policies [85]. Due to the importance of policy evaluations, an effective systemic evaluation framework in exploring the potential innovation problems, deriving corresponding innovation policy portfolios, and thus, helping the formulating the systemic innovation policy roadmapping is indispensable. In addition, an appropriate systemic evaluation framework can also enhance the performances of innovation policy configuration and reconfiguration.

For the past few years, an increasing number of scholars have defined MADM frameworks to solve numerous complex problems of policy analysis and definition [86-89]. The MADM methods based frameworks can tackle with these multi-faceted decision making problems and capture the complexity arisen. Thus, policy makers can easily understand the nature of these problems and define appropriate policies [90]. The primary advantage of MADM based frameworks is to compromise opinions being provided by different stakeholders or experts' preferences [91]. Such frameworks can also be utilized to establish a causal model based on various experts' perspectives without strictly assumptions and hypotheses [92]. Moreover, MADM based analytic frameworks have also been applied into policy evaluation. For example, Huang, Shyu [89] defined an analytical framework based on MADM methods to reconfigure the combination of innovation policies for SIP mall industry in Taiwan; Liu, Tzeng [93] proposed a hybrid MADM model to improve the tourism policy, Kao, Nawata [14] proposed a Bayesian Rough MADM model to evaluate systemic functions for industrial sustainability of IoT.

The process of MADM is characterized by imprecision and uncertainty of transforming linguistic variables into real values in terms of subjective judgments [14]. During the past decades, novel theories like the fuzzy, grey, and other theories were proposed to resolve these problems of imprecision and uncertain in variables. These theories use interval methods to handle evaluation values. However, defining the interval boundaries based interval numbers by human judgments is not easy. To solve the above-mentioned imprecision and uncertainty problems which were usually seen in the transformation of evaluation values, the RST being proposed by Pawlak [94] can be very suitable. The reasons can be split into two-fold. The first reason is that the rough interval number based rough set concepts will be more efficient than fuzzy and grey theories, since the use of rough interval number do not have to consider the definition of membership function such as fuzzy set. The second reason is that rough interval numbers are determined based on collective evaluation values, all the values will be adopted to derive the interval boundaries. Thus, every interval values transformed can be varied. Unlike conventional methods such as fuzzy and grey methods, the each value transformed will be the fixed interval numbers given the designed interval boundaries.

In lights of existing literatures, the RST being integrated into MADM models has extensively been leveraged to a board of domains, which include the evaluations of logistics providers [95], product-service systems [23], identifications of risk factors in supply chain management [96], etc. Given the successful applications of the RST in tackling the inaccuracies and uncertainties in decision making problems, an introduction of the RST into the decision making framework will be very suitable. This study thus proposes an MADM based integrated framework for systemic innovation policy portfolio modeling and policy roadmapping definition.

2.7 Research gaps

In summary, several research gaps can be identified. First of all, prior literature verified the feasibility of TIS framework in various settings [9, 16, 34, 44, 45, 97]. Nevertheless, the causality among TIS functions (systemic factors) seemed to be seldom illustrated. The causal relationships of systemic factors in the real world are always dependent. Hence, there is gap can be solved by deriving the causal analysis between systemic factors influencing industrial sustainability. Meanwhile, policy suggestions can either be presented. On the other hand, performance evaluations in systemic innovation problems were rare [9, 16, 34, 97]. Past TIS literature focused on innovation performance and systemic problems analysis based on systemic functions. However, how to improve the innovation performance and systemic problems based on systemic functions has been little addressed. From the systemic improvement, an understanding of the performance-gaps between the ideal goal and the current systemic problem is essential. Thus, this research provides an analytical method for performance-gap assessment for this research gap. Additionally, policy recommendations and enhancement directions for systemic innovation problems can also be presented. Conventional systemic innovation policy analyses would largely use the literature in policy events as basis for policy formulation. However, the literature regarding policy evaluation was still rare, especially regarding the systemic innovation policy evaluation versus systemic innovation problems. In this view, it is necessary to explore the relations between systemic innovation problems and innovation policy portfolios and thus, design the policy roadmap in different systemic problems.

Second of all, analytical model and processes helping promote the industrial sustainability relied on TIS framework and systemic innovation policy tools were scarce [10, 16, 34, 44, 97]. The evaluation models for enhancing systemic problems impacting industrial sustainability were also rare [8, 9, 16, 98]. For filling research gaps, the authors provide a TIS based systemic performance evaluation method for dealing with systemic problem improvement. Previous innovation policy studies were often conducted using several steps, consisting of the analysis of technological innovation system functions, systemic innovation problems identification, and systemic innovation policies derivations [9]. Nevertheless, based on prior policy analyses, policy definitions or policy portfolios formulation may neglect the dynamic development among various policies. On the basis of previous innovation policy studies, if dynamic perspective of policy priority can be incorporated in the analyses, then policy makers will have more sufficient information for helping policy planning. Therefore, this research will formulate the dynamic roadmaps of innovation policies based on each derived systemic innovation policy portfolio. Specifically, the proposed analytical framework will be used to systemically analyze and define related innovation policy portfolio and policy roadmap for help IoT industrial sustainability.

Third of all, past studies of systemic innovation policy often adopted qualitative method. Although such approach is effective, conventional qualitative ways could be subjective and misleading. To solve this problem, quantitative methods based analytical process can be the option for dealing with research gap. Additionally, to avoid and eliminate the vagueness and imprecision problems in human judgments, this research adopts Bayesian and Rough theories to deal with linguistic variable transformation and vague number interval definition. The proposed novel hybrid MADM based integrated model can also be a foundation contributing to advanced method development in systemic innovation policy analyses and MADM fields.

Eventually, empirical studies of the systemic innovation to IoT industries are still rare in recent years. Under the digitalization, most fast growing-up economies, such as Taiwan and South Korea, artificial intelligence and IoT applications that can push industrial digitalization is urgent. In this sense, analyzing the factors affecting industrial sustainability of smart manufacturing will be beneficial and will also cross the research gap. In addition, deriving systemic innovation policy portfolios and roadmapping for existing systemic problems impacting industrial sustainability of IoT in manufacturing industries is critical. Consequently, the proposed integrating model not only can arrange the different policy portfolio by focusing on different systemic innovation problems, but also such model can formulate systemic innovation policy roadmapping. The analytical results will be useful for improving the industrial sustainability in IoT based manufacturing industries.

Chpater 3 Systemic innovation policy

In advanced countries like Germany and Japan, national governments have enabled the IoT applications and development in manufacturing industries by using a set of policy instruments. The policy makers of these governments urge domestic manufacturing firms to acquire the benefits from IoT development and further enhance industrial competitiveness and stimulate economic growth of nations. For fast catching-up countries like Taiwan and South Korea, the government sectors, have also expected to follow up this trend to strengthen their competitiveness in manufacturing industries.

Taiwan has been a great manufacturing country in many productions of products, such as whole supply chain of semiconductor industry, computer products and related manufacturing equipment. In recent, IoT techniques and applications have been influenced industrial development and transformation. Thus developing IoT based applications and how to push IoT sustainable development in terms of perspective of governments need to be taken carefully into consideration. Taiwanese government aggressively implemented some supportive policies to help development of IoT. Despite the huge efforts in IoT development, the diffusions and adoptions of IoT innovations and applications are comparatively lower than leading countries. Consequently, it is necessary for government sectors to adopt appropriate policies to overcome the barriers hampering current IoT development in Taiwan. In accordance with past research [9, 14, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 78, 98], performance evaluation has been proposed to solve problem improvement. Such means can be used with policy analysis for policy definition and systemic problem enhancement.

Based on previous studies on innovation policy fields, systemic innovation policy analyses have been extensively adopted [9, 14, 47, 48, 49, 50, 78, 98]. Therefore, related systemic innovation theories and empirical cases as the basis are pretty suitable for this research to deal with barriers of IoT sustainable development. In order to solve these problems, this research collected related innovation policies and made properly modification for perfect fitting the situation of IoT sustainable development. In the following, innovation policies will be presented and illustrated.

(1) *Develop technical standards*. Technical standards in IoT are extremely important. In recent, smart factory has gradually become essential for high-tech and technological intense products. Nevertheless, various immature technical standards such as communication of object through internet still confuse firms. This is because there is no apparently certain standard can replace and become a unique one. Therefore, in order to facilitate the development of IoT and define the useful technical standards, government needs to push the cooperation between research institutes, universities and industries.

(2) *Technology transfer and introduction*. Technology transfer has been an effective way for firms to enhance fast their competitive advantages without placing huge developing costs. Thus, government sectors should properly subsidy companies who will have sufficient leverages to transfer new technologies to enhance firms' competitive advantage. In the meantime, government can encourage firms to adopt technology transfer project with cost subsidy from technological research institute.

(3) *Revise the regulations and policies*. For developing IoT sustainability, rules and regulations need to be further relaxed. For example, once machines, in the factory, linked to the internet, information safety and privacy issues have to be emphasized. If government sectors have not set up corresponding measures for such situations, IoT development will suffer from obstacles and cannot move on. Consequently, appropriately revising regulations will be essential.

(4) *Infrastructure development for IoT*. In IoT development, infrastructure establishment and provision by government is necessary. The sufficient resources and infrastructures will be favorable for firms who will further leverage these resources to develop IoT based applications and integrate IoT technologies with their firms. Therefore, infrastructure establishment related policies should be adopted for government sectors.

(5) *Policies to support interdisciplinary collaboration*. This measure has been extensively utilized by various countries in a variety of industrial domains, especially in manufacturing industries and high-tech industries. For instance, for IoT industries, sustainable development is an achievable goal for countries and firms. However, only the introduction of IoT into the firms do not represent the firms have completed the transformation of IoT. The comprehensive structure of IoT introduction and sustainable development has to involve with data analytics and timely detection. Hence, government can motivate the collaboration between different industrial fields and technologies by using policy support.

(6) *Direct support to firm R&D and innovation*. The adoption of direct policies for the facilitation of R&D and innovation probably has been available means by policy makers. Recently, there have been a number of shifts based on the objectives of support schemes reflecting more and more complicated in the goals of innovation support. Likewise, direct support to firms has either become more elaborate with increase in certain goals in an effort to enhance capability or to look for specific solutions. In supporting the development of IoT, direct support can be a way that can stimulate the technological innovations.

(7) *Support experiments with novel applications*. With the increase development of IoT, related IoT applications and technologies have been launched. However, there are still many applications needs to further be invented and developed for specific industries and firms. Under such situation, government sectors should support experiments of IoT by providing resources such as subsidies and public supportive measures.

(8) *Technology resources integration*. Facilitating IoT innovation and sustainable development requires the resources allocation appropriately. Besides, resources integration is also important for IoT sustainability. Thus, government sectors need to place more efforts in pushing technology resources integration to help industrial development and technological innovations.

(9) *Provide professional training programs*. Professionals and talented people are always essential for industrial development and technological innovation. Facing the IoT and AI

generation, government and public research institutes should hold various training program and related seminars for people who are interested in this area. In addition, the advanced programs, including appealing professionals from abroad and providing talented students the chances to learn in foreign research labs and companies, should also be provided in order to train and cultivate high-talented people.

(10) *Technology support and assistance*. Besides to technology resource integration, government should also increase R&D expenses on IoT based projects and encourage more R&D in public sectors and industries. Therefore, government sectors can allocate and arrange different resources to help IoT development and technological innovations.

(11) *Support advocacy coalition*. Due to the fast development in IoT, many coalition and organization emerges who have strong knowledge and experience can push industrial development and provide meaningful suggestions for government sectors. In this sense, government sectors need carefully to listen, learn and exchange opinions with them. Thus, adopting support advocacy coalition measure will be necessary.

(12) *Overseas agents*. Collecting useful information of IoT industrial development and dynamic situations in IoT innovations is indispensable for domestic economic growth. For example, government should set up the overseas organization and overseas agents who can find out potential investment opportunities and collect useful industrial information for home country.

(13) *Timely procurements*. Procurement measure has been one of effective policies to assist industrial development. In order to accelerate IoT development, purchasing related equipment and devices by government sectors and can further offer these devices for firms to use will be beneficial for IoT innovation and development.

(14) *Provide demonstration fields*. IoT applications, such as automobile and larger devices applications, often need wide-and-large place and well-technological environment where firms can use these places to test and examine their products and experiments. For

government, open and provide such places and environment will be necessary.

Above-mentioned policies will be used in this research for policy portfolio definition and policy roadmapping. First, theses collected policies will be filtered by Modified Delphi method. Then, the investigation will be conducted in order to obtain the pairs comparison values between systemic innovation problems (the barriers influencing IoT sustainability) and innovation policies. The collected comparison values will be calculated for generating the policy portfolios which can solve systemic innovation problems. In the meantime, the policy roadmaps will also be depicted from each of policy portfolios. Such policy roadmaps can further illustrate the priority of policy implementation.

Chpater 4 Research methods

Industrial and technological development is involved with many features impacting the evaluation in terms of experts. This paper attempts to provide a newly hybrid MADM model integrating interval rough number, VIKOR, Bayesian theory, DEMATEL, DNP, GRA, and CSE. This research proposed a novel model. Such model is the first one being proposed for empirical case. The major differences of this model and other models are human judgment problem. This research combined the Rough set theory and Bayesian theory simultaneously to deal with imprecision from human judgment (such as linguistic transformation). Besides, this research also adopted CSE method to derive the policy roadmaps, such application can be the foundation for future analyses. The operation process of the proposed model can be classified into three parts. The first part is to focus on exploring the systemic factors influencing IoT industrial sustainability. In the second part, the performance evaluation of systemic innovation problems will be conducted. The eventual part concentrates on formulating the policy portfolios and policy roadmap within the systemic innovation problems.

4.1 The illustration of research methods

The objectives of this research can be split into three folds. In the first part, this research aims to explore and understand what kind of factors will influence IoT sustainable development in Taiwan. In the second part, this research attempted to find out which barriers, here these barriers namely systemic innovation problems, are hampering IoT sustainable development. Meanwhile, this paper will also explore how improve gaps between systemic innovation problems and ideal goals. This step can further understand the performances among systemic innovation problems. In the final part, this research had the attempts to establish the policy portfolios for each of systemic innovation problems, and thereby depict the policy roadmaps in each of policy portfolios.

In order to realize above objectives and issues, this research proposed a comprehensive framework which combined various method. These methods have their own characteristics that can be used to solve proposed objectives and issues. In the first topic, this research aimed to explore the factors influencing IoT sustainable development. In this sense, feature selection method and causal relationship network will be suitable for this issue. Feature selection method can filter feasible variables for later analysis. That is, least important feature will be removed from this research. Only the important features are able to be utilized in this research. To explore the causal relationships among these selected features, this paper used DEMATEL method to explain the relationships between features. By doing so, policy makers can easily understand which factor directly influences others and which one can also be influenced.

In the second topic, this paper aimed to explore the gaps between systemic innovation problems and ideal goals. This means policy makers can understand the performances of all of systemic innovation problems. In order to complete this objective, VIKOR method is pretty appropriate for this issue. The reason is that the VIKOR method has been extensively applied for evaluating alternatives (projects/strategies/options), the generalization and feasibility has also been verified. Thus, VIKOR method was used for obtaining the gap values. Based on the gap values, we can further understand the improving priority in systemic innovation problems.

In the final topic, in addition to exploration of how to improve systemic innovation problems, this research also aimed to define the policy portfolios and policy roadmaps to help improve the systemic innovation problems. Policy portfolios and policy roadmaps can be conducted by GRA and RSE methods. GRA is a well-known approach that can be used to discover the performances between alternatives and determine the possible alternative combinations. CSE method is based on the minimum generating tree algorithm and integer programming that can be utilized to derive the paths in terms of different variables. Comparing to Markov chain method, the outlook of derived path by CSE method like a tree, while Markov chain method merely develops the paths in one direction. More specifically, the derived paths by CSE can be a multi-way style. Consequently, GRA method can effectively derive the policy portfolios. Moreover, RSE method can further illustrate the policy roadmaps based on policy portfolios.

In short, the proposed methods in this research aim to deal with presented issues. Thus, these methods have their own uniqueness and representatives. In many research fields, these methods are either leveraged to tackle with different problems. Therefore, the proposed methods are rational and proper for this research. Also, this research also modified these conventional methods by incorporating Rough and Bayesian theories to deal with linguistic transformation problems in order to obtain precisely evaluation values. The comprehensive analytical procedure will be presented in Figure 1.

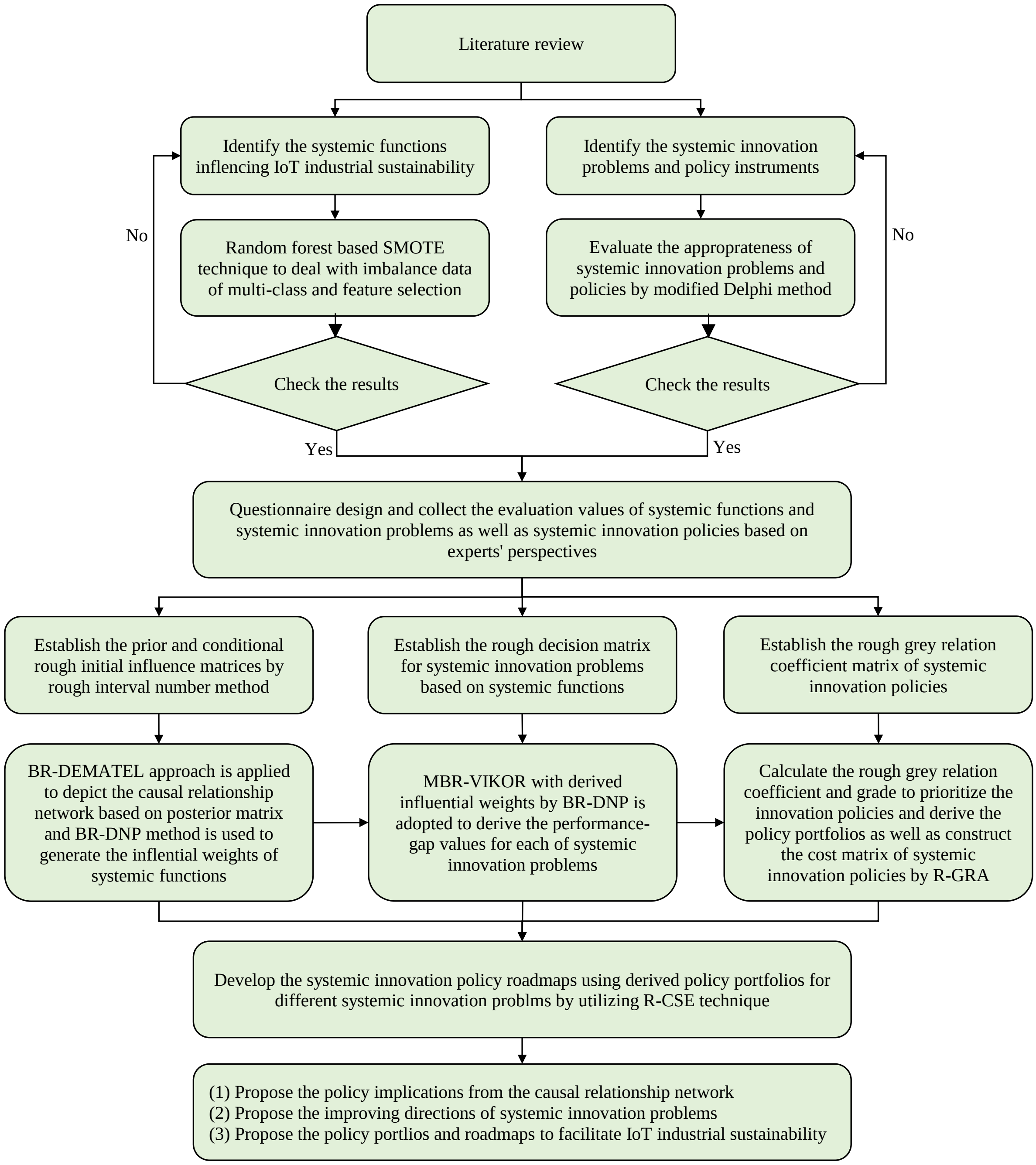


Figure 1 Analytical procedure of the proposed novel hybrid MADM based integrated framework.

4.2 Synthetic Minority Oversampling Technique (SMOTE)

SMOTE, proposed by Chawla, Bowyer [99], is kind of over-sampling method which often being utilized to solve class (or category) imbalance issues among raw data. The core aim of SMOTE is to focus on adopting random replication way for the minor categories among raw data [100]. In the meantime, adding these generated minor categories' samples in original raw data so that the samples from each category among raw data can reach balance.

4.3 Random Forest (RF)

RF is a machine learning method for dealing with various issues of predictions, and classification [101]. The RF operation process is shown in Figure 2.

The construction of such method relies on the best split within all of predictor features at every single node when generating an unpruned/un-cutting tree for all of bootstrap samples. RF is a non-parametric algorithm representing the values of variables without the limitation of any statistical distribution. In addition, such approach can avoid model-overfitting and possesses the strength based on computation speed in the relatively larger data sets [102].

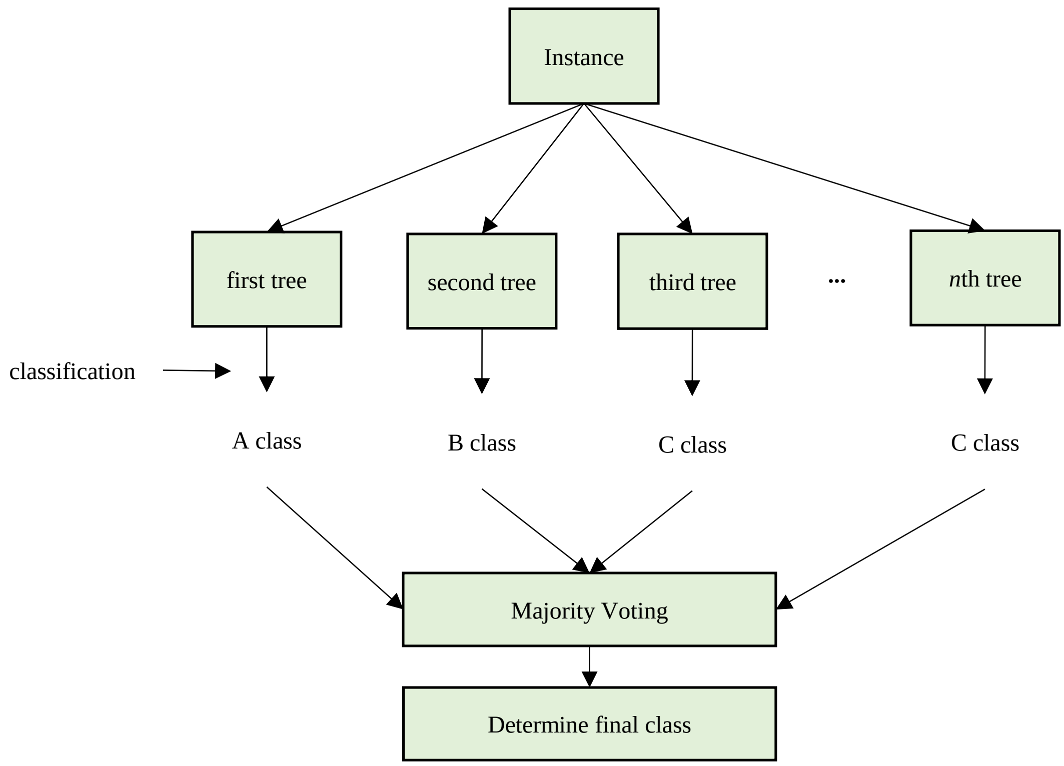


Figure 2 RF operation process.

Note: this is a process showing the method of random forest how to generate the classification result.

4.4 Modified Delphi method

The aim of modified Delphi method, comparing to original Delphi-based methods, focusing on simplifying the investigation processes in terms of collected responses of survey [103]. Specifically, modified version can accelerate whole data collection and analytical processes and can further converge collective opinions consensus more even quickly [104]. Conventional Delphi has been an effective method in different research fields. However, the procedure of original Delphi analysis always takes much time and at least two rounds for obtaining opinion consensus. Instead of original Delphi, this paper takes the Delphi as a foundation and further adjusts the original version to modified Delphi in which flexible round process for collecting opinions consensus can be achieved.

The operation of modified Delphi is presented as below: (1) confirm the experts for certain survey and send the survey invitation for these confirmed experts; (2) experts are ask to complete the first round survey; (3) after first round, if the opinions consensus from survey result is achieved, the survey round will be stopped. Otherwise, the second round survey is conducted; (4) constantly conduct the survey until the collective opinions consensus is stable. Once the consensus being achieved, the survey process can be finished [105]. Generally, once the consensus threshold in every round can over 80% on a certain problem or factor, the survey result is convergent. The Modified Delphi analysis has obtained huge successes in a broad variety of empirical studies [103-106].

4.5 Bayesian Rough Decision Making Trial and Evaluation Laboratory (BR-DEMATEL)

To analyze the causal relationship among systemic factors, the appropriate method is essential. Considering the advantages and disadvantages in experts' evaluation, this paper introduces the Bayesian theory and rough interval number skill to decrease the risk in linguistic transformation in evaluation. Besides, DEMATEL is an approach which can depict the causal relationships among variables. Based on mixed Bayesian and rough concept, the DEMATEL method can illustrate the causality between factors more accurately. The hybrid method termed BR-DEMATEL. Referring to the past research [23, 89, 107-109], the detailed calculation process of BR-DEMATEL being introduced as follow:

Step 1: Construct the initial group direct matrix, $\boldsymbol{M}^{\alpha}$, which contains the direct influences provided by experts.

For the construction of $\boldsymbol{M}^{\alpha}$ matrices, including the prior matrix of $\boldsymbol{M}^{p}$ (previous information in technology development) and the conditional matrix of $\boldsymbol{M}^{c}$ (current information in technology development), q experts are first asked to identify the level of influence from function *i* to function *j*, as indicated by m_{ij}^{α}, where:

$$m_{ij}^{\alpha} = [m_{ij}^{\alpha_1}, \cdots, m_{ij}^{\alpha_k}, \cdots, m_{ij}^{\alpha_q}] \tag{1}$$

using an integer scale from 0 to 4 (0—no influence, 1—low influence, 2—medium influence, 3—high influence, and 4—very high influence). Then, the non-negative $n \times n$ matrix, $\boldsymbol{DM}_{\boldsymbol{k}}^{\sigma}$, based on the opinions provided by the kth expert's evaluation is constructed, as illustrated below:

$$\boldsymbol{DM}_{k}^{\sigma} = \begin{bmatrix} 0 & m_{12}^{\sigma_k} & \cdots & m_{1n}^{\sigma_k} \\ m_{21}^{\sigma_k} & 0 & \cdots & m_{2n}^{\sigma_k} \\ \vdots & \vdots & 0 & \vdots \\ m_{n1}^{\sigma_k} & m_{n2}^{\sigma_k} & \cdots & 0 \end{bmatrix}, \ k = 1, \cdots, q; \ \sigma = p, c. \tag{2}$$

Here, $\boldsymbol{DM}_{\boldsymbol{k}}^{\sigma}$ represents kth opinions provided by *m* experts; p and c indicate the prior and condition matrix, respectively. Thus, the group initial direct matrix of $\boldsymbol{A}^{\sigma}$ can be defined as:

$$\boldsymbol{A}^{\sigma} = \begin{bmatrix} \{0,0,\cdots 0\} & \{a_{12}^{\sigma_1}, a_{12}^{\sigma_2}, \cdots a_{12}^{\sigma_q}\} & \cdots & \{a_{1n}^{\sigma_1}, a_{1n}^{\sigma_2}, \cdots a_{1n}^{\sigma_q}\} \\ \{a_{21}^{\sigma_1}, a_{21}^{\sigma_2}, \cdots a_{21}^{\sigma_q}\} & \{0,0,\cdots 0\} & \cdots & \{a_{2n}^{\sigma_1}, a_{2n}^{\sigma_2}, \cdots a_{2n}^{\sigma_q}\} \\ \vdots & \vdots & \{0,0,\cdots 0\} & \cdots \\ \{a_{n1}^{\sigma_1}, a_{n1}^{\sigma_2}, \cdots a_{n1}^{\sigma_q}\} & \{a_{n2}^{\sigma_1}, a_{n2}^{\sigma_2}, \cdots a_{n2}^{\sigma_q}\} & \cdots & \{0,0,\cdots 0\} \end{bmatrix}, \sigma = p, c., \tag{3}$$

Step 2: Determination of the rough group direct-influence matrix, $\tilde{\boldsymbol{Z}}^{\sigma}$.

Assume that $J^{\alpha}=[a_{ij}^{\sigma_1},a_{ij}^{\sigma_2},\cdots,a_{ij}^{\sigma_m}]$ is a vector consisting of the opinions provided by the experts (see $\boldsymbol{A}^{\sigma}$ matrix), where the opinions are ordered as $a_{ij}^{\alpha_1}<a_{ij}^{\alpha_2}<\cdots<a_{ij}^{\alpha_m}$. U is the universe that includes all the objects and P is an arbitrary object that is a subset of U. The lower approximation of $a_{ij}^{\sigma_k}{}_{(l)}$ and the upper approximation of $a_{ij}^{\sigma_k}{}_{(u)}$ can be defined as follows:

Lower approximation: $\underline{\text{Apr}}(a_{ij}^{\sigma_k}{}_{(l)})=\left\{P\in U\middle| J(P)\le r_{ij}^{\sigma_k}\right\}$ (4)

Upper approximation: $\overline{\text{Apr}}(a_{ij}^{\sigma_k}{}_{(u)})=\left\{P\in U\middle| J(P)\ge r_{ij}^{\sigma_k}\right\}$ (5)

Next, both the lower approximation, $a_{ij}^{\sigma_k}{}_{(l)}$, and the upper approximation, $a_{ij}^{\sigma_k}{}_{(u)}$, are defined by using the lower and upper limits, which is defined as follows:

Lower limits: $\underline{\text{Lim}}(a_{ij}^{\sigma_k}{}_{(l)})=\dfrac{1}{n_{ij\,(l)}^{\sigma}}\sum_{m=1}^{n_{ij(l)}}\eta_{ij}^{\sigma}$ (6)

Upper limits: $\overline{\text{Lim}}(a_{ij}^{\sigma_k}{}_{(u)})=\dfrac{1}{n_{ij\,(u)}^{\sigma}}\sum_{m=1}^{n_{ij(u)}}\mu_{ij}^{\sigma}$ (7)

When $\alpha=p$, the approximation matrix is considered as the prior matrix, $\boldsymbol{M}^{p}$. When $\alpha=c$, the approximation matrix is considered as the conditional matrix, $\boldsymbol{M}^{c}$. η_{ij}^{α} is the lower approximation for $a_{ij}^{\sigma_k}{}_{(l)}$ and y_{ij}^{α} is the upper approximation for $a_{ij}^{\sigma_k}{}_{(u)}$. $n_{ij\,(l)}^{\sigma}$ and $n_{ij\,(u)}^{\sigma}$ represent the number of objects included in the lower approximation, $a_{ij}^{\sigma_k}{}_{(l)}$, and upper approximation, $a_{ij}^{\sigma_k}{}_{(u)}$, respectively.

Subsequently, all collected expert opinions are filled into the $\boldsymbol{DM}_{k}^{\alpha}$ matrices. Each of the matrices is transformed into a rough interval number using Equations (4) to (7), as follows:

$RN(a_{ij}^{\sigma_k})=[\underline{\text{Lim}}(a_{ij}^{\sigma_k}{}_{(l)}),\overline{\text{Lim}}(a_{ij}^{\sigma_k}{}_{(u)})]=[a_{ij}^{\sigma_{kL}}{}_{(l)},a_{ij}^{\sigma_{kU}}{}_{(u)}]$ (8)

where the lower and upper limits are represented as $a_{ij}^{\sigma_{kL}}{}_{(l)}$ and $a_{ij}^{\sigma_{kU}}{}_{(u)}$, respectively, in

$RN(a_{ij}^{\sigma_k})$. Moreover, these two limits depict the level of vagueness. The prior and conditional rough sequences, $RN(\tilde{a}_{ij}^{p})$ and $RN(\tilde{a}_{ij}^{c})$, are derived as follows:

$$RN(\tilde{a}_{ij}^{p}) = \{[a_{ij}^{p_1}{}_{(l)}, a_{ij}^{p_1}{}_{(u)}], [a_{ij}^{p_2}{}_{(l)}, a_{ij}^{p_2}{}_{(u)}], \cdots, [a_{ij}^{p_q}{}_{(l)}, a_{ij}^{p_q}{}_{(u)}] \tag{9}$$

$$RN(\tilde{a}_{ij}^{c}) = \{[a_{ij}^{c_1}{}_{(l)}, a_{ij}^{c_1}{}_{(u)}], [a_{ij}^{c_2}{}_{(l)}, a_{ij}^{c_2}{}_{(u)}], \cdots, [a_{ij}^{c_q}{}_{(l)}, a_{ij}^{c_q}{}_{(u)}] \tag{10}$$

The mean rough interval numbers of the prior and conditional rough sequences are defined as $\overline{RN(\tilde{a}_{ij}^{p})}$ and $\overline{RN(\tilde{a}_{ij}^{c})}$, respectively. The two means are generated using the rough derivation equations defined in Equations (11) to (16), as follows:

$$\overline{RN(\tilde{a}_{ij}^{p})} = [a_{ij(l)}^{p}, a_{ij(u)}^{p}], \tag{11}$$

where:

$$a_{ij(l)}^{p} = \left(\sum_{k=1}^{m} a_{ij(l)}^{p_k} \right) \Big/ m \tag{12}$$

$$a_{ij(u)}^{p} = \left(\sum_{k=1}^{m} a_{ij(u)}^{p_k} \right) \Big/ m \tag{13}$$

$$\overline{RN(\tilde{a}_{ij}^{c})} = [a_{ij(l)}^{c}, a_{ij(u)}^{c}], \tag{14}$$

where:

$$a_{ij(l)}^{c} = \left(\sum_{k=1}^{m} a_{ij(l)}^{c_k} \right) \Big/ m \tag{15}$$

$$a_{ij(u)}^{c} = \left(\sum_{k=1}^{m} a_{ij(u)}^{c_k} \right) \Big/ m \tag{16}$$

The rough interval number $[a_{ij(l)}^{p}, a_{ij(u)}^{p}]$ represents the prior situation, where $a_{ij(l)}^{p}$ and $a_{ij(u)}^{p}$ represent the lower and upper limits of the sequence, respectively. In the conditional situation of $[a_{ij(l)}^{c}, a_{ij(u)}^{c}]$, $a_{ij(l)}^{c}$ and $a_{ij(u)}^{c}$ represent the lower and upper limits of the rough interval number $\overline{RN(\tilde{a}_{ij}^{c})} = [a_{ij(l)}^{c}, a_{ij(u)}^{c}]$. Based on the above calculations, the prior and conditional rough group direct influence matrices, $\tilde{\boldsymbol{Z}}^{p}$ and $\tilde{\boldsymbol{Z}}^{c}$, are defined as follows:

$$\tilde{\boldsymbol{Z}}^{p} = \left[\overline{RN(\tilde{a}_{ij}^{p})}\right]_{n\times n} = \begin{bmatrix} [0,0] & [a_{12(l)}^{p}, a_{12(u)}^{p}] & \cdots & [a_{1n(l)}^{p}, a_{1n(u)}^{p}] \\ [a_{21(l)}^{p}, a_{21(u)}^{p}] & [0,0] & \cdots & [a_{2n(l)}^{p}, a_{2n(u)}^{p}] \\ \vdots & \vdots & \ddots & \vdots \\ [a_{n1(l)}^{p}, a_{n1(u)}^{p}] & [a_{n2(l)}^{p}, a_{n2(u)}^{p}] & \cdots & [0,0] \end{bmatrix} \quad (17)$$

$$\tilde{\boldsymbol{Z}}^{c} = \left[\overline{RN(\tilde{a}_{ij}^{c})}\right]_{n\times n} = \begin{bmatrix} [0,0] & [a_{12(l)}^{c}, a_{12(u)}^{c}] & \cdots & [a_{1n(l)}^{c}, a_{1n(u)}^{c}] \\ [a_{21(l)}^{c}, a_{21(u)}^{c}] & [0,0] & \cdots & [a_{2n(l)}^{c}, a_{2n(u)}^{c}] \\ \vdots & \vdots & \ddots & \vdots \\ [a_{n1(l)}^{c}, a_{n1(u)}^{c}] & [a_{n2(l)}^{c}, a_{n2(u)}^{c}] & \cdots & [0,0] \end{bmatrix} \quad (18)$$

Step 3: Calculation of the normalized $\tilde{\boldsymbol{D}}^{\sigma}$ matrix.

Matrix $\tilde{\boldsymbol{D}}^{\sigma}$ is derived from the normalized group direct influence matrix, $\tilde{\boldsymbol{Z}}^{\alpha}$. During the calculation of matrix $\tilde{\boldsymbol{D}}^{\sigma}$, each element in matrix $\tilde{\boldsymbol{D}}^{\sigma}$ is designated a value between zero and one. The $\tilde{\boldsymbol{D}}^{\sigma}$ matrix, including $\tilde{\boldsymbol{D}}^{p}$ and $\tilde{\boldsymbol{D}}^{c}$, is acquired when each element, $\overline{RN(\tilde{a}_{ij}^{\sigma})}$, of matrix $\tilde{\boldsymbol{Z}}^{\alpha}$ is divided by the maximum value of every rough interval number, as illustrated in Equations (19) to (22):

$$\tilde{\boldsymbol{D}}^{p} = \left[\overline{RN(\tilde{d}_{ij}^{p})}\right]_{n\times n} = \begin{bmatrix} [0,0] & [d_{12(l)}^{p}, d_{12(u)}^{p}] & \cdots & [d_{1n(l)}^{p}, d_{1n(u)}^{p}] \\ [d_{21(l)}^{p}, d_{21(u)}^{p}] & [0,0] & \cdots & [d_{2n(l)}^{p}, d_{2n(u)}^{p}] \\ \vdots & \vdots & \ddots & \vdots \\ [d_{n1(l)}^{p}, d_{n1(u)}^{p}] & [d_{n2(l)}^{p}, d_{n2(u)}^{p}] & \cdots & [0,0] \end{bmatrix} \quad (19)$$

$$\tilde{\boldsymbol{D}}^{c} = \left[\overline{RN(\tilde{d}_{ij}^{c})}\right]_{n\times n} = \begin{bmatrix} [0,0] & [d_{12(l)}^{c}, d_{12(u)}^{c}] & \cdots & [d_{1n(l)}^{c}, d_{1n(u)}^{c}] \\ [d_{21(l)}^{c}, d_{21(u)}^{c}] & [0,0] & \cdots & [d_{2n(l)}^{c}, d_{2n(u)}^{c}] \\ \vdots & \vdots & \ddots & \vdots \\ [d_{n1(l)}^{c}, d_{n1(u)}^{c}] & [d_{n2(l)}^{c}, d_{n2(u)}^{c}] & \cdots & [0,0] \end{bmatrix}, \quad (20)$$

where $\overline{RN(\tilde{d}_{ij}^{p})}$ and $\overline{RN(\tilde{d}_{ij}^{c})}$ are calculated based on the following equations:

$$\overline{RN(\tilde{d}_{ij}^{p})} = \left(\overline{RN(\tilde{a}_{ij}^{p})}\right) \Big/ k^{(p)}, \text{ where } k^{(p)} = \max_{1 \le i \le n}\left(\sum_{j=1}^{n} a_{ij(u)}^{p}\right) \tag{21}$$

$$\overline{RN(\tilde{d}_{ij}^{c})} = \left(\overline{RN(\tilde{a}_{ij}^{c})}\right) \Big/ k^{(c)}, \text{ where } k^{(c)} = \max_{1 \le i \le n}\left(\sum_{j=1}^{n} a_{ij(l)}^{c}\right) \tag{22}$$

Step 4: Establishing the total influence matrix $\tilde{\boldsymbol{T}}$

Based on equation (23), the total influence matrix $\tilde{\boldsymbol{T}}^{\sigma}$, consisting of $\boldsymbol{T}_{(l)}^{p}, \boldsymbol{T}_{(u)}^{p}, \boldsymbol{T}_{(l)}^{c}$, and $\boldsymbol{T}_{(u)}^{c}$, can be derived, where I denotes the identity matrix of the $n \times n$ rank. The total influence matrix based on the prior situation can be denoted as $\tilde{\boldsymbol{T}}^{p} = \left[\boldsymbol{T}_{(l)}^{p}, \boldsymbol{T}_{(u)}^{p}\right]$. Similarly, using the condition situation, the total influence matrix is depicted as $\tilde{\boldsymbol{T}}^{c} = \left[\boldsymbol{T}_{(l)}^{c}, \boldsymbol{T}_{(u)}^{c}\right]$.

$$\begin{aligned}
&\boldsymbol{T}_{(l)}^{p} = (\boldsymbol{D}_{(l)}^{p}) + (\boldsymbol{D}_{(l)}^{p})^{2} + \cdots + (\boldsymbol{D}_{(l)}^{p})^{\theta} = (\boldsymbol{D}_{(l)}^{p})(\boldsymbol{I} - \boldsymbol{D}_{(l)}^{p})^{-1}, \\
&\boldsymbol{T}_{(u)}^{p} = (\boldsymbol{D}_{(u)}^{p}) + (\boldsymbol{D}_{(u)}^{p})^{2} + \cdots + (\boldsymbol{D}_{(u)}^{p})^{\theta} = (\boldsymbol{D}_{(u)}^{p})(\boldsymbol{I} - \boldsymbol{D}_{(u)}^{p})^{-1}, \\
&\boldsymbol{T}_{(l)}^{c} = (\boldsymbol{D}_{(l)}^{c}) + (\boldsymbol{D}_{(l)}^{c})^{2} + \cdots + (\boldsymbol{D}_{(l)}^{c})^{\theta} = (\boldsymbol{D}_{(l)}^{c})(\boldsymbol{I} - \boldsymbol{D}_{(l)}^{c})^{-1}, \text{ and} \\
&\boldsymbol{T}_{(u)}^{c} = (\boldsymbol{D}_{(u)}^{c}) + (\boldsymbol{D}_{(u)}^{c})^{2} + \cdots + (\boldsymbol{D}_{(u)}^{c})^{\theta} = (\boldsymbol{D}_{(u)}^{c})(\boldsymbol{I} - \boldsymbol{D}_{(u)}^{c})^{-1}, \text{ when } \theta \to \infty.
\end{aligned} \tag{23}$$

$$\tilde{\boldsymbol{T}}^{p} = \left[\overline{RN(\tilde{t}_{ij}^{p})}\right]_{n \times n} = \begin{bmatrix} [0,0] & [t_{12(l)}^{p}, t_{12(u)}^{p}] & \cdots & [t_{1n(l)}^{p}, t_{1n(u)}^{p}] \\ [t_{21(l)}^{p}, t_{21(u)}^{p}] & [0,0] & \cdots & [t_{2n(l)}^{p}, t_{2n(u)}^{p}] \\ \vdots & \vdots & \ddots & \vdots \\ [t_{n1(l)}^{p}, t_{n1(u)}^{p}] & [t_{n2(l)}^{p}, t_{n2(u)}^{p}] & \cdots & [0,0] \end{bmatrix} \tag{24}$$

$$\tilde{\boldsymbol{T}}^{c} = \left[\overline{RN(\tilde{t}_{ij}^{c})}\right]_{n \times n} = \begin{bmatrix} [0,0] & [t_{12(l)}^{c}, t_{12(u)}^{c}] & \cdots & [t_{1n(l)}^{c}, t_{1n(u)}^{c}] \\ [t_{21(l)}^{c}, t_{21(u)}^{c}] & [0,0] & \cdots & [t_{2n(l)}^{c}, t_{2n(u)}^{c}] \\ \vdots & \vdots & \ddots & \vdots \\ [t_{n1(l)}^{c}, t_{n1(u)}^{c}] & [t_{n2(l)}^{c}, t_{n2(u)}^{c}] & \cdots & [0,0] \end{bmatrix} \tag{25}$$

After the calculation of the total influence matrix, the next step is to convert these matrices into the posterior matrix utilizing Equations (24) to (26). The posterior matrix is derived as shown below:

$$\tilde{\boldsymbol{T}} = \tilde{\beta} \times \boldsymbol{P}(\tilde{\boldsymbol{T}}^p | \tilde{\boldsymbol{T}}^c) = \tilde{\beta} \times \boldsymbol{P}(\tilde{\boldsymbol{T}}^p \cap \tilde{\boldsymbol{T}}^c) / \boldsymbol{P}(\tilde{\boldsymbol{T}}^c)$$
$$= \tilde{\beta} \times \left(\boldsymbol{P}(\tilde{\boldsymbol{T}}^c | \tilde{\boldsymbol{T}}^p) \boldsymbol{P}(\tilde{\boldsymbol{T}}^p) \right) \Big/ \sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{t}_{ij}^{c'} \times \tilde{t}_{ij}^{p'} , \tag{26}$$

where $\mathrm{P}(\tilde{T}^p) = \left[\tilde{t}^{p'}_{ij(l)}, \tilde{t}^{p'}_{ij(u)} \right]_{n \times n}$ and $\mathrm{P}(\tilde{T}^c) = \left[\tilde{t}^{c'}_{ij(l)}, \tilde{t}^{c'}_{ij(u)} \right]_{n \times n}$ represent the probability matrices that are being normalized from the total influence matrices, and $\tilde{\beta}$ is a parameter acquired through the sum of posterior probability matrices. $\tilde{\beta}$ is used for transforming the posterior probability matrices into the posterior total influence matrix. The posterior rough total influence matrix of $\tilde{\boldsymbol{T}}$ is shown below:

$$\tilde{\boldsymbol{T}} = \left[\overline{RN(\tilde{t}_{ij})} \right]_{n \times n} = \begin{bmatrix} [0,0] & [t_{12(l)}, t_{12(u)}] & \cdots & [t_{1n(l)}, t_{1n(u)}] \\ [t_{21(l)}, t_{21(u)}] & [0,0] & \cdots & [t_{2n(l)}, t_{2n(u)}] \\ \vdots & \vdots & \ddots & \vdots \\ [t_{n1(l)}, t_{n1(u)}] & [t_{n2(l)}, t_{n2(u)}] & \cdots & [0,0] \end{bmatrix} \tag{27}$$

To examine the reliability of the collected data, the inconsistency rate is calculated using Equation (28):

$$\text{Inconsistency ratio} = \frac{1}{n(n-1)} \sum_{i=1}^{n} \sum_{j=1}^{n} \left| \frac{t_{ij}^{n} - t_{ij}^{n-1}}{t_{ij}^{n}} \right| \times 100\%, \tag{28}$$

where $t_{ij} = (t_{ij(l)} + t_{ij(u)})/2,\ t_{ij}^{n}$ is the average influence of factor i on j. n denotes the number of samples. An inconsistency rate that is less than 5% represents the reliability of the collected samples.

Using equations (29)-(30), row sums and column sums are respectively defined as $\boldsymbol{h}_i = [h_{i(l)}, h_{i(u)}]$ ($h_{i(l)}$ and $h_{i(u)}$ are the lower limit and upper limit) and $\boldsymbol{v}_i = [v_{i(l)}, v_{i(u)}]$ ($v_{i(l)}$ and $v_{i(u)}$ are the lower limit and upper limit) within the posterior rough total influence matrix $\tilde{T}$.

$$\boldsymbol{h}_i = [h_{i(l)}, h_{i(u)}] = [\sum_{j=1}^{n} t_{ij(l)}, \sum_{j=1}^{n} t_{ij(u)}] \tag{29}$$

$$\boldsymbol{v}_j = [v_{j(l)}, v_{j(u)}] = [\sum_{i=1}^{n} t_{ij(l)}, \sum_{i=1}^{n} t_{ij(u)}] \tag{30}$$

Then, a de-roughness approach is used to convert the interval rough numbers into crisp values. By the method of Opricovic and Tzeng [1], vague numbers can be effectively transformed into crisp values. The de-roughness algorithm is described in the following several steps:

Normalization:

$$\tilde{h}_i^L = (h_i^L - \min_i h_i^L) \Big/ \Delta_{h_{\min}}^{h_{\max}} \tag{31}$$

$$\tilde{h}_i^U = (h_i^U - \min_i h_i^L) \Big/ \Delta_{h_{\min}}^{h_{\max}} \tag{32}$$

$$\tilde{v}_j^L = (v_j^L - \min_i v_j^L) \Big/ \Delta_{h_{\min}}^{h_{\max}} \tag{33}$$

$$\tilde{v}_j^U = (v_j^U - \min_i v_j^L) \Big/ \Delta_{h_{\min}}^{h_{\max}}, \tag{34}$$

where $\Delta_{h_{\min}}^{h_{\max}} = \max_i h_i^U - \max_i h_i^L$ and $\Delta_{v_{\min}}^{v_{\max}} = \max_i v_i^U - \max_i v_i^L$, $\tilde{h}_i^L, \tilde{h}_i^U, \tilde{v}_i^L, \tilde{v}_i^U$ are the normalized scores. After that, the total normalized crisp values and final crisp values can be computed by Equations (35) to (38), respectively:

$$hp_i = \frac{\tilde{h}_i^L \times (1 - \tilde{h}_i^L) + \tilde{h}_i^U \times \tilde{h}_i^U}{1 - \tilde{h}_i^L + \tilde{h}_i^U} \tag{35}$$

$$vp_j = \frac{\tilde{v}_i^L \times (1 - \tilde{v}_i^L) + \tilde{v}_i^U \times \tilde{v}_i^U}{1 - \tilde{v}_i^L + \tilde{v}_i^U} \tag{36}$$

$$r_i = \min_i h_i^L + hp_i \Delta_{h_{\min}}^{h_{\max}} \tag{37}$$

$$c_j = \min_j v_j^L + vp_j \Delta_{v_{\min}}^{v_{\max}} \tag{38}$$

where r_i and c_j are the final transformed crisp values and $i = j$.

When the value $(r_i - c_i)$ is positive, this factor is classified to the cause group where the factor, *i*, will affect other factors. Conversely, when the value $(r_i - c_i)$ is negative, the factor will be classified to the effect group, where factor *i* can be affected by other factors.

4.6 BR-DEMATEL based ANP (BR-DNP)

DEMATEL based ANP method (DNP) for the past few years has been demonstrated the effectiveness and robustness for deriving the weight of factors/criteria/variables [110-113]. This research attempts to extend BR-DEMATEL by incorporating ANP concept to obtain the factors' weight, such combination method termed BR-DNP. The calculation process based on prior BR-DEMATEL steps is depicted below:

Step 5: Computing the unweighted supermatrix $W = \left(\tilde{T}_C^{\alpha}\right)'$. Based on BR-DEMATEL method, the total influence matrix $\tilde{T}$ can be denoted as $\tilde{T}_C$ by assuming that there were p functions and n criteria in $\tilde{T}$, as indicated in Equation (39) where $\tilde{T}_C^{ij}$ as a $p_i \times p_j$ submatrix.

$$\tilde{T}_C = \begin{matrix} F_1 \\ \vdots \\ F_i \\ \vdots \\ F_p \end{matrix} \overset{\begin{matrix} F_1 & \cdots & F_i & \cdots & \cdots & F_p \end{matrix}}{\begin{bmatrix} \tilde{T}_C^{11} & \cdots & \tilde{T}_C^{1j} & \cdots & \tilde{T}_C^{1p} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_C^{i1} & \cdots & \tilde{T}_C^{ij} & \cdots & \tilde{T}_C^{ip} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_C^{p1} & \cdots & \tilde{T}_C^{pj} & \cdots & \tilde{T}_C^{pp} \end{bmatrix}} \tag{39}$$

Through the normalization principle, the normalized matrix $\tilde{T}_C^{\alpha}$ can be obtained, as denoted in Equation (40).

$$\tilde{T}_C^{\alpha} = \begin{matrix} F_1 \\ \vdots \\ F_i \\ \vdots \\ F_p \end{matrix} \overset{\begin{matrix} F_1 & \cdots & F_1 & \cdots & F_1 \end{matrix}}{\begin{bmatrix} \tilde{T}_C^{\alpha 11} & \cdots & \tilde{T}_C^{\alpha 1j} & \cdots & \tilde{T}_C^{\alpha 1p} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_C^{\alpha i1} & \cdots & \tilde{T}_C^{\alpha ij} & \cdots & \tilde{T}_C^{\alpha ip} \\ \vdots & & \vdots & & \vdots \\ \tilde{T}_C^{\alpha p1} & \cdots & \tilde{T}_C^{\alpha pj} & \cdots & \tilde{T}_C^{\alpha pp} \end{bmatrix}} \tag{40}$$

where the submatrix $\tilde{T}_C^{\alpha 11}$ can be acquired by using Equations (23) to (24); Likewise, all of other submatrices $\tilde{T}_C^{\alpha nn}$ can also be obtained.

$$
\tilde{T}_C^{11} =
\begin{array}{c}
 \\ c_{11} \\ \vdots \\ c_{1i} \\ \vdots \\ c_{1p_1}
\end{array}
\begin{array}{c}
\begin{array}{ccccc} c_{11} & \cdots & c_{1j} & \cdots & c_{1p_1} \end{array} \\
\left[\begin{array}{ccccc}
\tilde{t}_{C11}^{11} & \cdots & \tilde{t}_{C1j}^{11} & \cdots & \tilde{t}_{C1p_1}^{11} \\
\vdots & & \vdots & & \vdots \\
\tilde{t}_{Ci1}^{11} & \cdots & \tilde{t}_{Cij}^{11} & \cdots & \tilde{t}_{Cip_i}^{11} \\
\vdots & & \vdots & & \vdots \\
\tilde{t}_{Cp_11}^{11} & \cdots & \tilde{t}_{Cp_ij}^{11} & \cdots & \tilde{t}_{Cp_1p_1}^{11}
\end{array}\right]
\end{array}
\begin{array}{l}
 \\ \to \tilde{d}_1^{11} = \sum_{j=1}^{p_1} \tilde{t}_{C1j}^{11} \\ \qquad \vdots \\ \to \tilde{d}_i^{11} = \sum_{j=1}^{p_1} \tilde{t}_{Cij}^{11} \\ \qquad \vdots \\ \to \tilde{d}_{p_1}^{11} = \sum_{j=1}^{p_1} \tilde{t}_{Cp_ij}^{11}
\end{array}
\tag{41}
$$

where $d_i^{11} = \sum_{j=1}^{p_1} \tilde{t}_{Cij}^{11}, \quad i = 1, 2, \ldots, p_1$.

$$
\begin{aligned}
\tilde{T}_C^{11} &=
\begin{array}{c}
 \\ c_{11} \\ \vdots \\ c_{1i} \\ \vdots \\ c_{1p_1}
\end{array}
\begin{array}{c}
\begin{array}{ccccc} c_{11} & \cdots & c_{1j} & \cdots & c_{1p_1} \end{array} \\
\left[\begin{array}{ccccc}
\tilde{t}_{C11}^{11}/\tilde{d}_1^{11} & \cdots & \tilde{t}_{C1j}^{11}/\tilde{d}_1^{11} & \cdots & \tilde{t}_{C1p_1}^{11}/\tilde{d}_1^{11} \\
\vdots & & \vdots & & \vdots \\
\tilde{t}_{Ci1}^{11}/\tilde{d}_1^{11} & \cdots & \tilde{t}_{Cij}^{11}/\tilde{d}_1^{11} & \cdots & \tilde{t}_{Cip_i}^{11}/\tilde{d}_1^{11} \\
\vdots & & \vdots & & \vdots \\
\tilde{t}_{Cp_11}^{11}/\tilde{d}_1^{11} & \cdots & \tilde{t}_{Cp_ij}^{11}/\tilde{d}_1^{11} & \cdots & \tilde{t}_{Cp_1p_1}^{11}/\tilde{d}_1^{11}
\end{array}\right]
\end{array} \\
&=
\begin{array}{c}
 \\ c_{11} \\ \vdots \\ c_{1i} \\ \vdots \\ c_{1p_1}
\end{array}
\begin{array}{c}
\begin{array}{ccccc} c_{11} & \cdots & c_{1j} & \cdots & c_{1p_1} \end{array} \\
\left[\begin{array}{ccccc}
\tilde{t}_{C11}^{\alpha 11} & \cdots & \tilde{t}_{C1j}^{\alpha 11} & \cdots & \tilde{t}_{C1p_1}^{\alpha 11} \\
\vdots & & \vdots & & \vdots \\
\tilde{t}_{Ci1}^{\alpha 11} & \cdots & \tilde{t}_{Cij}^{\alpha 11} & \cdots & \tilde{t}_{Cip_i}^{\alpha 11} \\
\vdots & & \vdots & & \vdots \\
\tilde{t}_{Cp_11}^{\alpha 11} & \cdots & \tilde{t}_{Cp_ij}^{\alpha 11} & \cdots & \tilde{t}_{Cp_1p_1}^{\alpha 11}
\end{array}\right]
\end{array}
\end{aligned}
\tag{42}
$$

Then, the unweighted supermatrix $\tilde{W} = \left(\tilde{T}_C^{\alpha}\right)'$ can be obtained in terms of transpose form, as shown in Equation (43).

$$
\tilde{W} = \left(\tilde{T}_C^{\alpha}\right)' = \begin{array}{c} \\ F_1 \\ \vdots \\ F_j \\ \vdots \\ F_p \end{array} \begin{array}{c} \begin{array}{ccccc} F_1 & \cdots & F_j & \cdots & F_p \end{array} \\ \begin{bmatrix} \tilde{W}^{11} & \cdots & \tilde{W}^{i1} & \cdots & \tilde{W}^{p1} \\ \vdots & & \vdots & & \vdots \\ \tilde{W}^{1j} & \cdots & \tilde{W}^{ij} & \cdots & \tilde{W}^{pj} \\ \vdots & & \vdots & & \vdots \\ \tilde{W}^{1p} & \cdots & \tilde{W}^{ip} & \cdots & \tilde{W}^{pp} \end{bmatrix} \end{array} \tag{43}
$$

where submatrix $\tilde{W}^{11}$ denotes values of criteria influences using transpose principle within F_1 aspect.

Step 6: Computing the weighted supermatrix $\tilde{\boldsymbol{W}}^{\alpha} = \tilde{\boldsymbol{T}}_{\boldsymbol{D}}^{\alpha}\tilde{\boldsymbol{W}}$. The weighted supermatrix $\tilde{W}^{\alpha}$ can be gained by multiplying normalized total influence matrix $\tilde{\boldsymbol{T}}_{\boldsymbol{D}}^{\alpha}$ and unweighted supermatrix $\tilde{\boldsymbol{W}}$. The normalized total influence matrix $\tilde{\boldsymbol{T}}_{\boldsymbol{D}}^{\alpha}$ is stated in Equation (44).

$$
\tilde{\boldsymbol{T}}_{\boldsymbol{D}}^{\alpha} = \begin{array}{c} c_{11} \\ \vdots \\ c_{1i} \\ \vdots \\ c_{1p_1} \end{array} \begin{bmatrix} \tilde{t}_{11}^{D_{11}} \Big/ \sum_{j=1}^{p} \tilde{t}_{1j}^{D_{1j}} & \cdots & \tilde{t}_{C1j}^{11} \Big/ \sum_{j=1}^{p} \tilde{t}_{1j}^{D_{1j}} & \cdots & \tilde{t}_{C1p_1}^{11} \Big/ \sum_{j=1}^{p} \tilde{t}_{1j}^{D_{1j}} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_{i1}^{D_{i1}} \Big/ \sum_{j=1}^{p} \tilde{t}_{ij}^{D_{ij}} & \cdots & \tilde{t}_{Cij}^{11} \Big/ \sum_{j=1}^{p} \tilde{t}_{ij}^{D_{ij}} & \cdots & \tilde{t}_{Cip_i}^{11} \Big/ \sum_{j=1}^{p} \tilde{t}_{ij}^{D_{ij}} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_{p1}^{D_{p1}} \Big/ \sum_{j=1}^{p} \tilde{t}_{pj}^{D_{pj}} & \cdots & \tilde{t}_{Cp_ij}^{11} \Big/ \sum_{j=1}^{p} \tilde{t}_{pj}^{D_{pj}} & \cdots & \tilde{t}_{Cp_1p_1}^{11} \Big/ \sum_{j=1}^{p} \tilde{t}_{pj}^{D_{pj}} \end{bmatrix} = \begin{bmatrix} \tilde{t}_{11}^{\alpha_{11}} & \cdots & \tilde{t}_{i1}^{\alpha_{i1}} & \cdots & \tilde{t}_{p1}^{\alpha_{p1}} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_{1j}^{\alpha_{1j}} & \cdots & \tilde{t}_{ij}^{\alpha_{ij}} & \cdots & \tilde{t}_{pj}^{\alpha_{pj}} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_{1p}^{\alpha_{1p}} & \cdots & \tilde{t}_{ip}^{\alpha_{ip}} & \cdots & \tilde{t}_{pp}^{\alpha_{pp}} \end{bmatrix} \tag{44}
$$

Once the $\tilde{T}_D^{\alpha}$ matrix is derived, the weighted supermatrix $\tilde{W}^{\alpha}$ will be calculated, as indicated in Equation (45).

$$
\tilde{\boldsymbol{W}}^{\alpha} = \tilde{\boldsymbol{T}}_{\boldsymbol{D}}^{\alpha}\tilde{\boldsymbol{W}} = \begin{bmatrix} \tilde{t}_{11}^{\alpha_{11}}\tilde{\boldsymbol{W}}^{11} & \cdots & \tilde{t}_{i1}^{\alpha_{i1}}\tilde{\boldsymbol{W}}^{i1} & \cdots & \tilde{t}_{p1}^{\alpha_{p1}}\tilde{\boldsymbol{W}}^{p1} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_{1j}^{\alpha_{1j}}\tilde{\boldsymbol{W}}^{1j} & \cdots & \tilde{t}_{ij}^{\alpha_{ij}}\tilde{\boldsymbol{W}}^{ij} & \cdots & \tilde{t}_{pj}^{\alpha_{pj}}\tilde{\boldsymbol{W}}^{pj} \\ \vdots & & \vdots & & \vdots \\ \tilde{t}_{1p}^{\alpha_{1p}}\tilde{\boldsymbol{W}}^{1p} & \cdots & \tilde{t}_{ip}^{\alpha_{ip}}\tilde{\boldsymbol{W}}^{ip} & \cdots & \tilde{t}_{pp}^{\alpha_{pp}}\tilde{\boldsymbol{W}}^{pp} \end{bmatrix} \tag{45}
$$

Step 7: Calculating the influential crisp weights with the limiting process approach. The weighted supermatrix will be raised to limiting powers until convergence. It means that such matrix will become a long-term stable supermatrix where the global influence weights can be thereby derived, such as $\lim_{x\to\infty}\left(\tilde{W}^{\alpha}\right)^{x}$, $\tilde{W}^{\alpha}$ denotes limited supermatrix while x stands for the any number. The final crisp weights can be derived through arithmetic average method, such as $\tilde{W}^{\alpha}_{global} = (\tilde{W}^{\alpha}_{(l)} + \tilde{W}^{\alpha}_{(u)})/2$.

4.7 Modified Bayesian rough VIKOR (MBR-VIKOR)

In general, conventional VIKOR aims to evaluate the alternatives in multivariate condition with a measure of proximity to the ideal solution. The concept of relative good for evaluating MCDM problems may not effectively reflect the real-world situation. Thus, Opricovic and Tzeng [56] further proposed the extended VIKOR for replacing traditional one by using the concept of aspiration level. In this research, in order to explore the systemic innovation problems under vague circumstance, the rough interval numbers and Bayesian theory will simultaneously be introduced. The VIKOR method will be modified accordingly. The modified VIKOR will be named as Modified Bayesian Rough VIKOR (MBR-VIKOR). Besides, the weights being derived by the BR-DNP will also be introduced into the MBR-VIKOR approach for evaluating the systemic innovation problems. The computing process is illustrated as follows [56, 114-116]:

Step 8: Construct a rough decision matrix $\boldsymbol{VD}_R^{\alpha}$ and define an aggregation function for the compromise ranking. The rough decision matrix $\boldsymbol{VD}_R^{\alpha}$ is first established in by using the concept of Equations (1)–(5), where alternatives are denoted as $\overline{Al}_1, \overline{Al}_2, ..., \overline{Al}_k, ..., \overline{Al}_m$ and $\boldsymbol{VD}_R^{\alpha} = [\boldsymbol{VD}_1^{\alpha}, \boldsymbol{VD}_2^{\alpha}, ..., \boldsymbol{VD}_n^{\alpha}]$ represents the rough decision matrices derived by each of experts' opinions. The performance score of the *j*th criterion is denoted by $\tilde{g}^{\alpha}_{jk(l)} = \left[g^{\alpha}_{jk(l)}, g^{\alpha}_{jk(u)}\right]$ for the k_{th} alternative $\overline{Al}_k$. Here, the $\boldsymbol{VD}_R^{\alpha}$ comprises of the prior decision matrix $\boldsymbol{VD}_R^{\alpha}$ and the conditional decision matrix $\boldsymbol{VD}_R^{\alpha}$.

$$\boldsymbol{VD}_R^{\alpha} = \begin{array}{c} \\ \end{array}\begin{array}{cccc} \overline{Al_1} & \overline{Al_2} & \cdots & \overline{Al_m} \end{array}$$

$$\boldsymbol{VD}_R^{\alpha} = \begin{bmatrix} \left[g_{11(l)}^{\alpha}, g_{11(u)}^{\alpha}\right] & \left[g_{12(l)}^{\alpha}, g_{12(u)}^{\alpha}\right] & \cdots & \left[g_{1m(l)}^{\alpha}, g_{1m(u)}^{\alpha}\right] \\ \left[g_{21(l)}^{\alpha}, g_{21(u)}^{\alpha}\right] & \left[g_{22(l)}^{\alpha}, g_{22(u)}^{\alpha}\right] & \cdots & \left[g_{2m(l)}^{\alpha}, g_{2m(u)}^{\alpha}\right] \\ \vdots & \vdots & \ddots & \vdots \\ \left[g_{n1(l)}^{\alpha}, g_{n1(u)}^{\alpha}\right] & \left[g_{n2(l)}^{\alpha}, g_{n2(u)}^{\alpha}\right] & \cdots & \left[g_{nm(l)}^{\alpha}, g_{nm(u)}^{\alpha}\right] \end{bmatrix}, R = 1, 2, \ldots, n \tag{46}$$

After the obtain of the $\boldsymbol{VD}_R^{\alpha}$, by utilizing Equation (47), the posterior matrix can be acquired, as depicted below:

$$\tilde{\boldsymbol{\Omega}} = \tilde{\delta} \times \frac{\left(\mathbf{P}(\mathbf{VD}_k^c) \mid \mathbf{P}(\mathbf{VD}_k^p)\mathbf{P}(\mathbf{VD}_k^p)\right)}{\sum_{i=1}^{n}\sum_{i=1}^{m} g_{ij}^{c'} \times g_{ij}^{p'}} \tag{47}$$

where $\mathbf{P}(\mathbf{VD}_k^p) = \left[g_{ij(l)}^{p'}, g_{ij(u)}^{p'}\right]_{n\times m}$ and $\mathbf{P}(\mathbf{VD}_k^c) = \left[g_{ij(l)}^{c'}, g_{ij(u)}^{c'}\right]_{n\times m}$ stand for the probability matrices that are being normalized from the aggregation matrices, and $\tilde{\delta}$ is a parameter gained by the sum of posterior probability matrices. $\tilde{\delta}$ is utilized for converting the posterior probability matrices into the posterior total influence matrix. The posterior aggregation matrix of $\tilde{\boldsymbol{\Omega}}$ is shown below:

$$\tilde{\boldsymbol{\Omega}} = \left[\overline{RN(\tilde{\rho}_{ij})}\right]_{n\times m} = \begin{bmatrix} [\rho_{11(l)}, \rho_{11(u)}] & [\rho_{12(l)}, \rho_{12(u)}] & \cdots & [\rho_{1m(l)}, \rho_{1m(u)}] \\ [\rho_{21(l)}, \rho_{21(u)}] & [\rho_{22(l)}, \rho_{22(u)}] & \cdots & [\rho_{2m(l)}, \rho_{2m(u)}] \\ \vdots & \vdots & \ddots & \vdots \\ [\rho_{n1(l)}, \rho_{n1(u)}] & [\rho_{n2(l)}, \rho_{n2(u)}] & \cdots & [\rho_{nm(l)}, \rho_{nm(u)}] \end{bmatrix} \tag{48}$$

Then, an aggregation function, L_p *metric*, can be derived by Equation (49) according to [117].

$$L_k^a = \left\{ \sum_{j=1}^{n} \left[\tilde{w}_j \left|\tilde{\rho}_j^* - \tilde{\rho}_{kj}\right| \Big/ \left|\tilde{\rho}_j^* - \tilde{\rho}_{kj}^-\right| \right]^a \right\}^{1/a}, 1 \le a \le \infty; \quad k = 1, 2, \ldots, m \tag{49}$$

Step 9: Calculate the ranking measures of $\tilde{S}_k = \left[S_k^L, S_k^U \right]$ and $\tilde{Q}_k = \left[Q_k^L, Q_k^U \right]$. Based on the L_p *metric*, the ranking measures of $\tilde{S}_k$ and $\tilde{Q}_k$ can further be derived as $\tilde{L}_k^{a=1}$ and $\tilde{L}_k^{a=\infty}$, respectively.

$$\tilde{S}_k = \tilde{L}_k^{a=1} = \sum_{j=1}^{n} \left[\tilde{w}_j \left| \tilde{\rho}_j^* - \tilde{\rho}_{kj} \right| / \left| \tilde{\rho}_j^* - \tilde{\rho}_j^- \right| \right]; \tag{50}$$

$$\tilde{Q}_k = \tilde{L}_k^{a=\infty} = \max_{j=1,2,\ldots,n} \left(\sum_{j=1}^{n} \left[\tilde{w}_j \left| \tilde{\rho}_j^* - \tilde{\rho}_{kj} \right| / \left| \tilde{\rho}_j^* - \tilde{\rho}_j^- \right| \right] \right) \tag{51}$$

According to Equation (50) to (51), the best values is denoted by $\tilde{\rho}_j^*$, which means the aspiration level of the *j*th criterion. The worst value is denoted by $\tilde{\rho}_j^-$, while means the tolerable value of the *j*th criterion. Then, the compromise ranking measure, $\tilde{R}_k = \left[R_{k(l)}, R_{k(u)} \right]$, can be derived based on the $\tilde{S}_k$, $\tilde{Q}_k$, and the weighted group utility (i.e., weight = v) as well as the individual regret (i.e., weight = 1- v) as follows:

$$\tilde{R}_k = v \times \frac{\left(\tilde{S}_k - \tilde{S}^* \right)}{\left(\tilde{S}^- - \tilde{S}^* \right)} + \left(1 - v \right) \times \frac{\left(\tilde{Q}_k - \tilde{Q}^* \right)}{\left(\tilde{Q}^- - \tilde{Q}^* \right)} \tag{52}$$

where $\tilde{S}^* = \min_k \tilde{S}_k$, $\tilde{S}^- = \max_k \tilde{S}_k$, $\tilde{Q}^* = \min_k \tilde{Q}_k$, $\tilde{Q}^- = \max_k \tilde{Q}_k$.

Based on the concept of the aspiration level, here the best value will be set as 0 and the worst value will be set as 1. To easily analyze the performance-gap and rank the alternatives, the rough interval values of $\tilde{R}_k$ matrix will be converted into crisp scores by using the arithmetic average method. Through the analytic framework hybridizing the BR-DNP and the MBR-VIKOR, the compromise solution can be determined. In addition, the gap analysis of systemic innovation problems in vague environment can also be proposed. With the results of gap analysis, the improvement directions of systemic innovation problems will be clearly illustrated.

4.8 Rough grey relation analysis (R-GRA)

GRA, which originally proposed by Deng [118], can be used to capture the correlations between the desired alternative and other compared alternatives in a evaluation system. GRA method has been widely applied for aiding MCDM problems across different research areas. In this work, the GRA based rough interval number will be leveraged for deriving the innovation policy portfolios versus systemic innovation problems influencing IoT industrial sustainability. In the following, the concepts of calculation process for GRA based rough interval numbers (R-GRA) model are be illustrated.

Step 10: Construct initial rough relationship matrix $\tilde{G}$

Designing the relationship scale into five levels for survey, where scores 0, 1, …, 4 represents the range from "no relationship" to "very high relationship" between the identified factors and other alternatives. Suppose a research problem having q alternatives Al_1, Al_2, …, Al_q and n evaluation criteria E_1, E_2, …, E_n. Each alternative is assessed based on the n evaluation criteria. All the evaluate values are assigned to alternatives with respect to a $q \times n$ matrix, called initial relationship matrix $G = \left[g_{ij} \right]_{q\times n}$. In accordance with the definition of rough number [23, 119], the initial average rough relationship matrix $\tilde{G} = \left[\overline{RN\left(g_{ij}\right)} \right]_{q\times n}$ is constructed, as shown below:

$$\tilde{G} = \begin{array}{c} \\ Al_1 \\ Al_2 \\ \vdots \\ Al_n \end{array} \begin{array}{c} \begin{array}{cccc} E_1 & E_1 & \cdots & E_1 \end{array} \\ \begin{bmatrix} \overline{RN\left(g_{11}\right)} & \overline{RN\left(g_{12}\right)} & \cdots & \overline{RN\left(g_{1n}\right)} \\ \overline{RN\left(g_{21}\right)} & \overline{RN\left(g_{22}\right)} & \cdots & \overline{RN\left(g_{2n}\right)} \\ \vdots & \vdots & \cdots & \vdots \\ \overline{RN\left(g_{q1}\right)} & \overline{RN\left(g_{q2}\right)} & \cdots & \overline{RN\left(g_{qn}\right)} \end{bmatrix} \end{array}$$

Step 11: Calculate the normalized relationship matrix X.

$$X = \begin{array}{c} \\ Al_1 \\ Al_2 \\ \vdots \\ Al_n \end{array} \begin{array}{c} \begin{array}{cccc} E_1 & E_1 & \cdots & E_1 \end{array} \\ \begin{bmatrix} \overline{RN(x_{11})} & \overline{RN(x_{12})} & \cdots & \overline{RN(x_{1n})} \\ \overline{RN(x_{21})} & \overline{RN(x_{22})} & \cdots & \overline{RN(x_{2n})} \\ \vdots & \vdots & \cdots & \vdots \\ \overline{RN(x_{q1})} & \overline{RN(x_{q2})} & \cdots & \overline{RN(x_{qn})} \end{bmatrix} \end{array}$$

where the normalized value $\overline{RN(x_{ij})} = \overline{RN(g_{ij})}\overline{(RN(\max(g_{ij})))}^{-1}$, $i = 1,2,...,q$ and $j = 1,2,...,n$.

Step 12: Construct the rough distance relationship matrix Δ. The distance $\overline{RN(\delta_{ij})}$ interval value between the desired value and each comparison value is given as $\overline{RN(\delta_{ij})} = \overline{RN(r_{0j})} - \overline{RN(r_{ij})}$. After the calculation, the distance relationship matrix Δ can then be derived as:

$$\Delta = \begin{bmatrix} \overline{RN(\delta_{11})} & \overline{RN(\delta_{12})} & \cdots & \overline{RN(\delta_{1n})} \\ \overline{RN(\delta_{21})} & \overline{RN(\delta_{22})} & \cdots & \overline{RN(\delta_{2n})} \\ \vdots & \vdots & \cdots & \vdots \\ \overline{RN(\delta_{q1})} & \overline{RN(\delta_{q2})} & \cdots & \overline{RN(\delta_{qn})} \end{bmatrix}_{q\times n}$$

Step 13: Calculate the rough grey relation coefficient. The grey relation coefficient $\overline{RN(x_{ij})}$ is defined as $\overline{RN(x_{ij})} = \dfrac{\overline{RN(d_{\min})} + \zeta \overline{RN(x_{\max})}}{\overline{RN(d_{ij})} + \zeta \overline{RN(x_{\max})}}$, $i = 1,2,...,m;\ j = 1,2,...,n$.

where the ζ is the distinguished coefficient ($\zeta \in [0,1]$). Generally, we pick ζ =0.5. The $\overline{RN(d_{\min})}$ stands for the minimum value of lower limit in interval number of $\overline{RN(d_{ij})}$; The $\overline{RN(d_{\max})}$ represents the maximum value of upper limit in interval number of $\overline{RN(d_{ij})}$.

Step 14: Calculate the rough grey relation grade.

$$\overline{RN(g_i)} = \sum_{j=1}^{n} w_j \times \overline{RN(x_{ij})}.\ i = 1,2,...,m.$$

where w_j is the weight of *j*th criterion, and $w_j \geq 0$, $\sum_{j=1}^{n} w_j = 1$. Here, the weight can be set as 1 divided by length of Δ. Thus, the weights will be the same for every variable.

Step 15: Rank the alternatives based on derivation values of grey relation grade. In order to obtain the crisp values g_i, the de-roughness of interval number will be conducted by the method of arithmetical mean. The larger the obtained crisp value g_i, the better the alternative Al_i is.

4.9 Rough competence set expansion (R-CSE)

GRA, which originally proposed by Deng [118], can be used to capture the Competence Set (CS) theory is proposed by Yu and Zhang [120] subsequently established the mathematical basis for CS theory. This method can be used to develop the path network and further derive the optimal roadmap of innovation policy for expanding competence set. In the operation process, the systemic innovation policies will be collected at first. Next, the cost matrix can be estabilished by collected systemic innovation policies based on R-GRA method. The cost matrix is a $n \times n$ matrix where each value stands for the competence cost from *i*th to *j*th policy. According to cost matrix, the optimal path can be further developed.

To consititute the optimal path, several approaoches, including the minimum spanning tree [121], the mathematical programming method [122] and the deduction graphs [123], have been adopted. The optimal expansion process from the existing competence set to the true competence set are modified from Huang, Tzeng [124] and can be described as follows.

Let $HD = SK \cup T$ where HD (habitual domains) is all the related skills needed to solve a particular problem, *SK* denotes the already acquired competence set and *T* denotes the true required competence set. Therefore, the optimal expansion process (learning sequence) can be obtained by minimizing the cost of acquiring x_j from x_i, that is, $\min\{c(x_i, x_j)$, where $x_i \in SK$ and $x_j \in T\}$. The corresponding expansion path graph can be represented as Figure 1.

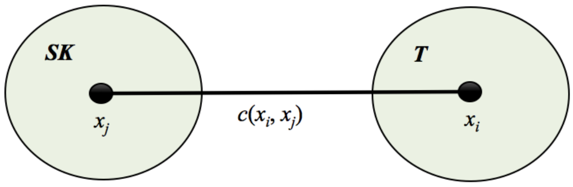


Figure 1 The cost function of competence set.

Note: this graph indicates the competence value of one factor influences another factor.

Since the relations between skills exist, learning cost has to reflect the relational level between skills. The bigger the relational degree, the smaller the learning cost. Based on this concept, the optimal learning sequence (expansion path) can then be obtained through the minimum learning cost. In order to effectively obtain learning cost, rough grey relation grade $\overline{RN\left(g_{Al_i}, g_{Al_j}\right)}$ of R-GRA can be served as the learning cost for deriving the expansion path network of CSE. The rough learning cost is defined as $\overline{RN\left(c\left(g_{Al_i}, g_{Al_j}\right)\right)} = 1 - \overline{RN\left(g_{Al_i}, g_{Al_j}\right)}$. The obtained rough learning cost can be further transformed into the crisp grey relation grade $c\left(g_{Al_i}, g_{Al_j}\right)$ by using the arithmetical mean.

Subsequently, the optimal expansion sequence can be developed based on the crisp grey relation grade. The calculation process of developing optimal expansion path is described as below in terms of mathematic programming model:

$$\min \quad MC(E) = \sum\nolimits_{g(i,j) \in E}^{n} c(i,j)\, v(0,j)$$

$$
\begin{aligned}
s.t.\quad & \sum_{j=1}^{n} v(0,j) = 1, \qquad j = 1,2,\cdots,n; \\
& u_i - u_j + (n+1)v(0,j) \le n, \\
& u_0 = 0,\ \ 0 \le i \le n, 1 \le j \le n; \\
& i \ne j,\ \forall v(0,j), u_i \in \{1,\cdots n\}, i = 1,2,...,n.
\end{aligned}
$$

Chpater 5 Empirical study

In this section, the three main analyses will be presented. First, the industrial background and research problems are introduced. Next, the process of data collection will be illustrated. Eventually, research results will further be proposed.

5.1 Industrial background and research problems

In advanced countries like Germany and Japan, national governments have enabled the IoT applications and development in manufacturing industries by using a set of policy instruments. The policy makers of these governments urge domestic manufacturing firms to acquire the benefits from IoT development and further enhance industrial competitiveness and stimulate economic growth of nations. For fast catching-up countries like Taiwan and South Korea, the government sectors, have also expected to follow up this trend to strengthen their competitiveness in manufacturing industries.

Taiwan has established a strong industrial basis in manufacturing industries in the past few decades. Developing IoT applications and promoting the industrial sustainability are relatively advantageous than most other countries. Thus, the Taiwanese government aggressively implemented some supportive policies to help development of IoT. Despite the huge efforts in IoT development, the diffusions and adoptions of IoT innovations and applications are comparatively lower than leading countries. Thus, there is a need to find out and overcome the difficulties and challenges influencing the development of sustainability in the IoT industry. Further, based on these difficulties and challenges, the systemic innovation policy portfolios and the roadmap for innovation policy implementation for facilitating IoT industrial sustainability should be defined.

According to the previous literature, on policy modeling and combination, systemic innovation policy analyses have been extensively adopted [9, 14, 47, 78, 98]. The analytical process and innovation policy literature can be used to design a set of proper innovation policies versus systemic innovation problems relative to particular technological innovations or industrial development. Therefore, related systemic innovation theories and empirical cases as the basis are pretty suitable for this research to deal with aforementioned practical issues. In order to solve these problems, this research hence provides a hybrid MADM based integrated framework for defining the innovation policy portfolios versus different systemic innovation problems and further developing the path expansion network of innovation policies. To effectively achieve the goal of this research, a series of tasks needs to be completed. Given that, several analytical tasks will be conducted, consisting of systemic functions evaluation, performance evaluation of systemic innovation problems, and the formulation of systemic innovation policy portfolios and policy roadmapping.

In this work, above mentioned tasks will be implemented by using the proposed novel hybrid MADM based integrated framework. The case in Taiwan for smart manufacturing industries involved in IoT applications will be utilized to empirically validate the applicability of proposed novel hybrid MADM model. Furthermore, the proposed model and analytical process can offer policy makers the insights to help designing and planning innovation policy with systemic perspectives.

5.2 Data collection

Raw data were mainly collected from questionnaires answered by Taiwanese experts over a fifteen-month period, from August 2017 to October 2018. The questionnaire investigation and expert interview can be divided into three stages. The investigation will be conducted through online meeting and physical meeting where author in person explain how to fill out the questionnaire and share the research background and discuss with these experts concerning the IoT sustainability. The research funding for whole investigation was supported by Fuji Xerox Kobayashi Fund and Faculty of Engineering, The Univeristy of Tokoy.

Three survey stages are associated each other. In other words, three surveys will be dependent each other. In the first stage, this research aims to explore what kind of factors will influence IoT sustainable development in manufacturing industries in Taiwan. By using the causal relationship network towards identified factors, policy analysts and researchers will easily understand the influential relationships among the identified factors. Thus, the first stage survey will be the important foundation for supporting later analyses, comprising of the analyses of systemic innovation problems and innovation policies.

In the second stage, this research will further explore which barriers (systemic innovation problems) that are hampering the IoT sustainability need to be preferentially improved. In the meantime, the gaps, which stand for the distance between each problem and optimal goal, will be derived for policy analysts and researchers to design corresponding policies in the future.

Based on prior two analyses, the factors influencing IoT sustainable development and how to improve the systemic problems have already been obtained. In the final stage, this research will thereby formulate feasible innovation policies and policy roadmaps. Hence, the survey will be conducted for investigating the relational values between systemic innovation problems and policies. By doing so, the innovation policy portfolios and policy roadmaps can be derived. The questionnaire design and format concerning the three survey stages is presented in Appendix A to C.

To sum up, the questionnaire for first stage is designed to evaluate factors' importance and assess the influences between any two pair-wise factors, using 5-point scale way. In second stage survey, questionnaire is set up to evaluate the relational values between influential factors (derived from first stage) and systemic innovation problems. Specifically, experts need to determine the relational values between any pair-wise combination from factors and systemic problems. In the final stage, the experts need to evaluate the relational values between systemic problems (derived from second stage) and innovation policies. Similarly, the evaluation way is the same as second stage.

5.2.1 Expert background and selection

This research was conducted in Taiwan. Therefore, the samples in Taiwan will be considered. First of all, the corporations as samples being selected in this paper are depending on the famous companies from Industrial Automation Exhibition in Taipei which supported by ministry of economic in Taiwan. Theses candidate companies/samples are further contacted in Taiwan. Not all of companies are interested in this research and are willing to be the respondents. Eventually, some of the potential companies are willing to accept the survey invitation. Besides, this research will also provide the research fee for those people involving in the survey.

This research also invites the industrial sectors from government, research institutes and university for this survey. Due to the limitation of sample collection, except for the industrial samples, the rest of samples from other three units are relatively few. The questionnaire and collected data has been shown in Appendix. Meanwhile, the selection of expert panels is based on snowball sampling method. This research randomly chooses one expert from collected data and asking this expert if he/she can suggest other experts from the collected data. By doing so, 15 in total experts with over 15 years of IoT industrial experiences are invited for the investigation. The job title of invited experts comprised of R&D, managers, top management. The expert information is shown in Appendix and survey flow is shown in below.

5.2.2 First stage questionnaire survey for the systemic functions evaluation

In questionnaire of first stage, the criteria/factors and functions/aspects for assessment are collected by past studies of technological innovations [6, 9, 10, 14, 125]. Subsequently, several functions could be obtained: (1) Entrepreneurial activities (F_1); (2) knowledge development (F_2); (3) knowledge diffusion through network (F_3); (4) guidance of the search (F_4); (5) market formation (F_5); (6) resource mobilization (F_6); and (7) creation of legitimacy (F_7). In the meantime, there were 28 possible criteria belonging to different functions being collected either. All of collected functions and criteria are shown in Table 1.

Table 1 Introduction of systemic functions and criteria from TIS studies.

Functions	Symbol	Features/Criteria
Entrepreneurial activities (F_1)	e_1	Experimenting new applications of IoT
	e_2	Launching pilot IoT projects
	e_3	Entry of firms to IoT markets
	e_4	System for innovation and incubation
Knowledge development (F_2)	k_1	Conducting feasible studies
	k_2	IoT market research and assessment
	k_3	Developing complementary technologies
	k_4	Network of technology and research cooperation
Knowledge diffusion through networks (F_3)	d_1	Training of professionals
	d_2	Conducting promotion campaigns
	d_3	Organizing conference/workshops/seminars/meetings
	d_4	Demonstrations and exhibitions
Guidance of the search (F_4)	g_1	Setting collective goals for IoT development
	g_2	Design of favorable rules and regulations
	g_3	Publicizing expectations
	g_4	Providing direction of development
Market formation (F_5)	m_1	Providing subsidies
	m_2	Government procurement programs
	m_3	Regulatory reform
	m_4	Standardizations
Resource mobilization (F_6)	r_1	Providing R&D budgets
	r_2	Providing financial grants and loans
	r_3	Launching IoT related education programs
	r_4	Mobilizing human resources
	r_5	Funding scale up on IoT projects
Creation of legitimacy (F_7)	c_1	Strength of lobby actions
	c_2	Rise and growth of interest groups
	c_3	Social acceptability

Next, collected factors are seen as the possible factors which means the suitability of factors for this research needs to be further examined. In this sense, this research conducts the feature selection task for these collected factors. The raw data being collected from various units, consisting of the industry, research institutes, universities and public sector. Some of these working units from raw data primarily focused on the IoT-oriented development or research, and the public sectors concerning technological development. The role of other remaining units is IoT device vendor focusing on smart machine development. In addition, the questionnaire was set up and collected on the website. All of invited units and experts were informed to complete the survey on particular website. The questionnaire being designed based on Likert evaluation of five-point way. Every participant was asked to evaluate the factors/criteria and aspects/functions using measure score from 0 to 4. Totally, the survey received 150 responses in which 106 responses were suitable. The valid response rate is 70.67%.

After feature selection, the questionnaire using pair-wise comparison between factors was set up. Meanwhile, by using the way of snowball sampling [126], 15 in total experts with over 15 years of IoT industrial experiences being invited for the investigation. Every expert was invited to participate the survey of 45 to 60 minutes by either video conference or interview in person (face to face by author).

In the survey, all of experts needed to share the notions for IoT industrial development and proposed potential and existing challenges impacting IoT sustainability. From the perspectives of experts, discussing how the public sectors should help industrial development by using policies and supportive means is important. Moreover, these experts were also asked to exploring IoT industrial sustainability by evaluating systemic factors.

5.2.3 Second stage questionnaire survey for the performance evaluation of systemic innovation problems

In the second stage, feasible systemic innovation problems being collected from the literature and experts' perspectives to establish the questionnaire will be depicted [6, 8, 9, 16, 20, 28, 47, 89].

First, the complete questionnaire was distribute to selected 15 experts from the first stage survey by email. Then, experts needed to evaluate the relationship value between the systemic innovation problems (*SP*s) and systemic factors. Table 2 introduces the identified *SP*s impacting the IoT industrial sustainability.

Table 2 The description of systemic innovation problems.

Problems	**Description**
Lack of uniform technical standards (SP_1)	Technical standard represents a norm for technological systems. For industries, technical standards directly influence industrial and technological development [127]. Lacking the uniform technical standards for IoT products will be able to lead to a problem in which many of electronic devices cannot communicate each other.
The innovation intensity is insufficient (SP_2)	Innovation is a necessary requirement for firms to survive in industrial competition [128]. Firms with high innovation intensity perform better than firms with lower innovation intensity [129]. In IoT industries, due to fast changing of IoT applications, firms need to enhance their innovation ability and intensity, so that they can continue to survive.

Regulatory constrains for IoT development (SP_3)	The regulation is a pretty important factor in stimulating innovation at the firm level [127]. However, tight regulations of product will be one of influential factors to slower industrial performance and constraint the industrial competition [130]. For IoT industries, restrictive regulations have limited the development and innovation of IoT applications.
Low level of interdisciplinary collaboration (SP_5)	To develop new technologies or innovations, interdisciplinary collaboration is indispensable. Based on different thoughts from a variety of domains, sometimes the products being produced will be very special and can receive much more attention in the market. To facilitate IoT industrial sustainability, interdisciplinary collaboration can be one of essential means that can positively affect IoT innovations in applications.
Lack of advanced sensor technology for IoT application (SP_6)	The advanced sensor technology is seen as a prerequisite for IoT [131]. In developing novel applications of IoT, advanced sensor technology will be necessary, since such technology can help manufacturing firms easily detect situations, collect data, and deal with data [132]. Therefore, strengthening sensor technology can also be an important issue for promotion of IoT applications.
Lack of effective innovation application services (SP_7)	Promotion of innovative applications of IoT has become one of the most important tasks for advanced countries. Through supportive measures by governments to stimulate IoT innovative application development is really important. In fast catching-up economies, encouraging novel IoT applications will bring about more possibilities for firms to earn the market share and enhance industrial competitiveness.
Low capability of platform integration (SP_8)	Platform integration and cooperation not only effectively promote the technological innovations of firms in particular fields, but also platform integration can reduce the manufacturing and operation cost, and further developing better IoT products. In IoT industries, low capability of platform integration is currently a severe problem that is hampering the industrial development of IoT.
Lack of professionals (SP_9)	The key factor of Facilitation of IoT industrial sustainability and technological innovations is lack of professionals. In manufacturing industries, many of SMEs need to upgrade and adopt IoT solutions for manufacturing. The use of IoT solution is easy. However, facing the increase of IoT development, talented people cannot fill up the gaps in time. This problem will further influence industrial and firms' performance.
Low level of industrial upgrading for SMEs (SP_{10})	In addition to lack of professionals, industrial upgrading of SMEs is also a significant problem. Except for leading companies in IoT industries, these SMEs are expected to adopt IoT solutions for manufacturing their products. However, there is no clear policy planning and measures for SMEs to upgrade. Such problem leads to industrial development in IoT is relatively slow in Taiwan.
Weak advocacy coalition (SP_{11})	Organization activity for promotion of IoT development is one of the problems affecting Taiwanese IoT industrial development. Based on the force of advocacy coalition for IoT, government and society will be thus influenced to put more efforts into IoT industrial development.

5.2.4 Third stage questionnaire survey for the formulations of policy portfolios and policy roadmaps

To assess the innovation policies and formulate policy portfolios and roadmaps, the third stage questionnaire survey was conducted. A questionnaire was designed by an expert panel. The systemic innovation policies (called alternatives) are given in Table 3 These policies are derived after discussions with experts and adjusted from existing literature on policy definition [6, 9, 89, 133]. The systemic innovation problems (called criteria) for the alternatives are obtained from literature review [4, 6, 8, 9, 11, 29, 31, 32, 79] and discussion with experts.

The survey will be split into three parts. In the first part, the feasibility of evaluation criteria and alternatives will be assessed based on experts' perspective using Modified Delphi Method. Second part will implement the policy portfolio analysis with the identified criteria and alternatives by a R-GRA approach. For the final part, the R-CSE technique is utilized to derive the policy path expansion. The evaluation criteria and alternatives were measured using a five-score scale on an interval degree ranging from "no relationship" to "very high relationship". The survey was conducted using two stages. In the first stage, 15 experts from first and two stages questionnaire survey were selected. A follow-up email was sent to those experts again to confirm the assessment results. After that, in the second stage, the survey of the relationships between criteria and alternatives was conducted, and 15 experts' responses were finally obtained. In the following section, the detailed analytical processes in three main themes are introduced and discussed.

Table 3 The systemic innovation policies.

The systemic innovation policies	**Symbol**
Develop technical standards	IP_1
Technology transfer and introduction	IP_2
Revise the regulations and policies	IP_3
Infrastructure development for IoT	IP_4
Policies to support interdisciplinary collaboration	IP_5
Direct support to firm R&D and innovation	IP_6
Support experiments with novel applications	IP_7
Technology resources integration	IP_8
Provide professional training programs	IP_9
Technology support and assistance	IP_{10}
Support advocacy coalition	IP_{11}
Overseas agents	IP_{12}

Timely procurements	IP_{13}
Provide demonstration fields	IP_{14}

5.3 Systemic functions evaluation for the sustainability of IoT in the manufacturing industries

In the stage of systemic function evaluation, the objective is to uncover the feasible evaluation factors influencing IoT industrial sustainability and, based on these factors, further depict a causal relationship networks. Thus, the feasible factors, including systemic functions and criteria were firstly confirmed by RF technique in terms of opinion survey from universities, public sectors, industries and research institutes. Then, the BR-DEMATEL method was used to derive the causal relationship networks relying on confirmed systemic factors.

5.3.1 Data pre-processing and feature selection

The systemic factors, including systemic functions and criteria, were collected in the past TIS research and experts' perspectives. However, the appropriateness of these systemic factors and related systemic problems as well as policies have to be examined.

First of all, 106 samples from various categories (universities, public sectors, industries, and research institutes) were used by RF approach. According to literature, if imbalanced categories exists in dataset, we can called it imbalance data. In imbalance data, one example is majority category significantly exceeds the number of the minority category. Such result will harm the prediction performance of model. Fortunately the re-sampling (e.g., SMOTE) approach is able to solve such imbalance category issue [99]. By SMOTE, the imbalanced categories consisting of 72 for industry, 17 for university, 8 for government sector, and 9 for research institute were re-sampled as 72 for industry, 72 for university, 72 for government sector, and 9 for research institute.

Second of all, the author further divided the sample randomly into three sub-datasets, including training set, testing set, and validation set. The portion of these dataset respectively is 60% (135 samples), 20% (45 samples), and 20% (45 samples). Subsequently, this paper further confirmed the performance in re-sample dataset comparing to original dataset by using various algorithms which includes logistic regression (LR), radial basis function kernel SVM (RBF-SVM), linear support vector machine (LS-SVM), and gradient boosting (GB) and RF. The classification result is show in Table 4. Based on Table 4, the performance of re-sampled classification is better than the performance of original one. Besides, the classification performance of RF outperform than other algorithms in this paper. Thus, RF algorithm was utilized for feature selection task.

Table 4 The accuracy of classification between re-sampled data and original data.

Algorithms	**Re-Sampled Data**			**Original Data**		
	Training	**Testing**	**Validation**	**Training**	**Testing**	**Validation**
RF	0.756	0.822	0.756	0.699	0.667	0.682
LR	0.698	0.667	0.689	0.573	0.714	0.636
LS-SVM	0.683	0.689	0.667	0.463	0.619	0.727
RBF-SVM	0.750	0.711	0.644	0.699	0.667	0.636
GB	0.712	0.889	0.733	0.601	0.714	0.596

Note: this table shows the classification result, all collected factors can be determined how many factors will be kept and how many factors will be dropped.

Finally, the feature selection process in total being conducted different five rounds with 5-fold cross-validations by RF. In cross-validation process, training set and testing set were established for 90/10, 80/20, 70/30, 60/40, and 50/50, respectively. The parameter setting in RF can be illustrated as: the estimator was set to be 10 and the minimum number of leaves in the samples was 1, and 'gini' was used as a criterion for evaluating the features. Based on feature selection result shown in Table 5, 23 criteria/factors being contained and can be leveraged for subsequent analyses.

Table 5 Derived criteria within six systemic functions.

Entrepreneurial activities (F_1)	e_1, e_3, e_4
Knowledge development (F_2)	k_1, k_3
Knowledge diffusion through networks (F_3)	kd_1, kd_3, kd_4
Guidance of the search (F_4)	g_1, g_2, g_3, g_4
Market formation (F_5)	m_1, m_2, m_3, m_4
Resource mobilization (F_6)	r_1, r_3, r_4, r_5
Creation of legitimacy (F_7)	c_1, c_2, c_3

Note: this table shows the classification result, all collected factors can be determined how many factors will be kept and how many factors will be dropped.

5.3.2 The derivation of the causal network via the BR-

DEMATEL method

By the responses of the 15 experts, causal relationships could be derived by BR-DEMATEL method. First, based on the evaluation scale from 0 to 4 (no influence to very high influence), the group direct-influence matrix being constructed. In **Table 6**, the scores on the left side are denoted as the values of prior situations (matrix) and the scores on the right side represent the values of current conditions (matrix). According to the rough interval number and the Equations (2) to (19), the all of evaluation scores by experts were converted into rough numbers. Each initial matrix was established based on 23 criteria belonging to seven systemic functions. Thus, the group rough direct influence matrices, $\tilde{Z}^p = \left[\overline{RN(\tilde{z}_{ij}^p)}\right]_{23\times23}$ and $\tilde{Z}^c = \left[\overline{RN(\tilde{z}_{ij}^c)}\right]_{23\times23}$ (see Table 7 and Table 8), are constituted. Next, the normalized rough matrices, including $D^p = \left[\overline{RN(\tilde{d}_{ij}^p)}\right]_{23\times23}$ and $D^c = \left[\overline{RN(\tilde{d}_{ij}^c)}\right]_{23\times23}$, are calculated by Equations (19) and (20), as depicted in Table 9 and Table 10.

Once the average rough matrix is constructed, the rough total influence matrices, $\tilde{T}^p$ and $\tilde{T}^c$ (see Table 11 and Table 12), can be derived using Equations (21) to (23). The network relationship map can be derived accordingly. In this step, Bayesian theory is also taken into consideration. The posterior rough total influence matrix, T, can then be derived based on Equations (24) to (26). Based on Equation (28), the reliability of the collected data can be derived. The inconsistency ratio is 3.75% (<5%), which means our collected samples are reliable.

In matrix T (see Table 13), by summing each row and column, $\tilde{T}^p$ and $\tilde{T}^c$ can be derived using Equations (29) and (30). The influential network relationship map and the causal relationships towards criteria can thus be illustrated. The next step to deriving the causal relationship is to convert the rough values into the crisp value based on Equations

(37) and (38). Crisp values, r and c, are eventually obtained and are shown in Table 14. The total influence relation matrix, the prominence, and relationships of the systemic function are demonstrated in Table 13. Finally, the causal network can be illustrated by mapping the crisp values of $r+c$ and $r-c$ (refer to Figure 3). Based on this causal network, policy makers can understand complex influence relationships among factors, which enhances the priority of the innovation policy formulation that can then be planned accordingly.

Table 6 The initial influence matrices by decision makers.

DM 1											
	e_1	e_3	e_4	k_1	k_3	kd_1	…	r_5	c_1	c_2	c_3
e_1	(0;0),	(4;0)	(4;4)	(4;4)	(4;4)	(4;4)	…	(4;4)	(4;4)	(4;4)	(4;4)
e_3	(4;4)	(0;0)	(4;4)	(4;4)	(4;4)	(4;4)	…	(4;4)	(4;4)	(4;4)	(4;4)
e_4	(3;3)	(2;2)	(0;0)	(3;3)	(2;2)	(3;3)	…	(4;3)	(2;3)	(2;3)	(2;2)
k_1	(4;3)	(4;3)	(4;4)	(0;0)	(4;4)	(4;4)	…	(4;3)	(4;2)	(4;2)	(4;2)
k_3	(4;4)	(4;4)	(4;4)	(3;3)	(0;0)	(3;3)	…	(3;2)	(3;2)	(3;2)	(3;2)
kd_1	(4;4)	(4;4)	(3;3)	(3;3)	(2;2)	(0;0)	…	(2;4)	(3;4)	(2;4)	(2;4)
…	…	…	…	…	…	…	…	…	…	…	…
r_5	(4;4)	(4;4)	(4;4)	(4;4)	(4;4)	(4;4)	…	(0;0)	(1;1)	(1;1)	(2;1)
c_1	(1;2)	(1;3)	(1;2)	(1;2)	(3;3)	(2;2)	…	(2;2)	(0;0)	(4;3)	(2;2)
c_2	(1;2)	(1;3)	(1;2)	(1;2)	(3;2)	(1;1)	…	(1;1)	(4;2)	(0;0)	(2;2)
c_3	(3;3)	(4;4)	(2;2)	(3;3)	(2;2)	(2;2)	…	(1;1)	(4;3)	(4;3)	(0;0)
⋮											
DM 15											
	e_1	e_3	e_4	k_1	k_3	kd_1	…	r_5	c_1	c_2	c_3
e_1	(0;0)	(4;4)	(4;4)	(4;4)	(4;4)	(4;4)	…	(3;4)	(2;4)	(2;4)	(2;4)
e_3	(4;3)	(0;0)	(4;4)	(4;4)	(4;4)	(4;4)	…	(4;1)	(4;1)	(4;3)	(4;2)
e_4	(2;4)	(2;4)	(0;0)	(2;4)	(2;4)	(4;4)	…	(4;3)	(4;3)	(4;3)	(4;2)
k_1	(4;4)	(4;4)	(2;4)	(0;0)	(4;4)	(4;4)	…	(3;3)	(2;2)	(2;2)	(2;2)
k_3	(4;4)	(4;4)	(4;4)	(3;4)	(0;0)	(4;4)	…	(2;2)	(2;2)	(2;2)	(2;2)
kd_1	(4;4)	(4;4)	(3;3)	(4;4)	(4;3)	(0;0)	…	(1;1)	(1;1)	(1;1)	(1;1)
…	…	…	…	…	…	…	…	…	…	…	…
r_5	(4;4)	(4;4)	(3;2)	(4;4)	(4;4)	(4;4)	…	(0;0)	(1;1)	(1;1)	(2;1)
c_1	(3;2)	(3;3)	(3;2)	(3;2)	(3;3)	(1;2)	…	(2;2)	(0;0)	(4;3)	(2;3)
c_2	(1;2)	(1;3)	(1;4)	(1;2)	(1;2)	(1;3)	…	(1;3)	(4;3)	(0;0)	(2;3)
c_3	(4;2)	(4;3)	(3;2)	(4;4)	(2;2)	(1;2)	…	(3;1)	(3;4)	(4;4)	(0;0)

Table 7 The rough direct influence relation matrix, .

	e_1	e_3	e_4	…	c_2	c_3
e_1	[0.000, 0.000]	[4.000, 4.000]	[4.000, 4.000]	…	[2.251, 3.229]	[2.073, 3.135]
e_3	[3.125, 3.793]	[0.000, 0.000]	[1.026, 2.970]	…	[2.293, 3.322]	[2.167, 3.306]

e_4	[2.926, 3.470]	[2.142, 2.924]	[0.000, 0.000]	…	[2.074, 2.760]	[1.898, 2.509]
k_1	[3.360, 3.840]	[3.284, 3.782]	[3.742, 3.991]	…	[2.467, 3.404]	[1.547, 3.042]
k_3	[3.640, 3.960]	[4.000, 4.000]	[3.640, 3.960]	…	[2.218, 2.716]	[1.435, 2.173]
kd_1	[3.640, 3.960]	[3.871, 3.996]	[3.004, 3.129]	…	[1.857, 2.963]	[1.367, 2.421]
…	…	…	…	…	…	…
r_5	[3.871, 3.996]	[3.871, 3.996]	[3.125, 3.793]	…	[1.018, 1.249]	[1.542, 2.328]
c_1	[0.808, 2.280]	[0.681, 2.098]	[0.817, 2.132]	…	[3.360, 3.840]	[1.747, 2.640]
c_2	[0.538, 1.138]	[0.637, 1.233]	[0.638, 1.071]	…	[0.000, 0.000]	[1.650, 2.350]
c_3	[2.542, 3.547]	[3.253, 3.947]	[1.996, 2.816]	…	[2.381, 3.674]	[0.000, 0.000]

Table 8 The rough direct influence relation matrix, .

	e_1	e_3	e_4	…	c_2	c_3
e_1	[0.000, 0.000]	[3.278, 3.973]	[3.871, 3.996]	…	[3.593, 3.982]	[3.502, 3.964]
e_3	[3.125, 3.793]	[0.000, 0.000]	[2.059, 3.607]	…	[2.639, 3.617]	[2.771, 3.749]
e_4	[2.360, 3.253]	[1.997, 2.945]	[0.000, 0.000]	…	[2.360, 3.253]	[2.080, 2.720]
k_1	[2.495, 3.463]	[2.781, 3.466]	[2.799, 3.714]	…	[1.769, 2.363]	[2.160, 2.640]
k_3	[3.593, 3.982]	[3.751, 3.982]	[2.128, 3.304]	…	[2.036, 2.498]	[2.036, 2.498]
kd_1	[2.840, 3.874]	[2.840, 3.874]	[2.502, 2.964]	…	[1.333, 2.667]	[1.519, 3.151]
…	…	…	…	…	…	…
r_5	[3.871, 3.996]	[3.871, 3.996]	[1.969, 2.951]	…	[1.000, 1.000]	[1.004, 1.129]
c_1	[2.354, 3.386]	[3.007, 3.651]	[2.000, 2.000]	…	[3.000, 3.000]	[2.751, 2.982]
c_2	[2.320, 3.280]	[2.349, 3.130]	[2.273, 2.938]	…	[0.000, 0.000]	[2.751, 2.982]
c_3	[2.672, 3.458]	[2.273, 3.308]	[2.166, 3.053]	…	[3.198, 3.850]	[0.000, 0.000]

Table 9 The normalized rough direct influence relation matrix, .

	e_1	e_3	e_4	…	c_2	c_3
e_1	[0.000, 0.000]	[0.049, 0.049]	[0.049, 0.049]	…	[0.027, 0.039]	[0.025, 0.038]
e_3	[0.038, 0.046]	[0.000, 0.000]	[0.012, 0.036]	…	[0.028, 0.040]	[0.026, 0.040]
e_4	[0.036, 0.042]	[0.026, 0.036]	[0.000, 0.000]	…	[0.025, 0.034]	[0.023, 0.030]
k_1	[0.041, 0.047]	[0.040, 0.046]	[0.045, 0.048]	…	[0.030, 0.041]	[0.019, 0.037]
k_3	[0.041, 0.048]	[0.049, 0.049]	[0.044, 0.048]	…	[0.027, 0.033]	[0.017, 0.026]

kd_1	[0.044, 0.048]	[0.047, 0.049]	[0.036, 0.038]	…	[0.023, 0.036]	[0.017, 0.029]
…	…	…	…	…	…	…
r_5	[0.047, 0.049]	[0.047, 0.049]	[0.038, 0.046]	…	[0.012, 0.015]	[0.019, 0.028]
c_1	[0.010, 0.028]	[0.008, 0.025]	[0.010, 0.026]	…	[0.041, 0.047]	[0.021, 0.032]
c_2	[0.007, 0.014]	[0.008, 0.015]	[0.008, 0.013]	…	[0.000, 0.000]	[0.020, 0.029]
c_3	[0.031, 0.043]	[0.040, 0.048]	[0.024, 0.034]	…	[0.029, 0.045]	[0.000, 0.000]

Table 10 The normalized rough direct influence relation matrix, $\boldsymbol{D}^c$.

	e_1	e_3	e_4	…	c_2	c_3
e_1	[0.000, 0.000]	[0.038, 0.046]	[0.044, 0.046]	…	[0.041, 0.046]	[0.040, 0.045]
e_3	[0.036, 0.044]	[0.000, 0.000]	[0.024, 0.041]	…	[0.030, 0.042]	[0.032, 0.043]
e_4	[0.027, 0.037]	[0.023, 0.034]	[0.000, 0.000]	…	[0.027, 0.037]	[0.024, 0.031]
k_1	[0.029, 0.040]	[0.032, 0.040]	[0.032, 0.043]	…	[0.020, 0.027]	[0.025, 0.030]
k_3	[0.041, 0.046]	[0.043, 0.046]	[0.024, 0.038]	…	[0.023, 0.029]	[0.023, 0.029]
kd_1	[0.033, 0.044]	[0.033, 0.044]	[0.029, 0.034]	…	[0.015, 0.031]	[0.017, 0.036]
…	…	…	…	…	…	…
r_5	[0.044, 0.046]	[0.044, 0.046]	[0.023, 0.034]	…	[0.011, 0.011]	[0.012, 0.013]
c_1	[0.027, 0.039]	[0.035, 0.042]	[0.023, 0.023]	…	[0.034, 0.034]	[0.032, 0.034]
c_2	[0.027, 0.038]	[0.027, 0.036]	[0.026, 0.034]	…	[0.000, 0.000]	[0.032, 0.034]
c_3	[0.031, 0.040]	[0.026, 0.038]	[0.025, 0.035]	…	[0.037, 0.044]	[0.000, 0.000]

Table 11 The rough total influence relation matrix, $\tilde{\boldsymbol{T}}^p$.

	e_1	e_3	e_4	…	c_2	c_3
e_1	[0.082, 0.240]	[0.128, 0.281]	[0.114, 0.257]	…	[0.083, 0.222]	[0.071, 0.218]
e_3	[0.106, 0.280]	[0.069, 0.232]	[0.070, 0.243]	…	[0.074, 0.221]	[0.065, 0.217]
e_4	[0.106, 0.263]	[0.097, 0.252]	[0.060, 0.196]	…	[0.074, 0.203]	[0.064, 0.197]
k_1	[0.111, 0.275]	[0.111, 0.270]	[0.103, 0.249]	…	[0.078, 0.217]	[0.059, 0.210]
k_3	[0.111, 0.260]	[0.115, 0.257]	[0.099, 0.235]	…	[0.073, 0.197]	[0.056, 0.188]
kd_1	[0.110, 0.239]	[0.103, 0.236]	[0.083, 0.206]	…	[0.062, 0.184]	[0.049, 0.175]
…	…	…	…	…	…	…

r_5	[0.011, 0.254]	[0.111, 0.251]	[0.092, 0.228]	…	[0.058, 0.175]	[0.056, 0.184]
c_1	[0.044, 0.174]	[0.043, 0.170]	[0.038, 0.155]	…	[0.064, 0.159]	[0.040, 0.143]
c_2	[0.034, 0.115]	[0.035, 0.114]	[0.031, 0.102]	…	[0.020, 0.079]	[0.036, 0.104]
c_3	[0.068, 0.187]	[0.076, 0.189]	[0.055, 0.162]	…	[0.056, 0.157]	[0.022, 0.111]

Table 12 The rough total influence relation matrix, $\tilde{\boldsymbol{T}}^{c}$.

	e_1	e_3	e_4	…	c_2	c_3
e_1	[0.087, 0.170]	[0.120, 0.209]	[0.111, 0.191]	…	[0.100, 0.167]	[0.099, 0.164]
e_3	[0.095, 0.200]	[0.058, 0.154]	[0.071, 0.177]	…	[0.072, 0.155]	[0.074, 0.154]
e_4	[0.087, 0.181]	[0.080, 0.173]	[0.047, 0.125]	…	[0.068, 0.141]	[0.065, 0.133]
k_1	[0.098, 0.184]	[0.098, 0.180]	[0.086, 0.167]	…	[0.068, 0.132]	[0.073, 0.133]
k_3	[0.117, 0.200]	[0.115, 0.196]	[0.084, 0.172]	…	[0.076, 0.141]	[0.076, 0.139]
kd_1	[0.078, 0.184]	[0.076, 0.180]	[0.065, 0.155]	…	[0.047, 0.132]	[0.050, 0.135]
…	…	…	…	…	…	…
r_5	[0.110, 0.173]	[0.107, 0.169]	[0.075, 0.145]	…	[0.058, 0.105]	[0.058, 0.105]
c_1	[0.077, 0.140]	[0.082, 0.140]	[0.063, 0.112]	…	[0.068, 0.108]	[0.066, 0.106]
c_2	[0.076, 0.142]	[0.074, 0.137]	[0.065, 0.124]	…	[0.035, 0.077]	[0.066, 0.109]
c_3	[0.077, 0.142]	[0.071, 0.138]	[0.062, 0.124]	…	[0.069, 0.119]	[0.034, 0.075]

Table 13 The rough total influence relation matrix, .

	e_1	e_3	e_4	…	c_2	c_3
e_1	[0.089, 0.232]	[0.191, 0.335]	[0.158, 0.280]	…	[0.103, 0.211]	[0.088, 0.204]
e_3	[0.126, 0.319]	[0.050, 0.203]	[0.062, 0.244]	…	[0.066, 0.194]	[0.059, 0.190]
e_4	[0.115, 0.270]	[0.098, 0.249]	[0.035, 0.139]	…	[0.062, 0.163]	[0.052, 0.149]
k_1	[0.137, 0.288]	[0.136, 0.277]	[0.111, 0.237]	…	[0.066, 0.163]	[0.054, 0.159]
k_3	[0.161, 0.297]	[0.165, 0.286]	[0.104, 0.230]	…	[0.069, 0.159]	[0.053, 0.149]
kd_1	[0.097, 0.250]	[0.098, 0.241]	[0.067, 0.182]	…	[0.037, 0.138]	[0.030, 0.134]
…	…	…	…	…	…	…
r_5	[0.152, 0.250]	[0.149, 0.242]	[0.086, 0.187]	…	[0.042, 0.105]	[0.040, 0.110]
c_1	[0.042, 0.140]	[0.044, 0.136]	[0.030, 0.099]	…	[0.054, 0.098]	[0.033, 0.086]
c_2	[0.032,	[0.033,	[0.025,	…	[0.009,	[0.029,

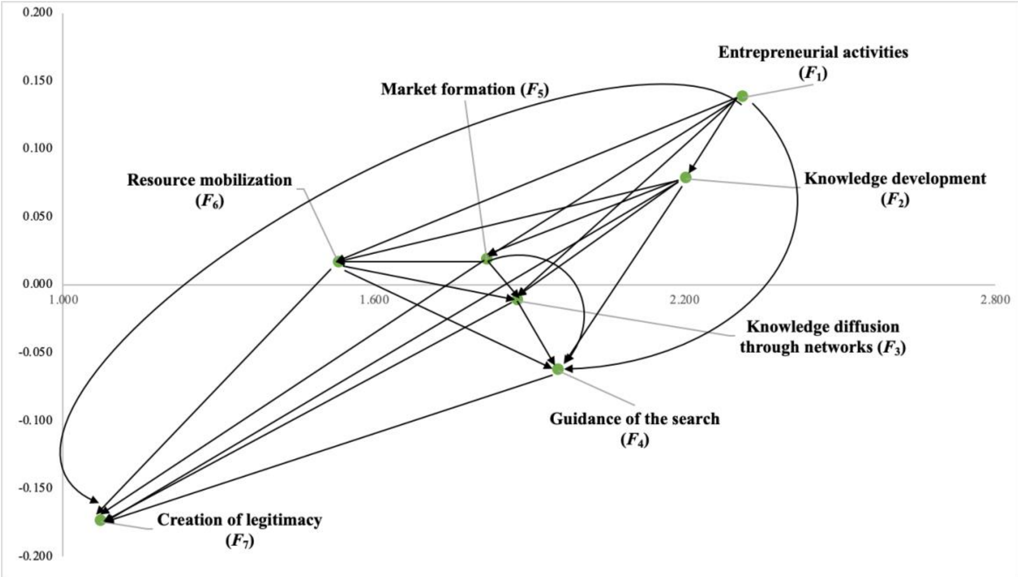
	0.093]	0.089]	0.072]		0.035]	0.065]
c_3	[0.065, 0.151]	[0.067, 0.148]	[0.043, 0.114]	…	[0.048, 0.106]	[0.009, 0.047]

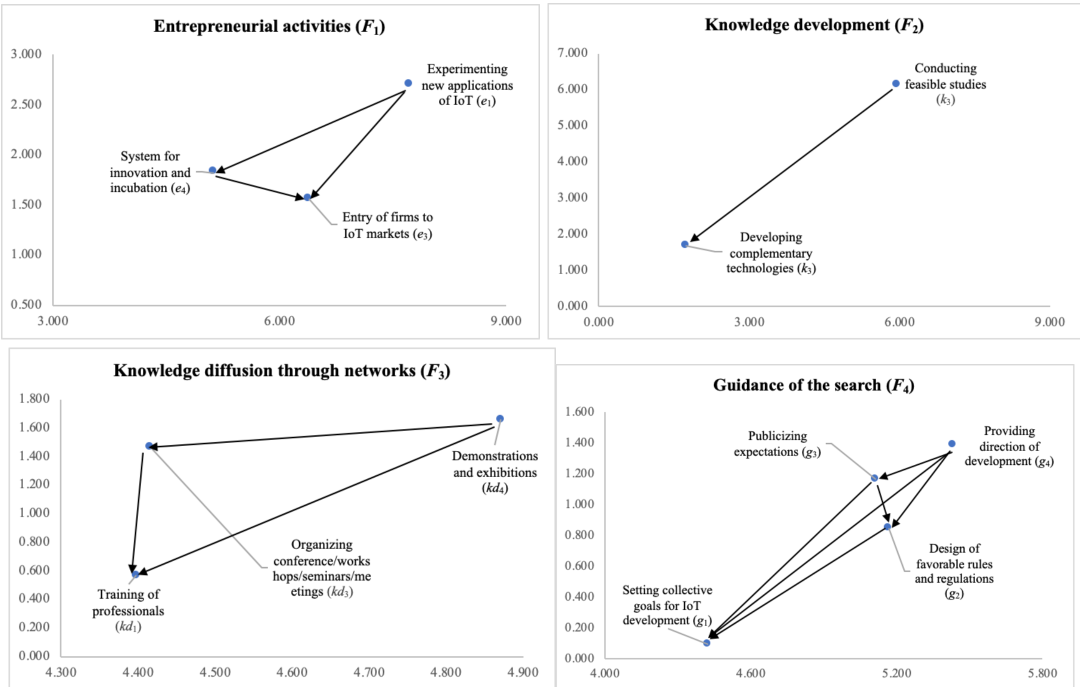
Table 14 The rough and de-roughness values of $r+c$ and $r-c$ for the systemic criteria.

	$\tilde{r}$	$\tilde{c}$	r	c	$r+c$	$r-c$
e_1	[3.334, 6.174]	[2.505, 5.335]	5.208	2.505	7.713	2.702
e_3	[1.957, 5.668]	[2.417, 5.115]	3.971	2.417	6.388	1.554
e_4	[2.051, 4.872]	[1.648, 4.096]	3.476	1.648	5.124	1.828
k_1	[2.373, 5.101]	[2.016, 4.847]	3.842	2.106	5.948	1.737
k_3	[2.470, 5.097]	[2.228, 4.796]	3.901	2.228	6.129	1.674
kd_1	[1.294, 4.146]	[1.916, 4.696]	2.481	1.916	4.397	0.566
kd_3	[1.694, 4.429]	[1.472, 4.338]	2.943	1.472	4.415	1.471
kd_4	[1.743, 4.869]	[1.606, 4.358]	3.265	1.606	4.871	1.660
g_1	[1.353, 3.700]	[2.615, 4.661]	2.260	2.165	4.425	0.095
g_2	[1.987, 4.209]	[2.161, 4.527]	3.005	2.161	5.166	0.845
g_3	[2.022, 4.386]	[1.975, 4.155]	3.140	1.975	5.114	1.165
g_4	[2.315, 4.506]	[2.023, 4.251]	3.408	2.023	5.431	1.385
m_1	[1.964, 3.981]	[1.733, 3.947]	2.853	1.733	4.586	1.120
m_2	[1.388, 3.039]	[1.951, 4.215]	1.935	1.951	3.886	-0.016
m_3	[1.793, 4.577]	[1.628, 3.623]	3.106	1.628	4.733	1.478
m_4	[2.175, 4.705]	[1.853, 4.096]	3.447	1.853	5.300	1.594
r_1	[1.109, 3.409]	[1.267, 3.283]	1.917	1.267	3.184	0.650
r_3	[1.698, 3.376]	[2.041, 4.240]	2.331	2.041	4.372	0.291
r_4	[1.426, 2.711]	[1.125, 2.791]	1.813	1.125	2.938	0.689
r_5	[2.117, 4.094]	[1.506, 3.239]	3.022	1.506	4.528	1.517
c_1	[0.846, 2.322]	[1.120, 2.746]	1.196	1.120	2.316	0.077
c_2	[0.666, 1.627]	[1.215, 3.024]	0.808	1.215	2.024	-0.407
c_3	[0.885, 2.330]	[1.004, 2.895]	1.231	1.004	2.235	0.227

Table 15 The total influence relation matrix and sum of the systemic function effect.

	F_1	F_2	F_3	F_4	F_5	F_6	F_7	R	C	R-C	R+C
F_1	0.178	0.203	0.181	0.200	0.184	0.153	0.127	1.225	1.087	2.312	0.138
F_2	0.202	0.159	0.173	0.194	0.166	0.139	0.107	1.140	1.062	2.202	0.078
F_3	0.165	0.156	0.121	0.147	0.132	0.111	0.099	0.932	0.944	1.875	0.012
F_4	0.161	0.167	0.147	0.139	0.134	0.113	0.085	0.947	1.010	1.956	0.063
F_5	0.165	0.162	0.137	0.141	0.116	0.107	0.088	0.917	0.899	1.816	0.018
F_6	0.138	0.137	0.122	0.125	0.103	0.083	0.065	0.773	0.757	1.530	0.016
F_7	0.079	0.078	0.062	0.063	0.065	0.050	0.051	0.449	0.623	1.072	0.174





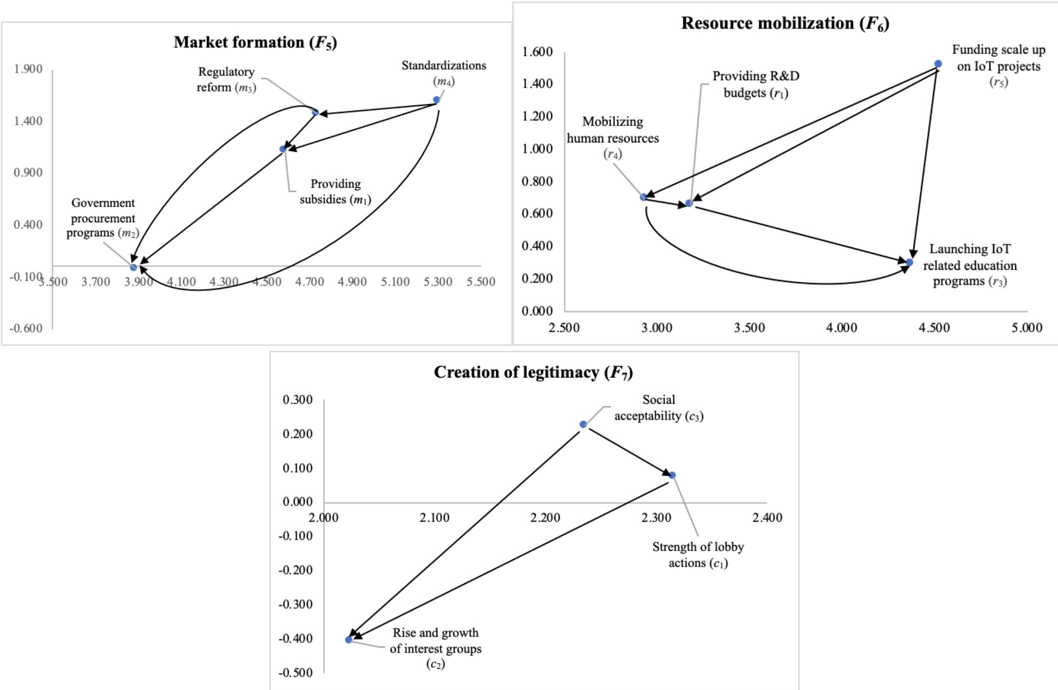


Figure 3 The IRM

Note: This IRM graph illustrates the influential relationships between factors. Directed line means causal relations from factor influencing others to factor being influenced.

5.4 Performance evaluation of systemic innovation problems for the sustainability of IoT in the manufacturing industries

After obtaining the results of systemic functions evaluation, the causal relationship network can be seen as a basis for policy makers and policy analysts who are able to understand what kind of factors will influence IoT industrial sustainability and how these factors influence each other. In this sub-Section, the systemic innovation problems will be explored and assessed. By the performance evaluation of systemic innovation problems, policy makers can easily understand how to incrementally improve these systemic problems to referring to performance-gap analyses.

By the prior literature [6, 8, 9, 16, 20, 28, 47, 89], the potential systemic innovation problems have been introduced in Table 2. The modified Delphi method (Section 3.4) was also depicted. According to the illustration modified Delphi, 75% was recognized as a minimum percentage of agreement for each alternative being evaluated. Table 16 depicts the evaluative results by modified Delphi and all systemic innovation problems over the minimum rate.

Table 16 The evaluative results of *SP*s based on the modified Delphi method.

No.	**Gender**	**Experiences**	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
1	Male	15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	Male	15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	Male	20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	Male	20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
5	Male	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	Male	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	Male	>20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
8	Male	15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	Male	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10	Male	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	Male	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12	Male	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
13	Male	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	Male	>20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
15	Male	>20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Agree (Yes)			15	15	15	15	15	15	15	15	15	15	12
Disagree (No)			0	0	0	0	0	0	0	0	0	0	3
Agree %			100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	80%
Disagree %			0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%

Note: Experience means the years of work experiences. SP means systemic problems. This table explains the suitability of SPs in accordance with experts' opinions.

5.4.1 The Derivation of the influential weights by the BR-DNP method

By the normalization way, the scores of criteria associated with each systemic function within the $\tilde{T}_D^{\alpha}$ were transformed into the values between 0 and 1. The unweighted supermatrix $\tilde{W} = \left(\tilde{T}_C^{\alpha}\right)$ can be derived by Equation (43). Then, the weighted supermatrix $\tilde{W}^{\alpha}$ can be derived by Equation (45). The final influential weights corresponding to each systemic function (Table 17) can be derived by raising the power of the weighted supermatrix to approach infinity. BR-DBP allows us to derive the local weights of the systemic criteria at their respective hierarchical levels as well as the global weights which can further confirm the importance assigned to each individual criterion. The result of the weights on systemic function and criteria being shown in Table 17. Based on BR-DNP result, developing complementary technologies (k_3), conducting feasibility studies (k_1), experimenting with new applications of IoT (e_1), entry of firms to IoT markets (e_4), and training of professionals (kd_1), were ranked as criteria with the highest weights.

Table 17 Influential weights on systemic functions and criteria.

Functions	Local Weight	Ranking	Criteria	Local Weight	Ranking	Global Weight	Ranking
F_1	0.172	1	e_1	0.375	1	0.065	3
			e_3	0.358	2	0.062	4
			e_4	0.267	3	0.046	7
F_2	0.168	2	k_1	0.493	2	0.083	2
			k_3	0.507	1	0.085	1
F_3	0.143	4	kd_1	0.364	1	0.052	5
			kd_3	0.312	2	0.045	8
			kd_4	0.324	1	0.046	6
F_4	0.160	3	g_1	0.259	1	0.042	9
			g_2	0.259	2	0.041	10
			g_3	0.238	4	0.038	14
			g_4	0.243	3	0.039	11
F_5	0.142	5	m_1	0.240	3	0.034	16
			m_2	0.271	1	0.038	13
			m_3	0.230	4	0.033	18
			m_4	0.259	2	0.037	15
F_6	0.119	6	r_1	0.227	3	0.027	22
			r_3	0.326	1	0.039	12
			r_4	0.200	4	0.024	23
			r_5	0.247	2	0.029	21
F_7	0.096	7	c_1	0.327	2	0.031	19
			c_2	0.355	1	0.034	17
			c_3	0.318	3	0.030	20

Note: This table shows the weights of factors (called F, systemic functions) and sub-factors (systemic criteria), and weights' ranking.

5.4.2 Assessing the gap between the current status and the aspired level by the MBR-VIKOR

In order to analyze the performance-gaps in the systemic innovation problems for helping define the IoT innovation policy, the MBR-VIKOR based BR-DNP weights was introduced to treat such problems. Based on the experts' opinions (refer to Table 18), the evaluation data are further transformed into the rough decision matrix by using the Equations (1) to (5). The results are demonstrated in Table 19 and Table 20. After that, Equations (46) to (52) were introduced to derive the performance-gaps. The priorities verse each function and criteria were ranked accordingly. The findings being derived from the hybrid Bayesian Rough framework can serve the basis of innovation policy reconfigurations by policy makers.

Table 18 Evaluation data for systemic innovation problems.

VD1							
Functions/Criteria		***SP*₁**	***SP*₂**	**…**	***SP*₉**	***SP*₁₀**	***SP*₁₁**
F_1	e_1	(4;4)	(3;2)	…	(4;3)	(3;2)	(2;1)
	e_3	(4;4)	(3;2)	…	(2;1)	(2;2)	(2;1)
	e_4	(3;3)	(3;3)	...	(3;3)	(1;1)	(0;1)
F_2	k_1	(2;2)	(2;2)	...	(2;0)	(1;1)	(0;3)
	k_3	(2;2)	(1;1)	...	(1;1)	(1;0)	(0;3)
F_3	kd_1	(0;0)	(0;0)	...	(2;2)	(3;3)	(0;4)
	kd_3	(0;0)	(0;0)	...	(3;3)	(1;0)	(2;2)
	kd_4	(0;0)	(1;1)	...	(3;3)	(1;0)	(2;2)
F_4	g_1	(0;3)	(0;0)	...	(3;3)	(1;0)	(0;2)
	g_2	(3;1)	(2;2)	...	(4;4)	(1;1)	(2;2)
	g_3	(1;1)	(2;2)	...	(3;3)	(1;1)	(0;2)
	g_4	(1;0)	(3;3)	...	(2;2)	(4;1)	(0;0)
F_5	m_1	(0;0)	(0;0)	...	(2;2)	(1;1)	(0;3)
	m_2	(0;0)	(1;1)	...	(2;2)	(1;1)	(2;2)
	m_3	(0;3)	(1;1)	...	(3;3)	(2;1)	(0;0)
	m_4	(3;0)	(2;2)	...	(3;3)	(2;1)	(4;0)
F_6	r_1	(0;2)	(2;2)	...	(0;1)	(0;1)	(0;3)
	r_3	(2;0)	(3;3)	...	(3;3)	(1;1)	(3;2)
	r_4	(0;0)	(0;0)	...	(3;3)	(4;1)	(0;2)
	r_5	(0;0)	(0;0)	...	(3;3)	(2;2)	(0;2)
F_7	c_1	(2;2)	(2;2)	...	(2;2)	(1;1)	(2;3)
	c_2	(1;1)	(1;1)	...	(2;2)	(2;2)	(2;2)
	c_3	(0;0)	(0;0)	...	(3;3)	(2;2)	(2;1)
⋮							
VD15							
Functions/criteria		SP_1	SP_2	...	SP_9	SP_{10}	SP_{11}
F_1	e_1	(3;4)	(3;4)	...	(3;4)	(2;4)	(2;4)
	e_3	(3;4)	(3;4)	...	(3;4)	(2;4)	(2;4)
	e_4	(4;4)	(4;4)	...	(4;4)	(4;4)	(2;2)
F_2	k_1	(4;4)	(4;4)	...	(4;4)	(4;4)	(2;2)
	k_3	(4;4)	(4;4)	...	(4;4)	(4;4)	(2;2)
F_3	kd_1	(4;4)	(4;4)	...	(4;4)	(4;4)	(3;3)
	kd_3	(4;4)	(4;4)	...	(2;2)	(4;4)	(2;2)
	kd_4	(4;4)	(3;3)	...	(4;4)	(4;4)	(2;2)
F_4	g_1	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
	g_2	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
	g_3	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
	g_4	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
F_5	m_1	(3;3)	(4;4)	...	(3;3)	(3;3)	(3;3)
	m_2	(4;4)	(1;1)	...	(1;1)	(3;3)	(3;3)

	m_3	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
	m_4	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
F_6	r_1	(3;3)	(4;4)	...	(4;4)	(4;4)	(4;4)
	r_3	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
	r_4	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
	r_5	(2;2)	(2;2)	...	(2;2)	(2;2)	(2;2)
F_7	c_1	(4;4)	(4;4)	...	(4;4)	(4;4)	(4;4)
	c_2	(3;3)	(3;3)	...	(3;3)	(3;3)	(3;3)
	c_3	(4;4)	(2;2)	...	(3;3)	(3;3)	(3;3)

Table 19 Rough decision matrix of systemic innovation problems, VD^p .

Criteria	SP_1	SP_2	…	SP_9	SP_{10}	SP_{11}
e_1	[3.751, 3.982]	[2.863, 3.788]	…	[2.361, 3.681]	[2.207, 2.875]	[1.692, 2.727]
e_3	[3.360, 3.840]	[2.704, 3.554]	…	[1.748, 2.119]	[2.403, 3.469]	[1.748, 2.119]
e_4	[1.738, 3.169]	[3.360, 3.840]	…	[2.738, 3.124]	[1.903, 3.521]	[1.225, 2.038]
k_1	[2.329, 3.721]	[2.947, 3.834]	…	[1.725, 2.881]	[1.439, 2.476]	[1.049, 2.520]
k_3	[2.678, 3.707]	[2.329, 3.727]	…	[1.853, 3.347]	[1.814, 3.518]	[1.049, 2.520]
kd_1	[1.091, 3.049]	[1.813, 3.656]	…	[2.569, 3.564]	[3.284, 3.782]	[0.893, 2.400]
⋮	⋮	⋮	⋮	⋮	⋮	⋮
r_5	[0.394, 1.914]	[0.417, 2.393]	…	[2.538, 2.929]	[2.099, 1.249]	[0.934, 2.496]
c_1	[2.349, 3.130]	[0.579, 1.862]	…	[2.065, 2.628]	[1.261, 3.840]	[1.964, 3.491]
c_2	[2.042, 3.002]	[1.168, 2.726]	…	[2.071, 2.462]	[2.108, 0.000]	[1.879, 3.320]
c_3	[0.693, 2.347]	[1.574, 2.881]	…	[3.000, 3.000]	[2.108, 3.674]	[1.791, 3.152]

Table 20 Rough decision matrix of systemic innovation problems, VD^c .

Criteria	SP_1	SP_2	…	SP_9	SP_{10}	SP_{11}
e_1	[3.284, 3.782]	[3.125, 3.793]	...	[2.679, 3.786]	[2.274, 3.078]	[1.404, 2.803]
e_3	[3.218, 3.716]	[3.007, 3.651]	...	[1.530, 2.379]	[2.250, 3.239]	[1.561, 2.757]
e_4	[1.578, 2.947]	[3.284, 3.782]	...	[2.738, 3.124]	[1.370, 2.922]	[1.180, 2.282]
k_1	[2.153, 3.692]	[3.125, 3.793]	...	[0.916, 2.494]	[1.214, 2.321]	[1.130, 2.927]
k_3	[2.863, 3.778]	[2.966, 3.789]	...	[1.333, 2.667]	[0.885, 2.812]	[1.130, 2.927]
kd_1	[1.651, 3.069]	[2.806, 3.784]	...	[2.222, 3.111]	[3.111, 3.556]	[1.315, 3.058]
⋮	⋮	⋮	⋮	⋮	⋮	⋮
r_5	[0.394, 1.914]	[0.417, 2.393]	...	[2.538, 3.929]	[2.099, 2.859]	[1.136, 2.604]
c_1	[2.349, 3.130]	[0.579, 1.862]	...	[2.065, 2.628]	[1.261, 2.609]	[2.020, 3.543]
c_2	[2.042, 3.002]	[1.168, 2.726]	...	[2.071, 2.462]	[2.108, 2.858]	[1.870, 3.320]
c_3	[0.693, 2.347]	[1.574, 2.881]	...	[3.000, 3.000]	[2.108, 2.858]	[1.680, 3.130]

The empirical results of performance-gap (see Table 21) analysis have pinpointed that which systemic criteria need to be improved preferentially. This practical and flexible instrument, on the one hand, enables policy makers to make decisions efficiently. Further, this analytical tool can derive the priorities in terms of all the systemic innovation problems to concentrate on the improvements of pain points in order to enhance the firm competitiveness within the related IoT industries. More specifically, the result of MBR-VIKOR, as show in Figure 4, illustrates that policy analysts and public sectors are able to understand the pros and cons for different systemic problems.

Table 21 Gap evaluation of systemic innovation problems by MBR-VIKOR approach.

Criteria	**Local Weights**	**Global Weights**	**The Performance Gap of Systemic Innovation Problems**										
			SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
F_1	0.172	–	0.007	0.004	0.011	0.014	0.005	0.024	0.010	0.004	0.021	0.018	0.037
e_1	0.375	0.065	0.001	0.005	0.017	0.014	0.003	0.014	0.003	0.006	0.011	0.022	0.040
e_3	0.358	0.062	0.002	0.007	0.007	0.012	0.007	0.035	0.015	0.002	0.045	0.015	0.039
e_4	0.267	0.046	0.017	0.001	0.010	0.015	0.004	0.022	0.013	0.005	0.007	0.015	0.032
F_2	0.168	–	0.017	0.010	0.064	0.031	0.023	0.038	0.025	0.030	0.065	0.074	0.085
k_1	0.493	0.083	0.021	0.006	0.050	0.026	0.031	0.050	0.026	0.037	0.072	0.085	0.080
k_3	0.507	0.085	0.013	0.015	0.079	0.037	0.015	0.026	0.024	0.024	0.058	0.063	0.090
F_3	0.143	–	0.040	0.010	0.044	0.043	0.009	0.076	0.018	0.018	0.005	0.024	0.033
kd_1	0.364	0.052	0.025	0.008	0.012	0.008	0.003	0.077	0.009	0.002	0.010	0.002	0.033
kd_3	0.312	0.045	0.048	0.014	0.057	0.060	0.015	0.075	0.026	0.027	0.003	0.044	0.032
kd_4	0.324	0.046	0.048	0.007	0.062	0.060	0.011	0.076	0.019	0.024	0.002	0.026	0.034
F_4	0.160	–	0.022	0.008	0.018	0.042	0.006	0.050	0.015	0.011	0.004	0.012	0.026
g_1	0.259	0.042	0.044	0.007	0.019	0.046	0.005	0.056	0.013	0.017	0.004	0.019	0.025
g_2	0.259	0.041	0.004	0.023	0.014	0.042	0.011	0.055	0.019	0.014	0.001	0.016	0.015
g_3	0.238	0.038	0.020	0.002	0.035	0.039	0.003	0.042	0.016	0.012	0.004	0.013	0.023
g_4	0.243	0.039	0.020	0.002	0.005	0.040	0.003	0.048	0.012	0.003	0.009	0.002	0.042
F_5	0.142	–	0.015	0.011	0.010	0.023	0.004	0.021	0.009	0.010	0.010	0.009	0.014
m_1	0.240	0.034	0.014	0.012	0.021	0.033	0.006	0.015	0.009	0.008	0.013	0.008	0.013
m_2	0.271	0.038	0.038	0.019	0.012	0.025	0.003	0.030	0.014	0.011	0.018	0.011	0.019
m_3	0.230	0.033	0.008	0.012	0.003	0.019	0.004	0.020	0.008	0.012	0.004	0.007	0.013
m_4	0.259	0.037	0.001	0.002	0.003	0.014	0.002	0.018	0.007	0.009	0.005	0.009	0.011
F_6	0.119	–	0.018	0.007	0.014	0.013	0.001	0.031	0.008	0.007	0.007	0.009	0.010
r_1	0.227	0.027	0.019	0.001	0.007	0.006	0.001	0.020	0.008	0.005	0.019	0.012	0.009
r_3	0.326	0.039	0.022	0.002	0.022	0.019	0.002	0.055	0.011	0.008	0.006	0.016	0.013
r_4	0.200	0.024	0.012	0.010	0.010	0.005	0.001	0.018	0.005	0.004	0.001	0.001	0.007
r_5	0.247	0.029	0.019	0.016	0.015	0.022	0.001	0.030	0.008	0.009	0.004	0.006	0.012
F_7	0.096	–	0.006	0.013	0.010	0.016	0.012	0.037	0.016	0.010	0.007	0.008	0.005
c_1	0.327	0.031	0.004	0.021	0.010	0.015	0.015	0.043	0.023	0.013	0.007	0.012	0.005
c_2	0.355	0.034	0.007	0.014	0.017	0.024	0.017	0.044	0.020	0.009	0.010	0.008	0.007
c_3	0.318	0.030	0.007	0.003	0.003	0.007	0.003	0.023	0.005	0.007	0.003	0.003	0.002
Gaps			0.231	0.116	0.284	0.324	0.099	0.486	0.170	0.151	0.193	0.250	0.343
Ranking			6	2	8	9	1	11	4	3	5	7	10

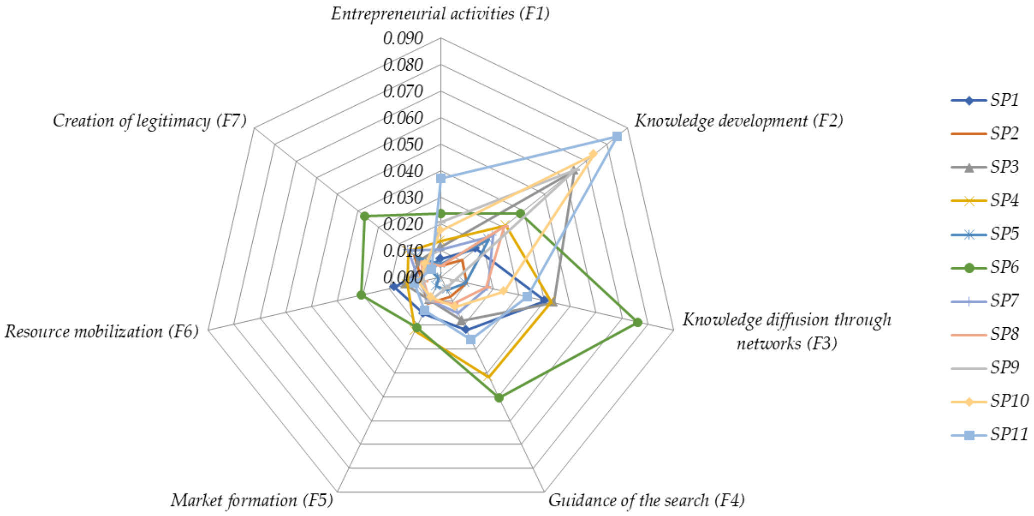


Figure 4 The comparative analysis of performance-gap based on systemic functions. Note: The wider the shape, the inferior the systemic factors' performance in each *SP*s.

5.5 The formulations of policy portfolio and roadmapping of systemic innovations for the Sustainability of the IoT Industry

In this sub-section, the policy portfolio formulation and policy roadmapping definition will be provided. The policy systemic innovation policies will be first confirmed the suitability for this research. Then, the R-GRA approach will be leveraged to derive the policy portfolios for different systemic innovation problems. Eventually, R-CSE technique will be utilized to generate the policy roadmapping based on derived policy portfolios.

5.5.1 The feasibility of alternatives by modified Delphi method

In order to precisely define innovation policy portfolios and policy path expansion in the subsequent analyses, the first step of this research is to assess the feasibility of collected systemic innovation problems (criteria) and innovation policies (alternatives) according to literature review and experts' discussion.

In this research, the systemic innovation problem influencing IoT industrial sustainability gives rise to eleven systemic innovation problems. The corresponding systemic innovation policies proposed to improve these systemic innovation problems consists of develop technical standards (IP_1), technology transfer and introduction (IP_2), revise the regulations and policies (IP_3), infrastructure development for IoT (IP_4), policies to support interdisciplinary collaboration (IP_5), direct support to firm R&D and innovation (IP_6), support experiments with novel applications (IP_7), technology resources integration (IP_8), provide professional training programs (IP_9), technology support and assistance (IP_{10}), support advocacy coalition (IP_{11}), overseas agents (IP_{12}), timely procurements (IP_{13}), and provide demonstration fields (IP_{14}).

The 15 experts who are serving for manufacturing firms in IoT based industries were invited to the investigation. Based on the results being concluded by the experts' assessment, the feasible systemic innovation problems (*SP*) and innovation policies (*IP*) for policy portfolios and policy path expansions were obtained in Table 22, respectively.

Table 22 Feasibility assessment of systemic innovation policies.

#	Years of work experience	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
1	15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2	15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3	20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4	20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
5	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7	>20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
8	15	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
10	15~20	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
11	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
12	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
13	15~20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
14	>20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
15	>20	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
	Agree	15	15	15	15	15	15	14	15	14	13	12	15	15	15
	Disagree	0	0	0	0	0	0	1	0	1	2	3	0	0	0
	Agree %	100%	100%	100%	100%	100%	100%	93%	100%	93%	87%	80%	100%	100%	100%
	Disagree %	0%	0%	0%	0%	0%	0%	7%	0%	7%	13%	20%	0%	0%	0%

5.5.2 Definition of innovation policy portfolios using R-GRA approach

After confirming the feasibility of *SP* and *IP*, the next step is to formulate the *IP* portfolios versus each *SP* problems using R-GRA approach. First, the initial relationship matrix being constructed from the experts' judgment is shown in Table 23. Subsequently, the values in initial relationship matrix can be translated into rough numbers and correspondingly the initial relationship matrix is converted into a rough average relationship matrix, as shown in Table 24. Next, the rough average relationship matrix is normalized. The rough grey relational coefficients are calculated by taking the distinguished value ζ as 0.5. The obtained results of rough grey relational coefficients are given in Table 25. The last step is to determine the rough grey relational grade. Here, the weights of each *IP* are set up equally. Therefore, the result of rough average grey relational grade is shown in Table 26. In addition, the systemic innovation policy portfolio versus each systemic innovation problems can be thereby derived using the result of rough grey relational coefficient. For example, for SP_1 problem in Table 25, the most relational systemic innovation policies can be grouped by taking a threshold as 75% of whole interval numbers in SP_1 column. As such, IP_1, IP_7, IP_8, and IP_{14} are selected as systemic innovation policy portfolio that can help solving SP_1 problem. The analytical result of systemic innovation policy portfolios is described in Table 27.

Table 23 The initial relationship matrix obtained from experts' judgment.

	SP_1	SP_2	SP_3	$\ldots SP_{11}$
Develop technical standards	[4,4,…,4]	[2,2,…,3]	[2,3,…,4]	…[0,3,…,3]
Technology transfer and introduction	[3,4,…,3]	[3,3,…,4]	[1,4,…,1]	…[1,3,…,1]
Revise the regulations and policies	[3,4,…,3]	[1,4,…,3]	[4,4,…,4]	…[1,3,…,1]
Infrastructure development for IoT	[1,3,…,4]	[3,4,…,3]	[1,3,…,2]	…[1,3,…,1]
Policies to support interdisciplinary collaboration	[4,4,…,3]	[3,2,…,3]	[1,3,…,2]	…[0,3,…,1]
Direct support to firm R&D and innovation	[3,4,…,4]	[4,4,…,3]	[1,3,…,1]	…[1,1,…,1]
Support experiments with novel applications	[2,3,…,4]	[4,4,…,3]	[1,4,....,1]	…[1,2,…,1]

Technology resources integration	[4,4,…,3]	[4,4,…,4]]	[1,4,…,1	…[3,4,…,1]
Provide professional training programs	[0,4,…,3]	[3,4,…,3]]	[1,4,…,1	…[1,4,…,1]
Technology support and assistance	[0,2,…,3]	[2,2,…,3]]	[3,2,…,1	…[4,2,…,1]
Support advocacy coalition	[0,4,…,2]	[0,2,…,2]]	[4,4,…,3	…[4,4,…,4]
Overseas agents	[2,2,…,3]	[3,3,…,3]]	[1,3,…,2	…[1,3,…,1]
Timely procurements	[1,1,…,3]	[2,3,…,3]]	[1,1,…,1	…[3,2,…,2]
Provide demonstration fields	[3,4,…,3]	[4,2,…,2]]	[2,3,…,2	…[3,3,…,3]

Table 24 The rough average relationship matrix.

	SP_1	SP_2	SP_3	…SP_{11}
Develop technical standards	[4.000,4.000]	[2.435,3.173]	[1.989,3.353]	[1.951,3.406 …]
Technology transfer and introduction	[2.524,3.561]	[3.444,3.889]	[1.819,2.884]	[1.360,2.253 …]
Revise the regulations and policies	[2.417,3.544]	[1.814,3.095]	[4.000,4.000]	[1.487,2.824 …]
Infrastructure development for IoT	[2.176,3.513]	[2.621,3.470]	[2.059,3.607]	[1.231,2.400 …]
Policies to support interdisciplinary collaboration	[2.311,3.623]	[2.754,3.246]	[2.278,3.668]	[1.383,2.739 …]
Direct support to firm R&D and innovation	[2.749,3.718]	[3.218,3.716]	[1.586,3.092]	[1.173,2.384 …]
Support experiments with novel applications	[3.062,3.727]	[2.747,3.640]	[1.670,3.002]	[1.108,2.228 …]
Technology resources integration	[2.906,3.722]	[2.524,3.561]	[1.577,2.964]	…[1.494,3.112]
Provide professional training programs	[2.343,3.765]	[2.032,3.198]	[1.734,3.055]	[1.282,2.953 …]
Technology support and assistance	[1.457,3.352]	[1.846,2.938]	[1.270,2.827]	[1.822,3.413 …]
Support advocacy coalition	[1.252,3.048]	[1.428,2.629]	[1.647,3.011]	[4.000,4.000 …]
Overseas agents	[2.144,3.325]	[2.881,3.252]	[1.347,2.309]	[1.046,2.163 …]
Timely procurements	[1.740,3.183]	[2.637,3.231]	[1.418,2.455]	[1.525,2.902 …]
Provide demonstration fields	[3.280,3.897]	[2.704,3.554]	[2.564,3.436]	[1.013,2.595 …]

Table 25 Rough grey relational coefficients.

	SP_1	SP_2	SP_3	…SP_{11}
Develop technical standards	[1.000,1.000]	[0.565,0.674]	[0.430,0.702]	[0.426,0.719 …]
Technology transfer and introduction	[0.507,0.776]	[1.000,1.000]	[0.411,0.577]	[0.365,0.465 …]
Revise the regulations and policies	[0.490,0.769]	[0.445,0.651]	[1.000,1.000]	[0.377,0.564 …]
Infrastructure development for IoT	[0.455,0.757]	[0.614,0.779]	[0.439,0.795]	[0.354,0.487 …]
Policies to support interdisciplinary collaboration	[0.474,0.801]	[0.655,0.697]	[0.469,0.821]	[0.367,0.547 …]
Direct support to firm R&D and innovation	[0.549,0.843]	[0.852,0.895]	[0.386,0.626]	[0.350,0.485 …]
Support experiments with novel applications	[0.618,0.848]	[0.652,0.856]	[0.395,0.604]	[0.345,0.462 …]
Technology resources integration	[0.581,0.846]	[0.587,0.818]	[0.386,0.595]	…[0.378,0.631

					]
Provide professional training programs	[0.478,0.866]	[0.481,0.681]	[0.402,0.617]	…	[0.359,0.592]
Technology support and assistance	[0.374,0.701]	[0.450,0.609]	[0.358,0.564]	…	[0.411,0.722]
Support advocacy coalition	[0.356,0.615]	[0.394,0.540]	[0.392,0.606]	…	[1.000,1.000]
Overseas agents	[0.450,0.693]	[0.699,0.699]	[0.364,0.473]	…	[0.340,0.453]
Timely procurements	[0.402,0.650]	[0.619,0.692]	[0.371,0.496]	…	[0.380,0.581]
Provide demonstration fields	[0.679,0.937]	[0.639,0.815]	[0.514,0.730]	…	[0.337,0.520]

Table 26 Rough average grey relational grade result.

	Grades	Ranking
Develop technical standards (IP_1)	0.639	3
Technology transfer and introduction (IP_2)	0.618	8
Revise the regulations and policies (IP_3)	0.549	11
Infrastructure development for IoT (IP_4)	0.597	9
Policies to support interdisciplinary collaboration (IP_5)	0.626	5
Direct support to firm R&D and innovation (IP_6)	0.711	1
Support experiments with novel applications (IP_7)	0.630	4
Technology resources integration (IP_8)	0.669	2
Provide professional training programs (IP_9)	0.626	6
Technology support and assistance (IP_{10})	0.594	10
Support advocacy coalition (IP_{11})	0.535	12
Overseas agents (IP_{12})	0.516	13
Timely procurements (IP_{13})	0.511	14
Provide demonstration fields (IP_{14})	0.619	7

5.5.3 Systemic innovation policy roadmapping by R-CSE Technique

After gaining the result of systemic innovation policy portfolios (see Table 27), the next step is to formulate the policy path network and, further develop its policy roadmapping. First, the relational matrix of systemic innovation policy is calculated based on R-GRA approach, as shown in Table 28. The relational matrix can be regarded as cost matrix for developing policy path expansion. Once obtaining the cost matrix, the policy path network can be thereby derived using R-CSE method.

The policy path expansion, based on the promotion of IoT industrial sustainability by utilizing R-CSE, is derived in Figure 5. In Figure 5, IP_8 stands for an innovation policy being launched initially. In the next stage, IP_6, IP_9, IP_5, and IP_1 will be developed respectively with the time. In the third stage, IP_7, IP_2, and IP_{14} will be adopted from IP_6, while IP_3, IP_4, IP_{11}, IP_{13}, and IP_1 will be used after IP_5. Moreover, according to Table 27, the ranking order of all systemic innovation problems shows that SP_5, SP_7, SP_8, and SP_2 are the most important systemic innovation problem comparing to other *SPs*. In each *SP* problem, a policy portfolio has been defined. Therefore, we can further derive corresponding policy network and policy path expansion for them through belonging policy portfolio. The Figure 6 depicts the systemic innovation policy path expansion in terms of systemic innovation problems including SP_5, SP_7, SP_8, and SP_2 respectively

Table 27 The analytical result of systemic innovation policy portfolios.

	Policy portfolios
Lack of uniform technical standards (SP_1)	IP_1, IP_7, IP_8, IP_{14}
The innovation intensity is insufficient (SP_2)	IP_2, IP_6, IP_7, IP_{14}
Regulatory constrains for IoT development (SP_3)	IP_3, IP_4, IP_5, IP_{14}
Lack of sufficient infrastructure for IoT development (SP_4)	IP_4, IP_5, IP_6, IP_{14}
Low level of interdisciplinary collaboration (SP_5)	IP_5, IP_6, IP_7, IP_8
Lack of advanced sensor technology for IoT application (SP_6)	IP_1, IP_4, IP_6, IP_{13}
Lack of effective innovation application services (SP_7)	IP_2, IP_7, IP_8, IP_9
Low capability of platform integration (SP_8)	IP_1, IP_2, IP_6, IP_8
Lack of professionals (SP_9)	IP_5, IP_8, IP_9, IP_{10}
Low level of industrial upgrading for SMEs (SP_{10})	IP_2, IP_5, IP_9, IP_{10}
Weak advocacy coalition (SP_{11})	IP_1, IP_8, IP_{10}, IP_{11}

Table 28 The cost matrix of systemic innovation policy

	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
IP_1	-	0.360	0.323	0.348	0.346	0.369	0.351	0.345	0.294	0.321	0.333	0.343	0.337	0.306
IP_2	0.393	-	0.343	0.313	0.361	0.326	0.300	0.334	0.336	0.353	0.333	0.325	0.356	0.314
IP_3	0.465	0.471	-	0.382	0.402	0.465	0.439	0.443	0.419	0.440	0.362	0.416	0.380	0.418
IP_4	0.433	0.399	0.335	-	0.380	0.377	0.376	0.407	0.363	0.400	0.380	0.352	0.380	0.339
IP_5	0.360	0.346	0.273	0.295	-	0.312	0.300	0.304	0.300	0.338	0.312	0.321	0.317	0.295
IP_6	0.391	0.305	0.399	0.307	0.351	-	0.237	0.289	0.323	0.397	0.397	0.362	0.382	0.278
IP_7	0.403	0.308	0.348	0.321	0.346	0.286	-	0.299	0.308	0.348	0.358	0.305	0.364	0.295
IP_8	0.343	0.307	0.328	0.334	0.312	0.284	0.269	-	0.285	0.314	0.333	0.340	0.376	0.308
IP_9	0.363	0.385	0.354	0.364	0.376	0.398	0.361	0.336	-	0.341	0.351	0.367	0.355	0.368
IP_{10}	0.409	0.411	0.387	0.403	0.426	0.462	0.431	0.419	0.360	-	0.330	0.382	0.389	0.401
IP_{11}	0.488	0.492	0.399	0.461	0.477	0.496	0.480	0.468	0.451	0.411	-	0.436	0.385	0.471
IP_{12}	0.462	0.425	0.360	0.371	0.435	0.451	0.394	0.437	0.397	0.389	0.363	-	0.322	0.405

IP_{13}	0.458	0.463	0.337	0.403	0.444	0.471	0.437	0.454	0.408	0.410	0.340	0.351	-	0.433
IP_{14}	0.358	0.326	0.330	0.293	0.322	0.333	0.297	0.326	0.297	0.344	0.349	0.317	0.342	-

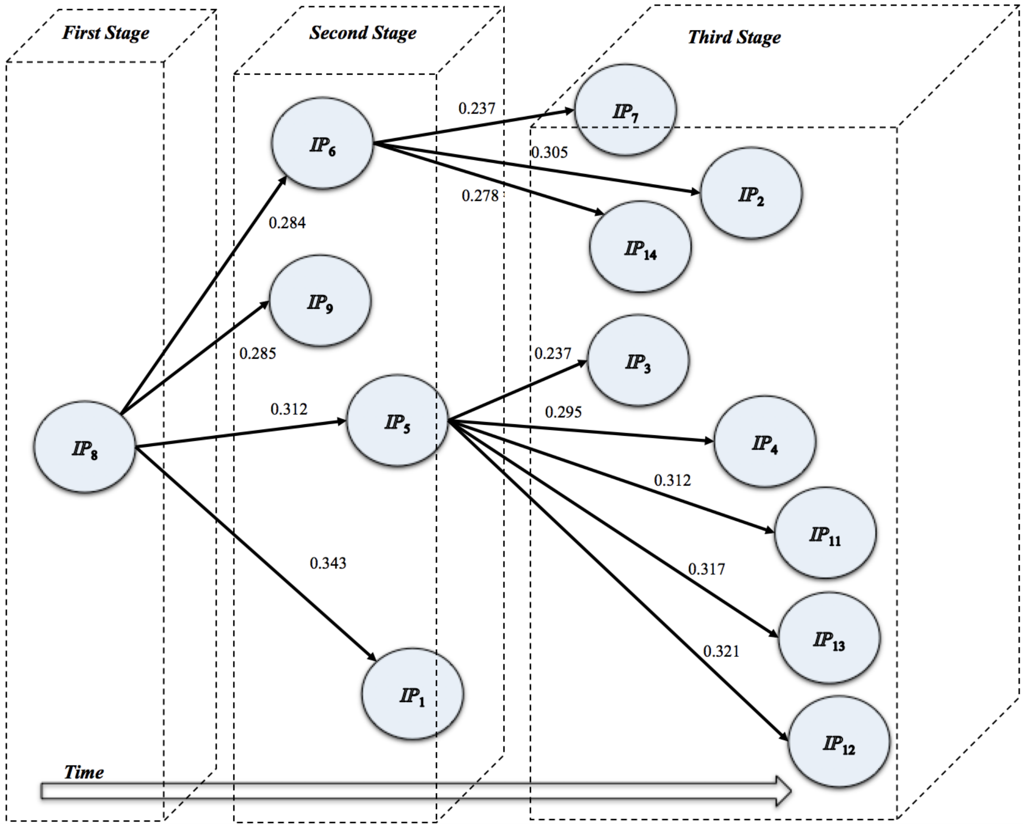


Figure 5 The path expansion of systemic innovation policy for IoT industrial sustainability (the time range will be set to a period of four years).

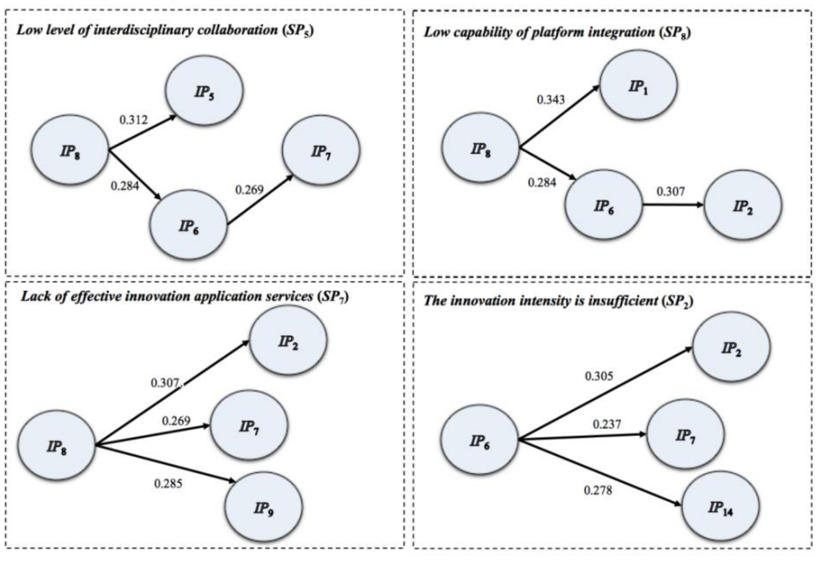


Figure 6 The systemic innovation policy path expansion for SP_5, SP_7, SP_8, and SP_2

Chpater 6 Discussion and Implications

In this research, the proposed hybrid novel MADM based integrated framework was validated with empirical case. The operation process of purposed model can be split into several folds: first, finding out the systemic factors and systemic innovation problems as well as corresponding innovation policies. Then, these systemic innovation policies and innovation problems as well as systemic factors will be further assessed the effectiveness for this research. Second, the cause-and-effect network was illustrated in terms of systemic factors. Third, systemic innovation problems were evaluated. Third, the systemic innovation policy portfolios versus systemic innovation problems influencing IoT industrial sustainability will be configured. Finally, developing the systemic innovation policy roadmapping based on these systemic innovation problems. Through empirical validation of proposed model, the analytical results were obtained. In this section, the discussion and implications will be further illustrated.

6.1 Implications of the systemic functions evaluation

To discuss the policy suggestions of the empirical analysis for IoT industrial sustainability, the analytical results of the functions and criteria level and the causal networks will be presented.

Based on the empirical analysis of causality in systemic factors (refer to Figure 3), the arrow direction, such as Entrepreneurial activities (F_1) → knowledge development (F_2), means F_1 influences F_2. The several major influential sequences can be described as follows:

(1) Entrepreneurial activities (F_1) → knowledge development (F_2) → knowledge diffusion through networks (F_3) → guidance of the search (F_4) → creation of legitimacy (F_7);

(2) Entrepreneurial activities (F_1) → knowledge development (F_2) → guidance of the search (F_4) → creation of legitimacy (F_7);

(3) Entrepreneurial activities (F_1) → knowledge development (F_2) → knowledge diffusion through networks (F_3) → creation of legitimacy (F_7);

(4) Entrepreneurial activities (F_1) → knowledge development (F_2) → market formation (F_5) →knowledge diffusion through networks (F_3) → creation of legitimacy (F_7);

(5) Entrepreneurial activities (F_1) → knowledge diffusion through networks (F_3) → creation of legitimacy (F_7); and

(6) Entrepreneurial activities (F_1) → market formation (F_5) → resource mobilization (F_6) →knowledge diffusion through networks (F_3) → creation of legitimacy (F_7).

Regarding to criterion level, Table 14 shows the innovative IoT experiments (e_1), conducting feasible studies (k_1), demonstrations and exhibitions (kd_4), providing direction of development (g_4), standardizations (m_4), funding scaling up on IoT projects (r_5), and social acceptability (c_3) have the greatest influence on other criteria within the relevant functions. In contrast, experimenting with new applications of IoT (e_1), developing complementary technologies (k_2), demonstrations and exhibitions (kd_4), providing direction of development (g_4), standardizations (m_4), funding scaling up on IoT projects (r_5), and strength of lobby actions (c_1) with the largest values of are the major criteria that influence other criteria within the observed functions. Further, derived causality network can be served as the reference for policy direction and industrial sustainability.

6.2 Implications of the systemic innovation problem evaluation

After the systemic innovation problems being identified, public sectors basing these problems can further provide a series of policies to deal with. This paper thus proposes an appropriate analytical framework for such problems. In the following, the systemic problems will be discussed in terms of result by BR-DNP and the MBR-VIKOK.

6.2.1 Gaps for each systemic innovation problem

Firstly, this paper conducts a sensitivity examination by adjusting 10% of the parameters at a time, as shown in Table 29, for understanding stability of the derived results by MBR-VIKOR. It can be noticed that a low level of interdisciplinary collaboration (SP_5) possesses the lowest scores of R_k (Table 29) implying that it has the maximum priority in most situations. More specifically, when v = 0.0 and 0.1, the lowest R_k is the "the innovation intensity is insufficient" (SP_2) with the values of 0.023 and 0.041. The largest R_k scores are "weak advocacy coalition" (SP_{11}) and the "lack of advanced sensor technology for IoT application" (SP_6) with, scores of 0.090 and 0.159, respectively. The ranking result of systemic problems reveals $SP_6 < SP_{11} < SP_4 < SP_3 < SP_{10} < SP_1 < SP_9 < SP_7 < SP_8 < SP_2 < SP_5$. Besides, systemic problems can be improved by the derived results. In this paper, the author will focus on the weakest problems and provide feasible enhancement strategies.

(1) **Insufficient infrastructure for IoT development (*SP*$_4$)**. Based on the performance-gap result by MBR-VIKOR, the most superior factor is resource mobilization (F_6) with the 0.013 gap ratio, while the most inferior factors are guidance of the search (F_4; gap ratio 0.042), knowledge diffusion through networks (F_3; gap ratio 0.043), and knowledge development (F_2; gap ratio 0.031). From perspective of enhancement, these inferior factors should be improved than other factors. Further, this paper also found the publicizing expectations (g_3; gap ratio 0.039), setting collective goals for IoT development (g_1; gap ratio 0.031), providing directions of development (g_4; gap ratio 0.040) and design of favorable rules and regulations (g_2; gap ratio 0.031) need to be improved preferentially. In practical, based on the analytical results, public sectors should plan even more budget for establishing the experiment center or open laboratory for start-ups and other companies in IoT industries. In the meantime, public sectors also need to push the collaboration activities for enhancing the connection between manufacturing firms and other units.

(2) **Lack of advanced sensor technology for IoT applications (*SP*$_6$)**. Based on the performance-gap result by MBR-VIKOR, the most superior functions are entrepreneurial activities (F_1; gap ratio 0.024), market formation (F_5; gap ratio 0.021). The experimenting new applications of IoT (e_1; gap ratio 0.014) is more superior factor

in the criterion level. From the perspective of improvement, the knowledge diffusion through networks function (F_3; gap ratio 0.076), the criteria for training of professionals (kd_1; gap ratio 0.077), organizing conference/workshops/seminars/meetings (kd_3; gap ratio 0.075), and demonstrations and exhibitions (kd_4; gap ratio 0.076) are placed on the enhancement list. It means these factors should be preferentially improved. Practically, public sectors need to focus on how to motivate network cooperation between different units and companies and based on such action to influence knowledge diffusion. On the other hand, public sectors can also hold various conferences and workshops regarding industrial innovation for cooperation of research and industry and offer exhibition center and area as open fields for innovative experiment and validation.

(3) Weak advocacy coalition (SP_{11}). By the empirical result, the most advantageous functions are social acceptability (c_3; gap ratio 0.002) and creation of legitimacy (F_7; gap ratio 0.005). Conversely, the most disadvantageous factors are knowledge development (F_2; gap ratio 0.085), developing complementary technologies (k_3; gap ratio 0.090) and conducting feasibility studies (k_1; gap ratio 0.080). In the perspective of improvement, conducting feasibility studies in IoT innovations can be the strategic action for promotion of IoT sustainability. By doing so, combining the power of interest groups, the mutual collaboration between industries will be well-developed.

Table 29 Sensitivity analysis for R_k score and ranking.

SP	v = 0	Ranking	v = 0.1	Ranking	v = 0.2	Ranking	v = 0.3	Ranking	v = 0.4	Ranking	v = 0.5	Ranking	v = 0.6	Ranking	v = 0.7	Ranking	v = 0.8	Ranking	v = 0.9	Ranking	v = 1.0	Ranking
SP_1	0.048	5	0.085	5	0.121	6	0.158	6	0.194	6	0.231	6	0.268	6	0.304	6	0.341	6	0.378	6	0.414	6
SP_2	0.023	1	0.041	1	0.060	2	0.079	2	0.097	2	0.116	2	0.135	2	0.153	2	0.172	2	0.191	2	0.210	2
SP_3	0.079	9	0.120	9	0.161	8	0.202	8	0.243	8	0.284	8	0.326	8	0.367	8	0.408	8	0.449	8	0.490	8
SP_4	0.060	6	0.113	7	0.166	9	0.218	9	0.271	9	0.324	9	0.377	9	0.429	9	0.482	9	0.535	9	0.588	9
SP_5	0.031	3	0.044	2	0.058	1	0.071	1	0.085	1	0.099	1	0.112	1	0.126	1	0.140	1	0.153	1	0.167	1
SP_6	0.077	8	0.159	11	0.241	11	0.323	11	0.404	11	0.486	11	0.568	11	0.650	11	0.732	11	0.814	11	0.896	11
SP_7	0.026	2	0.055	3	0.084	4	0.112	4	0.141	4	0.170	4	0.198	4	0.227	4	0.256	4	0.285	4	0.313	4
SP_8	0.037	4	0.060	4	0.083	3	0.106	3	0.129	3	0.151	3	0.174	3	0.197	3	0.220	3	0.243	3	0.266	3
SP_9	0.072	7	0.096	6	0.120	5	0.145	5	0.169	5	0.193	5	0.218	5	0.242	5	0.266	5	0.291	5	0.315	5
SP_{10}	0.085	10	0.118	8	0.151	7	0.184	7	0.217	7	0.250	7	0.283	7	0.316	7	0.349	7	0.382	7	0.415	7
SP_{11}	0.090	11	0.140	10	0.191	10	0.241	10	0.292	10	0.343	10	0.393	10	0.444	10	0.494	10	0.545	10	0.595	10

6.3 Implications of the systemic innovation policy portfolios

and policy roadmapping

In this part, the proposed hybrid framework was proposed to formulate policy portfolios and policy roadmapping. The operation process of purposed model can be split into three folds: first, finding out the systemic innovation problems and corresponding innovation policies. Then, these systemic innovation policies and innovation problems will be further assessed the effectiveness for this research. Second, the systemic innovation policy portfolios versus systemic innovation problems influencing IoT industrial sustainability will be configured. Third, developing the systemic innovation policy roadmapping based on these systemic innovation problems. Through empirical validation, the analytical results were obtained. In this section, the discussion will be illustrated.

6.3.1 The implications of systemic innovation policy portfolio modeling and policy roadmapping

Regarding the empirical analysis in this research, the low level of interdisciplinary collaboration (SP_5) has the greatest performance than other systemic problems. In general, industrial IoT application focuses on collecting data using sensor detection. Once the data extraction, transform, and load can be finished, the analysis can be further started. Except for the leading companies in industries, most of firms still seem that they cannot effectively employ big data and cloud computing techniques to deal with their collected data. In other words, how to transform these data into values is a challenge. Besides, the collaboration of IoT applications across different industries is relatively less. Based on the analytical result, a policy portfolio composed of four innovation policies consisting of policies to support interdisciplinary collaboration (IP_5), direct support to firm R&D and innovation (IP_6), support experiments with novel applications (IP_7) and technology resources integration (IP_8) can be used to solve this issue. Government sectors should shed more lights on enhancing the interdisciplinary collaboration among industries by taking into consideration the four policies. In solving the problem of interdisciplinary collaboration, the dynamic path expansion of policy network can also be considered. In Figure 6, the upper left graph expresses technology resources integration (IP_8) policy should be adopted in first stage, followed by direct support to firm R&D and innovation (IP_6) and support interdisciplinary collaboration (IP_5) polices in second stage, and followed by support experiments with novel applications policy (IP_7) in third stage.

The second important systemic innovation problem has to be focused is the innovation intensity is insufficient (SP_2). To strengthen innovation intensity, government sectors and policy makers should adopt a set of policies. In accordance with the analytical result of this research, a policy portfolio solving the problem of innovation intensity insufficient can give rise to four innovation policies: direct support to firm R&D and innovation (IP_6), support experiments with novel applications (IP_7), provide demonstration fields (IP_{14}) and technology transfer and introduction (IP_2). From the perspective of government sectors, in addition to encouragement of IoT innovation applications, offering many demonstration fields for enterprises to use is also pretty important. According to Figure 6, the bottom right diagram with regards to dynamic policy path expansion shows that the support to firm R&D and innovation (IP_6) is the initial policy for helping improving innovation intensity insufficient. The follow up policies can be adopted consisting of support experiments with novel applications (IP_7), provide demonstration fields (IP_{14}) and technology transfer and introduction (IP_2).

The third important systemic innovation problem that needs to be improved is lack of effective innovation application services (SP_7). In Taiwan, most of IoT innovation applications are introduced from other countries. From the government view of point, how to promote domestic firms to develop novel applications and services will be necessary. By some supportive policy tools for helping industries develop useful IoT applications, the industrial competitiveness and performance can be enhanced accordingly. In order to improve the problem of lacking the effective innovation applications and services, a policy portfolio comprising of technology transfer and introduction (IP_2), direct support to firm R&D and innovation (IP_6), support experiments with novel applications (IP_7) and technology resources integration (IP_8) is presented. In Figure 6, the bottom left graph describes technology resources integration (IP_8) policy will be first adopted in initial stage, followed by support experiments with novel applications policy (IP_7), provide professional training programs (IP_9) and technology transfer and introduction (IP_2) in the subsequent stage.

The fourth important systemic innovation problem of low capability of platform integration (SP_8) can be improved through a policy portfolio, including technology resources integration (IP_8), direct support to firm R&D and innovation (IP_6), develop technical standards (IP_1) and technology transfer and introduction (IP_2). The platform integration is a trend for manufacturing firms. This is because a comprehensive platform can be used to store, transmit, compute, visualize, and distribute the data conveniently. This integrating platform can effectively save cost in operation, manufacturing, and inventory, and enhance ability of resource allocation. With the increase of IoT application, customized product will be constantly emerging. Thus, relying on such platform to help manufacturing will be indispensable. In Figure 3, the upper right diagram illustrates technology resources integration (IP_8) policy will be first focused in the initial stage. Once the technology resources integration policy is set up, in the second stage is to introduce both innovation policies of direct support to firm R&D and innovation (IP_6) and develop technical standards (IP_1). In the final stage, technology transfer and introduction (IP_2) policy will be leveraged based on the policy of direct support to firm R&D and innovation (IP_6).

In order to facilitate the IoT industrial sustainability, the policy makers can also take into account the holistic policy path planning of systemic innovation policy, as shown in Figure 5. In Figure 5, the initial stage is to utilize the technology resources integration (IP_8) policy. In the second stage, there are four innovation policies will be considered, consisting of support to firm R&D and innovation (IP_6), provide professional training programs (IP_9), policies to support interdisciplinary collaboration (IP_5), and develop technical standards (IP_1). The support to firm R&D and innovation (IP_6) policy will be preferentially adopted than other polices in the second stage. This is because the path coefficient of IP_8 to IP_6 is

0.284, indicating the cost of efforts is least comparing to other policies in the second stage. In the third stage, two groups of policies will be considered. For the first one policy group, support experiments with novel applications (*IP_7*), provide demonstration fields (*IP_{14}*) and technology transfer and introduction (*IP_2*) policies will be used. For the second one policy group, revise the regulations and policies (*IP_3*), infrastructure development for IoT (*IP_4*), support advocacy coalition (*IP_{11}*), timely procurements (*IP_{13}*), overseas agents (*IP_{12}*) will be adopted.

Moreover, considering the time as unit, based on policy planning in a four-year lead of president in Taiwan, therefore, this research assume that the policy roadmap will last four years. Under such situation, using Figure 6 as example, the time period for policy implementation in total is four years. The unit of time is year. Hence, technology resources integration (*IP_8*) can be implemented at most one year in first stage. The support to firm R&D and innovation (*IP_6*), provide professional training programs (*IP_9*), policies to support interdisciplinary collaboration (*IP_5*) and develop technical standards (*IP_1*) need 1.137 years, 1.141 years, 1.248 years and 1.373 years, respectively (4 years multiply cost value of each path from *IP_8* to *IPs*). Next, after the policy implementation of support to firm R&D and innovation (*IP_6*), *IP_2*, *IP_7*, *and* *IP_{14}* need respectively 1.221 years, 0.949 years and 1.113 years to complete these policies. After policies to support interdisciplinary collaboration (*IP_5*), *IP_3*, *IP_4*, *IP_{11}*, *IP_{12}*, *and* *IP_{13}* need 1.091 years. 1.178 years, 1.246 years, 1.284 years, 1.268 years, respectively.

In short, policy makers can easily understand the dynamic path network of systemic innovation policies by the analytical result of proposed model. Based on the policy path expansions versus different systemic innovation problems, policy makers will be able to determine how to improve current challenges that IoT development faced, and further to promote IoT industrial sustainability.

6.4 Policy implications for sustainability of IoT in smart manufacturing

Based on the result of systemic function analysis, the systemic factors have been classified into two different groups: cause and effect. In the meantime, this paper also establishes the causal relationship network for illustrating the influential relationships between factors. Table 30 shows the influential sequences of factors.

According to Figure 3, the policy recommendation and discussion being derived: (1) From the notions of systemic function, the public sectors should first plan how knowledge development (F_2) can be conducted and how the entrepreneurial activities (F_1) can be promoted. In addition, public sectors should also establish friendly and well-functioning market for start-ups and various companies in IoT industries. In the meantime, public sectors should further re-allocate and allocate the financial resource encouraging talent mobilization from abroad to Taiwan. (2) To promote the entrepreneurial and business activities for generating possible business opportunities, the public sectors should use various policies to motivate IoT innovations and industrial sustainability. Moreover, public sectors have to keep developing the incubation activities, and encourage various units to set up incubation centers for industrial development and technological innovations. (3) In pushing IoT sustainability, public sectors need to work on planning carefully the industrial research project making the interaction between research institutes, SMEs and other units. (4) Public sectors should design a favorable market for IoT development. The first step is to adjust the existing regulations. With the reforms of regulations, the novel technologies and innovations will be suffered from regulatory limitation. Thus, appropriately modify the regulation is necessary. Besides, public sectors should also motivate companies and research organizations to develop the technical standards for IoT in manufacturing industry.

Table 30 The priority sequence for the enhancement of the innovation policy definition.

Schemes	Sequence of Enhancement Priorities
Influential causal diagram of systemic functions	(F_1), (F_2), (F_5), (F_6), (F_3), (F_4), (F_7)
Influential causal diagram of systemic criteria	(F_1): (e_1), (e_4), (e_3) (F_2): (k_1), (k_3) (F_3): (kd_4), (kd_3), (kd_1) (F_4): (g_4), (g_3), (g_2), (g_1) (F_5): (m_4), (m_3), (m_1), (m_2) (F_6): (r_5), (r_4), (r_1), (r_3)

(F_7): (c_3), (c_1), (c_2)

Note: This table shows the improving priorities based on systemic function and systemic criteria by using BR-DEMATEL. In the improving sequence of systemic function, F1 should be enhanced first, the follow up is F2, F5, and so on.

In the results of systemic innovation policy evaluation, the policy portfolios for systemic innovations have been derived. These policy portfolios depending on different systemic problems can make policy makers understand these systemic problems should be solved using what kind of policies. For instance, in the low level of interdisciplinary collaboration problem, IP_5, IP_6, IP_7, and IP_8 can be grouped as a portfolio and leveraged to improve this problem. At the same time, these policies will be arranged in terms of priority of policy implementation. In the low level of interdisciplinary collaboration problem, the priority of policy implementation in specific policy portfolio shows $IP_8 \rightarrow IP_5$ and $IP_8 \rightarrow IP_6 \rightarrow IP_7$. Given these results, policy roadmapping can be defined. For policy makers and policy analysts, such analytical results and methods can provide them a variety of viewpoints in designing and planning the policies to promote the IoT industrial sustainability and technological innovations.

6.5 The comparison of policy implementation

In this research, the author tried to analyze the IoT industrial sustainability by using quantitative model. The empirical validation showed the proposed model and analytical process are feasible. In order to further examine the effectiveness of proposed model, this research makes a comparison analysis between the event data of policy implementation by government sectors in Taiwan and empirical results of this paper. According to the national project in Taiwan, called “Asia silicon valley development project”, government sectors in recent have proposed several policies to push IoT development. The policies adopted by Taiwanese government can be illustrated as follow:

(1) Strengthening development, completing IoT innovation ecosystem. To complete this goal, Taiwanese government proposed four policies: (a) motivating IoT start-ups and innovative experiment; (b) constructing a IoT major league; (c) introducing international

resources and; (d) establishing Asia silicon valley college.

(2) Using Taiwan advantages to establish IoT software and hardware integration test beds. To complete this goal, Taiwanese government presented three policies: (a) application of smart city innovation; (b) exchange smart cities's promotion experience and; (c) regional revitalization.

Besides, in order to motivate the IoT start-ups and innovative experiment, Taiwanese government also implemented financial support, regulation change, talent invitation from abroad. For facilitating the collaboration between different units, government push the establishment of IoT league by inviting many companies including ASUS, Advantech, Acer, etc. In the meantime, government introduced the support from international companies such as Cisco and Microsoft to help establish the IoT technical standard and integrate the different software and hardware. Government also should provide the demonstration fields and motivate the IoT technical cooperation between industry and city government.

Regarding the empirical analysis in this research, the low level of interdisciplinary collaboration (SP_5) has been proposed. The collaboration of IoT applications across different industries is relatively less. Based on the analytical result, a policy portfolio composed of four innovation policies consisting of policies to support interdisciplinary collaboration (IP_5), direct support to firm R&D and innovation (IP_6), support experiments with novel applications (IP_7) and technology resources integration (IP8) can be used to solve this issue. The innovation intensity is insufficient (SP_2) has also been proposed. To strengthen innovation intensity, government sectors and policy makers should adopt a set of policies. In accordance with the analytical result of this research, a policy portfolio solving the problem of innovation intensity insufficient can give rise to four innovation policies: direct support to firm R&D and innovation (IP_6), support experiments with novel applications (IP_7), provide demonstration fields (IP_{14}) and technology transfer and introduction (IP_2).

In addition to above two proposed systemic problems for comparison to policy implementation by government sectors in Taiwan, the proposed empirical result is pretty similar to real situation of policy implementation by Taiwanese government. Also, this research also found there are still several systemic problems that Taiwanese government have not focused, such as insufficient infrastructure for IoT development (SP_4), lack of advanced sensor technology for IoT applications (SP_6) and weak advocacy coalition (SP_{11}). Thus, this research not only can provide an effective analysis and policy direction that is similar to real situation in Taiwan, but also present unique insight from other various systemic problems. In short, the proposed systemic problems and corresponding policy portfolio are feasible. In the future, government can take such analytical process and results as basis for definition of policy facilitating IoT industrial sustainability.

6.6 Advances in theoretical model and research methods

This research adopted an integrated MADM model hybridizing the Bayesian theory RF, rough interval number, modified Delphi method, DEMATL, DNP, GRA, modified VIKOR, and CSE for evaluating and analyzing industrial sustainability in IoT. In the analytical process, the critical systemic factors can be identified, the systemic innovation problems are explored and assessed, and policy portfolios and policy roadmap can be defined accordingly. Meanwhile, the proposed model and whole analytical process are empirically demonstrated the feasibility by using a manufacturing industry case in Taiwan.

The proposed model contributes to methodological development and policy modeling fields with several points. Firstly, original systemic innovation policy research being built by content analysis possibly including related documents exploitation and experts' interview. This paper takes much effort for illustrating the causal relationships between systemic factors and the evaluating of systemic innovation problems that are hampering IoT industrial sustainability in Taiwan. Given such works, the innovation policies will be proposed and used to be grouped to solve each of systemic problems and thus, policy roadmaps will be formed focusing on various systemic problems. Such analytical means not only can enhance conventional analytical process, but also can be as a novel policy evaluation tool providing a new thinking and insights on policy design and planning for policy analysts and policy makers.

Second, past studies of systemic innovation policy often adopted qualitative method. Although such approach is effective, conventional qualitative ways could be subjective and misleading [14]. To solve this problem, quantitative methods are leveraged in this paper. This research proposes an integrated MADM that can serve as an analytical tool for policy analysts to systemically analyze the industrial sustainability and policy definition issues.

Thirdly, fuzzy and grey theory as well as rough interval number often being used to deal with imprecise human judgment problem. Recently, Bayesian theory has started to integrated rough theory for tackling with human judgment problems [14]. The main advantageous of Bayesian theory is the reality of event illustration. This is because this method can simultaneously consider the conditional possibility and prior possibility of an event to derive final real outcome. Thus, the proposed methods here adopted Bayesian theory and rough interval number to deal with bias and imprecision resulted from human judgments instead [14]. Therefore, this research integrates the Bayesian theory and rough interval number into the hybrid MADM model for industrial sustainability in IoT and policy definition.

Finally, the application of systemic innovation policy roadmapping in conventional systemic innovation policy is relatively few. In this view, this research attempts to combine policy roadmapping into systemic innovation policy analysis. Given the empirical validation of proposed method, such concepts and method combination is applicable. For policy makers and policy analysts, the proposed methods will be a basis for helping innovation policy design and planning in technological innovation and industrial sustainable development.

Chpater 7 Conclusion

To help define innovation policy portfolios to improve current systemic problems hampering IoT industrial sustainability, this paper has presented a systemic evaluation model for policy makers. By hybridizing the Bayesian theory, rough interval number, RF-based SMOTE technique, and other MADM approaches, such integrating model depicted the causality among systemic factors that can facilitate the industrial sustainable development, evaluated the performances among the systemic innovation problems, determined the policy portfolios and policy roadmaps and therefore, from the basis for policy makers to policy design and planning.

In the analytical process for formulations of policy portfolios and policy roadmaps for IoT industrial sustainability, the feasible systemic innovation policy tools focusing on identified systemic innovation problems are firstly collected. Then, modified Delphi method is used to confirm the suitability of collected systemic innovation policies. Third, the R-GRA method is leveraged to define a systemic innovation policy portfolio and rank the systemic innovation problems. Finally, R-CSE method is utilized to derive the policy roadmap based policy portfolios. Based on the empirical results, low level of interdisciplinary collaboration (SP_5) needs to be enhanced since this problem has the largest gap values. Thus, the policies should be proposed to solve this problem. By using the derived policy portfolio consisting of IP_5, IP_6, IP_7, and IP_8, the policy roadmap in SP_5 can be defined as: $IP_8 \rightarrow IP_5$ and $IP_8 \rightarrow IP_6 \rightarrow IP_7$. The proposed innovation policy roadmap method is built on the dependency between systemic problems and innovation policies. Using the matrix generated by systemic problems and innovation policies, we can further use mathematical function to obtain the optimal solution instead of conventional qualitatively discussion. Therefore, R-CSE method can provide an effective perspective to deal with innovation policy definition.

This research aims to explore the IoT sustainability in manufacturing industries. In such issues, this research proposed a novel analytical framework by incorporating many methods, including DEMATEL, DNP, VIKOR, GRA, CSE, rough set theory, and Bayesian theory. In order to analyze comprehensively IoT sustainability, this research used manufacturing industries in Taiwan as empirical case. Taiwan not only has been played the essential role in recent decades in manufacturing industries, but also Taiwan has had the strong manufacturing capability and experiences that can be seen as a modern example. This research contributes the innovation policy fields and research methods with several innovations and ideas.

First, this research proposed an analytical process. In this analytical process, this research initially explores the causal relationship among factors in order to understand how the factors will influence each other. Following this path, this research further discusses what kind of problems which are hampering industrial sustainable development. Based on these problems, called systemic innovation problems, this research calculates the gap values of these problems. This way is to understand how the distance between ideal goal and current problems are, and how to thereby enhance these problems. Finally, this research proposed several important innovation policies that can be adopted to solve existing innovation problems. In addition, proposed analytical processes have improved conventional systemic policy analysis by integrating quantitative perspective and MADM concepts.

Second, this research proposed a novel model. Such model is the first one being proposed for empirical case. The major differences of this model and other models are human judgment problem. This research combined the Rough set theory and Bayesian theory simultaneously to deal with imprecision from human judgment (such as linguistic transformation). Besides, this research also adopted CSE method to derive the policy roadmaps, such application can be the foundation for future analyses.

Finally, this research identified the systemic factors, innovation problems, and innovation policies. The innovation problems being collected from the literature and made a modification for match the situations of manufacturing industries in Taiwan. The innovation policies have also been modified in order to compatible to innovation problems. Future studies can extend and refer to the identified innovation problems and policies.

Although this research has successfully establishes a novel hybrid MADM based integrated framework to analyze the IoT industrial sustainability with an empirical case validation in terms of systemic innovation perspectives in which systemic problems and factors are identified and explored, and the systemic innovation policy portfolios and the systemic innovation policy roadmapping are formulated, several limitations and some interesting issues can be discussed and proposed.

First, the sample collection is limited to the country of Taiwan, which implies that study reflects only the situation in that nation. Moreover, this research merely adopts a manufacturing industry in Taiwan as empirical case for validating the proposed framework. This means the generalization needs to be further examined and validated. Second, this research utilizes the systemic innovation theoretical concept to build up the evaluation framework. The limitation is the possibility of introducing other analytical concepts and theoretical models that are not considered in this research. In other words, future studies can utilize different theories and various criteria to empirically analyses.

Besides, the empirical results and used policies and systemic problems in this research are based on the specific situation, such as IoT industry. However, the suitability of framework for future studies needs to be re-designed. Thus, future studies can take this research framework and process as a basis, and further define appropriate systemic factors, problems and policies for certain industry or technology. Moreover, this paper collected the systemic problems and policies from the literature review. Based on the past studies, we can obtain many of innovation problems and policies. Then, these innovation policies and innovation problems can be grouped respectively as the candidate pools in which future studies can select potential candidates for policy analysis. Next, future studies can make a suitability check for these selected potential candidates for understanding if these candidates is appropriateness or not for research topic.

Third, although the rough interval numbers can effectively treat the subjective collective judgments, objective information and data should also be simultaneously taken into consideration, as this measure may be a better way to eliminate subjective judgments as much as possible. Finally, the proposed methodology achieved success with empirical validation. Nevertheless, it would be feasible to apply other approaches such as MAIRCA and fuzzy integral and compare their results. Therefore, future research can use the methods from this research as a reference for developing more robust techniques and can generalize it to other academic and practical areas. Further, the final limitation is that this research does not consider the relationships between current innovation policy portfolios and actors of related policy making. Future studies can attempt to focus this point in more detail.

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Appendix A1. Questionnaire for personal information

1. Gender:
   a. Male
   b. Female
2. Work experiences:
   a. Less than 5 years
   b. 5 – 10 years
   c. 10 – 15 years
   d. Over 15 years
3. Which of the following occupation fields you are currently serving for
   a. Manufacturing industries
   b. Research institutes
   c. Universities
   d. Government sectors
4. Job title: ____________________

Appendix A2. Questionnaire for evaluation of factor importance

Please check "√" for an appropriate answer.

Criteria	Symbol	Very High Importance	High Importance	Low Importance	Very Low Importance	No Importance

Experimenting new applications of IoT	e_1					
Launching pilot IoT projects	e_2					
Entry of firms to IoT markets	e_3					
System for innovation and incubation	e_4					
Conducting feasible studies	k_1					
IoT market research and assessment	k_2					
Developing complementary technologies	k_3					
Network of technology and research cooperation	k_4					
Training of professionals	d_1					
Conducting promotion campaigns	d_2					
Organizing conference/workshops/seminars/meetings	d_3					
Demonstrations and exhibitions	d_4					
Setting collective goals for IoT development	g_1					
Design of favorable rules and regulations	g_2					
Publicizing expectations	g_3					
Providing direction of development	g_4					
Providing subsidies	m_1					
Government procurement programs	m_2					
Regulatory reform	m_3					
Standardizations	m_4					
Providing R&D budgets	r_1					
Providing financial grants and loans	r_2					
Launching IoT related education programs	r_3					
Mobilizing human resources	r_4					
Funding scale up on IoT projects	r_5					
Strength of lobby actions	c_1					
Rise and growth of interest groups	c_2					
Social acceptability	c_3					

Appendix A3. Questionnaires for the influence from one criterion to another criterion

Please fill the influences of the criteria in the left hand side on the criteria being identified on the top of each column, where a “0” means no influence, a “1” means low influence, a “2” for medium influence, a “3” for high influence, and a “4” for very high influence.

Criteria/Symbol		e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
Experimenting new applications of IoT	e_1																							
Entry of firms to IoT markets	e_3																							
System for innovation and incubation	e_4																							
Conducting feasible studies	k_1																							
Developing complementary technologies	d_1																							
Training of professionals	d_4																							
Organizing conference/workshops/seminars/meetings	g_2																							
Demonstrations and exhibitions	g_3																							
Setting collective goals for IoT development	g_4																							
Design of favorable rules and regulations	m_1																							
Publicizing expectations	m_2																							
Providing direction of development	m_3																							
Providing subsidies	m_4																							
Government procurement programs	r_1																							
Regulatory reform	r_3																							
Standardizations	r_4																							
Providing R&D budgets	r_5																							

Launching IoT related education programs	c_2																							
Mobilizing human resources	c_3																							
Funding scale up on IoT projects	e_3																							
Strength of lobby actions	e_4																							
Rise and growth of interest groups	k_1																							
Social acceptability	k_3																							

Appendix B1. The suitability of systemic innovation problems

Please fill the needed information into the blank below. For each *SP*, please fill the "Yes" or "No" into the blank.

Gender	**Experiences**	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}

Note: Lack of uniform technical standards (SP_1); The innovation intensity is insufficient (SP_2); Regulatory constrains for IoT development (SP_3); Lack of sufficient infrastructure for IoT development (SP_4); Low level of interdisciplinary collaboration (SP_5); Lack of advanced sensor technology for IoT application (SP_6); Lack of effective innovation application services (SP_7); Low capability of system and platform integration (SP_8); Lack of professionals (SP_9); Low level of industrial upgrading for SMEs (SP_{10}); Weak advocacy coalition (SP_{11})

Appendix B2. Evaluation of systemic innovation problems

Please fill the relational values of the criteria in the left hand side on the *SPs* being identified on the top of each column, where a "0" means no relation, a "1" means low relation, a "2" for medium relation, a "3" for high relation, and a "4" for very high relation.

Criteria/Symbol		SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
Experimenting new applications of IoT	e_1											
Entry of firms to IoT markets	e_3											
System for innovation and incubation	e_4											
Conducting feasible studies	k_1											
Developing complementary technologies	d_1											
Training of professionals	d_4											
Organizing conference/workshops/seminars/meetings	g_2											
Demonstrations and exhibitions	g_3											
Setting collective goals for IoT development	g_4											
Design of favorable rules and regulations	m_1											
Publicizing expectations	m_2											
Providing direction of development	m_3											
Providing subsidies	m_4											
Government procurement programs	r_1											
Regulatory reform	r_3											
Standardizations	r_4											
Providing R&D budgets	r_5											
Launching IoT related education programs	c_2											
Mobilizing human resources	c_3											
Funding scale up on IoT projects	e_3											
Strength of lobby actions	e_4											
Rise and growth of interest groups	k_1											
Social acceptability	k_3											

Appendix C1. The suitability of systemic innovation policies

Please fill the needed information into the blank below. For each *SP*, please fill the "Yes" or "No" into the blank.

Gender	**Experiences**	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}

Note: Develop technical standards; Technology transfer and introduction (IP_1); Revise the regulations and policies; Infrastructure development for IoT (IP_2); Policies to support interdisciplinary collaboration (IP_3); Direct support to firm R&D and innovation (IP_4); Support experiments with novel applications (IP_5); Technology resources integration (IP_6); Provide professional training programs (IP_7); Support advocacy coalition (IP_8); Overseas agents (IP_9); Timely procurements (IP_{10}); Provide demonstration fields (IP_{11})

Appendix C2. The evaluation of systemic innovation policies

Please fill the relational values of the *SPs* in the left hand side on the *IPs* being identified on the top of each column, where a "0" means no relation, a "1" means low relation, a "2" for medium relation, a "3" for high relation, and a "4" for very high relation.

Criteria/Symbol		IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
Lack of uniform technical standards	SP_1														
The innovation intensity is insufficient	SP_2														
Regulatory constrains for IoT development	SP_3														
Lack of sufficient infrastructure for IoT development	SP_4														
Low level of interdisciplinary collaboration	SP_5														
Lack of advanced sensor technology for IoT application	SP_6														
Lack of effective innovation application services	SP_7														
Low capability of system and platform integration	SP_8														
Lack of professionals	SP_9														
Low level of industrial upgrading for SMEs	SP_{10}														
Weak advocacy coalition	SP_{11}														

Appendix D1. Data of factor importance

No.	e1	e2	e3	e4	k1	k2	k3	k4	d1	d2	d3	d4	g1	g2	g3	g4	m1	m2	m3	m4	r1	r2	r3	r4	r5	c1	c2	c3	units
1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3
2	5	4	4	3	4	5	4	4	5	4	4	4	4	5	4	4	2	5	3	4	5	4	5	3	4	4	2	3	2
3	4	4	4	5	5	5	4	4	4	4	4	4	5	4	3	4	4	4	3	3	4	4	4	4	4	4	3	3	1
4	4	4	5	5	4	5	5	5	5	4	5	5	5	5	4	5	4	5	4	5	5	5	5	5	5	5	4	4	1
5	3	4	4	4	3	4	4	4	4	4	2	3	4	5	5	5	5	5	4	3	5	5	5	4	4	4	2	4	1
6	5	5	4	5	4	4	4	4	5	4	5	4	4	5	4	4	4	5	4	4	5	4	5	4	4	3	5	3	1
7	5	5	5	4	4	5	4	5	5	4	4	4	5	4	4	5	3	4	4	5	4	5	4	4	4	4	4	3	1

8	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	3	3	4	4	3	3	3	3	3	3
9	4	5	4	4	4	5	3	5	4	4	3	5	5	4	4	4	4	5	4	4	3	4	4	4	4	4	4	3	1
10	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	4	5	2	1
11	4	4	5	4	4	4	5	5	5	5	5	5	5	4	4	5	4	5	4	4	5	5	5	4	4	4	4	4	1
12	5	5	5	3	5	4	3	5	5	4	4	4	3	3	3	5	3	3	3	4	3	4	4	5	4	4	4	3	2
13	5	5	4	5	4	4	5	5	4	3	4	4	3	5	3	4	4	5	3	4	3	4	4	3	3	4	3	4	2
14	5	3	5	4	4	5	5	4	4	5	3	5	4	4	3	3	5	5	5	5	4	4	3	5	5	3	5	5	2
15	5	4	5	5	4	4	4	4	4	4	4	3	2	3	2	1	2	4	4	4	5	3	3	4	4	2	4	5	2
16	5	5	5	5	5	5	5	5	5	5	5	4	5	5	4	5	5	4	5	5	5	5	5	5	4	5	4	5	2
17	3	3	4	3	3	4	4	4	4	3	3	3	4	4	3	3	3	4	3	3	3	3	3	4	3	3	2	2	1
18	5	5	5	4	4	5	3	4	4	4	3	4	4	5	5	4	2	4	4	5	4	4	4	4	4	4	5	5	2
19	4	4	5	4	5	4	4	4	5	3	4	5	4	5	3	4	5	3	4	3	4	5	5	3	3	4	3	3	3
20	4	4	4	4	4	4	4	4	4	4	5	4	5	4	4	4	4	4	4	4	4	4	4	4	5	5	4	5	1
21	4	4	3	3	4	4	4	4	5	3	4	4	3	5	4	5	4	5	3	3	4	3	3	3	4	4	3	3	1
22	4	4	3	3	4	5	4	4	5	5	5	4	5	4	5	5	3	4	4	4	5	4	5	5	4	4	5	4	1
23	4	4	4	5	5	5	4	4	5	5	4	4	4	4	4	5	4	4	4	4	4	4	4	4	5	4	3	4	1
24	5	4	4	3	5	4	3	5	5	4	5	4	5	5	4	5	5	5	4	5	4	5	3	5	3	5	2	1	1
25	4	5	5	5	5	5	5	5	5	4	4	4	4	5	4	5	3	5	5	4	4	5	4	5	4	5	3	3	4
26	4	3	4	4	3	2	3	3	5	2	2	3	4	4	5	4	4	5	4	3	3	4	4	4	4	3	3	3	1
27	5	5	4	4	5	3	5	5	5	4	4	4	2	5	3	5	5	3	3	5	5	5	5	5	5	5	2	4	1
28	4	4	3	3	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	4	3	4	3	3	3	3	3	1
29	4	4	5	5	4	4	5	5	4	3	3	4	4	4	4	4	3	5	4	4	4	4	4	4	3	4	4	4	1
30	4	5	4	4	4	5	5	5	5	4	4	4	5	4	4	5	3	5	4	5	5	4	4	4	4	4	4	3	1
31	4	4	3	4	4	5	5	4	4	3	3	3	5	5	4	4	2	5	2	3	4	2	4	3	4	3	4	3	1
32	4	5	4	4	5	4	4	4	4	3	4	5	5	4	4	4	4	4	3	3	4	4	4	5	5	4	3	3	1
33	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	4
34	4	4	4	4	4	4	5	5	5	4	3	4	3	3	4	4	4	3	4	4	4	4	4	4	3	4	3	3	1
35	2	3	3	2	3	3	3	3	4	3	3	3	3	4	3	2	3	3	3	3	3	3	3	3	4	3	3	2	1
36	4	4	5	4	4	5	4	5	5	4	4	4	4	4	4	4	4	5	5	4	5	5	5	5	4	4	3	3	1
37	5	5	4	5	4	4	5	4	5	4	5	4	4	5	4	4	5	4	4	4	5	5	4	4	4	4	3	3	3
38	4	4	5	5	4	4	5	3	4	3	3	3	2	5	1	1	4	4	3	5	4	5	4	5	4	5	2	1	1
39	5	5	4	4	4	4	4	4	4	5	5	5	5	4	4	5	4	4	5	5	4	4	4	4	4	4	4	5	1
40	5	5	5	5	5	5	5	5	5	5	3	3	5	5	4	5	4	5	3	4	5	5	5	5	5	5	3	2	3
41	4	4	4	3	3	3	5	4	5	4	4	5	4	4	5	4	5	4	4	4	5	5	3	5	5	4	4	4	3
42	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	5	5	5	5	5	5	3	1
43	4	4	4	3	4	3	3	5	5	4	3	4	4	4	3	3	3	5	3	4	3	4	4	4	4	3	4	4	1
44	3	4	3	3	4	4	4	4	4	3	3	3	3	3	3	4	4	4	4	3	4	4	4	3	3	3	3	2	1
45	4	4	4	3	4	4	3	4	5	4	3	4	3	3	4	3	5	4	3	4	4	5	3	4	4	3	3	4	3
46	5	5	4	4	4	4	5	4	5	5	3	4	3	5	5	5	4	4	3	3	4	5	5	4	5	4	3	2	1
47	4	5	5	4	4	4	5	5	5	4	3	3	4	4	5	5	3	4	1	5	5	4	4	1	4	5	3	3	4
48	4	4	5	4	4	5	3	4	4	4	3	2	4	4	4	4	5	2	4	4	4	5	4	4	4	4	1	2	1
49	4	5	4	5	5	5	5	4	4	4	4	4	5	4	4	5	5	4	5	5	5	5	4	5	4	4	4	4	1
50	5	5	4	4	5	4	4	5	5	4	3	4	5	5	4	5	5	5	4	5	5	5	5	5	4	4	4	3	4

51	4	4	5	5	5	5	4	4	5	4	4	4	4	4	5	5	4	4	4	4	4	5	5	4	5	5	4	4	1
52	4	4	3	4	4	4	4	4	5	4	4	4	3	4	4	4	3	5	4	2	4	4	4	4	4	4	3	4	1
53	5	5	5	4	5	4	4	4	5	5	4	4	4	5	4	4	4	5	4	4	4	4	4	4	4	4	4	4	1
54	5	5	5	5	5	4	4	4	4	4	3	4	4	4	4	4	3	3	2	3	4	4	4	4	5	4	4	4	1
55	5	4	4	5	4	5	4	4	4	4	3	5	4	4	3	5	4	4	5	5	4	4	4	5	5	3	3	3	1
56	4	4	4	5	4	5	4	4	5	4	4	4	4	5	4	4	3	5	3	3	4	4	4	4	4	4	3	3	1
57	4	3	3	3	4	3	3	4	3	3	3	2	4	5	3	3	2	2	2	2	2	3	3	3	3	2	1	1	4
58	5	4	5	4	4	5	4	4	5	4	4	4	5	5	4	5	3	5	4	5	5	5	5	4	4	4	4	4	1
59	4	4	4	4	4	5	4	4	5	4	4	5	4	4	4	4	4	4	4	4	4	4	4	5	4	4	3	3	1
60	4	4	4	4	4	4	4	4	5	3	3	3	4	4	4	5	3	4	4	3	3	4	4	4	3	3	2	2	3
61	4	4	4	4	4	5	4	4	5	3	4	4	4	4	3	4	5	4	4	4	5	4	4	4	4	4	3	3	1
62	5	5	5	4	4	5	5	4	5	4	4	5	4	4	5	4	3	4	3	4	4	4	4	3	3	5	3	2	4
63	4	4	4	5	5	4	4	3	4	3	4	5	5	4	4	4	3	4	3	4	4	5	4	2	4	3	4	4	3
64	4	3	4	3	5	5	5	5	4	4	4	4	3	4	4	4	3	4	4	4	4	4	3	4	4	4	4	3	1
65	5	4	4	3	4	4	4	4	4	4	3	3	4	4	3	4	4	3	3	3	4	4	4	4	4	4	3	4	1
66	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	1
67	4	5	3	4	5	4	5	4	4	5	4	4	5	4	3	5	4	4	5	4	4	5	4	4	4	5	5	4	3
68	4	4	5	5	5	5	5	4	5	4	3	4	4	3	4	3	3	3	4	4	4	4	5	4	5	5	4	5	1
69	4	4	5	4	4	5	4	5	5	3	4	3	5	5	5	4	4	5	4	5	5	3	4	5	4	3	3	3	1
70	4	4	5	3	4	4	5	5	5	3	4	4	5	4	4	5	4	5	3	4	4	4	4	4	4	4	4	3	1
71	5	5	5	5	5	5	4	4	5	4	3	4	5	5	3	5	4	4	5	4	4	4	5	4	5	5	4	3	1
72	5	5	5	5	5	5	5	4	5	4	4	4	5	5	5	5	4	4	3	5	4	5	4	4	4	3	3	3	3
73	5	5	5	4	5	5	5	5	5	5	4	5	5	5	4	4	5	5	4	5	5	5	5	5	4	5	4	4	3
74	4	4	4	4	4	4	4	4	5	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	1
75	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	5	3	4	4	4	4	4	4	1
76	4	4	5	5	4	5	4	5	4	4	4	4	4	4	4	5	2	5	4	3	4	5	4	3	4	4	3	3	3
77	5	5	5	5	5	5	5	5	5	4	5	4	4	3	4	4	4	4	3	4	4	4	4	4	4	4	3	3	1
78	4	4	5	4	4	5	4	5	4	3	3	5	4	4	4	5	3	4	4	4	5	4	5	3	4	4	5	5	1
79	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	4	4	4	4	5	4	5	4	4	4	4	4	4	1
80	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1
81	5	4	5	4	4	3	3	5	3	3	5	2	4	5	2	4	2	2	2	3	5	5	4	3	4	5	4	4	3
82	4	5	5	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	5	5	5	5	5	5	1
83	4	4	4	3	4	3	4	3	4	4	3	2	2	4	3	4	4	4	4	4	4	4	3	4	4	4	2	2	1
84	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
85	4	4	4	4	4	4	5	5	5	3	3	3	4	5	3	4	3	5	3	5	5	5	5	4	4	3	4	5	4
86	5	5	5	5	3	3	3	3	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1
87	5	5	4	5	5	5	5	5	5	3	5	3	5	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	1
88	4	4	4	3	4	4	5	5	5	5	5	5	4	4	5	4	4	4	5	5	4	5	4	5	5	5	4	3	1
89	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1
90	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	1
91	4	4	4	4	4	4	5	4	4	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4
92	4	4	4	5	4	4	5	5	5	4	5	4	5	4	5	4	4	5	4	5	5	5	4	3	5	4	4	5	3
93	5	5	5	3	5	5	4	5	5	4	3	3	5	4	5	5	3	5	4	5	5	3	3	4	4	5	3	3	1

94	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	5	5	5	3	4	5	1	4
95	4	4	4	4	4	4	4	4	4	4	4	5	5	4	5	5	4	4	5	5	5	5	5	4	4	4	4	3	1
96	4	4	4	5	4	3	3	4	5	5	5	5	3	3	3	3	3	3	3	2	4	4	5	5	5	4	4	4	1
97	4	4	3	3	4	4	5	5	4	5	3	4	4	4	3	3	5	3	3	5	4	4	4	4	5	4	4	3	1
98	4	4	4	2	4	4	5	5	5	4	4	5	3	5	3	5	3	5	3	2	5	4	5	4	3	4	3	4	1
99	4	4	3	4	3	3	4	4	4	3	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	1
100	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3
101	3	3	4	3	3	3	3	3	3	3	3	3	3	3	4	5	4	4	5	5	4	5	5	4	4	5	3	5	3
102	4	4	5	4	4	4	4	4	5	4	3	3	5	4	4	4	4	4	4	4	4	5	4	4	4	4	4	4	1
103	4	4	3	3	4	4	4	4	3	3	3	3	3	3	3	4	3	4	3	3	3	3	4	3	3	3	3	3	3
104	4	4	5	4	4	4	4	4	5	4	4	5	5	5	4	5	4	5	5	5	5	4	4	5	4	4	4	4	2
105	4	5	5	4	5	3	5	5	5	3	4	3	3	4	4	5	5	5	4	3	4	5	5	5	5	5	4	4	1
106	4	4	4	4	3	3	3	3	5	4	5	4	4	4	4	5	5	5	5	4	4	5	5	4	4	4	3	2	1

Appendix D2. The evaluation of factor influencing IoT sustainable development

Prior1	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	4	0	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	3	2	0	3	2	3	4	3	4	3	3	4	4	4	4	4	4	4	2	4	2	2	2
k_1	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
d_1	4	4	4	3	0	3	3	4	2	3	3	3	2	2	2	3	2	3	2	3	2	2	2
d_4	4	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	2	2
g_2	3	3	2	2	2	2	0	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g_3	3	2	3	2	2	2	2	0	2	2	2	2	2	2	2	1	0	1	2	2	2	2	2
g_4	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
m_1	4	4	1	4	4	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	2	2
m_2	4	4	3	4	4	3	3	3	3	3	0	3	3	3	3	4	4	4	2	4	2	2	2
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	2	2	2
m_4	4	4	3	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	2	2	2
r_1	4	3	3	4	3	3	3	3	3	3	3	2	2	0	3	3	2	4	2	2	2	2	2
r_3	4	3	4	4	4	4	4	4	4	4	3	3	2	4	0	2	2	3	2	3	2	2	3
r_4	4	4	2	3	3	3	3	3	3	4	3	3	3	3	3	0	2	3	2	2	2	2	3
r_5	1	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	0	1	1	1	1	1	1
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	4	2	2	2	2
c_3	4	3	2	3	3	3	3	3	3	3	2	3	2	2	2	3	2	2	0	2	1	1	2
e_3	4	4	4	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	2
e_4	1	1	1	1	3	2	2	2	1	1	1	1	2	2	1	1	2	2	2	2	0	4	2
k_1	1	1	1	1	3	1	2	2	2	2	1	2	2	2	1	1	1	1	1	1	4	0	2
k_3	3	4	2	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	4	4	0

Prior2	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	4	3	4	4	4	3	3	4	3	3	1	4	2	2	2
e_3	4	0	1	4	4	3	3	3	4	4	4	2	2	2	2	2	2	1	1	4	2	2	2
e_4	3	2	0	3	2	3	4	3	4	3	3	4	4	4	4	4	4	4	2	4	2	2	2
k_1	4	3	4	0	4	4	4	4	2	4	4	4	3	2	2	3	2	2	2	4	2	2	2

d_1	4	4	4	3	0	3	3	4	4	4	3	3	3	4	4	4	3	3	3	3	3	3	3
d_4	4	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	2	2
g_2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	3	2	2	2
g_3	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g_4	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	2	2
m_1	4	4	1	4	4	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	2	2
m_2	4	4	3	4	4	3	3	3	3	3	0	3	3	3	3	4	4	4	2	4	2	2	2
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	2	2	2
m_4	4	4	3	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	2	2	2
r_1	4	3	3	4	3	3	3	3	3	3	3	2	2	0	3	3	2	4	2	2	2	2	2
r_3	2	2	3	3	3	0	0	0	4	4	3	3	2	4	0	2	2	3	0	1	2	2	3
r_4	4	4	2	3	3	3	3	3	3	4	3	3	3	3	3	0	2	3	2	2	2	2	3
r_5	4	4	4	4	3	4	4	4	3	3	3	3	4	3	2	2	0	2	2	3	2	3	2
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	4	2	2	2	2
c_3	4	3	2	3	3	3	3	3	3	3	2	3	2	2	2	3	2	2	0	2	1	1	2
e_3	4	4	4	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	2
e_4	2	0	2	1	3	2	2	2	1	1	1	1	2	2	1	1	2	2	2	2	0	4	2
k_1	0	2	1	1	3	3	2	2	2	2	1	2	2	2	1	1	1	1	1	1	4	0	2
k_3	3	4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	0

Prior3	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	4	3	4	4	4	3	3	4	3	3	1	4	2	3	1
e_3	3	0	0	1	1	3	3	3	2	1	3	3	3	2	2	2	2	1	1	4	2	3	1
e_4	3	2	0	3	2	1	0	0	4	3	3	3	3	4	4	4	4	4	2	4	2	3	1
k_1	3	3	4	0	4	1	0	0	2	4	3	3	3	2	2	3	2	2	2	4	2	3	1
d_1	3	4	4	3	0	2	3	3	2	3	3	3	3	2	2	3	2	3	2	3	2	3	1
d_4	3	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	3	1
g_2	3	3	2	2	2	2	0	4	2	2	3	3	3	3	4	3	3	3	2	3	2	3	1
g_3	3	3	3	2	2	2	2	0	2	2	2	2	2	2	2	1	0	1	2	2	2	3	1
g_4	1	1	1	1	1	1	1	1	0	3	4	3	4	4	3	2	2	3	3	3	2	3	1
m_1	3	3	3	3	3	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	2	1
m_2	3	3	3	4	4	3	3	3	3	3	0	3	3	3	3	4	4	4	2	4	2	2	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	2	2	1
m_4	3	3	3	3	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	2	2	1
r_1	3	3	3	3	3	3	3	3	3	3	3	2	2	0	3	3	2	4	2	2	2	2	1
r_3	3	3	4	3	1	4	4	4	4	4	3	3	2	4	0	2	2	3	0	3	2	2	1
r_4	3	3	2	3	3	3	3	3	3	4	3	3	3	3	3	0	2	3	2	2	2	2	1
r_5	3	4	4	4	3	1	1	1	3	3	3	3	4	3	2	2	0	2	2	3	2	3	1
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	4	2	2	2	1
c_3	4	3	2	3	3	3	3	3	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	4	4	4	0	0	0	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	0	0	0	0	3	1	0	0	1	1	1	1	2	2	1	1	2	2	2	2	0	4	1
k_1	0	0	0	0	3	0	0	1	2	2	1	2	2	2	1	1	1	1	1	1	4	0	1
k_3	3	4	2	3	2	1	0	1	2	2	1	1	1	1	1	1	1	1	1	1	2	3	0

Prior4	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	4	3	4	4	4	3	3	4	3	3	1	4	2	2	2
e_3	3	0	0	1	1	3	3	2	2	1	3	2	2	2	2	2	2	1	1	4	2	2	2
e_4	3	2	0	3	2	1	0	0	4	3	3	4	4	4	4	4	4	4	2	4	2	2	2
k_1	3	3	4	0	4	1	0	0	2	4	4	4	3	2	2	3	2	2	2	4	2	2	2
d_1	3	4	4	3	0	2	4	4	4	3	3	3	2	4	4	4	2	4	4	3	2	2	2
d_4	3	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	2	2
g_2	3	3	2	2	2	0	0	2	2	2	3	3	3	3	4	4	3	3	2	3	2	2	2
g_3	3	3	3	2	2	2	0	0	2	2	2	2	2	2	2	1	0	1	2	2	2	2	2
g_4	1	1	1	1	1	2	2	0	0	3	4	3	4	4	3	2	2	3	3	3	2	2	2
m_1	3	3	1	4	4	1	1	1	4	0	4	4	2	2	3	4	3	4	2	2	2	2	2

m_2	3	3	3	4	4	4	4	4	3	3	0	3	3	3	3	4	4	4	2	4	2	2	2
m_3	3	3	2	3	3	3	3	3	4	4	3	0	3	3	3	4	3	2	2	2	2	2	2
m_4	3	3	3	3	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	2	2	2
r_1	3	3	3	3	3	4	4	4	3	3	3	2	2	0	3	3	2	4	2	2	2	2	2
r_3	3	3	4	3	4	3	3	3	4	4	3	3	2	4	0	2	2	3	2	3	2	2	3
r_4	3	3	2	3	3	4	4	4	3	4	3	3	3	3	3	0	2	3	2	2	2	2	3
r_5	3	4	4	4	3	3	3	3	3	3	3	3	4	3	2	2	0	2	2	3	2	3	2
c_2	3	3	3	3	3	1	1	1	3	3	2	4	2	2	2	3	2	0	4	2	2	2	2
c_3	4	3	2	3	3	4	3	3	3	3	2	3	2	2	2	3	2	2	0	2	1	1	2
e_3	4	4	4	4	4	3	3	3	3	3	2	2	4	3	2	2	4	3	1	0	1	1	2
e_4	0	0	0	0	3	2	0	0	1	1	1	1	2	2	1	1	2	2	2	2	0	4	2
k_1	0	0	0	0	3	2	0	0	2	2	1	2	2	2	1	1	1	1	1	1	4	0	2
k_3	3	4	2	3	2	2	0	0	2	2	1	1	1	1	1	1	1	1	1	1	4	4	0

Prior5	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2
e_3	3	0	1	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2
e_4	3	2	0	3	2	1	0	0	4	3	3	4	4	4	4	4	4	4	4	4	2	2	2
k_1	3	3	4	0	4	1	0	0	2	4	4	4	4	4	4	4	4	4	4	4	2	2	2
d_1	4	4	4	3	0	2	4	4	2	3	3	3	2	2	2	3	2	3	2	3	2	2	2
d_4	4	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	2	2
g_2	2	2	2	2	2	2	0	4	2	2	3	3	3	3	4	4	3	3	2	3	2	2	2
g_3	4	4	3	2	2	2	2	0	2	2	2	2	2	2	2	1	0	1	2	2	2	2	2
g_4	4	3	3	3	3	1	1	1	0	3	4	3	4	4	3	2	2	3	3	3	2	2	2
m_1	4	4	1	4	4	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	2	2
m_2	4	4	3	4	4	3	3	3	3	3	0	3	3	3	3	4	4	4	2	4	2	2	2
m_3	4	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	2	2	2
m_4	4	4	3	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	2	2	2
r_1	4	3	3	4	3	3	3	3	3	3	3	2	2	0	3	3	2	4	2	2	2	2	2
r_3	4	3	4	4	4	4	4	4	4	4	3	3	2	4	0	2	2	3	2	3	2	2	3
r_4	4	4	2	3	3	3	3	3	3	4	3	3	3	3	3	0	2	3	2	2	2	2	3
r_5	4	4	4	4	3	1	1	1	3	3	3	3	4	3	2	2	0	2	2	3	2	3	2
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	4	2	2	2	2
c_3	4	3	2	3	3	3	3	3	3	3	2	3	2	2	2	3	2	2	0	2	1	1	2
e_3	4	4	4	4	4	0	0	0	3	3	2	2	4	3	2	2	4	3	1	0	1	1	2
e_4	1	1	1	1	3	0	0	0	0	0	0	0	2	1	1	1	2	2	2	2	0	4	2
k_1	1	1	1	1	3	0	0	0	1	2	0	1	1	1	1	1	1	1	1	1	4	0	2
k_3	3	4	2	3	2	0	0	0	2	2	2	3	2	2	1	1	1	1	1	1	4	4	0

Prior6	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	0	0	4	3	4	4	4	3	3	4	3	3	1	4	2	2	2
e_3	3	0	1	4	4	3	0	0	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2
e_4	3	2	0	3	2	1	0	0	4	3	3	4	4	4	4	4	4	4	4	4	2	2	2
k_1	3	3	4	0	4	1	0	0	2	4	4	4	3	2	2	3	2	2	2	4	2	3	1
d_1	4	4	4	3	0	2	4	4	2	3	3	3	2	2	2	3	2	3	2	3	2	3	1
d_4	4	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	3	1
g_2	3	3	2	2	2	2	0	4	2	2	3	3	3	3	4	4	3	3	2	3	2	3	1
g_3	3	2	3	2	2	2	2	0	2	2	2	2	2	2	2	1	0	1	2	2	2	3	1
g_4	1	1	1	1	1	1	1	1	0	3	4	3	4	4	3	2	2	3	3	3	2	3	1
m_1	4	4	1	4	4	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	2	1
m_2	2	2	2	2	2	3	3	3	3	3	0	3	1	1	0	2	2	1	1	1	0	0	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	2	2	1
m_4	4	4	3	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	2	2	1
r_1	4	3	3	4	3	3	3	3	3	3	3	2	2	0	3	3	2	4	2	2	2	2	1
r_3	4	3	4	4	1	4	4	4	1	1	3	3	2	4	0	2	2	3	2	3	2	2	1
r_4	4	4	2	3	3	3	3	3	3	4	3	3	3	3	3	0	2	3	2	2	2	2	1

r_5	4	4	4	4	3	1	1	1	3	3	3	3	4	3	2	2	0	2	2	3	2	3	1
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	4	2	2	2	1
c_3	4	3	2	3	3	3	3	3	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	4	4	4	0	0	0	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	1	1	1	1	3	0	0	0	1	1	1	1	2	2	1	1	2	2	2	2	0	4	1
k_1	1	1	1	1	3	0	0	0	2	2	1	2	2	2	1	1	1	1	1	1	4	0	1
k_3	3	4	2	3	2	0	0	0	2	2	1	1	1	1	1	1	1	1	1	1	2	3	0

Prior7	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	3	3	4	3	3	1	4	2	2	2
e_3	4	0	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	4	2	2	2
e_4	3	2	0	3	2	3	4	3	4	3	3	4	4	4	4	4	4	4	4	4	2	2	2
k_1	4	4	4	0	4	4	4	4	4	4	4	4	3	2	2	3	2	2	2	4	2	3	1
d_1	4	4	4	3	0	3	3	4	2	3	3	3	2	2	2	3	2	3	2	3	2	3	1
d_4	4	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	3	1
g_2	2	2	2	2	2	2	0	3	2	2	3	3	3	3	2	2	2	3	2	3	2	3	2
g_3	3	2	3	2	2	2	2	0	2	2	2	2	2	2	2	1	0	1	2	2	2	3	1
g_4	1	1	1	1	1	1	1	1	0	1	1	3	4	4	3	2	2	3	3	3	2	3	1
m_1	4	4	1	4	4	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	2	1
m_2	4	4	3	4	4	3	3	3	3	3	0	3	1	1	0	2	2	1	1	1	0	0	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	2	2	1
m_4	4	4	3	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	2	2	1
r_1	4	3	3	4	3	3	3	3	3	3	3	2	2	0	3	3	2	4	2	2	2	2	1
r_3	4	3	4	4	4	4	4	4	4	4	3	3	2	4	0	2	2	3	2	3	2	2	1
r_4	4	4	2	3	3	3	3	3	3	4	3	3	3	3	3	0	2	3	2	2	2	2	1
r_5	1	1	1	1	1	1	1	1	1	1	1	3	4	3	2	2	0	2	2	3	2	3	1
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	4	2	2	2	1
c_3	4	3	2	3	3	3	3	3	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	4	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	1	1	1	1	3	2	2	2	1	1	1	1	2	2	1	1	2	2	2	2	0	4	1
k_1	1	1	1	1	3	1	2	2	2	2	1	2	2	2	1	1	1	1	1	1	4	0	1
k_3	3	4	2	3	2	2	2	2	2	2	1	1	1	1	1	1	1	1	1	1	2	3	0

Prior8	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	4	0	4	4	4	4	4	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	3	2	0	3	2	3	4	3	4	3	3	3	3	3	3	4	4	4	2	4	2	2	2
k_1	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
d_1	4	4	4	3	0	3	3	4	2	3	3	3	3	3	3	3	2	3	2	3	2	2	2
d_4	4	4	3	3	2	0	3	2	2	2	2	2	2	2	2	3	2	3	2	2	3	2	2
g_2	3	3	2	2	2	2	0	4	2	2	3	2	3	2	3	4	3	3	2	3	2	2	2
g_3	1	2	1	1	2	1	0	0	1	1	1	1	2	2	2	1	0	1	2	1	1	1	4
g_4	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1
m_1	4	4	1	4	4	4	4	4	4	0	4	2	2	2	2	3	3	4	2	2	2	2	2
m_2	4	4	3	4	4	3	3	3	3	3	0	2	3	2	3	4	4	4	2	4	2	2	2
m_3	3	3	2	3	3	4	4	4	4	4	3	0	2	2	2	1	3	2	2	2	2	2	2
m_4	4	4	3	4	4	4	4	4	3	1	2	2	0	2	2	2	1	4	3	3	2	2	2
r_1	4	3	3	4	3	3	3	3	3	3	3	2	2	0	2	3	2	4	2	2	2	2	2
r_3	4	4	1	4	4	4	4	4	1	4	4	4	2	2	0	2	2	3	2	3	2	2	3
r_4	4	4	3	4	4	3	4	4	3	4	4	3	2	2	2	0	2	3	2	2	2	2	3
r_5	3	3	2	3	3	4	3	3	2	3	3	4	2	2	2	1	0	1	1	1	1	1	1
c_2	4	4	1	4	4	4	4	4	1	4	4	4	2	2	2	3	2	0	4	2	2	2	2
c_3	4	4	3	4	4	3	4	4	3	4	4	3	2	2	2	3	2	2	0	2	1	1	2
e_3	3	3	2	3	3	4	3	3	2	3	3	4	2	2	2	2	2	2	2	0	2	2	2
e_4	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1	1	1	1	0	3	3
k_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	0	3

k_3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	3	3	0

Prior9	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	3	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	4	0	3	3	4	4	3	4	4	4	4	4	3	3	4	4	4	4	4	4	3	4	4
e_4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
k_1	4	4	4	0	4	3	2	4	4	4	4	4	4	3	4	4	4	3	3	4	4	4	4
d_1	4	4	3	4	0	3	2	2	4	4	4	4	4	4	3	3	4	3	3	3	3	3	3
d_4	4	4	3	4	4	0	3	4	4	4	4	4	4	4	4	4	3	4	4	4	4	4	4
g_2	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	3	4	2	3	4	3	4
g_3	4	4	2	4	4	4	4	0	4	4	4	4	3	3	3	4	3	3	2	3	4	3	4
g_4	4	4	4	4	4	4	2	3	0	4	4	4	3	4	2	4	4	4	2	3	4	3	4
m_1	4	4	4	4	4	2	1	2	4	0	4	4	1	4	4	4	3	4	2	2	3	2	3
m_2	4	4	3	4	4	4	2	4	4	4	0	4	4	4	3	4	4	4	2	4	4	4	4
m_3	4	4	4	4	4	4	1	3	4	4	4	0	4	3	3	4	4	4	3	3	4	4	4
m_4	4	4	4	4	4	4	4	4	4	4	4	4	0	4	2	4	4	4	3	4	4	2	4
r_1	2	2	4	2	2	1	1	1	4	4	4	4	4	0	4	4	4	3	1	2	2	4	4
r_3	4	4	3	4	4	4	1	4	4	4	4	4	3	4	0	4	3	4	2	2	2	3	4
r_4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0	4	4	3	3	4	4	4
r_5	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	4	0	4	2	4	2	2	4
c_2	4	4	3	4	4	4	3	4	4	4	4	4	3	3	1	2	3	0	2	1	3	2	3
c_3	4	4	2	4	4	4	2	2	3	3	3	3	2	1	1	1	1	4	0	1	2	1	1
e_3	4	4	3	4	4	4	4	4	4	4	4	4	4	1	1	4	4	4	3	0	2	1	3
e_4	3	3	3	3	3	1	2	1	4	4	4	4	2	2	4	4	2	3	1	1	0	3	3
k_1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	2	0	2
k_3	4	4	3	4	4	1	1	2	3	3	3	3	1	1	1	1	1	1	1	1	3	1	0

Prior10	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	3	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	4	0	3	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	4	4	0	4	4	4	4	4	4	4	4	4	3	3	3	4	4	4	2	4	2	2	2
k_1	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
d_1	4	4	3	4	0	3	2	2	4	4	4	4	3	3	3	3	2	3	2	3	2	2	2
d_4	4	4	3	4	4	0	3	4	4	4	4	4	2	2	2	3	2	3	2	2	3	2	2
g_2	4	4	4	4	4	4	0	4	4	4	4	4	3	2	3	4	3	3	2	3	2	2	2
g_3	2	2	2	2	2	2	4	0	4	4	4	4	2	2	2	1	0	1	2	2	2	2	2
g_4	4	4	4	4	4	4	2	3	0	4	4	4	1	1	1	1	1	1	1	1	1	1	1
m_1	4	4	4	4	4	2	1	2	4	0	4	4	2	2	2	3	3	4	2	2	2	2	2
m_2	4	4	3	4	4	4	2	4	4	4	0	4	3	2	3	4	4	4	2	4	2	2	2
m_3	4	4	4	4	4	4	1	3	4	4	4	0	2	2	2	1	3	2	2	2	2	2	2
m_4	4	4	4	4	4	4	4	4	4	4	4	4	0	2	2	2	1	4	3	3	2	2	2
r_1	2	2	4	2	2	1	1	1	4	4	4	4	2	0	2	3	2	4	2	2	2	2	2
r_3	4	4	3	4	4	4	1	4	4	4	4	4	2	2	0	2	2	3	2	3	2	2	3
r_4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	0	2	3	2	2	2	2	3
r_5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	0	1	1	1	1	1	1
c_2	4	4	3	4	4	4	3	4	4	4	4	4	2	2	2	3	2	0	4	2	2	2	2
c_3	4	4	2	4	4	4	2	2	3	3	3	3	2	2	2	3	2	2	0	2	1	1	2
e_3	4	4	3	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2	2	0	2	2	2
e_4	3	3	3	3	3	1	2	1	4	4	4	4	1	2	1	1	1	1	1	1	0	3	3
k_1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1	1	1	1	1	1	3	0	3
k_3	4	4	3	4	4	1	1	2	3	3	3	3	1	1	1	1	1	1	1	1	3	3	0

Prior11	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	0	0	4	3	4	4	4	3	3	4	3	3	1	4	2	2	2
e_3	3	0	1	4	4	3	0	0	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2
e_4	3	2	0	3	2	1	0	0	4	3	3	4	4	4	4	4	4	4	4	4	2	2	2

k_1	3	3	4	0	4	1	0	0	2	4	4	4	3	2	2	3	2	2	2	4	2	3	1
d_1	4	4	4	3	0	2	0	0	2	3	3	3	2	2	2	3	2	3	2	3	2	3	1
d_4	4	4	3	3	2	0	3	2	2	2	2	2	0	1	1	3	2	3	2	2	3	3	1
g_2	3	3	2	2	2	2	0	4	2	2	3	3	3	3	4	4	3	3	2	3	2	3	1
g_3	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g_4	1	1	1	1	1	1	1	1	0	3	4	3	4	4	3	2	2	3	3	3	2	3	1
m_1	4	4	1	4	4	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	2	1
m_2	4	4	3	4	4	4	2	4	4	4	0	4	4	4	3	4	4	4	2	4	4	4	4
m_3	4	4	4	4	4	4	1	3	4	4	4	0	4	3	3	4	4	4	3	3	4	4	4
m_4	4	4	4	4	4	4	4	4	4	4	4	4	0	4	2	4	4	4	3	4	4	2	4
r_1	2	2	4	2	2	1	1	1	4	4	4	4	4	0	4	4	4	3	1	2	2	4	4
r_3	4	4	3	4	4	4	1	4	4	4	4	4	3	4	0	4	3	4	2	2	2	3	4
r_4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	0	4	4	3	3	4	4	4
r_5	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	4	0	4	2	4	2	2	4
c_2	4	4	3	4	4	4	3	4	4	4	4	4	3	3	1	2	3	0	2	1	3	2	3
c_3	4	4	2	4	4	4	2	2	3	3	3	3	2	1	1	1	1	4	0	1	2	1	1
e_3	4	4	3	4	4	4	4	4	4	4	4	4	4	1	1	4	4	4	3	0	2	1	3
e_4	1	1	2	2	3	1	1	1	1	1	1	4	2	2	4	4	2	3	1	1	0	3	3
k_1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	0	2
k_3	1	1	2	2	2	1	1	1	1	1	1	3	1	1	1	1	1	1	1	1	3	1	0

Prior12	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	0	0	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2
e_3	3	0	0	4	4	3	0	0	2	4	4	4	4	4	4	4	4	4	4	4	2	2	2
e_4	3	2	0	3	2	1	0	0	4	3	3	4	4	4	3	4	4	4	2	4	2	2	2
k_1	3	3	4	0	4	1	0	0	4	4	4	4	4	4	4	4	4	4	4	4	2	3	1
d_1	3	4	4	3	0	2	0	0	2	3	3	3	2	2	3	3	2	3	2	3	2	3	1
d_4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g_2	3	3	2	2	2	2	0	4	2	2	3	3	3	3	3	4	3	3	2	3	2	3	1
g_3	3	3	3	2	2	2	2	0	2	2	2	2	2	2	2	1	0	1	2	2	2	3	1
g_4	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	3	1
m_1	3	3	3	4	4	4	4	4	4	0	4	4	2	2	2	3	3	4	2	2	2	2	1
m_2	3	3	3	4	4	4	2	4	3	3	0	3	3	3	3	4	4	4	2	4	2	4	4
m_3	3	3	2	4	4	4	1	3	4	4	3	0	3	3	2	1	3	2	2	2	2	4	4
m_4	3	3	3	4	4	4	4	4	3	1	2	1	0	4	2	2	1	4	3	3	2	2	4
r_1	3	3	3	2	2	1	1	1	3	3	3	2	2	0	2	3	2	4	2	2	2	4	4
r_3	2	2	2	2	2	2	1	2	2	2	2	2	2	4	0	2	2	3	2	3	2	3	4
r_4	3	3	2	4	4	4	4	4	3	4	3	3	3	3	2	0	2	3	2	2	2	4	4
r_5	3	4	4	4	4	4	4	4	1	1	1	1	1	3	2	1	0	1	1	1	1	2	4
c_2	3	3	3	4	4	4	3	4	3	3	2	4	2	2	2	3	2	0	4	2	2	2	3
c_3	4	3	2	4	4	4	2	2	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	4	4	4	4	4	4	3	3	2	2	4	3	2	2	2	2	2	0	2	1	3
e_4	0	0	0	2	3	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	0	3	3
k_1	0	0	0	1	1	1	1	1	2	2	1	2	2	2	1	1	1	1	1	1	2	0	2
k_3	3	4	2	2	2	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	2	1	0

Prior13	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	3	2	4	4	4	4	4	4	3	3	4	3	3	1	4	2	2	2
e_3	4	0	3	3	4	4	3	4	4	4	4	4	3	2	2	2	2	1	1	4	2	2	2
e_4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	2	4	2	2	2
k_1	4	4	4	0	4	3	2	4	4	4	4	4	4	2	2	3	2	2	2	4	2	2	2
d_1	4	4	3	4	0	3	2	2	4	4	4	4	4	2	4	3	4	4	2	3	2	2	2
d_4	4	4	3	4	4	0	3	4	4	4	4	4	4	1	1	3	2	3	2	2	3	2	2
g_2	4	4	4	4	4	4	0	4	4	4	4	4	4	3	4	4	3	3	2	3	2	2	2
g_3	4	4	2	4	4	4	4	0	4	4	4	4	3	2	2	1	0	1	2	2	2	2	2
g_4	4	4	4	4	4	4	2	3	0	4	4	4	3	4	3	2	2	3	3	3	2	2	2

m_1	4	4	4	4	4	2	1	2	4	0	4	4	1	2	3	4	3	4	2	2	2	2	2
m_2	4	4	3	4	4	4	2	4	4	4	0	4	4	3	3	4	4	4	2	4	2	2	2
m_3	4	4	4	4	4	4	1	3	4	4	4	0	4	3	3	4	3	2	2	2	2	2	2
m_4	3	3	3	4	4	4	4	4	3	4	4	4	0	4	1	1	1	4	3	3	2	2	2
r_1	3	3	3	2	2	1	1	1	3	4	4	4	4	0	3	3	2	4	2	2	2	2	2
r_3	2	2	2	2	2	2	1	4	4	4	4	4	3	4	0	2	2	3	2	3	2	2	3
r_4	3	3	2	4	4	4	4	4	3	4	4	4	4	3	3	0	2	3	2	2	2	2	3
r_5	3	4	4	4	4	4	4	4	1	4	4	4	4	3	2	2	0	2	2	3	2	3	2
c_2	4	4	3	4	4	4	3	4	4	4	4	4	3	2	2	3	2	0	4	2	2	2	2
c_3	4	4	2	4	4	4	2	2	3	3	3	3	2	2	2	3	2	2	0	2	1	1	2
e_3	4	4	3	4	4	4	4	4	4	4	4	4	4	3	2	2	4	3	1	0	1	1	2
e_4	3	3	3	3	3	1	2	1	4	4	4	4	2	2	1	1	2	2	2	2	0	4	2
k_1	1	1	1	1	1	1	1	1	2	2	2	1	1	2	1	1	1	1	1	1	4	0	2
k_3	4	4	3	4	4	1	1	2	3	3	3	3	1	1	1	1	1	1	1	1	4	4	0

Prior14	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	4	3	4	4	4	3	3	4	4	4	4	4	4	4	4
e_3	4	0	2	3	2	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	4	3	4
e_4	4	4	0	3	2	3	3	3	3	3	3	4	4	4	4	4	1	4	2	3	3	3	2
k_1	4	4	4	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	3	3
d_1	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	3	3	3	4	4	0	2	2	2	3	3	4	0	1	1	3	0	4	4	1	1	1	1
g_2	2	2	3	3	2	4	0	4	2	2	2	3	3	3	4	4	2	3	1	1	1	1	1
g_3	4	4	3	4	4	3	3	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	4	4	2	3	3	4	4	3	0	3	4	3	4	4	3	3	2	3	3	3	2	2	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	2	4	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	3	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	4	4	3	0	2	2	2	3	3	2	2	0	3	2	1	3	1	1	0	2	2
r_3	2	2	2	2	2	2	2	2	2	4	2	2	4	2	0	3	3	3	2	3	3	3	3
r_4	4	3	3	4	4	2	2	2	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	1	1	1	3	2	1	1	1	1	1	3	3	4	3	2	2	0	2	2	4	2	2	1
c_2	4	4	3	2	3	4	3	3	3	3	1	4	0	1	1	3	1	0	4	1	2	2	1
c_3	4	4	3	2	2	2	2	2	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	3	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	4	4	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	4	3	3	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	4	4	4	2	4	4	2	2	4	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Prior15	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	2	2	2
e_3	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	2	2	0	2	2	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4
k_1	4	4	2	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2
d_1	4	4	4	3	0	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	4	4	3	4	4	0	2	2	2	3	3	4	0	1	1	3	0	4	4	1	1	1	1
g_2	1	1	1	1	1	1	0	4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
g_3	4	4	3	4	3	3	3	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	4	3	2	2	3	3	3	2	2	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	4	3	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	3	4	3	1	2	2	2	3	3	2	2	0	3	2	1	3	1	1	0	0	0
r_3	2	2	2	2	2	2	2	2	2	2	2	2	4	4	0	3	3	3	2	3	3	3	3

r_4	4	4	3	4	4	1	1	1	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	2	1	2	3	1	1	1	1	3	3	3	3	4	3	2	2	0	2	2	4	2	2	1
c_2	3	3	3	3	3	4	3	3	3	3	1	4	0	1	1	1	1	0	4	1	2	2	1
c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	3	4	4	4	4	4	3	3	2	4	4	1	1	4	4	4	3	0	1	1	2
e_4	3	3	3	3	3	1	1	1	1	1	1	4	2	2	4	4	2	3	1	2	0	4	2
k_1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1	1	1	1	1	1	4	0	2
k_3	4	4	3	4	2	1	1	1	2	2	1	3	1	1	1	1	1	1	1	3	3	4	0

Cond1	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	3	2	0	3	2	3	3	3	3	3	3	4	4	4	4	4	3	4	2	3	3	3	2
k_1	3	3	4	0	4	4	4	4	4	4	4	4	3	2	2	3	2	2	2	3	2	2	2
d_1	4	4	4	3	0	3	3	4	4	3	3	3	2	2	2	3	2	3	2	3	2	2	2
d_4	4	4	3	3	2	0	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4
g_2	3	3	2	2	2	2	0	4	4	2	3	3	3	3	4	4	3	3	2	3	2	4	4
g_3	3	2	3	2	2	2	2	0	1	1	1	1	1	2	2	1	0	1	2	2	3	2	2
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	4	3	2	2	3	3	3	2	2	3
m_1	4	4	1	4	4	4	4	4	4	0	4	4	2	2	3	4	3	4	2	2	2	1	1
m_2	4	4	4	4	4	3	3	3	3	3	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	3	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	3	4	3	2	3	3	3	3	3	2	2	0	3	3	2	4	2	2	0	0	0
r_3	4	3	4	4	4	4	4	4	4	4	3	3	2	4	0	2	2	3	2	1	1	1	1
r_4	4	4	2	3	3	2	2	2	3	4	3	3	3	3	3	0	2	3	2	2	3	2	4
r_5	1	1	1	1	1	0	0	0	3	3	3	3	4	4	2	2	0	2	2	3	2	3	1
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	4	2	2	2	2
c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	4	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	2	3	2	2	3	2	2	2	1	1	1	1	2	2	1	1	2	2	2	2	0	3	2
k_1	2	3	2	2	2	1	3	3	2	2	1	1	3	2	2	1	2	2	1	1	2	0	2
k_3	3	4	2	3	2	2	2	2	1	2	1	1	3	2	2	1	2	2	1	1	3	3	0

Cond2	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	3	3	2	2	2
e_3	2	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	2	2	0	2	2	3	1	1	3	2	4	2	2	2	2	4	0	4	4	4	4	4	4
k_1	2	3	2	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2
d_1	2	3	2	3	0	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	4	4	3	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g_2	3	3	3	3	2	2	0	2	4	4	2	3	3	3	4	4	2	3	3	3	4	4	4
g_3	4	4	3	3	4	3	4	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	4	3	2	2	3	3	3	2	2	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1

m_2	4	4	2	4	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	4	4	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	1	3	4	3	1	2	2	2	3	3	2	2	0	3	2	1	3	1	1	0	1	0
r_3	4	4	4	4	4	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	3	4	4	1	1	1	4	4	2	2	4	3	4	0	2	3	2	2	3	2	4
r_5	1	1	1	4	1	4	4	4	3	3	3	3	4	4	2	2	0	2	3	4	2	2	1
c_2	3	3	3	3	3	4	3	3	3	3	1	4	0	1	1	1	1	0	4	1	2	2	1
c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	1	2	0	2	1	1	1
e_3	4	4	3	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	2	3	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	2	2	2	2	2	1	3	3	2	2	1	1	3	2	2	1	2	2	1	1	2	0	3
k_3	3	4	2	2	2	2	2	2	1	2	1	1	3	2	2	1	2	2	1	1	3	3	0

Cond3	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	4	0	1	2	2	2	2	2	2	1	3	2	2	1	1	3	2	1	1	1	1	3	2
e_4	3	1	0	2	2	1	1	1	3	3	3	4	4	4	4	4	3	4	2	3	3	3	2
k_1	2	3	3	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2
d_1	3	3	3	3	0	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	4	4	3	4	4	0	2	2	2	3	3	4	0	1	1	3	0	4	4	4	4	4	4
g_2	4	4	3	3	2	1	0	4	4	4	2	3	3	3	4	4	2	3	3	3	4	4	4
g_3	4	4	3	3	4	3	3	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	4	4	2	3	3	4	4	3	0	3	4	3	4	4	3	3	2	3	3	3	2	2	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	3	4	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	4	4	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	3	3	3	4	3	3	1	3	2
r_1	4	3	4	4	3	0	2	2	2	3	3	2	2	0	3	2	1	3	1	1	0	2	0
r_3	2	2	2	2	2	2	2	2	2	4	2	2	4	2	0	3	3	3	2	3	3	3	3
r_4	4	3	3	4	4	2	2	2	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	1	1	1	3	2	1	1	1	1	1	3	3	4	3	2	2	0	2	3	4	2	2	1
c_2	4	4	3	1	1	4	3	3	3	3	1	4	0	1	1	3	1	0	4	1	2	2	1
c_3	4	4	3	1	1	2	2	2	3	3	2	3	2	2	2	3	1	2	0	2	1	1	1
e_3	4	4	3	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	4	4	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	4	3	3	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	4	4	4	2	4	4	2	2	4	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Cond4	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	4	3	4	4	4	3	3	4	4	4	4	4	4	4	4

e_3	4	0	2	3	2	3	3	3	3	3	3	3	3	3	3	3	2	3	3	3	4	3	4
e_4	4	4	0	3	2	3	3	3	3	3	3	4	4	4	4	4	1	4	2	3	3	3	2
k_1	4	4	4	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	3	3
d_1	4	4	3	3	0	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	3	3	3	4	4	0	2	2	2	3	3	4	0	1	1	3	0	4	4	4	4	4	4
g_2	4	4	3	3	2	4	0	4	4	4	2	3	3	3	4	4	2	3	3	3	4	4	4
g_3	4	4	3	4	4	3	3	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	4	4	2	3	3	4	4	3	0	3	4	3	4	4	3	3	2	3	3	3	2	2	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	2	4	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	3	4	3	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	2	4	3	3	1	2	2	2	3	3	2	2	0	3	2	1	3	1	1	2	2	2
r_3	4	3	4	3	4	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	3	3	3	4	1	1	1	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	3	3	2	3	3	3	3	3	3	3	3	3	4	3	2	2	0	2	2	4	2	2	1
c_2	3	3	3	1	1	4	3	3	3	3	1	4	0	1	1	1	1	0	4	1	2	2	1
c_3	3	3	2	1	1	2	2	2	3	3	2	3	2	2	2	3	2	1	0	2	1	1	1
e_3	4	4	2	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	4	4	2	1	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	2	3	3	1	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	4	2	4	2	4	4	2	2	4	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Cond5	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	1	1	3	2	2
e_4	3	2	0	3	2	3	3	3	3	3	4	4	4	4	4	4	2	2	3	3	3	2	2
k_1	3	3	4	0	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2	2
d_1	4	4	2	3	0	3	3	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2
d_4	4	4	3	3	2	0	3	2	3	3	4	0	4	4	4	4	4	4	4	1	1	1	3
g_2	4	4	4	4	4	4	0	4	4	2	3	3	3	4	4	2	3	3	3	4	4	4	4
g_3	3	2	3	2	2	2	2	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	4	3	3	2	3	3	3	2	2	3
m_1	4	4	1	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	2	4	4	3	3	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	2	4	3	2	3	2	2	3	3	2	2	0	3	2	1	3	1	1	2	2	1
r_3	4	3	4	2	4	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	2	3	3	2	2	1	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	1	1	1	3	3	2	4	4	3	3	3	3	4	3	2	2	0	2	2	4	2	2	1
c_2	3	3	3	2	3	4	3	3	3	3	1	4	0	1	1	1	1	0	1	1	2	2	1

c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	2	4	0	2	1	1	1
e_3	4	4	3	4	4	4	4	4	3	3	2	2	4	3	2	2	0	3	1	0	1	1	1
e_4	2	3	2	2	3	2	2	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	2	2	2	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	3	2	2	3	2	2	2	2	4	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Cond6	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	3	3	4	4	4	4	4	4	4	4	4
e_3	4	0	4	4	4	4	4	4	4	4	4	4	1	1	3	2	1	1	1	1	3	2	4
e_4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	0	2	3	3	3	2	2
k_1	1	1	2	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2	3
d_1	4	4	3	3	0	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2
d_4	4	4	3	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	1	1	1	1	1
g_2	3	3	3	4	2	4	0	4	4	4	2	3	3	4	4	2	3	3	3	4	4	4	4
g_3	4	4	3	4	3	3	3	0	4	4	4	4	4	4	4	4	2	2	3	3	3	3	3
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	3	3	2	3	3	3	2	2	3	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	2	3	4	1	4	1	1	1	1	1	1
m_2	4	4	1	4	4	3	2	2	2	2	0	3	3	3	4	4	4	2	4	1	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	2	2	2	1	2	2	2	3	3	2	2	0	3	2	1	3	1	1	3	3	1
r_3	4	3	4	2	2	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	3	2	2	1	1	1	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	1	1	1	2	2	2	2	2	3	3	3	3	4	3	2	2	0	2	2	4	2	2	1
c_2	3	3	3	2	2	4	3	3	3	3	1	4	0	1	1	1	1	0	2	1	2	2	1
c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	2	4	0	2	1	1	1
e_3	4	4	3	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	4	4	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	4	3	3	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	4	3	4	2	4	4	2	2	4	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Cond7	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	3	3	3	4	4	4	3	4	4	4	3	3	4	3	4	4	4	2	3	2
e_3	4	0	1	2	2	2	2	2	2	1	3	2	2	1	1	3	2	1	1	3	4	3	4
e_4	3	2	0	3	2	3	3	3	3	3	4	4	4	4	4	4	1	2	3	3	3	3	2
k_1	3	3	4	0	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	3	2	3	3
d_1	4	4	3	3	0	3	3	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2
d_4	4	4	3	3	2	0	3	2	3	3	4	0	1	1	3	0	4	4	1	1	1	1	1
g_2	3	3	2	2	2	2	0	2	4	2	3	3	3	4	4	2	3	3	3	3	4	4	4
g_3	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	4	3	3	2	3	3	3	2	2	3

m_1	4	4	1	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	4	4	4	3	3	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	4	3	3	4	4	4	4	4	3	0	3	3	3	4	4	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	3	4	3	2	3	2	2	3	3	2	2	0	3	2	1	3	1	1	1	1	0
r_3	2	2	2	2	2	2	2	2	2	2	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	2	3	3	2	2	1	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	2	2	2	4	1	1	1	1	3	3	3	3	4	3	2	2	0	2	2	4	2	2	1
c_2	3	3	3	3	3	4	3	3	3	3	1	4	0	1	1	1	1	0	3	1	2	2	1
c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	2	4	0	2	1	1	1
e_3	4	4	3	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	4	4	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	4	3	3	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	4	3	4	2	4	4	2	2	4	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Cond8	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	3	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	2	2	0	2	2	4	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4
k_1	4	4	2	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2
d_1	4	4	4	3	0	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	4	4	3	4	4	0	2	2	2	3	3	4	0	1	1	3	0	4	4	1	1	1	1
g_2	3	3	3	4	2	4	0	1	4	4	2	3	3	3	4	4	2	3	3	3	4	4	4
g_3	4	4	3	4	3	3	4	0	4	4	4	4	4	4	4	4	4	2	2	3	3	3	3
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	4	3	2	2	3	3	3	2	2	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	4	3	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	3	4	3	1	2	2	2	3	3	2	2	0	3	2	1	3	1	1	0	0	0
r_3	4	3	3	4	4	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	3	4	4	1	1	1	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	2	1	2	3	1	1	1	1	3	3	3	3	4	3	2	2	0	2	4	4	2	2	1
c_2	3	3	3	3	3	4	3	3	3	3	1	4	0	1	1	1	1	0	3	1	2	2	1
c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	2	2	0	2	1	1	1
e_3	4	4	2	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	2	3	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	2	2	2	2	2	1	3	3	2	2	1	1	3	2	2	1	2	2	1	1	2	0	3
k_3	3	3	2	3	2	2	2	2	1	2	1	1	3	2	2	1	2	2	1	1	3	3	0

Cond9	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3

e_1	0	4	4	3	3	3	4	4	4	3	4	4	3	3	4	4	4	4	4	4	4	4	4
e_3	4	0	4	2	4	2	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_4	2	2	0	2	2	3	3	3	3	3	3	4	4	4	4	4	3	4	4	4	4	4	4
k_1	4	4	4	0	4	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	2	2	2
d_1	4	4	1	3	0	3	3	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	4	4	3	3	2	0	3	2	2	2	2	4	1	1	3	0	4	4	4	1	1	1	1
g_2	3	3	3	2	2	2	0	2	4	2	3	3	3	4	4	2	3	3	3	3	4	4	4
g_3	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	2	2	2	3	3	3	3
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	3	3	2	3	3	3	3	2	2	3
m_1	4	4	2	4	4	4	4	4	4	0	4	4	2	3	4	1	4	4	1	1	1	1	1
m_2	4	4	4	3	4	3	3	3	3	3	0	3	3	3	4	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	3	3	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	2	3	3	2	3	3	3	3	3	2	2	0	3	2	1	3	1	1	0	0	0
r_3	2	2	2	2	2	2	2	2	2	2	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	3	2	2	2	2	2	3	4	3	2	2	3	4	0	2	3	2	2	3	2	4
r_5	2	2	2	1	2	0	0	0	1	1	1	1	4	3	2	2	0	2	2	4	2	2	1
c_2	3	3	3	2	3	4	3	3	3	3	2	4	0	1	1	1	1	0	3	1	2	2	1
c_3	3	3	2	0	2	2	2	2	3	3	2	3	2	2	2	3	1	2	0	2	1	1	1
e_3	4	4	1	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	2	3	2	2	3	2	1	2	1	1	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	2	2	2	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	3	3	2	2	4	4	2	2	1	2	1	1	3	2	2	3	2	2	1	1	3	3	0

Cond10	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	3	4	4	4	3	4	4	4	3	3	3	3	3	3	4	4	4	4	4	4	4	4
e_3	2	0	1	2	2	2	2	2	2	1	3	2	2	3	3	3	2	3	3	3	2	2	3
e_4	3	4	0	3	2	3	3	3	3	3	3	3	3	3	4	4	2	4	2	3	2	2	2
k_1	3	3	3	0	4	4	4	4	4	4	4	2	3	3	3	3	3	3	3	3	2	3	3
d_1	4	4	1	4	0	4	4	4	4	4	4	3	4	4	4	4	4	3	2	2	2	2	2
d_4	3	3	3	4	4	0	2	2	2	3	3	2	0	1	1	3	0	3	4	1	1	1	1
g_2	4	4	4	4	3	4	0	3	3	3	2	3	3	3	4	4	2	3	3	3	4	4	4
g_3	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	3	4	2	2	3	3	3	3
g_4	3	4	2	3	3	4	4	3	0	3	4	3	3	3	3	3	2	3	3	3	2	2	3
m_1	4	3	2	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	4	3	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	1	3	4	4	4	3	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	3	3	3	3	2	1	2	2	2	3	3	2	2	0	3	2	1	3	1	1	0	0	1
r_3	2	2	2	2	2	2	2	2	2	3	3	3	3	3	0	3	3	3	2	3	3	3	3
r_4	4	4	3	4	4	1	1	1	3	3	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	1	2	2	2	2	4	4	4	3	3	3	3	4	3	2	2	0	2	1	3	2	2	2

c_2	3	3	3	3	3	4	3	3	3	3	1	4	0	1	1	1	1	0	3	2	2	2	2
c_3	3	3	2	3	2	2	2	2	3	3	2	3	2	2	2	3	4	2	0	2	1	1	2
e_3	3	4	3	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	2
e_4	3	2	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	4	3	3	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	2	2	2	0	3
k_3	3	3	3	2	2	2	2	2	4	2	1	1	3	2	2	3	2	2	2	2	4	4	0

Cond11	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	3	3	4	3	4	4	4	4	4	4	4	4	4	4	2	4	4	4	4	4	4
e_3	3	0	3	4	4	4	4	4	4	4	4	4	4	4	4	4	0	4	4	4	4	4	4
e_4	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2
k_1	3	3	3	0	3	3	3	3	3	3	3	3	3	3	2	3	3	3	1	3	1	1	3
d_1	4	4	3	4	0	4	4	4	4	4	4	4	4	4	4	4	1	4	4	4	4	4	4
d_4	3	3	3	4	4	0	3	3	3	4	4	3	3	3	4	4	3	3	3	3	4	4	4
g_2	4	4	4	4	4	3	0	3	2	2	2	2	2	2	2	2	0	2	1	1	2	2	2
g_3	4	4	4	4	4	4	4	0	2	2	2	2	2	2	2	3	0	2	1	1	2	2	2
g_4	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3
m_1	3	3	3	3	3	3	1	1	1	0	1	3	1	2	2	3	1	2	1	2	2	2	1
m_2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2
m_3	4	4	3	3	3	3	3	3	3	3	3	0	3	3	4	2	4	3	2	4	2	2	2
m_4	4	4	4	4	3	2	1	1	1	1	1	1	0	2	2	2	0	2	0	4	1	1	2
r_1	4	3	2	2	3	0	2	2	2	3	3	2	2	0	3	2	1	3	1	1	0	0	0
r_3	4	3	1	1	4	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	3	4	4	2	2	2	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4
r_5	1	1	1	3	3	0	0	0	3	2	2	2	2	3	2	2	0	2	1	4	2	2	1
c_2	4	4	3	3	3	4	3	3	3	3	1	4	0	1	1	3	1	0	2	1	2	2	1
c_3	4	2	3	3	2	2	2	2	3	3	2	3	2	2	2	3	3	4	0	2	1	1	1
e_3	4	3	3	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	3	0	1	1	1
e_4	4	4	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	4	4	3	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0

Cond12	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	3	0	3	4	4	4	4	4	4	4	2	2	1	1	3	2	1	1	1	1	3	2	2
e_4	2	2	0	2	2	2	2	2	2	2	4	4	4	4	4	4	4	2	3	3	3	2	2
k_1	3	3	3	0	3	3	3	3	3	3	4	3	3	3	3	3	1	3	3	2	2	2	2
d_1	4	4	3	4	0	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2	2
d_4	1	1	1	1	1	0	1	1	1	1	4	0	1	1	3	0	4	4	1	1	1	1	3
g_2	3	2	2	2	2	1	0	3	2	2	3	3	3	4	4	2	3	3	3	4	4	4	4
g_3	4	4	4	4	4	4	4	0	2	2	4	4	4	4	4	4	4	2	2	3	3	3	3

g_4	3	3	3	3	3	3	3	3	0	3	4	3	4	4	3	3	2	3	3	3	2	2	3
m_1	3	3	3	3	3	3	1	1	1	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	2	2	2	2	2	2	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	4	4	3	4	3	3	3	3	3	3	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	3	4	4	3	2	1	1	1	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	2	2	2	0	2	2	2	3	3	2	2	0	3	2	1	3	1	1	1	1	1
r_3	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2
r_4	4	3	3	4	4	4	4	4	4	4	4	4	4	3	4	0	4	4	4	4	4	4	4
r_5	2	2	3	3	3	4	4	4	3	3	3	3	4	3	2	2	0	2	2	4	2	2	1
c_2	4	3	3	2	3	4	3	3	3	3	1	4	0	1	1	1	1	0	2	1	2	2	1
c_3	4	2	3	1	2	2	2	2	3	3	2	3	2	2	2	3	4	3	0	2	1	1	1
e_3	4	4	2	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	4	0	1	1	1
e_4	4	4	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	4	4	3	2	2	1	3	3	2	2	1	1	3	2	2	3	2	2	1	1	2	0	3
k_3	2	2	2	2	2	2	2	2	2	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Cond13	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	3	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	3	0	3	4	4	4	4	4	4	4	4	4	4	4	4	4	0	4	4	4	4	4	4
e_4	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2
k_1	3	3	3	0	3	3	3	3	3	3	3	3	3	3	2	3	3	3	1	3	1	1	3
d_1	4	4	3	4	0	4	4	4	4	4	4	4	4	4	4	4	1	4	4	4	4	4	4
d_4	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	3	1	1	1	2
g_2	3	2	2	2	2	1	0	3	2	2	2	2	2	2	2	2	0	2	1	1	2	2	2
g_3	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2
g_4	3	3	3	3	3	3	3	3	0	3	3	3	3	3	3	3	3	3	3	3	3	3	3
m_1	3	3	3	3	3	3	1	1	1	0	1	3	1	2	2	3	1	2	1	2	2	2	1
m_2	2	2	2	2	2	2	2	2	2	2	0	2	2	2	2	2	2	2	2	2	2	2	2
m_3	4	4	3	3	3	3	3	3	3	3	3	0	2	3	1	2	1	3	2	1	2	2	2
m_4	4	4	4	4	2	2	1	1	1	1	1	1	0	2	2	2	0	2	0	4	1	1	2
r_1	4	3	3	3	3	0	2	2	2	3	3	2	2	0	3	2	1	3	1	1	1	1	1
r_3	2	2	2	2	2	2	2	2	2	2	2	2	2	4	0	2	2	3	2	1	1	1	1
r_4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	3	0	2	3	2	2	3	2	4
r_5	2	2	2	3	3	2	2	2	3	3	3	3	4	3	2	2	0	2	4	3	2	3	1
c_2	3	3	3	3	3	4	3	3	3	3	2	4	2	2	2	3	2	0	2	2	2	2	2
c_3	3	3	2	1	2	2	2	2	3	3	2	3	2	2	2	3	2	4	0	2	1	1	1
e_3	4	4	2	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	4	0	1	1	1
e_4	2	3	2	2	3	2	2	2	1	1	1	1	2	2	1	1	2	2	2	2	0	3	2
k_1	2	2	2	2	2	1	3	3	2	2	3	1	3	2	2	4	4	4	4	4	4	0	2
k_3	3	3	2	2	2	2	2	2	1	2	1	1	3	2	2	1	2	2	1	1	3	3	0

Cond14	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	3	0	1	2	2	2	2	4	4	4	2	2	1	1	3	2	1	1	1	1	1	3	2
e_4	3	2	0	3	2	3	3	2	2	2	4	4	4	4	4	4	2	4	2	3	3	3	2
k_1	3	3	4	0	4	4	4	3	3	3	4	3	3	3	3	3	3	3	3	3	2	2	2
d_1	4	4	2	3	0	3	3	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	4	4	3	3	2	0	3	1	1	1	4	0	1	1	3	0	4	4	4	1	1	1	1
g_2	3	3	2	2	2	2	0	2	4	2	3	3	3	3	4	2	3	3	3	3	4	4	4
g_3	3	2	3	2	2	2	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	3	3	2	3	3	3	3	2	2	3
m_1	4	4	1	4	4	4	4	1	1	0	4	4	0	3	4	1	4	4	1	1	1	1	1
m_2	4	4	1	2	4	3	3	2	2	2	0	3	3	3	4	4	4	4	2	4	1	1	1
m_3	3	3	2	3	3	4	4	3	3	3	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	1	1	1	2	1	0	4	1	1	1	4	3	3	1	3	2
r_1	4	3	3	3	3	2	3	2	2	3	3	2	2	0	3	2	1	3	1	1	1	1	1
r_3	4	3	2	3	4	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4	0	4	4	4	4	4	4	4
r_5	1	1	2	3	3	0	1	1	3	3	3	3	4	4	2	2	0	2	3	4	2	2	1
c_2	3	3	3	3	3	4	3	3	3	3	1	4	0	1	1	1	1	0	2	1	2	2	1
c_3	3	3	2	0	2	2	2	2	3	3	2	3	2	2	2	3	2	4	0	2	1	1	1
e_3	4	4	1	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	4	0	1	1	1
e_4	2	3	2	2	3	2	2	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	2	2	2	2	2	1	3	3	2	2	1	1	3	2	4	3	2	2	1	3	3	0	3
k_3	3	1	2	2	2	2	2	2	2	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Cond15	e_1	e_3	e_4	k_1	k_3	d_1	d_3	d_4	g_1	g_2	g_3	g_4	m_1	m_2	m_3	m_4	r_1	r_3	r_4	r_5	c_1	c_2	c_3
e_1	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
e_3	3	0	4	4	4	4	4	4	4	4	4	4	4	1	1	3	2	1	1	1	1	3	2
e_4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	1	4	2	3	3	3	2
k_1	4	4	4	0	4	4	4	4	4	4	4	4	3	3	3	3	3	3	3	3	2	2	2
d_1	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	2	2	2	2	2
d_4	4	4	3	4	3	0	2	2	2	3	3	4	0	1	1	3	0	4	4	1	1	1	1
g_2	3	3	2	2	2	3	0	3	4	2	3	3	3	3	4	4	2	3	3	3	4	4	4
g_3	4	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
g_4	3	3	2	3	3	4	4	3	0	3	4	3	4	4	3	3	2	3	3	3	2	2	3
m_1	4	4	3	4	4	4	4	4	4	0	4	4	0	2	3	4	1	4	1	1	1	1	1
m_2	4	4	1	4	4	3	2	2	2	2	0	3	3	3	3	4	4	4	2	4	1	1	1
m_3	3	3	2	2	3	4	4	4	4	4	3	0	3	3	3	4	3	2	2	2	3	3	3
m_4	4	4	4	4	4	4	4	4	3	1	2	1	0	4	3	3	3	4	3	3	1	3	2
r_1	4	3	3	2	3	1	2	2	2	3	3	2	2	0	3	2	1	3	1	1	1	1	3
r_3	4	3	3	2	4	4	4	4	4	4	3	3	4	4	0	3	3	3	2	3	3	3	3
r_4	4	4	3	4	4	1	1	1	4	4	2	2	2	3	4	0	2	3	2	2	3	2	4

r_5	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	0	2	2	4	2	2	1
c_2	3	3	3	3	3	4	3	3	3	3	1	4	0	1	1	1	1	0	4	1	2	2	1
c_3	3	3	2	0	2	2	2	2	3	3	2	3	2	2	2	3	2	4	0	2	1	1	1
e_3	4	4	2	4	4	4	4	4	3	3	2	2	4	3	2	2	4	3	1	0	1	1	1
e_4	2	3	2	2	3	2	1	1	1	3	1	1	3	3	3	2	2	2	2	2	0	3	3
k_1	2	3	4	2	2	3	3	3	2	2	1	1	3	2	4	3	2	2	1	3	3	0	3
k_3	2	3	2	2	2	2	2	2	1	2	1	1	3	2	2	3	2	2	1	1	4	4	0

Appendix E. Data for evaluation of systemic innovation problems

Prior1	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	3	2	2	3	1	3	3	4	3	2
e_3	4	3	3	2	2	1	2	3	2	2	2
e_4	3	3	2	0	2	1	2	3	3	1	0
k_1	2	2	1	2	0	1	2	3	2	1	0
d_1	2	1	0	2	0	1	1	3	1	1	0
d_4	0	0	4	4	3	1	2	3	2	3	0
g_2	0	0	1	0	1	0	0	0	3	1	2
g_3	0	1	0	0	2	0	0	0	3	1	2
g_4	0	0	0	0	3	0	0	0	3	1	0
m_1	3	2	2	1	0	0	0	1	4	1	2
m_2	1	2	1	0	3	0	0	1	3	1	0
m_3	1	3	2	0	3	0	1	2	2	4	0
m_4	0	0	1	0	0	0	0	0	2	1	0
r_1	0	1	0	0	2	0	0	1	2	1	2
r_3	0	1	0	0	0	0	1	1	3	2	0
r_4	3	2	2	1	2	0	1	0	3	2	4
r_5	0	2	1	0	1	0	1	1	0	0	0
c_2	2	3	1	1	3	0	1	1	3	1	3
c_3	0	0	0	2	2	0	1	2	3	4	0
e_3	0	0	0	0	2	0	1	1	3	2	0
e_4	2	2	1	1	2	0	0	1	2	1	2
k_1	1	1	0	0	2	0	1	2	2	2	2
k_3	0	1	1	0	3	0	2	1	3	2	2

Prior2	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}

e_1	4	2	2	2	3	1	3	2	4	3	1
e_3	4	2	3	2	2	1	2	3	2	2	1
e_4	3	3	2	0	2	1	2	1	3	1	1
k_1	2	2	1	2	0	1	2	0	2	1	1
d_1	2	1	0	2	0	1	1	1	1	1	1
d_4	0	0	4	4	3	1	1	3	2	3	1
g_2	0	0	1	0	1	0	0	0	3	1	2
g_3	0	1	0	0	2	0	0	0	3	1	2
g_4	0	0	0	0	3	0	0	0	3	1	1
m_1	3	2	2	1	0	0	0	1	4	1	2
m_2	1	3	1	0	3	0	1	1	3	1	2
m_3	1	3	3	0	3	0	1	2	2	4	0
m_4	0	0	1	0	3	0	0	0	2	1	3
r_1	0	0	4	0	3	0	0	1	2	1	2
r_3	2	0	4	0	3	0	1	0	3	2	1
r_4	3	3	3	2	3	0	1	1	3	2	1
r_5	0	3	1	3	4	0	1	1	0	0	1
c_2	2	3	1	1	3	0	1	2	3	1	1
c_3	0	0	0	2	3	0	1	1	3	4	1
e_3	0	0	0	1	4	0	1	1	3	2	1
e_4	2	0	0	1	1	0	0	1	2	1	4
k_1	2	0	0	1	1	0	1	2	2	2	4
k_3	0	0	0	1	3	0	2	1	3	2	4

Prior3	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	2	2	2	3	2	4	4	2	2	3
e_3	4	2	3	2	2	3	3	4	2	4	2
e_4	3	3	2	0	2	2	2	4	3	4	2
k_1	2	2	1	2	0	2	3	4	3	2	2
d_1	2	1	0	2	0	2	4	4	4	4	2
d_4	0	0	4	4	3	0	3	4	4	4	1
g_2	0	0	1	0	1	0	2	2	4	1	1
g_3	0	1	0	0	2	0	2	2	4	3	1
g_4	0	0	0	0	3	1	2	2	3	3	1
m_1	3	2	2	1	0	1	2	2	3	3	3
m_2	1	4	0	0	3	1	2	2	3	3	1
m_3	1	4	4	0	3	1	2	4	3	4	1
m_4	3	4	2	0	3	4	2	4	2	4	1
r_1	0	4	2	3	4	3	2	3	2	4	1
r_3	3	4	4	3	4	3	3	3	2	4	1

r_4	4	4	4	3	4	4	4	4	2	4	2
r_5	1	4	4	3	4	1	1	3	2	4	2
c_2	0	4	2	3	4	0	4	3	2	4	2
c_3	2	4	3	2	4	0	3	3	4	4	2
e_3	2	4	4	2	4	2	3	3	2	4	2
e_4	3	1	3	2	1	0	0	1	3	4	4
k_1	3	3	3	2	1	0	0	1	3	4	4
k_3	1	3	3	2	1	0	2	1	3	4	3

Prior4	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	2	2	2	3	3	4	4	2	2	3
e_3	4	2	3	2	2	3	3	4	2	4	2
e_4	3	3	2	0	2	3	2	4	3	4	2
k_1	2	2	1	2	0	3	3	4	3	2	2
d_1	2	1	0	2	0	3	4	4	4	4	2
d_4	0	0	4	4	3	0	3	4	4	4	1
g_2	0	0	1	0	1	0	2	2	4	1	1
g_3	0	1	0	0	2	0	2	2	4	3	1
g_4	0	0	0	0	3	1	2	2	3	3	1
m_1	3	2	2	1	0	1	2	2	3	3	3
m_2	1	4	1	0	3	1	2	2	3	3	1
m_3	1	4	2	0	3	1	2	4	3	4	1
m_4	3	4	1	0	0	4	2	4	2	4	1
r_1	0	4	0	0	2	3	2	3	2	4	1
r_3	3	4	0	0	0	3	1	0	3	1	0
r_4	4	4	2	1	2	4	1	1	3	1	0
r_5	1	4	1	0	1	1	1	1	1	1	3
c_2	2	3	1	1	3	0	1	2	3	1	2
c_3	0	0	0	2	2	0	1	1	3	1	2
e_3	0	0	0	0	2	0	1	1	3	2	2
e_4	3	1	1	1	2	0	0	1	2	1	3
k_1	3	3	0	0	2	0	1	2	2	2	2
k_3	1	3	1	0	3	0	2	1	3	2	1

Prior5	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	2	3	3	3	4	4	2	2	3
e_3	3	3	3	3	3	3	3	4	2	4	2
e_4	1	4	2	3	3	3	2	4	3	4	2
k_1	4	4	2	3	3	3	3	4	3	2	2

d_1	4	4	2	3	4	3	4	4	4	4	2
d_4	3	4	2	3	3	0	3	4	4	4	1
g_2	0	4	0	0	3	0	2	2	4	1	1
g_3	0	4	0	0	3	0	2	2	4	3	1
g_4	0	3	3	0	3	1	2	2	3	3	1
m_1	3	0	2	0	3	1	2	2	3	3	3
m_2	1	3	1	0	3	1	2	2	3	3	1
m_3	1	3	3	0	3	1	2	4	3	4	1
m_4	0	0	1	0	3	4	2	4	2	4	1
r_1	0	0	4	0	3	3	2	3	2	4	1
r_3	2	0	4	0	3	3	1	0	3	2	3
r_4	3	3	3	2	3	4	1	1	3	2	3
r_5	0	3	1	3	4	1	1	1	0	0	0
c_2	2	3	1	1	3	0	1	2	3	1	1
c_3	0	0	0	2	3	0	1	1	3	4	1
e_3	0	0	0	1	4	0	1	1	3	2	1
e_4	3	1	3	2	1	0	0	1	2	1	1
k_1	3	3	3	2	1	0	1	2	2	2	3
k_3	1	3	3	2	1	0	2	1	3	2	3

Prior6	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	2	3	3	2	3	3	4	3	2
e_3	3	3	3	3	3	1	3	3	2	2	2
e_4	1	4	2	3	3	0	3	3	3	1	0
k_1	4	4	2	3	3	0	3	3	2	1	0
d_1	4	4	2	3	4	2	3	3	1	1	0
d_4	3	4	2	3	3	0	3	3	2	3	0
g_2	0	4	0	0	3	0	0	0	3	1	2
g_3	0	4	0	0	3	0	0	0	3	1	2
g_4	0	3	3	0	3	0	0	0	3	1	0
m_1	3	0	2	0	3	0	0	1	4	1	2
m_2	1	3	1	0	3	0	0	1	3	1	0
m_3	1	3	3	0	3	0	1	2	2	4	0
m_4	0	0	1	0	3	0	0	0	2	1	0
r_1	0	0	4	0	3	0	0	1	2	1	2
r_3	2	0	4	0	3	2	0	1	3	2	0
r_4	3	3	3	2	3	2	3	0	3	2	4
r_5	0	3	1	3	4	2	3	1	0	0	0
c_2	2	3	1	1	3	1	3	1	3	1	3
c_3	0	0	0	2	3	0	3	2	3	4	0

e_3	0	0	0	1	4	0	3	1	3	2	0
e_4	3	1	3	2	1	0	0	1	2	1	2
k_1	3	3	3	2	1	0	1	2	2	2	2
k_3	1	3	3	2	1	0	2	1	3	2	2

Prior7	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	2	3	3	1	4	2	3	2	1
e_3	3	3	3	3	3	1	3	3	1	2	2
e_4	1	4	2	3	3	1	3	1	3	1	2
k_1	4	4	2	3	3	1	3	0	0	1	1
d_1	4	4	2	3	4	1	4	1	1	0	2
d_4	3	4	2	3	3	1	4	3	2	3	2
g_2	0	4	0	0	3	0	4	1	3	0	1
g_3	0	4	0	0	3	0	4	1	3	0	1
g_4	0	3	3	0	3	0	4	1	3	0	2
m_1	3	0	2	0	3	0	3	1	4	1	2
m_2	1	3	1	0	3	0	3	1	3	1	2
m_3	1	3	3	0	3	0	3	2	2	1	1
m_4	0	0	1	0	3	0	3	0	2	1	1
r_1	0	0	4	0	3	0	3	1	2	1	2
r_3	2	0	4	0	3	0	3	0	3	1	1
r_4	3	3	3	2	3	0	3	1	3	1	1
r_5	0	3	1	3	4	0	3	1	1	1	1
c_2	2	3	1	1	3	0	3	2	3	1	2
c_3	0	0	0	2	2	0	3	1	3	1	2
e_3	0	0	0	0	2	0	3	1	3	2	1
e_4	2	2	1	1	2	0	3	1	2	1	2
k_1	1	1	0	0	2	0	1	2	2	2	1
k_3	1	1	1	1	3	1	1	1	3	2	2

Prior8	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	3	3	4	3	4	4	2	2	3
e_3	4	4	4	3	4	1	3	4	2	4	2
e_4	2	4	4	3	4	1	2	4	3	4	2
k_1	0	4	2	3	4	4	3	4	3	2	2
d_1	2	4	3	2	4	4	4	4	4	4	2
d_4	2	4	4	2	4	4	3	4	4	4	1
g_2	3	1	3	2	1	0	2	2	4	1	1
g_3	3	3	3	2	1	0	2	2	4	3	1

g_4	1	3	3	2	1	0	2	2	3	3	1
m_1	3	3	3	3	3	0	2	2	3	3	3
m_2	3	3	3	3	3	0	2	2	3	3	1
m_3	3	3	3	3	3	0	2	4	3	4	1
m_4	3	3	3	3	3	0	2	4	2	4	1
r_1	3	3	3	3	3	0	2	3	2	4	1
r_3	3	4	4	3	4	0	3	3	3	1	3
r_4	4	4	4	3	4	0	3	3	3	1	3
r_5	1	4	4	3	4	0	3	3	1	1	3
c_2	0	4	2	3	4	0	3	3	3	1	3
c_3	2	4	3	2	4	0	3	3	3	1	3
e_3	2	4	4	2	4	0	3	3	3	2	3
e_4	3	1	3	2	1	0	3	3	2	1	3
k_1	3	3	3	2	1	0	3	3	2	2	3
k_3	1	3	3	2	1	0	3	3	3	2	2

Prior9	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	3	4	1	4	3	1	2	2
e_3	4	4	4	3	4	1	4	3	1	2	2
e_4	4	4	4	3	4	1	4	3	1	2	2
k_1	4	4	4	3	4	1	4	3	1	2	2
d_1	4	4	2	3	4	3	4	4	4	4	1
d_4	4	4	2	3	4	0	4	4	4	4	1
g_2	4	4	0	0	4	0	4	2	4	1	1
g_3	4	4	0	0	4	0	4	2	4	3	1
g_4	4	4	2	0	4	1	4	2	3	3	1
m_1	4	4	3	0	4	1	4	2	3	3	1
m_2	4	4	0	0	4	1	4	2	3	3	1
m_3	4	4	4	0	4	1	4	4	3	4	1
m_4	4	4	2	0	4	4	4	4	2	4	1
r_1	4	4	2	3	4	3	4	3	2	4	1
r_3	4	4	4	3	4	3	4	3	2	4	1
r_4	4	4	4	0	4	1	4	4	3	4	1
r_5	4	4	4	0	4	4	4	4	2	4	1
c_2	4	4	4	3	4	3	4	3	2	4	1
c_3	4	4	4	3	4	3	4	3	2	4	1
e_3	4	4	4	0	4	0	4	1	3	2	1
e_4	4	4	4	1	4	0	4	1	2	1	1
k_1	4	4	4	0	4	0	4	2	2	2	1
k_3	4	4	4	0	4	0	4	1	3	2	1

Prior10	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	2	3	3	1	4	4	2	2	1
e_3	3	3	3	3	3	1	3	4	2	4	1
e_4	1	4	2	3	3	1	2	4	3	4	1
k_1	4	4	2	3	3	1	3	4	3	2	1
d_1	4	4	2	3	4	1	4	4	4	3	1
d_4	3	4	2	3	3	1	3	4	4	4	1
g_2	0	4	0	0	3	1	4	2	4	1	1
g_3	0	4	0	0	3	1	4	2	4	3	1
g_4	0	3	3	0	3	1	4	2	3	3	1
m_1	3	0	2	0	3	1	4	2	3	3	1
m_2	1	3	1	0	3	1	4	2	3	3	1
m_3	1	3	3	0	3	1	4	4	3	4	1
m_4	0	0	1	0	3	0	4	4	2	4	1
r_1	0	0	4	0	3	0	4	3	2	4	1
r_3	2	0	4	0	3	0	4	3	2	4	1
r_4	3	3	3	2	3	0	4	4	2	4	1
r_5	0	3	1	3	4	0	4	3	2	4	1
c_2	0	3	2	3	4	0	4	3	2	4	1
c_3	2	3	3	2	4	0	3	3	4	4	1
e_3	2	3	4	2	4	0	3	3	2	4	1
e_4	3	1	3	2	1	0	0	1	3	4	1
k_1	3	3	3	2	1	0	0	1	3	4	1
k_3	4	3	3	2	1	0	2	1	3	4	1

Prior11	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	3	3	3	3	1	3	4	4	3	2
e_3	3	3	4	3	3	1	2	4	2	2	2
e_4	3	3	2	3	3	2	2	4	3	1	2
k_1	3	4	1	2	3	2	2	4	2	1	4
d_1	3	3	0	2	4	3	4	4	1	1	4
d_4	1	3	2	2	3	0	4	4	2	3	4
g_2	1	3	1	0	3	0	4	4	3	1	2
g_3	1	3	1	0	3	2	4	4	3	1	2
g_4	0	3	3	0	3	0	4	4	3	1	3
m_1	3	0	2	0	3	0	4	4	4	1	2
m_2	1	3	1	0	3	2	4	4	3	1	2
m_3	1	3	3	0	3	0	4	4	2	4	0

m_4	0	0	1	0	3	2	4	4	2	1	3
r_1	0	0	4	0	3	0	4	4	2	1	2
r_3	2	0	4	0	3	0	4	4	3	2	4
r_4	3	3	3	2	3	2	4	4	3	2	4
r_5	0	3	1	3	4	0	1	4	0	0	3
c_2	2	3	1	1	3	0	1	3	3	1	4
c_3	0	0	0	2	3	2	1	3	3	4	4
e_3	0	0	0	1	4	0	1	3	3	2	4
e_4	2	0	1	1	1	0	0	3	2	1	4
k_1	2	0	0	1	1	0	1	3	2	2	4
k_3	0	1	0	1	3	0	2	3	3	2	4

Prior12	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	4	4	4	3	4	4	3	2
e_3	4	4	4	4	4	4	3	4	2	3	2
e_4	1	4	2	3	3	4	3	4	3	3	2
k_1	4	4	4	4	4	4	3	0	2	3	4
d_1	4	4	4	4	4	4	3	1	1	3	4
d_4	3	4	2	3	3	1	3	4	2	3	4
g_2	0	4	0	0	3	1	3	4	3	3	2
g_3	0	4	0	0	3	1	3	4	3	3	2
g_4	0	3	3	0	3	1	3	4	3	3	3
m_1	3	0	2	0	3	1	3	4	4	3	2
m_2	1	3	1	0	3	1	3	4	3	3	2
m_3	1	3	3	0	3	1	4	4	2	4	0
m_4	0	0	1	0	3	1	4	4	2	1	3
r_1	0	0	4	0	3	1	4	4	2	1	2
r_3	2	0	4	0	3	0	4	4	3	2	4
r_4	3	3	3	2	3	2	4	4	3	2	4
r_5	0	3	1	3	4	0	1	4	0	0	3
c_2	2	3	1	1	3	0	1	3	3	1	4
c_3	0	0	0	2	3	2	1	3	3	4	4
e_3	0	0	0	1	4	0	1	3	3	2	4
e_4	2	0	1	1	1	0	0	3	2	1	4
k_1	2	0	0	1	1	0	1	3	2	2	4
k_3	0	1	0	1	3	0	2	3	3	2	4

Prior13	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	4	4	4	3	4	4	3	2

e_3	4	4	4	4	4	4	2	4	2	3	2
e_4	3	3	2	3	3	4	2	4	3	3	2
k_1	4	4	4	4	3	4	2	4	2	3	1
d_1	3	3	2	2	4	4	1	4	1	3	1
d_4	2	3	2	2	3	1	2	4	2	3	2
g_2	2	3	1	2	3	1	0	4	3	3	2
g_3	2	3	2	2	3	1	4	4	3	3	2
g_4	2	3	3	2	3	1	4	4	3	3	3
m_1	3	0	2	2	3	1	0	4	4	3	2
m_2	4	4	4	4	4	1	0	4	3	3	2
m_3	4	4	4	4	4	1	1	4	2	3	0
m_4	4	3	2	2	3	1	2	4	2	3	3
r_1	2	3	4	2	3	1	1	4	2	3	2
r_3	2	2	4	2	3	1	1	4	3	3	4
r_4	3	3	3	2	3	1	1	4	3	3	4
r_5	4	3	1	3	4	1	1	4	0	3	3
c_2	2	3	1	1	3	1	1	4	3	3	1
c_3	2	0	0	2	3	1	1	4	3	3	1
e_3	3	0	0	1	4	1	1	4	3	3	1
e_4	2	0	1	1	1	1	0	4	2	3	2
k_1	2	0	0	1	1	1	1	4	2	3	2
k_3	3	3	3	3	3	3	3	4	3	3	2

Prior14	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	4	4	4	4	4	4	4	4
e_3	4	4	4	4	4	3	3	4	2	4	3
e_4	4	4	4	4	4	3	2	4	3	4	3
k_1	4	4	4	4	4	3	3	4	3	2	3
d_1	4	4	4	4	4	3	4	4	4	4	3
d_4	4	4	4	4	4	0	3	4	4	4	3
g_2	0	4	0	0	3	0	2	2	4	1	3
g_3	0	4	0	0	3	0	2	2	4	3	3
g_4	0	4	2	0	3	1	2	2	3	3	3
m_1	3	4	3	0	3	1	2	2	3	3	3
m_2	1	4	0	0	3	1	2	2	3	3	3
m_3	1	4	4	0	3	1	2	4	3	4	3
m_4	3	4	2	0	3	4	2	4	2	4	3
r_1	0	4	2	3	4	3	2	3	2	4	3
r_3	3	4	4	3	4	3	3	3	2	4	3
r_4	4	4	4	3	4	4	4	4	2	4	3

r_5	1	4	4	3	4	1	1	3	2	4	3
c_2	0	4	2	3	4	0	4	3	2	4	3
c_3	2	4	3	2	4	0	3	3	4	4	3
e_3	2	4	4	2	4	2	3	3	2	4	3
e_4	3	1	3	2	1	0	0	1	3	4	4
k_1	3	3	3	3	3	3	3	3	3	3	3
k_3	3	3	3	3	3	3	3	3	3	3	3

Prior15	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	3	4	4	4	4	4	3	2	2
e_3	3	3	3	4	4	4	4	4	3	2	2
e_4	4	4	4	4	4	4	4	4	4	4	2
k_1	4	4	4	4	4	4	4	4	4	4	2
d_1	4	4	4	4	4	1	4	4	4	4	2
d_4	4	4	2	4	4	1	4	3	4	4	3
g_2	4	4	3	2	4	1	4	4	2	4	2
g_3	4	3	3	4	4	1	4	4	4	4	2
g_4	4	4	4	4	4	1	4	4	4	4	4
m_1	4	4	4	4	4	1	4	4	4	4	4
m_2	4	4	4	4	4	1	4	4	4	4	4
m_3	4	4	4	4	4	1	4	4	4	4	4
m_4	3	4	2	4	3	1	3	3	3	3	3
r_1	4	1	3	4	4	1	4	1	1	3	3
r_3	4	4	4	4	4	1	4	4	4	4	4
r_4	4	4	4	4	4	1	4	4	4	4	4
r_5	3	4	3	4	4	1	4	4	4	4	4
c_2	4	4	4	4	4	1	4	4	4	4	4
c_3	4	4	4	4	4	1	4	4	4	4	4
e_3	2	2	2	2	2	1	2	2	2	2	2
e_4	4	4	4	4	4	1	4	4	4	4	4
k_1	3	3	3	3	3	1	3	3	3	3	3
k_3	4	2	4	4	3	1	2	2	3	3	3

Cond1	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	2	2	2	3	3	3	2	3	2	1
e_3	4	2	3	2	2	1	2	3	1	2	1
e_4	3	3	2	0	2	1	2	1	3	1	1
k_1	2	2	1	2	0	4	2	0	0	1	3
d_1	2	1	0	2	0	4	1	1	1	0	3
d_4	0	0	4	4	3	4	2	3	2	3	4

g_2	0	0	1	0	1	0	0	0	3	0	2
g_3	0	1	0	0	2	0	0	0	3	0	2
g_4	0	0	0	0	3	0	0	0	3	0	2
m_1	3	2	2	1	0	0	0	1	4	1	2
m_2	1	2	1	0	3	0	0	1	3	1	2
m_3	1	3	2	0	3	0	1	2	2	1	0
m_4	0	0	1	0	0	0	0	0	2	1	3
r_1	0	1	0	0	2	0	0	1	2	1	2
r_3	0	1	0	0	0	0	1	0	3	1	0
r_4	3	2	2	1	2	0	1	1	3	1	0
r_5	0	2	1	0	1	0	1	1	1	1	3
c_2	2	3	1	1	3	0	1	2	3	1	2
c_3	0	0	0	2	2	0	1	1	3	1	2
e_3	0	0	0	0	2	0	1	1	3	2	2
e_4	2	2	1	1	2	0	0	1	2	1	3
k_1	1	1	0	0	2	0	1	2	2	2	2
k_3	0	1	1	0	3	0	2	1	3	2	1

Cond2	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	3	2	3	4	3	3	4	3	1
e_3	3	3	3	2	3	1	2	3	2	2	1
e_4	3	3	3	2	3	0	2	3	3	1	1
k_1	3	3	3	2	3	0	2	3	2	1	1
d_1	3	3	3	2	4	3	1	3	1	1	1
d_4	1	3	3	2	3	0	1	3	2	3	1
g_2	1	3	1	1	3	0	1	3	3	1	2
g_3	1	3	1	1	3	0	1	3	3	1	2
g_4	0	3	3	1	3	0	1	3	3	1	1
m_1	3	0	2	1	3	0	1	3	4	1	2
m_2	1	3	1	1	3	0	1	3	3	1	2
m_3	1	3	3	1	3	0	1	3	2	4	0
m_4	0	0	1	1	3	0	1	3	2	1	3
r_1	0	0	4	1	3	0	1	3	2	1	2
r_3	2	0	4	1	3	0	1	3	3	2	1
r_4	3	3	3	2	3	0	1	3	3	2	1
r_5	0	3	1	3	4	0	1	3	0	0	1
c_2	2	3	1	1	3	0	1	3	3	1	1
c_3	0	0	0	2	3	0	1	3	3	1	1
e_3	0	0	0	1	4	0	1	3	3	1	1
e_4	2	0	0	1	1	0	2	3	2	1	4
k_1	2	0	0	1	1	0	1	3	2	1	4

k_3	0	0	0	1	3	0	1	3	3	1	4

Cond3	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	2	3	4	4	4	4	2	2	3
e_3	4	4	2	3	4	3	3	4	2	4	2
e_4	1	4	2	3	4	3	2	4	3	4	2
k_1	4	4	2	3	4	3	3	4	3	2	2
d_1	4	4	2	3	4	3	4	4	4	4	2
d_4	3	4	2	3	4	0	3	4	4	4	1
g_2	0	4	0	1	3	0	2	4	4	1	1
g_3	0	4	0	1	3	0	2	4	4	3	1
g_4	0	4	2	1	3	1	2	4	3	3	1
m_1	3	4	3	1	3	1	2	4	3	3	3
m_2	1	4	0	1	3	1	2	4	3	3	1
m_3	1	4	4	1	3	1	2	4	3	4	1
m_4	3	4	2	1	3	4	2	4	2	4	1
r_1	0	4	2	3	4	3	2	3	2	4	1
r_3	3	4	4	3	4	3	3	3	2	4	1
r_4	4	4	4	3	4	4	4	4	2	4	2
r_5	1	4	4	3	4	1	1	3	2	4	2
c_2	0	4	2	3	4	0	4	3	2	4	2
c_3	2	4	3	2	4	0	3	3	4	4	2
e_3	2	4	4	2	4	2	3	3	2	4	2
e_4	3	1	3	2	1	0	0	1	3	4	4
k_1	3	3	3	2	1	0	0	1	3	4	4
k_3	1	3	3	2	1	0	2	1	3	4	3

Cond4	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	2	2	3	4	3	2	3	2	1
e_3	3	3	3	2	2	3	2	3	3	3	3
e_4	1	4	2	0	2	3	2	1	3	1	1
k_1	4	4	1	2	0	3	2	0	0	1	3
d_1	4	4	0	2	0	3	1	1	1	0	3
d_4	3	4	4	4	3	0	3	3	2	3	4
g_2	0	4	1	0	1	0	1	0	3	0	2
g_3	0	4	0	0	2	0	1	3	3	0	2
g_4	0	4	0	0	3	1	1	3	3	0	2
m_1	3	4	2	1	0	1	1	1	4	1	2
m_2	1	4	1	0	3	1	1	1	3	1	2
m_3	1	4	2	0	3	1	1	2	2	1	0
m_4	3	4	1	0	0	4	4	0	2	1	3

r_1	0	4	0	0	2	3	2	1	2	1	2
r_3	3	4	0	0	0	3	1	0	3	1	0
r_4	4	4	2	1	2	4	1	1	3	1	0
r_5	1	4	1	0	1	1	1	1	1	1	3
c_2	2	3	1	1	3	0	1	2	3	1	2
c_3	0	0	0	2	2	0	1	1	3	1	2
e_3	0	0	0	0	2	0	1	1	3	2	2
e_4	3	1	1	1	2	0	0	1	2	1	3
k_1	3	3	0	0	2	0	1	2	2	2	2
k_3	1	3	1	0	3	0	2	1	3	2	1

Cond5	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	4	4	3	4	4	3	2	4	3	1
e_3	4	4	4	3	4	3	2	3	2	2	1
e_4	1	4	4	3	4	3	2	1	3	1	1
k_1	0	4	2	3	4	3	2	0	2	1	0
d_1	2	4	3	2	4	3	1	1	1	1	0
d_4	2	4	4	2	4	0	2	3	2	3	1
g_2	3	1	3	2	1	0	2	0	3	1	0
g_3	3	3	3	2	1	0	2	0	3	1	0
g_4	1	3	3	2	1	1	2	0	3	1	0
m_1	3	4	3	0	3	1	2	1	4	1	1
m_2	1	4	0	0	3	1	2	1	3	1	0
m_3	1	4	4	0	3	1	1	2	2	4	0
m_4	3	4	2	0	3	4	3	0	2	1	3
r_1	0	4	2	3	4	3	1	1	2	1	2
r_3	3	4	4	3	4	3	1	0	3	2	3
r_4	4	4	4	3	4	4	1	1	3	2	3
r_5	1	4	4	3	4	1	1	1	0	0	0
c_2	2	3	1	1	3	0	1	2	3	1	1
c_3	0	0	0	2	3	0	1	1	3	4	1
e_3	0	0	0	1	4	0	1	1	3	2	1
e_4	3	1	3	2	1	0	0	1	2	1	1
k_1	3	3	3	2	1	0	1	2	2	2	3
k_3	1	3	3	2	1	0	2	1	3	2	3

Cond6	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	2	3	3	4	3	3	4	3	2
e_3	3	3	3	3	3	1	3	3	2	2	2
e_4	1	4	2	3	3	0	3	3	3	1	0
k_1	4	4	2	3	3	0	3	3	2	1	0

d_1	4	4	2	3	4	3	3	3	1	1	0
d_4	3	4	2	3	3	0	3	3	2	3	0
g_2	0	4	0	1	3	0	0	0	3	1	2
g_3	0	4	0	1	3	0	0	0	3	1	2
g_4	0	3	3	1	3	0	0	0	3	1	0
m_1	3	0	2	1	3	0	0	1	4	1	2
m_2	1	3	1	1	3	0	0	1	3	1	0
m_3	1	3	3	1	3	0	1	2	2	4	0
m_4	0	0	1	1	3	0	0	0	2	1	0
r_1	0	0	4	1	3	0	0	1	2	1	2
r_3	2	0	4	1	3	3	0	1	3	2	0
r_4	3	3	3	2	3	3	3	0	3	2	4
r_5	0	3	1	3	4	4	3	1	0	0	0
c_2	2	3	1	1	3	1	3	1	3	1	3
c_3	0	0	0	2	3	0	3	2	3	4	0
e_3	0	0	0	1	4	0	3	1	3	2	0
e_4	3	1	3	2	1	0	0	1	2	1	2
k_1	3	3	3	2	1	0	1	2	2	2	2
k_3	1	3	3	2	1	0	2	1	3	2	2

Cond7	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	4	4	4	4	2	3	2	1
e_3	3	3	3	3	3	3	3	3	1	2	2
e_4	3	3	3	3	3	3	3	1	3	1	2
k_1	3	3	3	3	3	3	3	0	0	1	1
d_1	4	3	3	3	4	3	4	1	1	0	2
d_4	3	3	3	3	3	3	4	3	2	3	2
g_2	3	3	3	3	3	3	4	1	3	0	1
g_3	4	3	3	3	4	3	4	1	3	0	1
g_4	3	3	3	3	3	3	4	1	3	0	2
m_1	3	3	3	3	3	3	3	1	4	1	2
m_2	3	3	3	3	3	3	3	1	3	1	2
m_3	4	3	3	3	4	3	3	2	2	1	1
m_4	0	0	1	1	0	0	3	0	2	1	1
r_1	0	1	0	1	2	0	3	1	2	1	2
r_3	0	1	0	1	0	0	3	0	3	1	1
r_4	3	2	2	1	2	0	3	1	3	1	1
r_5	0	2	1	0	1	0	3	1	1	1	1
c_2	2	3	1	1	3	0	3	2	3	1	2
c_3	0	0	0	2	2	0	3	1	3	1	2
e_3	0	0	0	0	2	0	3	1	3	2	1

e_4	2	2	1	1	2	0	3	1	2	1	2
k_1	1	1	0	0	2	0	1	2	2	2	1
k_3	1	1	1	1	3	1	1	1	3	2	2

Cond8	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	3	3	4	3	3	3	3	2	4
e_3	4	4	4	3	4	1	3	3	1	2	4
e_4	2	4	4	3	4	1	3	3	3	1	4
k_1	0	4	2	3	4	4	3	3	0	1	4
d_1	2	4	3	2	4	4	3	3	1	0	4
d_4	2	4	4	2	4	4	3	3	2	3	2
g_2	3	1	3	2	1	0	3	3	3	0	2
g_3	3	3	3	2	1	0	3	3	3	0	2
g_4	1	3	3	2	1	0	3	3	3	0	2
m_1	3	3	3	3	3	0	3	3	4	1	3
m_2	3	3	3	3	3	0	3	3	3	1	3
m_3	3	3	3	3	3	0	3	3	2	1	3
m_4	3	3	3	3	3	0	3	3	2	1	3
r_1	3	3	3	3	3	0	3	3	2	1	3
r_3	3	4	4	3	4	0	3	3	3	1	3
r_4	4	4	4	3	4	0	3	3	3	1	3
r_5	1	4	4	3	4	0	3	3	1	1	3
c_2	0	4	2	3	4	0	3	3	3	1	3
c_3	2	4	3	2	4	0	3	3	3	1	3
e_3	2	4	4	2	4	0	3	3	3	2	3
e_4	3	1	3	2	1	0	3	3	2	1	3
k_1	3	3	3	2	1	0	3	3	2	2	3
k_3	1	3	3	2	1	0	3	3	3	2	2

Cond9	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	3	4	1	4	3	1	2	2
e_3	4	4	4	3	4	1	4	3	1	2	2
e_4	4	4	4	3	4	1	4	3	1	2	2
k_1	4	4	4	3	4	1	4	3	1	2	2
d_1	4	4	2	3	4	3	4	4	4	4	1
d_4	4	4	2	3	4	0	4	4	4	4	1
g_2	4	4	0	0	4	0	4	2	4	1	1
g_3	4	4	0	0	4	0	4	2	4	3	1
g_4	4	4	2	0	4	1	4	2	3	3	1
m_1	4	4	3	0	4	1	4	2	3	3	1
m_2	4	4	0	0	4	1	4	2	3	3	1

m_3	4	4	4	0	4	1	4	4	3	4	1
m_4	4	4	2	0	4	4	4	4	2	4	1
r_1	4	4	2	3	4	3	4	3	2	4	1
r_3	4	4	4	3	4	3	4	3	2	4	1
r_4	4	4	4	0	4	1	4	4	3	4	1
r_5	4	4	4	0	4	4	4	4	2	4	1
c_2	4	4	4	3	4	3	4	3	2	4	1
c_3	4	4	4	3	4	3	4	3	2	4	1
e_3	4	4	4	0	4	0	4	1	3	2	1
e_4	4	4	4	1	4	0	4	1	2	1	1
k_1	4	4	4	0	4	0	4	2	2	2	1
k_3	4	4	4	0	4	0	4	1	3	2	1

Cond10	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	1	3	4	4	4	4	2	2	1
e_3	3	3	2	3	4	3	3	4	2	4	1
e_4	1	3	2	3	4	3	2	4	3	4	1
k_1	4	3	2	3	4	3	3	4	3	2	1
d_1	4	3	2	3	4	3	4	4	4	3	1
d_4	3	3	2	3	4	0	3	4	4	4	1
g_2	1	3	0	1	3	0	4	2	4	1	1
g_3	1	3	0	0	3	0	4	2	4	3	1
g_4	1	3	2	0	3	1	4	2	3	3	1
m_1	3	3	3	1	3	1	4	2	3	3	1
m_2	1	3	0	0	3	1	4	2	3	3	1
m_3	1	3	4	0	3	1	4	4	3	4	1
m_4	3	3	2	0	3	4	4	4	2	4	1
r_1	0	3	2	3	4	3	4	3	2	4	1
r_3	3	3	4	3	4	3	4	3	2	4	1
r_4	4	3	4	3	4	4	4	4	2	4	1
r_5	1	3	4	3	4	1	4	3	2	4	1
c_2	0	3	2	3	4	0	4	3	2	4	1
c_3	2	3	3	2	4	0	3	3	4	4	1
e_3	2	3	4	2	4	2	3	3	2	4	1
e_4	3	1	3	2	1	0	0	1	3	4	1
k_1	3	3	3	2	1	0	0	1	3	4	1
k_3	4	3	3	2	1	0	2	1	3	4	1

Cond11	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	3	2	3	4	3	4	4	3	2
e_3	3	3	3	3	3	1	2	4	2	2	2

e_4	3	3	2	3	3	2	2	4	3	1	2
k_1	3	3	1	2	3	2	2	4	2	1	4
d_1	3	3	0	2	4	3	4	4	1	1	4
d_4	1	3	2	2	3	0	4	4	2	3	4
g_2	1	3	1	0	3	0	4	4	3	1	2
g_3	1	3	1	0	3	2	4	4	3	1	2
g_4	0	3	3	0	3	0	4	4	3	1	3
m_1	3	0	2	0	3	0	4	4	4	1	2
m_2	1	3	1	0	3	2	4	4	3	1	2
m_3	1	3	3	0	3	0	4	4	2	4	0
m_4	0	0	1	0	3	2	4	4	2	1	3
r_1	0	0	4	0	3	0	4	4	2	1	2
r_3	2	0	4	0	3	0	4	4	3	2	4
r_4	3	3	3	2	3	2	4	4	3	2	4
r_5	0	3	1	3	4	0	1	4	0	0	3
c_2	2	3	1	1	3	0	1	3	3	1	4
c_3	0	0	0	2	3	2	1	3	3	4	4
e_3	0	0	0	1	4	0	1	3	3	2	4
e_4	2	0	1	1	1	0	0	3	2	1	4
k_1	2	0	0	1	1	0	1	3	2	2	4
k_3	0	1	0	1	3	0	2	3	3	2	4

Cond12	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	3	2	3	4	3	4	4	3	2
e_3	3	3	3	3	3	4	3	4	2	3	2
e_4	3	3	2	3	3	4	3	4	3	3	2
k_1	3	3	2	2	3	4	3	0	2	3	4
d_1	3	3	2	2	4	4	3	1	1	3	4
d_4	2	3	2	2	3	1	3	4	2	3	4
g_2	2	3	1	2	3	1	3	4	3	3	2
g_3	2	3	2	2	3	1	3	4	3	3	2
g_4	2	3	3	2	3	1	3	4	3	3	3
m_1	3	0	2	2	3	1	3	4	4	3	2
m_2	2	3	1	2	3	1	3	4	3	3	2
m_3	2	3	3	2	3	1	3	2	2	3	0
m_4	4	3	2	2	3	1	3	0	2	3	3
r_1	2	3	4	2	3	1	3	1	2	3	2
r_3	2	0	4	0	3	0	3	0	3	2	4
r_4	3	3	3	2	3	2	3	1	3	2	4
r_5	0	3	1	3	4	0	3	1	0	0	3
c_2	2	3	1	1	3	0	3	2	3	1	4

c_3	0	0	0	2	3	2	3	1	3	4	4
e_3	0	0	0	1	4	0	3	1	3	2	4
e_4	2	0	1	1	1	0	3	1	2	1	4
k_1	2	0	0	1	1	0	3	2	2	2	4
k_3	0	1	0	1	3	0	2	1	3	2	4

Cond13	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	3	3	3	2	3	4	3	4	4	3	2
e_3	3	3	3	3	3	4	2	4	2	3	2
e_4	3	3	2	3	3	4	2	4	3	3	2
k_1	3	3	2	2	3	4	2	4	2	3	1
d_1	3	3	2	2	4	4	1	4	1	3	1
d_4	2	3	2	2	3	1	2	4	2	3	2
g_2	2	3	1	2	3	1	0	4	3	3	2
g_3	2	3	2	2	3	1	4	4	3	3	2
g_4	2	3	3	2	3	1	4	4	3	3	3
m_1	3	0	2	2	3	1	0	4	4	3	2
m_2	2	3	1	2	3	1	0	4	3	3	2
m_3	2	3	3	2	3	1	1	4	2	3	0
m_4	4	3	2	2	3	1	2	4	2	3	3
r_1	2	3	4	2	3	1	1	4	2	3	2
r_3	2	2	4	2	3	1	1	4	3	3	4
r_4	3	3	3	2	3	1	1	4	3	3	4
r_5	4	3	1	3	4	1	1	4	0	3	3
c_2	2	3	1	1	3	1	1	4	3	3	1
c_3	2	0	0	2	3	1	1	4	3	3	1
e_3	3	0	0	1	4	1	1	4	3	3	1
e_4	2	0	1	1	1	1	0	4	2	3	2
k_1	2	0	0	1	1	1	1	4	2	3	2
k_3	3	3	3	3	3	3	3	4	3	3	2

Cond14	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	4	4	2	4	4	4	4	4
e_3	4	4	2	3	4	3	3	4	2	4	3
e_4	1	4	2	3	4	3	2	4	3	4	3
k_1	4	4	2	3	4	3	3	4	3	2	3
d_1	4	4	2	3	4	3	4	4	4	4	3
d_4	3	4	2	3	4	0	3	4	4	4	3
g_2	0	4	0	0	3	0	2	2	4	1	3
g_3	0	4	0	0	3	0	2	2	4	3	3
g_4	0	4	2	0	3	1	2	2	3	3	3

m_1	3	4	3	0	3	1	2	2	3	3	3
m_2	1	4	0	0	3	1	2	2	3	3	3
m_3	1	4	4	0	3	1	2	4	3	4	3
m_4	3	4	2	0	3	4	2	4	2	4	3
r_1	0	4	2	3	4	3	2	3	2	4	3
r_3	3	4	4	3	4	3	3	3	2	4	3
r_4	4	4	4	3	4	4	4	4	2	4	3
r_5	1	4	4	3	4	1	1	3	2	4	3
c_2	0	4	2	3	4	0	4	3	2	4	3
c_3	2	4	3	2	4	0	3	3	4	4	3
e_3	2	4	4	2	4	2	3	3	2	4	3
e_4	3	1	3	2	1	0	0	1	3	4	4
k_1	3	3	3	3	3	3	3	3	3	3	3
k_3	3	3	3	3	3	3	3	3	3	3	3

Cond15	SP_1	SP_2	SP_3	SP_4	SP_5	SP_6	SP_7	SP_8	SP_9	SP_{10}	SP_{11}
e_1	4	4	4	4	4	2	4	4	4	4	4
e_3	4	4	4	4	4	2	4	4	4	4	4
e_4	4	4	4	4	4	2	4	4	4	4	2
k_1	4	4	4	4	4	2	4	4	4	4	2
d_1	4	4	4	4	4	2	4	4	4	4	2
d_4	4	4	2	4	4	2	4	3	4	4	3
g_2	4	4	3	2	4	2	4	4	2	4	2
g_3	4	3	3	4	4	2	4	4	4	4	2
g_4	4	4	4	4	4	2	4	4	4	4	4
m_1	4	4	4	4	4	2	4	4	4	4	4
m_2	4	4	4	4	4	2	4	4	4	4	4
m_3	4	4	4	4	4	2	4	4	4	4	4
m_4	3	4	2	4	3	3	3	3	3	3	3
r_1	4	1	3	4	4	2	4	1	1	3	3
r_3	4	4	4	4	4	2	4	4	4	4	4
r_4	4	4	4	4	4	2	4	4	4	4	4
r_5	3	4	3	4	4	2	4	4	4	4	4
c_2	4	4	4	4	4	2	4	4	4	4	4
c_3	4	4	4	4	4	2	4	4	4	4	4
e_3	2	2	2	2	2	2	2	2	2	2	2
e_4	4	4	4	4	4	2	4	4	4	4	4
k_1	3	3	3	3	3	3	3	3	3	3	3
k_3	4	2	4	4	3	3	2	2	3	3	3

Appendix F. Data for evaluation of systemic innovation policies

1	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	2	2	3	4	3	3	4	3	2	0	4	2	2
SP_2	3	3	1	1	3	2	3	3	1	4	1	3	3	1
SP_3	3	1	4	1	2	0	0	1	1	1	1	3	1	4
SP_4	1	3	1	4	1	3	1	1	1	1	1	1	3	1
SP_5	4	3	1	1	4	1	3	3	3	2	0	4	3	1
SP_6	3	4	1	1	3	3	4	3	1	0	1	3	4	1
SP_7	2	4	1	2	4	2	4	3	1	0	1	2	4	1
SP_8	4	4	1	2	4	1	4	4	4	2	3	4	4	1
SP_9	0	3	1	1	4	0	3	2	4	0	1	0	3	1
SP_{10}	0	2	3	1	4	0	3	2	1	4	4	0	2	3
SP_{11}	0	0	4	1	1	0	1	1	3	4	4	0	0	4

2	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	2	3	3	3	3	3	4	4	4	3	4	2	3
SP_2	4	3	4	4	4	4	3	4	4	3	3	4	3	4
SP_3	4	4	4	3	3	4	4	3	3	3	3	4	4	4
SP_4	3	4	3	3	3	4	4	3	3	3	3	3	4	3
SP_5	4	2	3	2	4	4	2	4	3	3	3	4	2	3
SP_6	4	4	3	4	4	4	4	4	2	3	1	4	4	3
SP_7	3	4	4	4	3	3	4	4	2	1	2	3	4	4
SP_8	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SP_9	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SP_{10}	2	2	2	2	4	3	3	3	4	4	2	2	2	2
SP_{11}	4	2	4	3	3	3	3	3	4	4	4	4	2	4

3	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	2	2	2	2	2	2	2	2	3	4	3	2
SP_2	4	4	2	1	3	1	4	4	4	3	1	4	4	2
SP_3	4	1	4	3	1	2	3	1	1	3	1	4	1	4
SP_4	3	1	1	4	1	2	4	3	2	1	1	3	1	1
SP_5	3	4	1	1	4	1	4	4	3	3	1	3	4	1
SP_6	4	4	1	1	4	4	4	4	4	3	1	4	4	1
SP_7	4	4	1	1	4	1	4	4	4	3	2	4	4	1
SP_8	4	4	1	1	4	1	4	4	3	2	1	4	4	1
SP_9	4	3	1	1	4	1	4	3	4	1	1	4	3	1
SP_{10}	2	1	1	1	2	1	4	3	3	4	1	2	1	1
SP_{11}	3	1	1	2	2	1	2	1	1	1	4	3	1	1

4	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	2	2	2	2	2	2	2	2	2	2	4	2	2
SP_2	4	4	2	2	2	2	2	2	2	2	2	4	4	2
SP_3	2	2	4	2	2	2	2	2	2	2	2	2	2	4
SP_4	3	3	3	4	3	3	3	3	3	2	1	3	3	3
SP_5	3	3	2	2	4	2	2	2	2	2	2	3	3	2
SP_6	3	3	1	1	3	4	4	4	2	3	1	3	3	1
SP_7	3	3	1	1	3	1	4	3	2	2	0	3	3	1
SP_8	3	3	1	1	3	1	3	4	2	2	0	3	3	1
SP_9	3	3	1	1	3	1	3	3	4	2	0	3	3	1

SP_{10}	1	1	1	1	3	1	3	3	1	4	1	1	1	1
SP_{11}	3	3	1	1	3	1	3	3	1	1	4	3	3	1

5	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	4	4	4	4	3	3	4	3	3	4	3	4
SP_2	4	3	4	4	4	3	4	3	4	3	3	4	3	4
SP_3	4	3	4	4	4	4	2	2	3	3	3	4	3	4
SP_4	4	4	4	4	4	4	4	4	4	4	3	4	4	4
SP_5	4	4	4	3	4	3	3	4	3	4	3	4	4	4
SP_6	3	3	4	4	4	4	4	4	3	3	3	3	3	4
SP_7	3	4	3	4	3	4	4	3	4	3	2	3	4	3
SP_8	4	3	3	4	4	2	3	4	3	3	3	4	3	3
SP_9	4	4	3	4	4	4	4	3	4	4	4	4	4	3
SP_{10}	0	1	0	0	4	4	4	4	4	4	4	0	1	0
SP_{11}	3	2	3	4	4	3	3	3	3	3	4	3	2	3

6	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	2	1	1	1	1	2	2	0	0	1	4	2	1
SP_2	3	4	2	1	2	3	3	3	1	3	1	3	4	2
SP_3	3	1	4	1	0	0	2	3	1	2	2	3	1	4
SP_4	3	4	4	4	2	3	3	4	1	2	3	3	4	4
SP_5	3	3	2	3	4	2	3	4	4	3	2	3	3	2
SP_6	3	4	2	2	4	4	4	4	4	1	1	3	4	2
SP_7	3	2	2	1	4	3	4	4	4	1	1	3	2	2
SP_8	3	1	2	2	4	3	4	4	3	3	4	3	1	2
SP_9	3	0	2	0	3	3	2	3	4	3	1	3	0	2
SP_{10}	4	4	2	1	3	1	3	3	4	4	2	4	4	2
SP_{11}	3	1	3	1	3	0	3	3	2	1	4	3	1	3

7	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	2	4	4	3	3	3	4	1	1	2	4	2	4
SP_2	3	3	2	2	3	2	4	3	2	3	2	3	3	2
SP_3	3	1	4	1	3	1	1	1	1	1	4	3	1	4
SP_4	3	3	1	3	4	3	1	1	1	1	3	3	3	1
SP_5	2	3	3	3	4	3	3	3	3	3	2	2	3	3
SP_6	4	4	1	0	4	4	3	3	4	3	2	4	4	1
SP_7	4	4	2	0	4	2	4	3	4	3	4	4	4	2
SP_8	4	4	1	0	4	2	3	4	3	2	2	4	4	1
SP_9	4	3	2	3	4	3	2	3	4	1	2	4	3	2
SP_{10}	4	3	1	2	2	2	4	3	3	4	2	4	3	1
SP_{11}	4	1	1	2	2	2	2	1	1	1	4	4	1	1

8	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	2	2	3	3	3	4	4	2	2	4	3	2
SP_2	3	4	2	0	2	3	3	4	4	2	1	3	4	2
SP_3	3	2	4	0	0	0	4	4	3	2	3	3	2	4
SP_4	4	4	4	4	0	3	4	3	3	2	1	4	4	4
SP_5	2	3	4	4	4	2	2	4	3	2	1	2	3	4
SP_6	4	4	2	3	4	4	4	4	2	2	4	4	4	2
SP_7	4	2	2	2	4	3	4	4	2	1	2	4	2	2

SP_8	3	2	2	1	4	2	4	4	4	2	2	3	2	2
SP_9	4	1	2	2	4	3	4	4	4	2	3	4	1	2
SP_{10}	4	2	2	0	3	1	3	3	4	2	1	4	2	2
SP_{11}	2	1	3	1	3	0	3	3	2	2	4	2	1	3

9	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	1	1	2	4	4	4	2	2	4	4	3	1
SP_2	2	3	2	1	3	3	4	4	2	1	1	2	3	2
SP_3	2	3	4	3	1	2	4	4	4	2	2	2	3	4
SP_4	2	3	1	4	1	1	4	4	4	2	1	2	3	1
SP_5	2	3	3	1	3	2	3	3	4	2	2	2	3	3
SP_6	3	3	2	2	4	2	4	4	4	2	1	3	3	2
SP_7	3	2	2	1	3	1	4	4	4	1	2	3	2	2
SP_8	3	3	2	1	4	3	4	4	4	2	3	3	3	2
SP_9	4	2	3	1	3	4	4	4	4	2	3	4	2	3
SP_{10}	4	3	1	1	2	2	3	3	4	2	4	4	3	1
SP_{11}	1	3	1	2	2	1	3	4	3	2	4	1	3	1

10	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	4	4	4	3	3	4	4	4	4	4	4	4	4
SP_2	2	4	2	1	3	2	4	4	4	2	2	2	4	2
SP_3	2	3	4	3	1	2	3	2	4	0	4	2	3	4
SP_4	2	3	4	4	4	2	3	2	1	4	1	2	3	4
SP_5	4	3	4	3	4	2	2	2	2	2	2	4	3	4
SP_6	4	3	4	4	4	2	4	4	2	3	1	4	3	4
SP_7	4	4	3	4	3	3	4	3	2	2	1	4	4	3
SP_8	4	3	3	4	4	2	3	4	2	2	2	4	3	3
SP_9	2	3	3	4	4	2	3	3	4	2	2	2	3	3
SP_{10}	2	3	4	4	4	2	3	3	1	4	4	2	3	4
SP_{11}	0	3	2	2	2	2	4	4	4	2	4	0	3	2

11	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	2	2	2	2	3	3	3	2	4	4	3	2
SP_2	4	4	2	2	2	1	4	4	1	2	3	4	4	2
SP_3	4	3	4	2	2	2	2	2	2	2	1	4	3	4
SP_4	4	2	3	4	3	2	1	1	1	3	4	4	2	3
SP_5	4	3	4	2	4	3	3	3	3	2	4	4	3	4
SP_6	4	3	3	4	4	4	4	3	1	3	2	4	3	3
SP_7	4	3	3	3	4	3	4	3	1	2	3	4	3	3
SP_8	4	3	3	3	3	3	4	4	4	3	4	4	3	3
SP_9	4	3	3	3	3	3	3	2	4	4	3	4	3	3
SP_{10}	4	3	3	3	3	4	4	4	4	4	4	4	3	3
SP_{11}	4	3	2	1	3	4	3	3	3	2	4	4	3	2

12	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	2	2	2	1	2	4	3	3	3	4	3	2
SP_2	3	4	3	3	4	3	3	3	1	3	2	3	4	3
SP_3	3	4	4	4	3	2	1	1	1	2	2	3	4	4
SP_4	3	3	4	4	4	2	1	1	1	2	1	3	3	4
SP_5	3	3	4	3	4	2	3	3	3	2	4	3	3	4
SP_6	3	3	3	4	4	4	4	3	1	2	4	3	3	3

SP_7	3	3	3	3	4	2	4	3	1	3	2	3	3	3
SP_8	3	2	3	3	3	1	4	4	4	2	3	3	2	3
SP_9	3	2	3	3	3	2	3	2	4	3	4	3	2	3
SP_{10}	3	3	3	3	3	1	3	3	3	4	1	3	3	3
SP_{11}	1	3	3	3	3	1	2	1	1	2	4	1	3	3

13	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	3	3	3	4	4	4	3	4	3	4	3	3
SP_2	3	4	2	2	3	3	4	3	1	3	2	3	4	2
SP_3	3	3	4	2	3	2	4	1	1	3	2	3	3	4
SP_4	4	3	4	4	4	3	4	1	1	2	1	4	3	4
SP_5	4	3	4	4	4	1	3	3	3	3	2	4	3	4
SP_6	4	4	4	4	4	4	4	3	1	2	1	4	4	4
SP_7	4	3	4	4	4	2	4	3	1	2	1	4	3	4
SP_8	4	3	4	4	4	2	4	4	4	2	2	4	3	4
SP_9	4	3	4	4	4	2	3	2	4	4	1	4	3	4
SP_{10}	4	3	4	4	4	3	4	3	3	3	4	4	3	4
SP_{11}	2	3	3	1	3	2	4	1	1	2	4	2	3	3

14	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	4	4	4	4	4	4	4	4	4	4	4	4	4
SP_2	1	4	4	4	4	4	3	3	3	3	2	1	4	4
SP_3	1	3	4	4	4	2	2	3	1	3	1	1	3	4
SP_4	1	3	4	4	4	3	2	1	2	2	2	1	3	4
SP_5	1	2	4	4	4	2	3	3	3	2	2	1	2	4
SP_6	3	3	3	4	4	4	4	3	1	2	2	3	3	3
SP_7	3	3	3	3	4	3	4	3	1	2	1	3	3	3
SP_8	3	3	3	3	3	3	4	4	4	2	1	3	3	3
SP_9	1	3	3	3	3	2	3	2	4	4	2	1	3	3
SP_{10}	1	2	3	3	3	2	2	1	1	3	4	1	2	3
SP_{11}	1	3	1	1	1	4	2	2	2	4	4	1	3	1

15	IP_1	IP_2	IP_3	IP_4	IP_5	IP_6	IP_7	IP_8	IP_9	IP_{10}	IP_{11}	IP_{12}	IP_{13}	IP_{14}
SP_1	4	3	4	1	4	3	3	4	3	1	3	4	3	4
SP_2	3	4	1	4	4	1	4	4	4	1	1	3	4	1
SP_3	3	3	4	3	4	2	4	4	4	2	1	3	3	4
SP_4	4	3	2	4	4	1	3	4	3	1	1	4	3	2
SP_5	3	3	2	4	4	1	4	4	4	2	1	3	3	2
SP_6	4	3	1	4	4	4	4	4	4	2	1	4	3	1
SP_7	4	3	1	4	4	1	4	3	3	1	1	4	3	1
SP_8	3	4	1	1	4	1	3	4	3	2	1	3	4	1
SP_9	3	3	1	3	1	1	3	3	4	2	1	3	3	1
SP_{10}	3	3	1	2	3	1	3	4	3	4	1	3	3	1
SP_{11}	2	2	3	4	4	1	2	2	1	2	4	2	2	3

Appendix F. The Background Information of Experts

No.	Industry	Position	No.	Industry	Position
1	Robot Automation Mfg.	Executive director	9	Designing and Mfg.	Product Manager
2	Robot Automation Mfg.	Senior Tech. Engineer	10	Smart System Mfg.	R&D Manager
3	Robot Automation Mfg.	Sales Manager	11	Industrial IoT Mfg.	R&D Manager

4	Industrial Computer and IoT	R&D Assistant Manager	12	Industrial IoT Mfg.	R&D Manager
5	Industrial Computer and IoT	Senior Engineer	13	Industrial IoT Mfg.	R&D Manager
6	Designing and Mfg.	R&D Manager	14	Industrial IoT Mfg.	R&D Manager
7	Designing and Mfg.	R&D Manager	15	Industrial IoT Mfg.	R&D Manager
8	Designing and Mfg.	Tech. Integration Manager			

Remark: “mfg.” is the abbreviation for “manufacturing.”; “tech.” is the abbreviation for “technical”.