Asian Journal of Innovation and Policy (2017) 6.2:111-137
DOI: http//dx.doi.org/10.7545/ajip.2017.6.2.111

S&T Policy Trend Using Language Network Analysis: Focusing on Science and Technology Basic Plan

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Abstract This study analyzes a language network of Science and Technology Basic Plan, which is the basis for science and technology policy in Korea, for the next Science and Technology Basic Plan. Language network analysis was adopted for a quantitative approach measuring the trend of policies. Several techniques such as keyword analysis, language network map analysis, quantitative characteristics analysis and keyword-related major-word analysis have been performed. Results show that there are common policies emphasized by all Science and Technology Basic Plans in the past, and there are also specific policies emphasized in each period of the Science and Technology Basic Plan. These specific policies come from a 'change of times' when the Science and Technology Basic Plans were established, as well as the philosophy of the national government.

Keywords Science and technology policy, science and technology policy basic plan, language network, policy trend

I. Introduction

Korea has achieved remarkable growth in the world over the last 50 years. It is now in the forefront of achieving per capita Gross Domestic Income (GDP) of US$30,000, growing to become the 14th largest economy in the world. Only 50 years ago the country relied on international aid. The science and technology policy, which was pursued as a sub-plan of the 5-year economic development plan in 1961, had been promoted as a policy to lead economic growth through the high-growth period of the 1980s. Based on this, Korea's GDP per capita exceeded $20,000 - 780 times more the 1953 figure. In the 2000s, the country pursued a strategy to lead the world market in its pursuit to join advanced

Submitted, December 23, 2016; 1st Revised, February 8, 2017; Accepted, March 13
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countries. In the aftermath of the global economic crisis, the country is preparing to leapfrog its economy through creative innovation.

The government establishes and implements a science and technology plan that integrates science-related plans and policies every five years in accordance with Article 7 of the Basic Law on Science and Technology. In the next five years, Korea will set goals and policy directions for the development of science and technology, and propose policies to deal with them. Therefore, the basic plan for science and technology is a basic guide that suggests the direction of the government's science and technology-related policies, and it is a comprehensive plan that systematizes each department's science and technology policies and projects.

The First Science and Technology Basic Plan was established in 2003 and the Second Science and Technology Basic Plan in 2008. The Third Science and Technology Basic Plan was finalized at the National Science and Technology Council on July 26, 2013. This year will see the establishment of the Fourth Science and Technology Basic Plan. Efforts should be made to analyze the implications of existing Science and Technology Basic Plans and to reflect on these results as one proceeds to establish the Fourth Science and Technology Basic Plan.

In this study, we try to apprehend the shared meaning by analysing structurally the text of the previous Science and Technology Basic Plans. Policy is constructed on language, and it can be said that various stakeholders in the policy process exchange their arguments through discussion (Majone, 1989). The policy decision process is a process in which the ideas of various policy stakeholders are organized into language. Our language can be visualized in the form of a network, and through network analysis, it is possible to grasp not only the meaning on the surface, but also the meaning hidden inside. As the language structure is spatially represented, it is possible to visually apprehend the relationship between the main concepts shown in the text and other concepts (Carley, 1997).

The purpose of this study is to examine and analyze the value orientation and policy priorities of Science and Technology Basic Plan through the analysis of language network. It performs inter-language language network analysis used in Science and Technology Basic Plan. It performs a language network analysis between the words used in the Science and Technology Basic Plan and the words used in the project title to compare the value orientation of the overall basic plan with the policy priorities. Next, we will analyze the continuity of the Science and Technology Basic Plan, which has a significant meaning as the top level plan of science and technology policy, and find out the value continually pursued by our science and technology policy.

The structure of this paper is as follows. In Section 2, we examine qualitatively the change of science and technology policy by the past

governments. Section 3 describes the methodology for language network analysis and its scope. The results of frequency analysis, language network map analysis, and quantitative characteristics analysis are then presented in Section 4. The last section is the conclusion in which we synthesize the results of the study and offer a plan to utilize its results.

II. Changes in Science and Technology Policy by Government

We examine Korea's science and technology policy since the Roh Moo-hyun administration that established the Science and Technology Basic Plan examined here. Whenever the regime changed, such as the 'Roh Moo-hyun government-Innovation economy', 'The Lee Myung-bak government-Green economy', and the 'Park Geun-hye government-Creative economy', there was always an economic policy promoted by the government.

Since the 2000s, the development of science and technology has been put forward as one of the national tasks. The Roh Moo-hyun government proposed the establishment of a science-based society, and the introduction of a second science and technology plan around the setting up of a hub for R&D in Northeast Asia. There was a national vision rooted on science and technology that would sustain a new growth engine and strengthen national competitiveness. The objective was building a society that centers on all fields such as politics, economy and culture. To this end, the National Innovation System (NIS) was established in July 2004. By this time, science and technology policy was extended from being centralized to being localized. Since the enactment of the Balanced National Development Act in 2004, local innovation policies have begun to work in the framework of government policies. From this moment on, we have been working to develop regional strategic industries, strengthening innovation capacities at local universities, creating techno parks, research and development schemes, and cluster policies.

In 2008, the Lee Myung-bak government proposed the low-carbon green growth as the central tenet of his administration. Since then, a green growth committee has been established and a national strategy for going green together with a five-year plan to promote green growth policies throughout the entire country have been implemented. It is characterized by a reorganization of governance to nurture human resources through the linkage of higher education and science policy, while developing a synergy in the integration of education and science in various facets of education, science, technology and industry. The Science and Technology Innovation Headquarters was abolished and the Ministry of Education and the Ministry of Science and Technology were integrated into the Ministry of Education, Science and Technology. Various

Table 1 Comparison of major policies of previous government

	Roh Moo-hyun government	Lee Myung-bak government	Park Geun-hye government
Direction	National Science and Technology Innovation System (NIS) ▪ Promotion of national science and technology innovation system to lead innovation-driven economic growth ▪ Propose and promote balanced national development as a major policy measure as an alternative to compensate for the disproportionate growth of the land	Harmony of economy and environment, balanced growth ▪ New technologies and green technologies that pursue growth and sustainability at the same time. New growth engines and job creation. New economic growth (new national growth) paradigm.	Job-centered creation economy ▪ Changes in economic paradigm for creating high-quality jobs by fostering new markets and industries through creativity, imagination, science and technology and ICT convergence ▪ Employment and national welfare catching two rabbits
Key Plans and Goals	National Science and Technology Innovation System (NIS) Plan ▪ Five major innovation areas: 30 key projects National Balanced Development Five-year plan ▪ To foster global innovation cluster, regional balanced industrial development plan, network-type land structure	Green Growth National Strategy and Five-Year Plan ▪ The world's top 7 green power companies by 2020 ▪ Ten policy directions ▪ Foster green technology industry as a new growth engine	Creative Economic Action Plan ▪ Creation of 2.38 million jobs by 2017, 70% employment rate

Source: Reorganized the contents of the Korea Institute of S&T Evaluation and Planning (2015)

functions of R&D budget coordination and allocation and specific evaluation were transferred to the Ministry of Education, Science and Technology and the Ministry of Strategy and Finance, as was basic research support, nuclear energy promotion, safety and science and technology policy establishment. In December 2010, the National Science and Technology Council sponsored a bill at the National Assembly reflecting the concerns of the scientific and technology community that no organization existed to manage science and technology policies. Responsibilities such as budget allocation, coordination

and performance evaluation functions for major national R&D projects were transferred from the Ministry of Strategy and Finance to the National Science and Technology Council, newly set up in March 2011. The Council was responsible for evaluating the practicality of the preliminary feasibility study system.

The Park Geun-hye government that came to power in February 2013, put the creative economy at the forefront of the national economy. It defined the creative economy as "a new economic strategy that creates good jobs by creating new industries and markets by combining people's imagination and creativity with science and technology and ICT, and strengthening existing industries". In the plan for implementing the creative economy, 24 tasks were announced for realizing three goals: creating new jobs and creating new markets, strengthening the global economy, creating a society where creativity is valued highly. It is an extension of existing national economic and science and technology policies, such as fostering IT ventures, launching new growth engines, and creating jobs through solving social problems.

III. Analysis

1. Methodology

This study uses the language network method to analyze the basic plan in the field of science and technology policy. In general, we use social network analysis for network analysis because it examines the network through 'relationships' in which the components of a social system structure are connected (Wasserman and Faust, 1994). An important factor in analyzing the content of a message from a social network perspective is the semantic relation between keywords. Recently, language network analysis is being studied as a new type of text-based quantitative content analysis. Language network analysis is a technique for analyzing phenomena through a network constructed by displaying the relationship between words and words appearing in text as links (Popping, 2000). This is based on the recognition that language and knowledge are networks formed through the relationship between words (Sowa, 1984). In other words, language network analysis can be understood as an attempt to improve knowledge and understanding of specific research fields and phenomena by linking social network analysis technique with text analysis (Choi and Park, 2011).

Table 2 Language network analysis existing research

Research scope and target	Analysis method	Author
Early Presidential Speeches of the Lee Myung-bak government and the Roh Moo-hyun government	Network density, connection centrality, inequality index of language structure, GINI coefficient, presentation of two governments' socio-graphic	Lee (2010)
Saemaul Undong Movement policy	Frequency of key words appearing in one editorial, connection centrality, network map presentation	Choi (2011)
Female policy	The frequency of words appearing in the title, network map, connectivity	Kim (2012)
Frequency policy issues of convergence environment in US Telephony, Korea's Digital Times	Presenting the relationship that emerged in one article as the result of analysis of centrality, cluster analysis, and multidimensional scale	Kim (2010)
US Presidential Inaugural Address	Analyze similarities between presidential inaugural speeches, digitize text data, and deploy it on a network	Light (2014)
Sudan Tribune's newspaper article	A method of extracting network information from a large amount of irregular text-based information	Tamba yong, (2013)
Statement of mission of all medical schools in the United States	Calculate density and connectivity for concept within mission statement, and present subset in network map	Grbic (2013)
New Nazism and Jihadist Promotion	Compare the differences and similarities between Shin Nazi and Jihad propaganda by frequency analysis	Morris (2014)

Source: Domestic articles rearranged the contents of Chi Sung Park (2013)

There are a number of domestic studies that have examined policy using language network analysis. Park (2013) summarized the existing research that began in the fields of journalism, information science, and linguistics. The following is a study of policy analysis. Lee (2010) conducted a language network analysis on Lee Myung-bak's government and Roh Moo-hyun government's early speeches. Choi (2011) analyzed the Saemaul Undong Movement Policy, and Kim (2012) analyzed the women's policy. In the news site, frequency policy issues in the convergence environment are analyzed (Kim et al., 2010). Studies using language network analysis have also been carried

out overseas. These studies are at the core of the US Presidential Speech (Light, 2014), Sudanese newspaper articles (Tambayong, 2013), the Medical School Mission Statement (Grbic, 2013), and New Nazism and Jihadist Advocacy (Morris, 2014). We use language network methodology for content analysis. This study uses the same methodology as the existing research, but it differs from the science and technology policy setting.

From the methodological point of view, frequency analysis, language network map analysis, and quantitative characteristics (density, GINI coefficient, centrality) were analyzed in order to apply the analysis methods performed in the existing language network analysis research as much as possible.

There are also studies that examine Science and Technology Basic Plans. Song (2007) has looked at eleven five-year plans from the Fifth Five-Year Technology Promotion Plan (1962-1966) to the Second Science and Technology Basic Plan as illustrating the policy environment, promotion system, policy goal, and policy scope. Hong (2012) compared the basic science and technology trends in Korea and Japan. This study differs from previous researches in that it visualizes and quantifies the relationship between words constituting the Science and Technology Basic Plan while analyzing only its Basic Plan. This will increase understanding of the flow of science and technology policy.

The network map, which shows the relationship between the main words in the text as a link, uses the VOSviewer program to create a network visualization and a density map. VOSviewer uses VOS mapping technique and VOS clustering technique to analyze and visualize it. Network relationships are spatially expressed using Kullback-Leibler distance based on the frequency of coincidence of keywords. Also, after clustering the related words with the same color, they are located closer to each other as the frequency of coexistence is higher in the same color group, and farther apart as the frequency is lower (Van Eck and Waltman, 2009). This is based on the assumption that these keywords are related if two or more keywords are used simultaneously in one document (Van Eck et al., 2010).

The purpose of this paper is to highlight the difference in science and technology basic plans visually captured from network map through quantitative characteristics of network. The analysis items include network density, GINI coefficient, and centrality. Network density refers to the actual connectedness of the maximum number of connectable words among the keywords used in the key task (Wasserman and Faust, 1994). This means that words have a strong or weak linkage structure (Valente and Foreman, 1998). In this study, we used VantagePoint to measure the density of inter-word network in the previous Science and Technology Basic Plan. The formula for obtaining the network density is as follows.

$$Network\ Density = \frac{1}{\frac{1}{\frac{n(n-1)}{2}}} \quad (1)$$

l denotes the number of links connected to the network, and n denotes the total number of nodes.

Value Orientation of the past Science and Technology Basic Plan Indicators for measuring the imbalance are the GINI coefficients, which describe the inequality index of the keywords and surrounding words[1]. This is because even if the value-oriented intensity in the whole network is the same, there may be an imbalance between individual oriented values. (Borgatti and Everett, 1999). In other words, the degree of variance in the core position and the peripheral position are calculated based on the coincidence frequency. The GINI coefficient is 1 if all the other surrounding words are connected to one extreme keyword. If all the words without the keyword are connected to the same score in a balanced way, the GINI coefficient becomes zero. The formula to obtain the GINI coefficient is as follows (Rafols and Meyer, 2010).

$$GINI\ Coefficient = \sum_i^n p_i ln p_i \quad (2)$$

Here, p_i denotes the ratio of i major words, and the GINI coefficient takes a logarithmic function to normalize.

Next, comparable network characteristics refer to the centrality of individual words. Centrality is an important criterion that indicates the value orientation and policy priorities of a centrally-located word on the network rather than the absolute frequency around the coexistence frequency (Freeman, 1979; Wasserman Faust, 1994). There are three types of centrality: betweenness centrality, degree centrality, and closeness centrality. Centroids are useful for analyzing nodes in a network. This is because the concept of centrality is seen as an influential concept in understanding the meaning that stakeholders want to convey. In other words, a high centrality implies that a certain concept is a bridge in the middle of creating a meaning by connecting various other concepts. Thus, the subgroups with various meanings are interconnected around concepts with high centrality, therefore forming the speaker's overall argument or policy agenda for a particular policy.

Connection centrality plays a role as a hub in a sub-cluster centered on a node with a high connection center, rather than plays an important role in the

[1] It can be measured by the centralization index based on centrality. However, since it represents only the concentration of the connection to the core word rather than considering the subordinate order, it is necessary to consider the core word and the surrounding word at the same time.

semantic flow of concepts in the whole network. The near-centricity represents the average shortest path distance between one node and all other nodes. The point at which the sum of the path distances is the smallest occupies the center of the network with the highest total centrality. In this study, we analyze the phases of major words in Science and Technology Basic Plan by using the centroid and connection centroid. It can be seen that nodes with high centrality between connection center performance and junction centrality are relatively low, but nodes with high centrality serve as junctions that provide meaningful connections between sub-structures. On the other hand, the connection centrality is relatively high, and the nodes with low centrality can be seen as a concept that mainly affects the meaning formation of the group in the subgroup (Paranyushkin, 2011).

2. Analysis Target and Scope

This study analyzes the First, Second, and Third Science and Technology Basic Plan that covers science and technology policy from 2003 to 2017 (Ministry of Science and Technology, 2003; Ministry of Education, Science and Technology, 2008; Ministry of Science, ICT and Future Planning, 2013). The Science and Technology Basic Plan is a bureaucratic plan that articulates the directions and blueprints for the development of science and technology based on the Basic Law of Science and Technology. It is an action plan that draws not only development goals of science and technology, but also important issues for each sector. The five-year plan for the transfer of the Basic Law on Science and Technology has played an ancillary role in the economic development plan. But since the enactment of the Basic Law on Science and Technology in 2001, it has been upgraded to an independent court plan.

The scope of the keyword analysis of the past science and technology policy is the policy field of the Science and Technology Basic Plan and the main project. The ten policy areas of the First Science and Technology Basic Plan are changed into nine policy fields as the Second Science and Technology Basic Plan increases the role of science and technology and spreads science and technology culture. With the establishment of the Third Science and Technology Basic Plan, the number of policy areas will expand to 19 with the expansion of the national key technology and the small and medium venture technology innovation field of the Second Science and Technology Basic Plan. The number of projects to be promoted by the Science and Technology Basic Plan also changed. Some 67 projects in the First Basic Plan, 50 projects in the Second Basic Plan, and 78 projects in the Third Basic Plan were analyzed.

In this study, we examine the connecting structure of words that appear at the same time by dividing them into policy field names and key promotion task

names in the Science and Technology Basic Plans. For example, we analyse the linkage structure of words appearing simultaneously in the policy field name 'Expansion and Efficiency of National R&D Investment' in the Third Science and Technology Basic Plan. The frequency of the simultaneous occurrence of words was transformed into network type data for 233 policy areas and key tasks. It is the same word among 3,606 words included in these sentences, but words to be processed by other words (basic research-basic science, enterprise-industry-private enterprise-private sector, research expenses-research and development expenses, scientist-researchers, science and technology personnel-science and technology talents, science culture-science and technology culture, etc.). In addition, research on the word was removed and pre-processing was performed to remove the separated words without meaning, and the final 2,471 words were analyzed. VantagePoint, Ucinet and VOSviewer software were used as analysis tools.

Table 3 Scope of science and technology basic plan

	1st Basic Plan	2nd Basic Plan	3rd Basic Plan
Number of Policy Sectors	10	9	19
Number of priority projects	67	50	78
Number of words used	966	701	804

IV. Results

1. Keyword Frequency Analysis

As shown in Table 4, the most frequently used words were ‘comprehensive’ (2003-2017), followed by ‘S&T’, ‘R&D’, ‘S&T manpower’, ‘region’, ‘invest’, ‘basic research’, ‘uses’, ‘enlargement’ and ‘government’. Among the policy areas related to science and technology, ‘human policy’, ‘regional policy’, ‘investment in R&D’ and ‘basic research policy’ are the areas mainly promoted. ‘Invest’ and ‘government’ are ranked in the top 10, so it seems that the science and technology policy has been promoted in the past 15 years as government-led investment expansion. Industry and SMEs are also frequently appearing, indicating that they are focusing on economic growth through science and technology.

In the First Science and Technology Basic Plan (2003-2007), the frequency of ‘S&T’, ‘S&T manpower’, and ‘R&D’ is high. Major keywords are ‘industry’, ‘government’, ‘regional’, ‘S&T culture’, ‘basic research’, ‘training’, and ‘R&D program’. This is the time when the Science and Technology Basic Plan was

first established and the existing science and technology policy has been promoted as part of the industrial promotion policy, so the frequency of 'industry' and 'government' is high. The 'S&T culture' has a high frequency because the sectors that correspond to the S&T culture are divided into 'increasing the role of science and technology in response to social demand' and 'diffusion of science and technology culture with the people'.

In the Second Science and Technology Basic Plan (2008-2012), the frequency of 'S&T', 'R&D', and 'S&T manpower' is high. The most important feature of science and technology policy in this period is the emphasis of basic research. The frequency of 'basic research' is 2.6%, which is higher than the frequency of 'total synthesis' 1.7%. In the actual setting of the main quantitative targets of the Second Science and Technology Basic Plan, the priority of basic research is set to be higher than that of the basic research, which is set as 50% of the government R&D investment.

In the Third Science and Technology Basic Plan (2013-2017), the frequency of 'S&T', 'R&D' and 'S&T manpower' is high. It is characterized by the frequency of 'SMEs', 'start-up', 'convergence,' 'jobs', 'intellectual property', 'creative', and 'participation' where the frequency is low in other Science and Technology Basic Plans. It can be identified that the direction of science and technology policy has changed compared with the existing First and Second Science and Technology Basic Plans. The impact of the creative economy of the government was reflected in science and technology policies.

In summary, the main words of the First Science and Technology Basic Plan and the Second Science and Technology Basic Plan are focused on changes in frequency, while the policy direction has not changed. The Second Science and Technology Basic Plan is strongly characterized by the establishment of a policy in the field of science and technology, and continuing existing policies. In the Third Science and Technology Basic Plan, the direction of the policy has changed because the related words appear to have a higher ratio than the words that have been covered in the previous plans.

Table 4 Keywords frequency analysis results

	Overall(2003~2017)			1st Basic Plan (2003~2007)			2nd Basic Plan (2008~2012)			3rd Basic Plan (2013~2017)		
Order	Key words	Freq.	%	Key words	Freq.	%	Key words	Freq.	%	Key words	Freq.	%
1	S&T	55	6.5%	S&T	27	8.3%	S&T	14	6.0%	S&T	13	4.7%
2	R&D	32	3.8%	S&T manpower	11	3.4%	R&D	12	5.2%	R&D	10	3.6%
3	S&T manpower	26	3.1%	R&D	9	2.8%	S&T manpower	8	3.4%	S&T manpower	7	2.5%
4	region	20	2.4%	industry	8	2.4%	ability	7	3.0%	region	7	2.5%
5	invest	16	1.9%	government	8	2.4%	basic research	6	2.6%	SMEs	6	2.2%
6	basic research	14	1.7%	region	8	2.4%	uses	6	2.6%	strartup	6	2.2%
7	uses	14	1.7%	S&T Culture	4	1.2%	strategic	5	2.2%	creation	6	2.2%
8	ability	13	1.5%	basic research	4	1.2%	region	5	2.2%	convergence	5	1.8%
9	enlargement	13	1.5%	training	4	1.2%	invest	5	2.2%	jobs	5	1.8%
10	government	12	1.4%	R&D program	4	1.2%	S&T Culture	4	1.7%	construct	5	1.8%
11	innovation	12	1.4%	invest	4	1.2%	training	4	1.7%	IP	5	1.8%
12	S&T Culture	11	1.3%	innovation	4	1.2%	enlargement	4	1.7%	creative	5	1.8%
13	industry	11	1.3%	uses	4	1.2%	advancement	3	1.3%	GRIs	5	1.8%
14	training	9	1.1%	International	3	0.9%	management	3	1.3%	invest	5	1.8%
15	SMEs	9	1.1%	Private firm	3	0.9%	build	3	1.3%	innovation	5	1.8%
16	creative	9	1.1%	social	3	0.9%	social	3	1.3%	activation	5	1.8%
17	creation	9	1.1%	result	3	0.9%	industry	3	1.3%	global	4	1.4%
18	strartup	8	0.9%	ability	3	0.9%	innovation	3	1.3%	basic research	4	1.4%
19	activation	8	0.9%	Information	3	0.9%	development	2	0.9%	infra	4	1.4%
20	IP	7	0.8%	promotion	3	0.9%	nation	2	0.9%	enlargement	4	1.4%

2. Language Network Map Analysis

First, we make a visual check of the differences in the science and technology basic plan orders mentioned above through the network map. Figure 1 to Figure 6 show a network map created by using the VOSviewer program with the main word network data of the key project in the Science and Technology Basic Plan. Figures 1, 2 and 3 visualize the network relationship between the main words in the network map (Figures 4, 5, 6). From Figure 1 to Figure 3, the terms 'S&T', 'R&D' and 'S&T manpower' are common in the network in the Science and Technology Basic Plan. Although some relative proportions are different, we believe that the past Science and Technology Basic Plans share a lot of value. In the Science and Technology Basic Plans of all orders, the words with the highest frequency of R&D are 'government' and 'invest'. In the past 15 years, the trend in the use of 'expansion of government R&D investment' has been steadily maintained in science and technology policy.

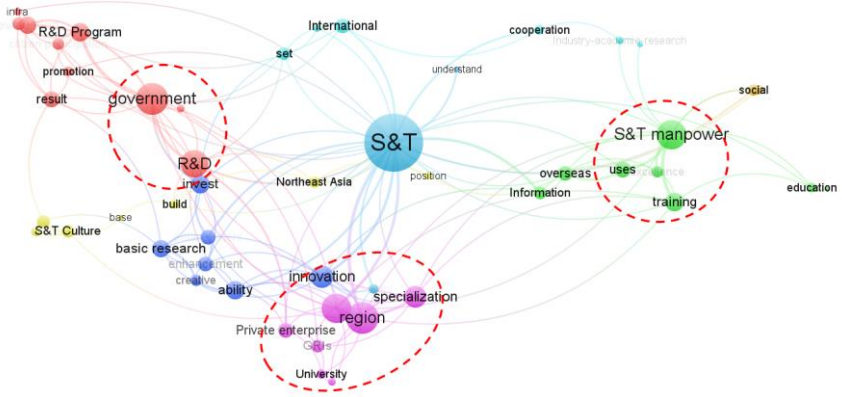

Figure 1 Language network of the First Basic Plan

In the First and Second Science and Technology Basic Plan, the words 'excellent' and 'uses' are common, and the word 'training' is shown in the First Science and Technology Basic Plan. In the early stage of science and technology policy promotion, the 'training' of science and technology manpower is emphasized. After the Second Science and Technology Basic Plan, 'uses' is emphasized rather than 'training'. In the Third Science and Technology Basic Plan, the keywords of 'creative' occurs almost as frequently as 'S&T manpower'. It can be seen that the trend has shifted from the policy-

oriented principle of 'excellent science and technology manpower' to the 'creative science and technology manpower'.

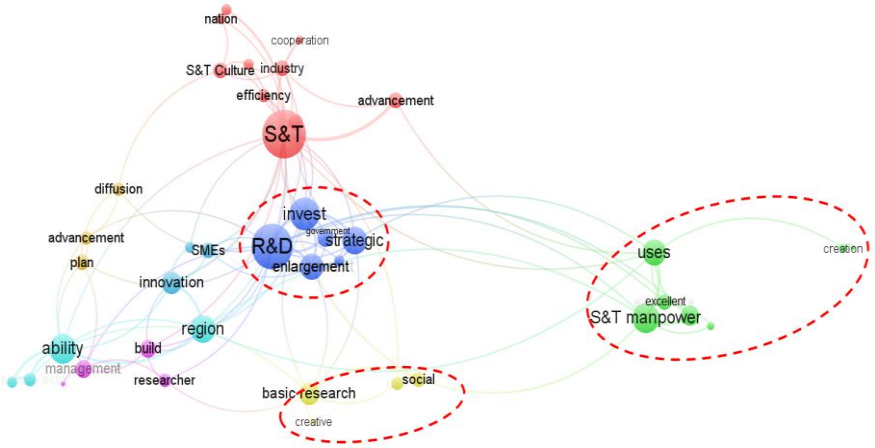

Figure 2 Language network of the Second Basic Plan

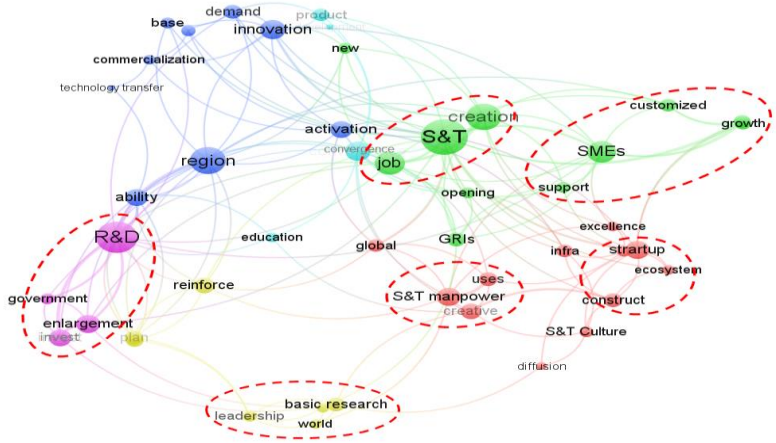

Figure 3 Language network of the Third Basic Plan

The basic research field emphasizes ‘creative research’ in the First and Second Science and Technology Basic Plan. The Third Science and Technology Basic Plan emphasizes 'the world leading research'.

A sub-cluster that encompasses the creation of jobs through science and technology, the support for tailor-made growth of SMEs, and the creation of

entrepreneurial ecosystems are newly included in the Third Science and Technology Basic Plan (Figure 3). The subgroups of the network are derived from the VOSviewer, in which the main words related to each other are grouped into the same color. This is interpreted as reflecting the policy direction pursued by the Park Geun-hye government as well as the situation and circumstances of a given science and technology. As the order of Science and Technology Basic Plan increases, the frequency in the emergence of 'SMEs' is increasing. It can be seen that the subgroups related to the 'basic research' are far away from the core language, and the linkage is weak. Table 5 shows the main words of the sub-communities according to the Science and Technology Basic Plan level derived from the language network.

Table 5 List of key words in the language network analysis subgroup

	Subgroups
First Basic Plan	① excellence-S&T manpower-training-uses, ② government-R&D-advancement, ③ region-specialization-industry
Second Basic Plan	① government-R&D-invest-strategic-enlargement, ② creative-basic research-social-role, ③ excellence-S&T manpower-uses-creation
Thired Basic Plan	① S&T-jobs-creation, ② startup-ecosystem-construct, ③ government-R&D-invest-enlargement, ④ SMEs-growth-customized-support, ⑤ creative-S&T manpower-uses, ⑥ basic research-world-leadership

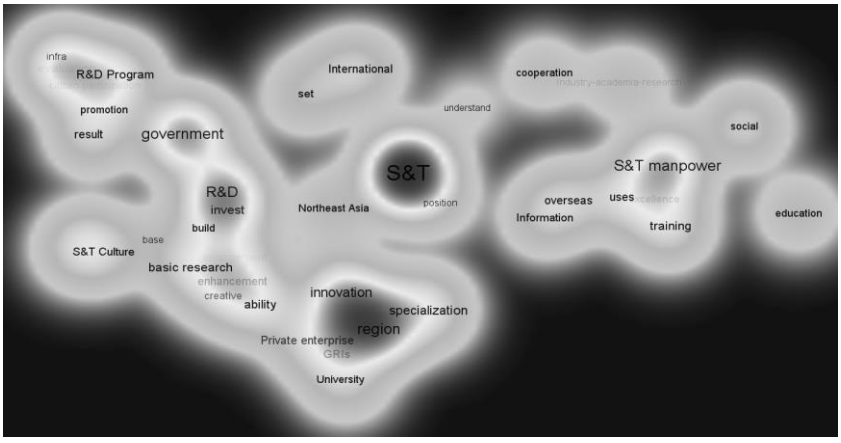

Figure 4 Language network density map of the First Basic Plan

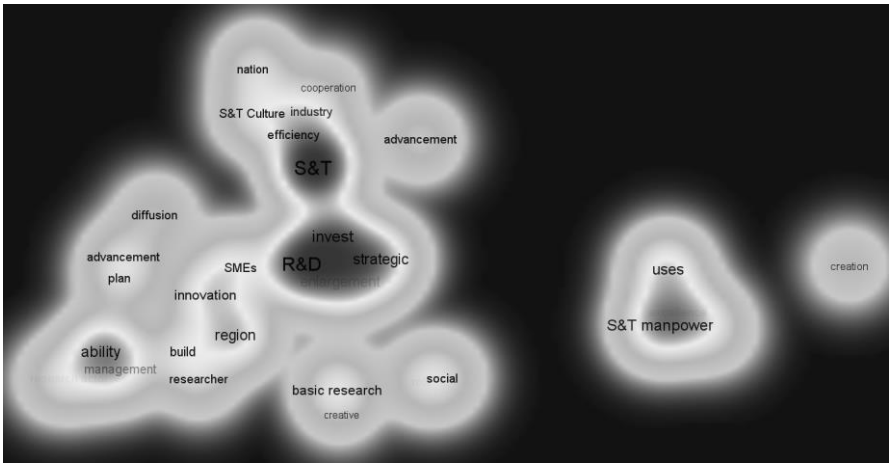

Figure 5 Language network density map of the Second Basic Plan

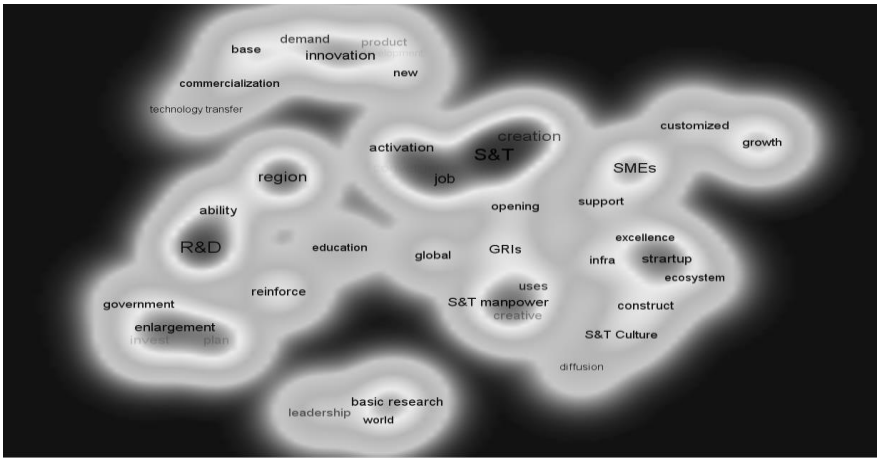

Figure 6 Language network density map of the Third Basic Plan

Figure 4, 5 and 6 offer visualizations of network density using VOS viewer. The frequency analysis through the word cloud simply expresses how frequently each keyword is used in the whole data, while the density map expresses the density of the main word in each group of highly related keywords (Van Eck et al., 2010). The First Science and Technology Basic Plan is high density centered on 'S&T', 'industry (region)', 'R&D' and 'S&T manpower'. The Second Science and Technology Basic Plan is highly dense, centered on

'S&T', 'R&D', 'S&T manpower' and 'competence'. The Third Science and Technology Basic Plan has high density of 'S&T', 'R&D', 'S&T manpower', 'start-up' and 'enlargement'.

3. Quantitative Characteristic Analysis

As mentioned above, the difference of value orientation of the previous Science and Technology Basic Plan can be ascertained by comparing the position and connection relation of the words in the three figures. The difference is more apparent when the visual content of the network map is analyzed through the characteristics of a more quantitative network. Table 6 shows the network density, GINI coefficient, and centrality of the three network characteristics mentioned above.

The network density of the First Science and Technology Basic Plan is 0.346, the Second Science and Technology Basic Plan is 0.262, and the Third Science and Technology Basic Plan is 0.311. Although the network density of the First Science and Technology Basic Plan is relatively higher than the density of the Second Science and Technology Basic Plan, there is no big difference. All the main words are connected about 26% - 35%. Though the First Science and Technology Basic Plan had the highest network density and the Second Science and Technology Basic Plan had the lowest density, it did not show any significant difference. It is assumed that the First and Third Science and Technology Basic Plans have established a Basic Plan using a variety of keywords compared to the Second Science and Technology Basic Plan (Watts and Strogatz, 1998).

As shown in Table 6, the GINI coefficient in the First Science and Technology Basic Plan is 0.50, it is 0.46 in the Second Science and Technology Basic Plan and 0.48 in the Third Science and Technology Basic Plan. This means that the subordinate words are more intensively connected to the keywords that are relatively higher than in the First Science and Technology Basic Plan. This first plan is interpreted as having a relatively high priority policy, while the low priority policy index is relatively low. By contrast, the Second Science and Technology Basic Plan is relatively inferior to other Science and Technology Basic Plans (Lee, 2010). For example, the First Science and Technology Basic Plan has been strongly promoted by the establishment of a national science and technology innovation system, a national innovation policy, and deep innovation and local policies related to balanced national development.

Table 6 Comparison of density, GINI coefficient and centrality (top 10)

	Density	GINI	Centrality		1	2	3	4	5	6	7	8	9	10
1st	0.346	0.50	betweenness	word	S&T	R&D	government	social	evaluation	region	industry	enlargement	manpower	invest
				level	0.150	0.071	0.046	0.017	0.017	0.009	0.008	0.006	0.004	0.004
			degree	word	S&T	region	R&D	government	manpower	industry	evaluation	invest	social	innovation
				level	0.265	0.082	0.082	0.082	0.061	0.061	0.061	0.061	0.041	0.041
2nd	0.262	0.46	betweenness	word	S&T	innovation	region	ability	manpower	invest	R&D	enlargement	basic r.	training
				level	0.033	0.026	0.023	0.019	0.004	0.003	0.001	0.001	0	0
			degree	word	S&T	invest	manpower	R&D	enlargement	ability	government	region	innovation	strategic
				level	0.125	0.100	0.075	0.075	0.075	0.075	0.050	0.050	0.050	0.050
3rd	0.311	0.48	betweenness	word	S&T	R&D	manpower	region	SMEs	strartup	creation	GRIs	invest	innovation
				level	0.013	0.008	0	0	0	0	0	0	0	0
			degree	word	S&T	R&D	invest	creation	enlargement	jobs	strartup	construct	manpower	region
				level	0.128	0.106	0.043	0.043	0.043	0.043	0.021	0.021	0.021	0.021

As a result of a correlation analysis between keywords and connection centrality of major words in the network structure between major words extracted from the previous Science and Technology Basic Plans, all the Science and Technology Basic Plans showed a positive correlation, as well as a strong positive correlation coefficient in the Third Science and Technology Basic Plan. This is because the core words of the First and Third Science and Technology Basic Plans are more faithful to the intersection point that connects different words and meanings in comparison with the Second Science and Technology Basic Plan.

Table 7 The correlation between and degree centrality correlation analysis

	correlation analysis	
	correlation coffecient	p-value
First Basic Plan	0.886**	0.000
Second Basic Plan	0.610**	0.000
Third Basic Plan	0.839**	0.000

** : 99% Valid in confidence interval

When we look at the betweenness centrality and degree centrality of each word, 'S&T' and 'R&D' are highly centered and connected in all Science and Technology Basic Plans. As shown in the network map, 'S&T' and 'R&D' are intersecting with the hub of science and technology policy. The First Science and Technology Basic Plan is characterized by the fact that the word 'social' is not frequent, but the betweenness centrality is high. The degree centrality is relatively low, so that the connection between the subgroups is facilitated in the First Science and Technology Basic Plan. Indeed, the keywords 'social' play a role in connecting the subgroups that are centered on science and technology personnel, such as 'social role of science and technology' and 'responding to social issues of science and technology personnel'. On the other hand, in the 'region', degree centrality is higher than 'S&T', but betweenness centrality is relatively low. The 'region' is mainly used in the First Science and Technology Basic Plan to formulate projects in the local area. In the Second Science and Technology Basic Plan, the frequency of 'basic research' is high, but it is not included in the top ten words of centrality. Although 'basic research' was emphasized, it did not promote the overall science and technology policy centered on basic research within the Second Science and Technology Basic Plan. In the Second Science and Technology Basic Plan, 'innovation' plays a leading role in the formation of the meaning of the whole science and technology policy because it is highly centrality. For example, innovations such as 'S&T innovation,' 'S&T innovation,' and 'Regional innovation cluster

building' are used in various subgroups to form the whole meaning. The 'invest' is centralized at a higher degree than the betweenness centrality, so it has been confirmed that it has played a major role in the specific policy related to investment. This tendency continues in the Third Science and Technology Basic Plan. 'Invest' has not been among the top ten in terms of frequency, but degree centrality is the third highest. It seems that the project to increase the investment of R&D budget and the efficiency in basic research and local policy is reflected in the meaning formation. In the Third Science and Technology Basic Plan, the word with a high betweenness centrality, but relatively low degree centrality is a 'S&T manpower'. Scientific and technical personnel are used in the field of private R&D, regional and human resource development policies, such as 'influx of excellent S&T manpower in SMEs', 'cultivation of localized S&T manpower', and 'maximization of the potential of female S&T manpower'.

4. Analysis of the Change in Words Associated with Keywords

The results of the language network analysis, show that there are words that play a central role in the overall network of Science and Technology Basic Plans and policy areas. 'S&T' as a whole is a keyword and plays a central role. We analyze how the major words related to this keyword are changed through the Basic Plan order, and we try to understand what kind of policy objective science and technology as a means in the past Science and Technology Basic Plans achieved.

Table 8 Key words associated with S&T

	Overall (2003~17)		1st (2003~2007)		2nd (2008~2012)		3rd (2013~2017)	
	Key word		Key word	S.A.	Key word	S.A.	Key word	S.A.
1	innovation	7	region	4	advancement	3	SMEs	2
2	region	5	innovation	3	innovation	2	strartup	2
3	enlargement	4	Information	3	internationalization	2	creation	2
4	industry	4	industry	3	always	2	innovation	2
5	cooperation	4	enlargement	2	cooperation	2	jobs	2
6	advancement	4	cooperation	2	ability	1	Global	2
7	Information	4	understand	2	uses	1	activation	1
8	invest	3	R&D	2	strategic	1	construct	1
9	ability	3	ability	2	region	1	enlargement	1
10	creation	3	social	2	invest	1	Infra	1

Note: S.A. = simultaneous appearance

As shown in Table 8, in the First Science and Technology Basic Plan, the relation between regional innovation policy and industry is high, centered on

S&T. This is in line with the pursuit of a balanced national development and the nationalist philosophy of the Roh Moo-hyun administration. In the Third Science and Technology Basic Plan, we can see that science and technology, such as SMEs, start-up, and jobs, have changed into strategies for creating high quality jobs. It is also consistent with the creative economy and direction of the job-centered philosophy of the Park Geun-hye government. The results of this analysis are consistent with the major policy directions of the previous government as presented in Table 1.

V. Conclusions

1. Comprehensive Language Network Analysis Results

The results of the language network analysis show that there is a differentiated policy according to the policy and the degree steadily promoted in the Science and Technology Basic Plan. The policy that has been emphasized continuously in the Science and Technology Basic Plan for the past 15 years is 'to cultivate and utilize excellent science and technology manpower' and 'to invest in government research and development'. We are developing a policy to utilize well-trained manpower on an on-going basis while cultivating science and technology manpower. The government carry on investing in R&D. In particular, the basic research field has made continued efforts to expand basic research investment. This study confirms the fact that the scientific and technological community is pursuing a consistent policy.

The policy direction was derived based on the different emphasis placed by each Science and Technology Basic Plan over time. The First Science and Technology Basic Plan emphasized regional policy and the Second Science and Technology Basic Plan emphasized the social role as well as basic research in creative research. The Third Science and Technology Basic Plan is emphasizing job creation through science and technology, start-ups, and support for SMEs. This is reflected in the core contents of the national keynote in the First and Third Science and Technology Basic Plans. The Roh Moo-hyun government, which established the First Science and Technology Basic Plan, presented the balanced national development as a major policy direction. This is reflected in the national keynote, and in the First Science and Technology Basic Plan, the keywords of ‘S&T’ and ‘region’ are closely related. In the Third Science and Technology Basic Plan, ‘S&T’, ‘jobs,’ and ‘SMEs’ played a central role, reflecting the principle of the creation of a job-centered creative economy.

Table 9 Direction of policy emphasis by Science and Technology Basic Plan

Policy direction	First Basic Plan	Second Basic Plan	Third Basic Plan
common	·excellence-S&T manpower-uses		
		·government-R&D-invest-enlargement	
difference	·region-specialization -industry ·government-R&D -advancement	·creative-bssic research -social-role	·S&T-jobs-creation ·SMEs-customized -growth-support ·stratup-ecosystem -construct

2. Use Language Network Analysis Results

2.1 Things to Consider for the 4th Basic Plan

Based on the results of the language network analysis, we highlight elements to be considered in the formulation of the Fourth Science and Technology Basic Plan in 2017. This study can usefully contribute, not only to the analysis of the characteristics of the Science and Technology Basic Plans established in the past, but also for the science and technology policy direction to be carried out in the future.

First, it is necessary to review and identify whether the policy direction that has been steadily promoted for 15 years in the Science and Technology Basic Plan will succeed in the next Science and Technology Basic Plan (Type 1). For example, it is necessary to examine the impact of government investment in R&D on the growth rate. Second, if a policy direction needs to be pursued, practical effectiveness should be measured (Type 2). If we keep a policy to strengthen creativity and carry on basic research, we need to make it more concrete and effective. Third, there is a field in which the policy direction has evolved according to the type of Science and Technology Basic Plan (Type 3). For example, the field of human resources development has evolved from training to utilization, and the field of internationalization has shifted to a direction of providing support from the position of receiving support. All these show the necessity to review and, if needed, alter the policy direction of the Science and Technology Basic Plan. Table 10 shows the items to be considered when establishing the Fourth Science and Technology Basic Plan in each major policy field related to the above three perspectives.

Table 10 Considerations for the 4th Basic Plan by type

	Considerations
Type 1	· As summarized in <Table 9>, the expansion of government R & D investment is common in the 2nd and 3rd Science and Technology Basic Plan. Government R & D investment growth is on the decline, and it is necessary to worry about whether it will continue to expand investment. · In the language network map (Figure 1 ~ 3), basic research is connected with investment and expansion, so that the proportion of basic research investment is continuously increasing. Will we continue to expand basic research investment in the future?
Type 2	· As summarized in <Table 5>, basic research in the Second and Third Science and Technology Basic Plan emphasized creative and leading research. How can you achieve effectiveness if you maintain these creative and challenging basic research policies? · As summarized in <Table 9>, policies for the use of S&T manpower are being pursued. As the securing of manpower liquidity becomes important in the era of the fourth industrial revolution, how to secure the effectiveness of the utilization policy of S&T manpower emphasized in the Science and Technology Basic Plan? · As shown in <Table 9>, in the Third Science and Technology Basic Plan, the startup and job policies were differentiated from the existing Science and Technology Basic Plan. As the importance of job creation is still high, how do you secure the effectiveness of startup and job creation through science and technology?
Type 3	· The results of the analysis of <Table 8> show that the most emphasized regional policy together with the key words of science and technology in the First Science and Technology Basic Plan has become less significant since the Second Science and Technology Basic Plan. How do you set the direction of regional policy in the Fourth Basic Science and Technology Plan?

2.2 Applicability of Policy Research in Language Network Analysis

As a result of the research, we found that the methodology applied to this study could be useful for the future analysis of other science and technology policies. This paper attempts to summarize the examples of science and technology policy research using language network analysis.

This type of analysis can be used to evaluate Science and Technology Basic Plans. After focusing on the direction of the policy network through an examination of the language network, we analyze how much the government R&D budget is instrumental in these issues. We try to assess how much of what is contained in the whole text of the Science and Technology Basic Plan is actually implemented. It is possible to analyze the coherence between the Science and Technology Basic Plan and the performance of the plan. The Science and Technology Basic Plan is tasked to review the results every year with a view to an effective implementation of the plan the subsequent year. It

is possible to explore how the results of the language network analysis of the projects' content of the Science and Technology Basic Plan compared with a similar analysis of the performance and implementation plans reported to the National Science and Technology Council.

This methodology can be applied to the analysis of the compatibility between the mid-term plans of science and technology and the Science and Technology Basic Plan. When establishing the Third Science and Technology Basic Plan, the government has decided to establish mid- and long-term plans for each ministry based on the Basic Plan in order to enhance the effectiveness of the Science and Technology Basic Plan. The government delineated a mid- to long-term representative plan for each field of the basic plan, and then analyse them (Ministry of Science, ICT and Future Planning, 2016). If the language network analysis is performed on the top-level Science and Technology Basic Plan and the sub mid- and long-term plans, it is possible to judge whether there is some degree of linkage and mutually oriented policy directions.

It is also possible to analyze trends in the latest science and technology policies. The government announced two rounds of the Government R&D Innovation Plans in 2015 and 2016. A language network analysis can reveal the differences and commonalities of the two innovation schemes. In comparison with the Third Science and Technology Basic Plan, it is also possible to apprehend the changes in science and technology policy at the beginning of the present government.

2.3 Limitations of Research

The research methodology that identifies trends by applying language network analysis to the field of science and technology policy brings about clear results. But there are limitations in terms of contents. Trend analysis was only performed on the Science and Technology Basic Plan. In 2015, a total of 112 science and technology mid- to long-term plans have been established and implemented by 17 central government departments. Had we been able to analyze all these plans, we could have come up with more accurate trends. Another limitation is to have analysed only the contents of the plans. Examining their implementation and performance would have made it possible to look at trends in science and technology policy over the past 15 years.

There is also a limit in the methodology. Although it is a method that minimizes the subjective interpretation over the conventional intuitive method of analyzing the meaning, the subjective interpretation still plays a role in the interpretation of the results. The quality of interpretation and research can be influenced by researchers' expertise in science and technology policy. In addition, as in the case of content analysis in research design and data refinement, coding, and analysis, empirical methods are used for semantic

identification, so researchers' expertise and the use of detailed techniques are required. Finally, since the network structure varies depending on the extent of the relation between the main words, it is necessary to carry on studies that seek to define the relation between the main words.

Acknowledgements

This paper summarizes the research projects of Korea Science and Engineering Planning and Evaluation Agency in 2016 that authors participated.

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