

Research Trends and Correlation Analysis of Technological Innovation and Absorptive Capacity

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Abstract: The purpose of this study is to identify the research trend of innovation capacity and technological innovation that are recently required in companies. This was done by collecting and analyzing dissertation abstracts from Springer and Scopus, which are websites with a collection of dissertations. For the research method, this study used NetMiner 4 and R program for text data analysis amongst unstructured data analysis, and analysis methods like keyword network analysis, LDA, and TreeMap were applied. The analysis results showed that there is a difference in the importance of technological innovation and absorptive capacity of Springer and Scopus

Keywords: Technological Innovation, Absorptive Capacity, LDA, Network Analysis, TF-IDF

1. Introduction

Unlike the past, many changes are happening in our lives because of rapid technological advancement[1]. Recently, we have entered the Fourth Industrial Revolution followed by the First Industrial Revolution, Second Industrial Revolution, and Third Industrial Revolution. Various technologies are included in the Fourth Industrial Revolution. It was possible through innovation like IoT, big data, artificial intelligence, and Cloud[2,3]. Many developed countries, along with global companies, are competing on a national level to establish and support various policies for technological innovation. In particular, they are providing all their capacity to secure source technology. Currently, Singapore ranks 1st in the world competitive ranking of the Fourth Industrial Revolution followed by United States as 2nd, Hong Kong as 3rd, and South Korea coming in at 13th. Although the ranking has elevated significantly compared to the previous year, much more efforts are still required. In the Fourth Industrial Revolution referred to as ICBMA[1,2], technological innovation that corresponds should proceed in order for corporations to survive.

In other words, it is different from the past, as efforts are required in order to be equipped with the capacity to develop and apply the newest technology. Recently, many companies are racing to do their best for technological innovation, but because they are only focused on developing technology, they do not make an investment for the measures to apply the technology properly in the companies. In addition, in case the companies lack in their capacity of technological development, then externally developed technology has to be applied. Accordingly, absorptive capacity is required to apply the outside technology and knowledge internally[4]. In this study, the research trend of technological innovation and absorptive capacity trends are to be identified. Especially, the relevance between technological innovation and absorptive capacity will be identified and NetMiner will be applied for network analysis technique to execute the analysis. Moreover, technological innovation and absorptive capacity were the only dissertation titles searched on Springer and Scopus dissertation database.

This study will follow the following procedures. First, the introduction will explain the background and purpose of this study. In section 2, the theoretical background will be discussed. In section 3, the data analysis procedures and method will be described, followed by the research findings in section 4 and the conclusion and implication in section 5.

2. Related Work

2.1. Technology Innovation

Technology is a complicated field with the properties of rapid changes. In addition, companies are continuously making an attempt to create new markets, reduce the production cost, and bring differentiation by using technology as a measure to secure the competitive advantage. Schumpeter(1934) defined technological innovation as creative destruction and the innovation stages were classified into new production development stage, new production method adaptation and new technique development stage, new market colonization stage, new supply stage of raw materials, and new organization formation stage[5].

In addition, Schmookler(1966) based on the existing Schumpeter research and classified technological innovation into products and process innovation[6]. Damanpour & Evan(1984) claimed that newly applying technological innovation onto new products, service, system, procedures, program, and device to an organization through technological innovation and promoting changes in the organization represents technological innovation[7]. In the research by Park et al.(2018), technological innovation was categorized into product innovation, process innovation, marketing innovation, organization innovation, innovation that

reinforces key capabilities, innovation that destroys the key capabilities, product structure innovation, and parts innovation[8].

2.2. Absorptive Capacity

Absorptive capacity is the ability of an organization to convert and apply to acquire and digest outside knowledge and apply it for the intention[9,10]. In addition, the important fact is that absorptive capacity is linked to innovation and regarded as the key source of successful innovation[11,12]. While the absorptive capacity of Cohen & Levinthal(1990) was analyzed as the capacity of the company to absorb knowledge from the affiliated field[10], the absorptive capacity of Lane & Lubatkin(1998) was analyzed as the capacity to absorb knowledge from other companies and defined as applying and understanding the knowledge that results from other companies[13]. Zahra & George(2002) based on the concept of absorptive capacity of Cohen & Levinthal(1990) and claimed that the four competence including the acquisition, digestion, conversion, and application of external knowledge cause a path-dependency influence[14].

2.3. Text mining

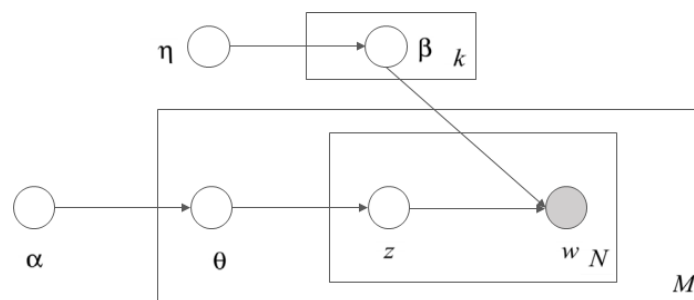
The purpose of text mining is to analyze the text data to identify the rules and the patterns and derive useful information. Generally, text mining collects data and executes the process of converting with noise removal, tokenization, POS tagging, stopword removal, and vector expression and applying the algorithm. By using text mining technology, natural language processing technique is applied first in the human centered unstructured data to extract meaningful number or word index from the extracted text[15]. The information included in the text is made so that it can be approached through various text mining algorithm like statistics or regular machine learning to extract meaningful information. In addition, text mining is the technique that is the basis of other unstructured data mining techniques like web mining, opinion mining, or social network analysis.

2.4. Network Analysis

Keyword network makes it possible to connect the keyword from the text and also extract the network of those concepts[16]. Generally, network analysis method includes network cohesion analysis, sub-network analysis, structural equivalence analysis, and centrality analysis. Additionally, measurement indicators to analyze the network cohesion include inclusiveness, degree, density, and clustering coefficient[17]. Keyword network analysis makes it possible to conduct structural analysis additionally through clustering analysis and centrality analysis, in addition to simple frequency analysis, and it has the advantage where methods for qualitative or quantitative analysis can be applied at the same time. In addition, the measurement indicators of centrality are degree centrality, betweenness centrality, and closeness centrality.

2.5. Latent Dirichlet Allocation

In natural language processing, Latent Dirichlet Allocation(LDA) refers to a probability model regarding topics existing in each given document[18,19]. Document topic distribution value (θ), word distribution value (β) of a topic and the number of topics (k) should be entered as hyper parameters beforehand. Based on the values entered, words (w) were observed, and each word was given an appropriate topic number (z).



- M: Number of documents
- N: Number of words in the document
- W: word
- Z: Topic number to which the word belongs
- k: Number of topics (Hyper parameter)
- α : Document-topic θ distribution value (Hyper parameter)

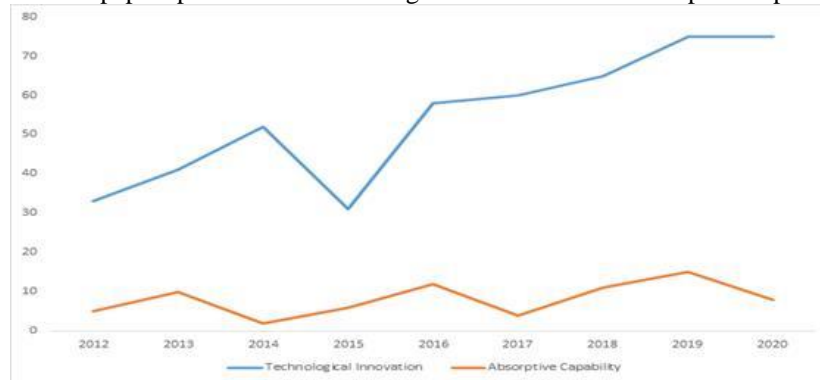
- η : Topic-word-by-word β distribution value (Hyper parameter)
- θ : Distribution of topics by document
- β : Word distribution of topics

3. Research Procedure

This study collected data with the following measures and conducted an analysis. First, Springer database was applied in NetMiner and abstracts were downloaded from the dissertation database of Scopus. For the collected data, technological innovation appeared as 103 for Springer and 701 for Scopus. In case of the absorptive capacity, Springer had 87 and Scopus had 92. On Springer, the dissertation title was limited through NetMiner and the keyword was set up as 'technological innovation' and 'absorptive capacity' to execute the analysis. On Scopus, the website was accessed and it was limited first as the dissertation title and the keyword were set up as 'technological innovation' and 'absorptive capacity,' the document type was set up as articles, and the keyword was fixed as technological innovation to conduct the analysis,

The collected data was set up so that it is suitable for network analysis through data cleansing and data pre-processing. Then, NetMiner and R were used to implement the keyword network, LDA, and TreeMap analysis. The data collection method and keyword network analysis method and procedures through NetMiner are as shown in figure 3. The methods and procedures of LDA and TreeMap analysis through R are as shown in figure 4.

Figure 1. Number of papers published in technological innovation and absorption capacity(scopus)



4. Results

4.1. Keyword Network (Springer)

4.1.1. Technological Innovation Analysis Results

Weight refers to the link frequency of the created word pair. In this study, 7 times and above was chosen as the standard. The # of sentences signifies the number of sentences/paragraphs/documents where the particular word pair appeared. First of all, it was displayed that innovation and performance are important. Weight appeared 20 times and the # of sentences as 11 and the Gini coefficient value appeared as 0.9. The next importance were the capacity and the knowledge. Weight appeared 28 times and the # of sentences appeared 19 times, and the Gini coefficient value appeared as 0.9. Aside from this, it was displayed that the capacity and innovation, knowledge and transfer are also important was shown in the Table 1.

Table 1. Keyword Network Analysis Results (Technological Innovation)

Source	Target	Weight	# of Articles	Gini Coefficient
capacity	development	7	7	0.9
capacity	capability	7	6	0.9
UIC	innovation	7	1	1
firm	capacity	8	7	0.9
supply	chain	8	1	1
RnD	cooperation	14	2	1
training	performance	8	2	1
productivity	growth	8	3	1
innovation	capability	8	2	1
capacity	firm	8	8	0.9
role	capacity	8	8	0.9
innovation	network	8	3	1
capacity	knowledge	28	19	0.9

valuation	1.2	networking	1.2
announcement	1.2	competence	1.4
internacionales	1.2	ICT	1.2
improvisation	1.2	intention	1.2
member	1.2	GBS	1.2
PLC	1.4	savoirs	1.3
Vietnam	1.2	site	1.2
delivery	1.2	office	1.2
subsidy	1.4	training	1.3
team	1.5	science	1.2
attitude	1.2	l'apprentissage	1.3
startups	1.2	emission	1.4
survival	1.2	développement	1.2
EMR	1.4	wellbeing	1.2
supply	1.5	continuance	1.2
filter	1.4	trait	1.3
selfefficacy	1.2	aprendizaje	1.2
buyersupplier	1.2	PAC	1.3
NPD	1.3	Lithuania	1.2
organisation	1.3	assignment	1.2
entre	1.3	blockchain	1.2

The terms that had high weight were supply, team, PLC, and NPD(new product development). This means that it is important to apply it for supply through technological innovation, team formation for technological innovation development, product life cycle, and new product development.

4.1.2. Absorptive Capacity Analysis Results (Springer)

The following are the absorptive capacity analysis results. Weight refers to the link frequency of the created word pair. In this study, 7 times and above was chosen as the standard. The # of sentences signifies the number of sentences/paragraphs/documents where the particular word pair appeared. First of all, it was displayed that innovation and performance are important. Weight appeared 48 times and the # of sentences as 47 and the Gini coefficient value appeared as 0.5. The next importance were the capacity and the knowledge. Weight appeared 48 times and the # of sentences appeared 9 times, and the Gini coefficient value appeared as 0.9. Aside from this, it was displayed that the capacity and innovation, knowledge and transfer are also important was shown in the Table 3.

Table 3. Keyword Network Analysis Results (Absorptive Capacity)

Source	Target	Weight	# of Articles	Gini Coefficient
innovation	enterprise	14	8	0.9
Total factor	energy	7	1	1
supply	chain	9	3	1
energy	efficiency	9	1	1
effect	innovation	7	7	0.9
risk	measure	7	2	1
innovation	strategy	8	3	1
efficiency	enterprise	9	2	1

enterprise	innovation	13	8	0.9
innovation	capability	24	9	0.9
impact	innovation	8	7	0.9
innovation	system	12	7	1
equipment	industry	9	3	1
development	innovation	7	7	0.9
adoption	innovation	9	5	1
innovation	process	13	9	0.9
science	technology	7	4	1
innovation	efficiency	19	6	1
technology	innovation	19	14	0.9
innovation	development	9	4	1
Technological	innovation	10	10	0.9
Total factor	efficiency	7	1	1
investment	innovation	7	5	1
innovation	paper	10	10	0.9
innovation	management	9	3	1
performance	bank	8	1	1
Technological	Innovation	48	47	0.5
Technological	Innovations	10	10	0.9

In other words, absorptive capacity is closely linked to technological innovation. This is the keyword network results based on the entire data where the analysis was conducted was shown in the Figure 3.

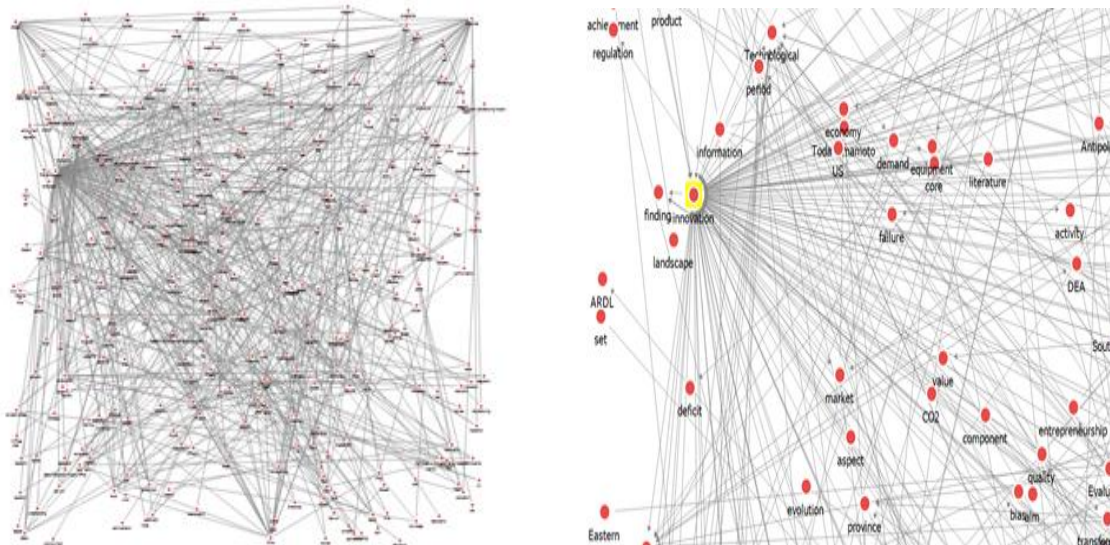


Figure 3. Visualize network analysis results(Absorptive Capacity)

To sum up, it was displayed that there is a rather close connection between absorptive capacity and technical innovation, and innovation. TF-IDF weighting method was used as the method to derive important terms. TF-IDF weight can be displayed like the following formula.

The value of keyword i that is affiliated to document j is the product of tf value and idf value. Here, $tf_{i,j}$ is the frequency of keyword i that appeared in document j , and $d \log \frac{1}{df_{i,j}}$ is the value of taking the log from the inverse number of the number of document containing keyword i . The following is the outcome of executing word-article net(TF-IDF). The results of only selecting the weight that is 1.2 and above out of the overall data is as

shown in the following table 4.

Table 4. TF-IDF analysis result (Absorptive Capacity)

Source	Weight	Source	Weight
bank	1.4	BRICS	1.3
Total factor	1.4	Sophia	1.3
family	1.3	Antipolis	1.3
PV	1.3	PLC	1.4
transaction	1.4	distortion	1.3
Anhui	1.4	leadership	1.3
affordance	1.3	engagement	1.3
coal	1.4		

The terms with high weight were displayed as PLC, coal, transaction, and bank. It appeared that product life cycle, coal, and bank are important factors for absorptive capacity. This is the keyword network results that base on the entire data where the analysis was performed. When it was examined closely, the important terms were displayed as innovation and technological.

4.2. LDA

The key words include innovation, air, model, mechanism, and technological, from which it can be inferred that ‘innovation’ is the topic. The verb key words include such positive key words. The lower the gamma value, the longer the red bar(Figure.4).

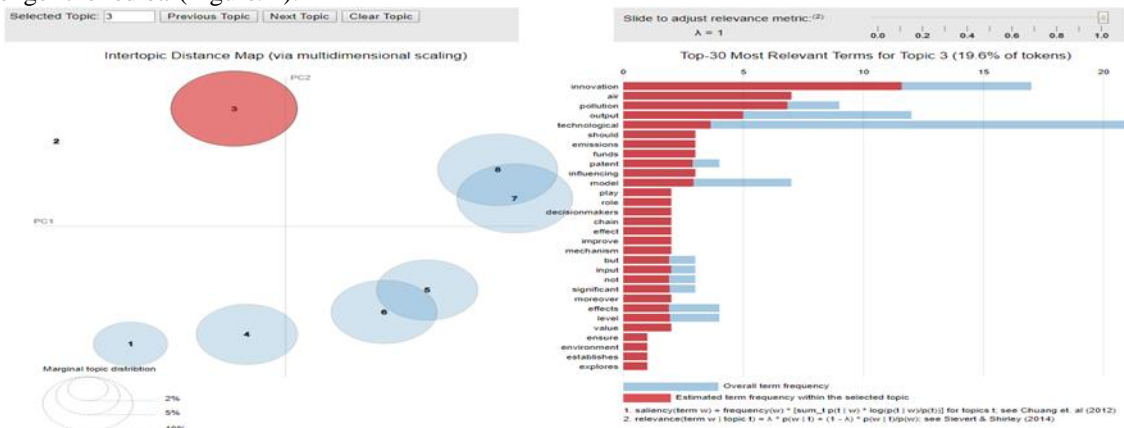


Figure 4. LDA analysis result 1 (Technological Innovation)

No.7 and No.8 topics are similar to each other. The key words include technological, scientific, potential, opportunity, and advancement, from which it can be inferred that ‘technology’ is the topic. The verb key words include such positive key words. The lower the gamma value, the longer the red bar(Figure. 5).

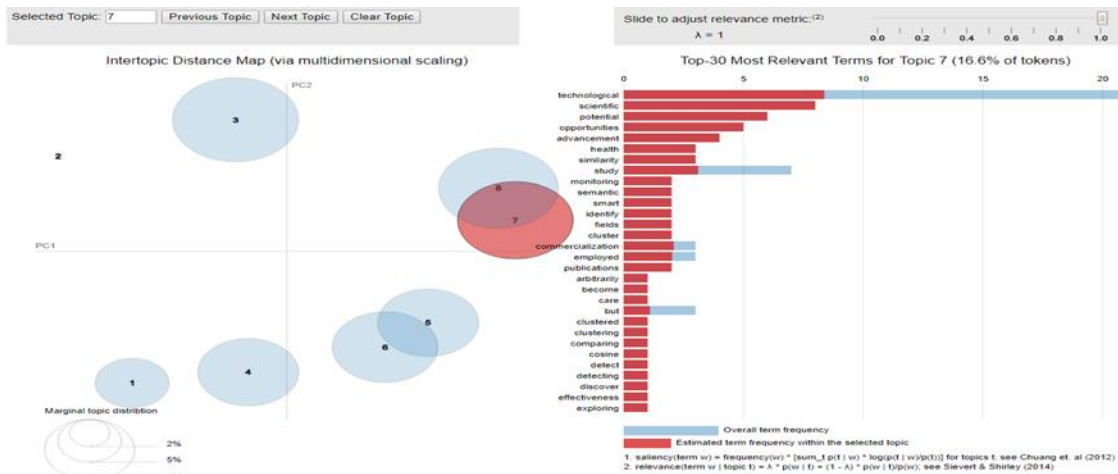


Figure 5. LDA analysis result 2 (Technological Innovation)

No.3 and No.5 topics are similar to each other. The key words include absorptive, capabilities, performance, innovation, and knowledge, from which it can be inferred that ‘absorptive’ is the topic. The verb key words include such positive key words. The lower the gamma value, the longer the red bar (Figure.6).

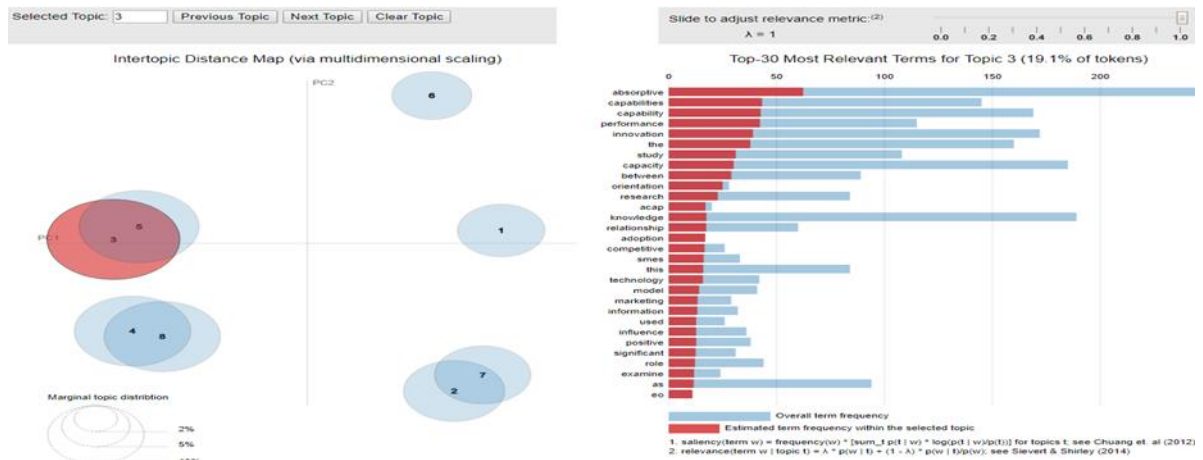


Figure 6. LDA analysis result 1(Absorptive Capacity)

No.4 and No.8 topics are similar to each other. The key words include absorptive, capability, knowledge, performance, innovation, and relationship, from which it can be inferred that ‘absorptive’ is the topic. The verb key words include such positive key words. The lower the gamma value, the longer the red bar (Figure. 7).

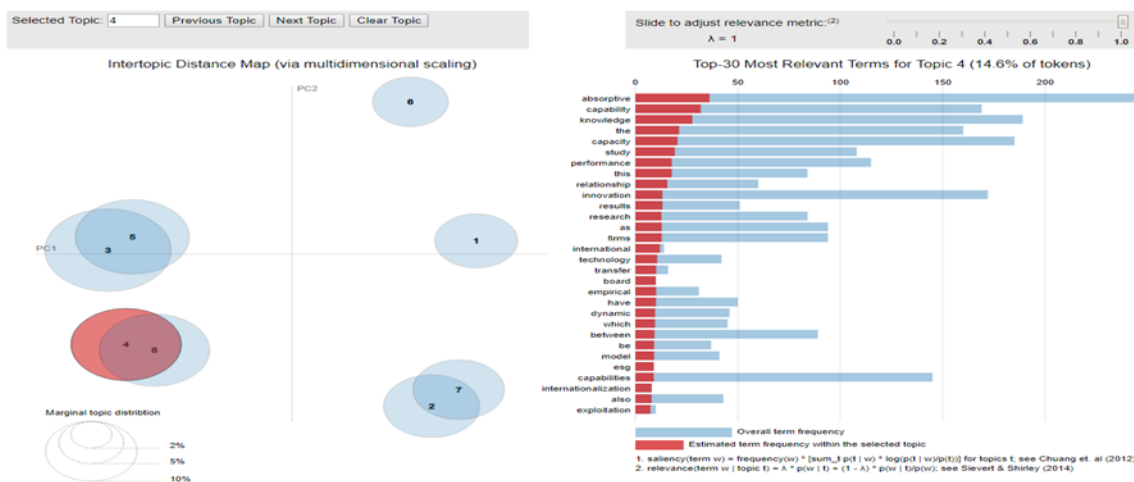


Figure 7. LDA analysis result 2(Absorptive Capacity)

4.3. Technology Innovation

The following are the results when displayed with Word Cloud. Adoption, calves, and transfer appeared as important factors. This means that big size is important in Treemap. The important terms were adoption, transfer, vitamin, competences, expert, and innovativeness was shown Figure 8.

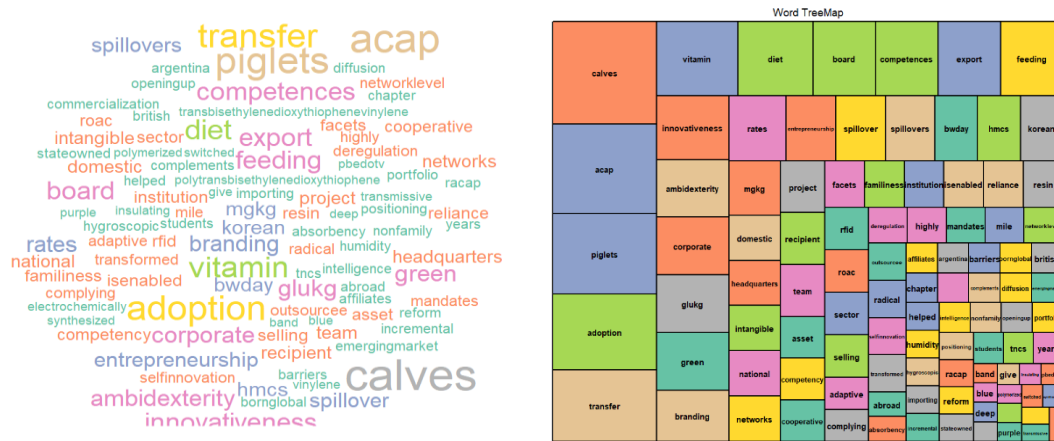


Figure 8. Wordcloud and TreeMap

4.4. Discussion

In this study, abstracts of 'technological innovation' and 'absorptive capacity' were collected from Springer and Scopus database and an analysis was performed. First of all, there were differences in the terms derived as important terms in the data analysis collected from Springer through NetMiner 4 and the terms derived as important from the data analysis collected from Scopus database. It can also be identified through the differences of significance between Springer and Scopus, but it seems like it is due to the differences in the amount of the data. However, in common, technological innovation and absorptive capacity are closely connected. In order for technological innovation to be successful, absorptive capacity is certainly required. From the company's position, research has to be performed in various ways to heighten the absorptive capacity instead of only focusing on technological innovation. Moreover, future studies will more likely to focus on further detailed causality instead of the simple causality of technological innovation and absorptive capacity in accordance with the recent trend.

5. Conclusions

The research findings of this study are as follows. The following are the important findings of technological innovation. innovation and performance, capacity, and knowledge appeared to be important. importance on innovation and technological, scientific, and potential. The following are the important findings of absorptive capacity. technological and innovation, innovation and capability appeared to be important. absorptive and capability, performance, and knowledge appeared to be important. In digital transformation times, technology and innovation represented by DNA are most important, so researches about it are likely to increase. In particular, absorptive capacity is important for technological innovation to be successful, more than the influential factor caused by technological innovation on the performance, so convergence research about it is likely to increase.

From the company's perspective, various measures are required to survive in the fierce competition. In the Convergence Age, it seems more appropriate to perform convergence research through the integral of different fields rather than only doing research on a single field. Since this study suggested the research trend and research directivity through abstracts of dissertation about technological innovation and absorptive capacity in academic database, it provides an academic implication at an academic level. In addition, the corporate situation about convergence research comes from practical implication. However, the limitation of this study is that other dissertation database were not taken into consideration besides the 2 dissertation database. Accordingly, various dissertation database data needs to be used in future research, and it is necessary to apply various big data analysis techniques.

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