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A Study on Agile Transformation in the New Digital Age

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Abstract

In the face of recent digital and digital transformation, companies and industries are trying to be agile to adapt and respond to change. Agile paradigm is spreading beyond the boundaries of existing applications such as IT-related projects and software development. In this regard, this study, we analyzed the diffusion of agile paradigm by text mining abstracts of research papers from 2001 to 2019. In addition, we discussed agile transformation in the Fourth Industrial Revolution. Through this study, we confirmed that we are studying agile transformation in various fields such as business environment, corporate organizational culture, manufacturing industry, and supply chain. The results of this study will contribute to understanding the meaning and role of agile as a basic paradigm for digital transformation in the Fourth Industrial Revolution.

Keywords: *Agile Transformation, Agile paradigm, Text mining, Topic modeling*

1. INTRODUCTION

In an increasingly digital world, companies and industries face a variety of challenges, such as changing customer volatility, increasing market dynamics and emerging developments in information technology (IT) [1]. Faced with the new digital world, companies and industries are striving to be agile to adapt and respond to changes in digital innovation and digital transformation [2]. This effort has resulted in agile transformation by introducing the paradigm of agile, which began with software development methodology, in various fields. The agile development methodology represents an iterative development approach that focuses on rapid deployment, responsiveness to change, and customer needs, unlike traditional plan-based approaches that involve detailed preplanning and extensive documentation [3].

Agile is a very good management model for solving problems such as uncertainty and rapid business change. The agile method is not only applied more and more in companies outside of the IT and software industries, but also spreads beyond the boundaries of existing applications such as IT-related projects and software development (SD). As a driving force for successful digital transformation, there is a growing interest in agile transformation.

At the beginning of the 2020s, now that the Fourth Industrial Revolution is in full swing, we need to understand where and how the introduction of the agile concept is going in the new context of digital transformation.

In this study, we analyze the diffusion of agile paradigm by analyzing the research papers with agile as a keyword. In addition, we will discuss agile transformation in the Fourth Industrial Revolution.

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2. RELATED WORKS

2.1 Agile methodology, agile paradigm, and agile transformation

Agile methodology is a development methodology designed to solve the problems that traditional software development methodologies cannot reasonably respond to rapidly changing customer demands. Agile methodology is designed to respond quickly to changing business requirements, to accommodate changes, to improve communication between developers and users, and to develop fast and high quality systems. The core value of the agile methodology is shown in the manifesto for agile software development, a result of a 2001 meeting at Snowbird [3].

Agile paradigm is about values and principles that are oriented toward the ability to actively respond and adapt to a competitive business environment, not just in the level of software precepts, but in the mindset [4]. Highsmith, one of the agile manifesto authors, defined Agility as "the ability to creatively respond to a rapidly changing business environment." In addition, we define three values to be pursued in agile project management [5]. First, it delivers value to customers rather than meeting project constraints (schedule, cost, scope). Second, lead teams rather than managing tasks. Third, actively respond to changes rather than follow project plans.
Unlike the traditional industry, the user-centric digital era has to constantly change and innovate quickly. In this era of change, agile transformation is a paradigm that aims to transform organization and process with agility to enhance the competitiveness of current business and to pursue new growth through new business.
Interest in agile transformation is growing rapidly, but research is still in its infancy. Olteanu(2018) presented a case study on the knowledge management problem and transformation process for IT agile adaptation as the organization changes [6]. Fuchs (2018) conceptualized the process of agile transformation in large organizations, conducted two in-depth case studies, and provided guidance for managers [7]. There are also studies on agile transformations of companies such as LEGO, Ericsson, ING, Samsung electronics, and Cisco [8-12].

Existing studies are limited to studies of agile application in IT-related projects or organizations and case studies of specific companies. In this study, we will examine the application of agile paradigm macroscopically beyond the limits of industry and companies.

2.2 Machine learning based text mining

Text mining is accomplished through a series of text analysis and processing that extracts meaningful information using natural language processing (NLP) in unstructured text. Topic modeling is a text mining method that identifies and classifies topics that are latent in a document. Topic modeling inferences topics by clustering words with similar meanings to find topics in a large unstructured document set [13, 14].

The most popular topic modeling technique is the potential probability estimation technique developed by Blei et al. [15]. The LDA assumes that a single document contains multiple topics or that multiple documents can share a common theme. The LDA calculate the probability that individual documents and words will be included in a particular topic and the probability that individual words derived from the entire document will be included in a particular topic.

Figure 1 shows the LDA as a graphical model [13, 15]. N is the number of words per document and indicates the length of the document. D represents a set of documents. Wd,n represents the n-th word of d document, which is determined by Z and β. Z represents a topic by word with a per-word topic assignment and is determined by the value θd, which is the subject distribution of the document. θ is the weight of each subject obtained using the parameter α and the Dirichlet distribution.

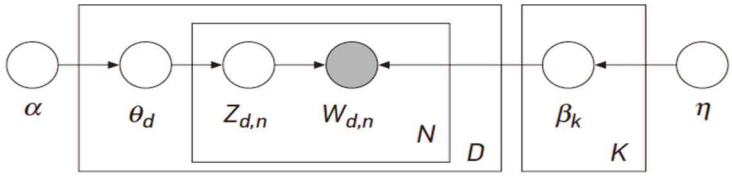


Figure 1. LDA graphical model for Topic modeling [13]

3. RESEARCH METHODS

3.1 Data collection

In order to collect the data, I searched journal articles written in English in SCOPUS. The retrieval period was from 2001 to 2019 when the agile manifesto was released. We retried for articles containing "agile" in "keywords" and collected 3,253 items. SCOPUS divides “keywords” into “Author keyword” and “Indexed keyword”. We filtered articles that contained "agile" in the "Author keyword" to collect articles that the researcher deliberately studied the "agile" paradigm, resulting in 1,923 entries. Among them, 1,567 articles that meet our research criteria were used as research data. The screening process of research data is as follows(Figure 2).

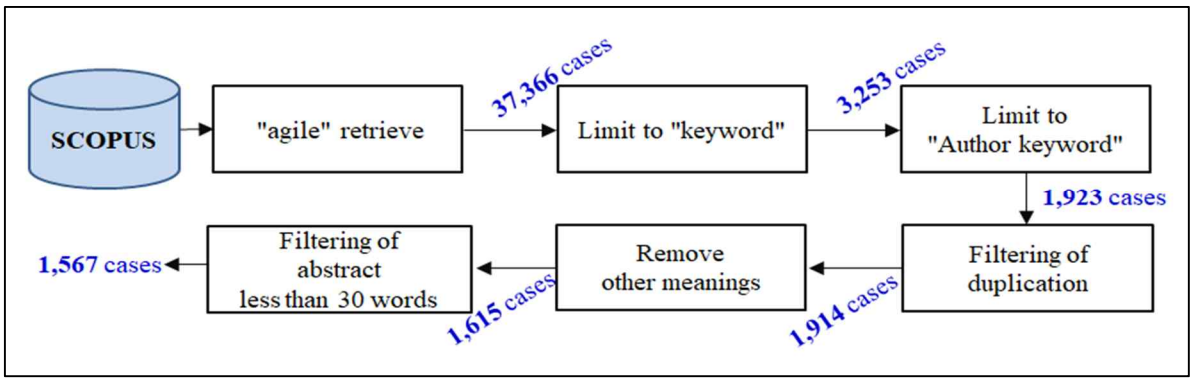


Figure 2. The screening process of research data

3.2 Data preprocessing

We have preprocessed on collected text data for analysis. We converted the words in the document into lowercase letters, and performed tokenization to separate them into words. Then, we removed stop words. Next, we performed lemmatization to extract the lemma for words used in various forms in the sentence. We used python 3.8, NLTK, and machine learning library scikit-learn, gensim for preprocessing and text mining.

3.3 Machine learning based text mining

To determine the optimal number of topics for LDA based topic modeling, we used topic coherence proposed by Newman [16]. The better the topic modeling, the more semantically similar words are gathered within the topic, which increases the coherence of the topic. The similarity calculation between words uses pointwise mutual information (PMI) index. The higher the PMI value, the higher the relevance between words .

In Equation (1), PMI(w_i, w_j) is calculated by using the probability of word w_i,, probability of word w_j and the probability of a word pair (w_i, w_j) appearing at the same time.

$$\mathrm{PMI}(w_i, w_j) = \log \frac{p(w_i, w_j)}{p(w_i)p(w_j)} \quad (1)$$

In this study, the topic coherence was calculated while the number of topics was varied from 2 to 40, and the number of topics with the highest coherence score was found. As a result, the number of topics in the LDA model was set to 8.

3.4 Normalized topic frequency

We calculated the topic frequency according to the year to analyze agile paradigm diffusion over time. The LDA algorithm assumed that one document can contain multiple topics or that multiple documents can share a common topic. Therefore, all of the topic proportions assigned to one document should be considered and

analyzed. We performed the normalization according to the topic proportions to identify the topic frequency by year. The equation for the normalized topic frequency is shown below [17].

Let $D_t = \{d_t^1, d_t^2, \ldots, d_t^{n_t}\}$ be the set of documents at time index (i.e., year) t, d_t^j be the jth document in this set ($\forall j$ = 1, …, n_t), where n_t represents the total number of documents in D_t. Correspondingly, the topic frequency for topic ID i at time index t is defined according to Equation (2).

$$\mathrm{Tf}_{i,t} = \frac{\sum_{j=1}^{n_t} \theta_{i,d_t^j}}{n_t} \quad (\forall i = 1, \ldots, K;\ \forall t = 1, \ldots, T) \qquad (2)$$

In this study, K is 7, so the topic ID i is a value from 0 to 6. Given that the data period is from 2001 to 2019, the time index t ranges from 1 = 2001 to T = 2019. The topic frequency graph normalized over time is shown in Figure 3.

4. RESULTS AND DISCUSSION

4.1 Results of topic analysis on agile

The results of the topic modeling based on LDA are shown in Table 1. The first column shows the topic IDs from 0 to 6. In the second column, we list 5 words distributed in the topic, in a descending order starting from the highest probability. The third column shows the top two representative documents based on topic proportions. We marked the topic proportions in parentheses. The last column is a label which symbolizes the topic. The LDA algorithm does not automatically generate labels for topics. Therefore, we discussed and decided the label of the topic with five agile method experts, referring to the documents with word distributions on the specific topic and the largest topic proportions.

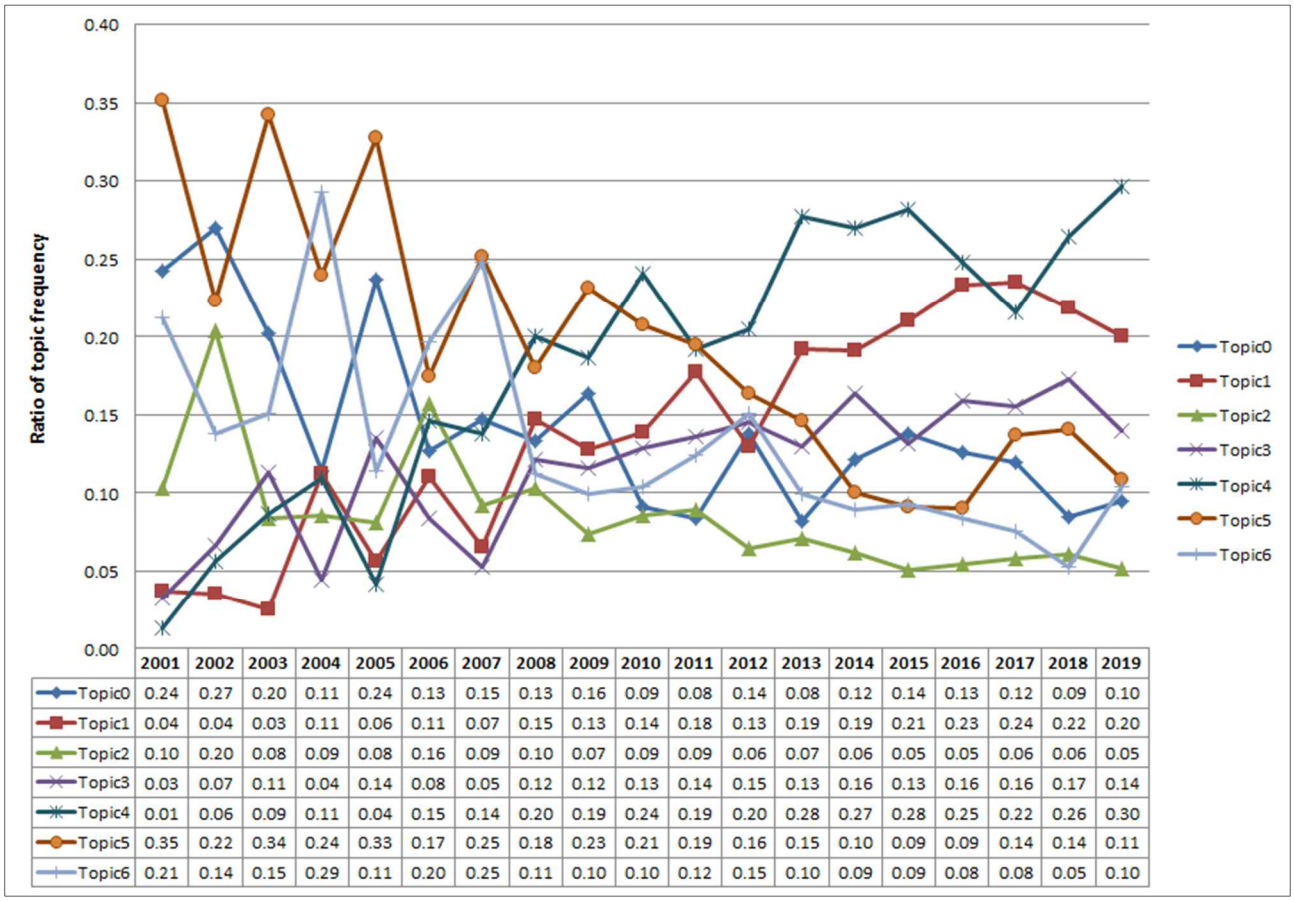
Table 1. Topic related to agile

Topic ID	Top 5 terms	Top 2 representative documents	Topic label
0	change, information, business, service, environment	d171 (0.96) d637 (0.96)	Agile business environment
1	project, method, management, practice, knowledge	d103 (0.99) d283 (0.99)	Agile project management
2	agility, enterprise, cost, activity, market	d53 (0.97) d1538 (0.94)	Enterprise agility
3	organization, practice, case, scrum, principle	d1166 (0.98) d9 (0.97)	Agile organization
4	software, team, requirement, model, quality	d117 (0.98) d278 (0.98)	Agile Software development
5	manufacturing, model, learn, product, strategy	d1157 (0.99) d222(0.98)	Agile manufacturing
6	supply, chain, network, decision, performance	d1173 (0.99) d57 (0.98)	Agile supply chain

4.2 Agile topic frequency trend

Figure 3 shows the normalized topic frequency over time from 2001 to 2019 based on Equation (2). Research topics have been rising and falling until 2008, and there is a big difference in the research volume of topics.

Topic 1 (Agile project management) and Topic 4 (Agile Software development) are related to IT development projects and are the original research topics of Agile, with the largest volume of research. Topic 3 (Agile organization) has been increasing in volume, and now has the third largest volume of research. Topic 5 (Agile manufacturing) has been accepted as an extension of lean manufacturing, and much research has been done in the early 2000s. Topic 6 (Agile supply chain) peaked in 2004 and 2007, and since 2010, research has declined and then increased again.



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Topic0	0.24	0.27	0.20	0.11	0.24	0.13	0.15	0.13	0.16	0.09	0.08	0.14	0.08	0.12	0.14	0.13	0.12	0.09	0.10
Topic1	0.04	0.04	0.03	0.11	0.06	0.11	0.07	0.15	0.13	0.14	0.18	0.13	0.19	0.19	0.21	0.23	0.24	0.22	0.20
Topic2	0.10	0.20	0.08	0.09	0.08	0.16	0.09	0.10	0.07	0.09	0.09	0.06	0.07	0.06	0.05	0.05	0.06	0.06	0.05
Topic3	0.03	0.07	0.11	0.04	0.14	0.08	0.05	0.12	0.12	0.13	0.14	0.15	0.13	0.16	0.13	0.16	0.16	0.17	0.14
Topic4	0.01	0.06	0.09	0.11	0.04	0.15	0.14	0.20	0.19	0.24	0.19	0.20	0.28	0.27	0.28	0.25	0.22	0.26	0.30
Topic5	0.35	0.22	0.34	0.24	0.33	0.17	0.25	0.18	0.23	0.21	0.19	0.16	0.15	0.10	0.09	0.09	0.14	0.14	0.11
Topic6	0.21	0.14	0.15	0.29	0.11	0.20	0.25	0.11	0.10	0.10	0.12	0.15	0.10	0.09	0.09	0.08	0.08	0.05	0.10

Figure 3. Normalized ratio of agile topic from 2001 to 2019

5. CONCLUSION

We analyzed existing studies using machine learning-based text mining techniques for agile transformation in order to adapt and respond to changes in digital innovation and digital transformation. The agile transformation (topic 1, topic 4) in IT development is clearly identified. In addition, agile transformation in other fields was analyzed.

Agile business environment (Topic 0) is an agile transformation in the business environment that business decision makers need to make quick decisions and run their businesses in response to rapidly changing market changes.

Agile organization (Topic 3) is an agile transformation in an organizational culture that breaks down boundaries between departments and organizes small cells as needed. They pursue a horizontal organization

that emphasizes individual ownership rather than a vertical organizational structure. Unlike traditional managers, leaders must act as professionals while coordinating and supporting the organization. This organizational culture was originally used by global IT companies such as Google and Facebook, but recently, it has been introduced to respond quickly to changing business environments regardless of industry.

Agile manufacturing (topic 5) is a way to quickly create a product, bring it to market, and improve and recreate the product based on customer feedback. In the manufacturing industry, agile transformation enables us to respond quickly to market changes and customer needs, while simultaneously considering product quality. Agile transformation of the commercialization process will now be required for agile manufacturing.

Agile supply chains (topic 6) are agile transformations in the supply chain that are designed to respond quickly and flexibly to changing demand. In today's business environment, where the online market is growing rapidly and competition between online and offline retailers is fierce, agile transformation can have a direct impact on sales performance and inventory cost efficiency.

Through this study, we confirmed that we are studying agile transformation in various fields such as business environment, corporate organizational culture, manufacturing industry, and supply chain. The results of this study will contribute to understanding the meaning and role of agile as a basic paradigm for digital transformation in the Fourth Industrial Revolution.

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