Characteristics of an Innovation Adopter's Network and the Information in a Diffusion Process

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Abstract:

The purpose of this paper is to clarify the information creation activities by innovation adopters and to analyze the contents of that information in the process of innovation diffusion. For the adopter, an innovation has never been used before and, therefore is characterized by a high level of uncertainty for him. In this paper, we assume that there is a relationship —kind of "communities of practice (Lave and Wenger 1991)" —in which innovation adopters are creating information together, considering for example the doctor's networking in the diffusion process for drug A. The information created in that doctor's network, perhaps a research paper, is considered to be important information when other doctors make decisions to adopt that new drug A. Hence, we analyze the content of the paper. As a result of the analysis, in the first half of the diffusion period, research was conducted with groups that included special experts in the field. In the latter period, a group that does not necessarily have experts was conducting research. Regarding the content of information created by the doctor's network, in the first half of the drug diffusion period, research on the early stage of dosing of drug A was conducted, and in the latter period, research on the next stage of dosing, such as side effects, was conducted. We conclude that the doctor's network creates information, and that the content of that information will vary depending on the stage of innovation diffusion.

Keywords
diffusion of innovation, co-authorship network, communities of practice, Qualitative Data Analysis, the pharmaceutical industry

(1) Introduction

Products and services, although excellent, may not enjoy wide popularity. There has been much research and development in the field of management theory. However, there is lack of study on the matter of diffusion.

Christensen (1997) states that people accept new technology, and the resulting theory suggests that people accept new technologies when they reach a satisfactory level in terms of technology use. However, Moore (1991) points out that some high-technology products cannot spread widely.

Rogers (2003) argues that individuals who actively work toward the reduction of

uncertainty in innovation innovate in their decision processes as well. One way to reduce uncertainty of innovation is to test it. If it is not easy, they then try innovation temporarily; "trial by others" (Rogers, 2003, p.177) as an alternative proposal. In the subsequent section, a case study is presented that show how peer information promotes diffusion of innovation.

This study focuses on the innovation adopter's network and its shared information. ITs main objective is the elucidation of mechanism of diffusion by analyzing the adopter's network and their information in the pharmaceutical industry.

(2) Literature review

1. Medical innovation study

Coleman et al. (1966) studied the pattern of diffusion of a new dug. They distinguished a sequence of founts of information pertaining to a new drug by diving them into three sources: primary source, intermediate source, and final source. The highest percentage of the primary source (of information that doctors know a new drug for the first time) was from the details man within a given pharmaceutical company. Likewise, the highest percentage of intermediate source came from the details man. However, the final source, in other words, the information used when making a decision, was different. The highest percentage of the final source was the doctor's colleague. This result showed that doctors had much confidence in existing users. In addition, there was a difference at the time of new drug adoption "between those doctors who were integrated into these network and those who were isolated" (Coleman et al., 1966, p.79). Early adopters were doctors whose networks were enhanced by a colleague who adopted a new drug early, whereas isolated doctors were late adopters. Therefore, doctors reduce the uncertainty of a new drug with organizational power.

2. Clinical information as complementary assets

Teece (1987) mentions that it is necessary to bridge the gap between innovation and problems to provide solutions to customers. Therefore, a few things that fills this gap are "complementary assets," such as distribution and after-sales service. In this paper, we assume that one of the complementary assets of a new drug is clinical information. We presume that the information as complementary assets is one with network externalities (Tsutsui, 2011). Hence, if there are competing products, securing critical mass becomes an immediate necessity in order to be the top drug picked by doctors.

The information as complementary goods strongly promoting the reach of innovation has the characteristics of a network externality.

3. Communities of practice as the parent body of learning

The concept of communities of practice is an effective means to clear the mechanism by which clinical information is generated and shared. The concept of communities of practice, proposed by Lave and Wenger

(1991), is cited in the field of management theory (Brown and Duguid, 1991). Communities of practice are "groups of people who share a concern, a set of problems, or a passion about a topic, and who deepen their knowledge and expertise in this area by interacting on an ongoing basis" (Wenger et al., 2002, p.4). They presented a case of the Tech Clubs as an example of communities of practices. When Chrysler was changed from a functional structure to product-oriented structure and engineers had to be allocated in separate units. It means that engineers lost a chance to learn from each other. Through these processes, the manager decided to assist in getting engineers to interact with each other. Engineers connected informally under the name of the Tech Clubs.

Similarly, a doctor can become a member of a practice community when obtaining medical knowledge at a medical school. Tsutsui (2011) considered the connection of communities of practice to influence the adoption of a new drug and conducted further research. Tsutsui (2011) assumed that a university hospital was the core element of doctors' communities of practice and examined an adoption rate of a new product in a university-affiliated hospital. As a result of research, an adoption rate of a new product in a university-affiliated hospital was higher than in those that had not adopted the new product.

This paper studies the influence of such communities for learning medical knowledge pertaining to the adoption of a new drug. However, doctors will not be tied down with a university hospital. Therefore, in the next section, I tried to clarify their research connection using co-authored data of the paper.

The logic of this paper is arranged follows. It is assumed that a doctor decides on adopting a new drug based on the information that a trustworthy doctor already uses the drug as part of his new medical supplies. It is assumed that doctors adopt various methods to share information with other doctors, both by personal interaction and participating in workshops.

In this study, we consider papers published in academic journals as important sources of information pertaining to the decision to adopt a new drug, thus, we analyze the paper's data. In many cases, papers are written by multiple authors. Therefore, it is possible to discover a network of doctors who collaborate to write a paper at the time of a new drug's diffusion.

(3) Network analysis of new drug diffusion

1. Data source and analysis methods

The present study focuses on drug A, available on the market since 1999 for the treatment for Alzheimer's disease.

Date were gathered from representative three journals in this field –the *Japanese Journal of Geriatric Psychiatry*, the *Journal of Japanese Society for Dementia Care*, and the *Japanese Journal of Geriatrics*. Then, the authors' data were collected from papers (around 2014) containing the name of drug A (whether having brand name or a generic one) in the title. By recognizing co-authored relationship as communities of

practice that collaborated on writing a paper, research networks were extracted. A total of 146 papers were collected from Ichushi service (http://www.jamas.or.jp/), with total listed authors was 753, and the actual number of authors being 480. Authors with the same family and surnames name were treated as one person.

Research was actively conducted twice during 2000 - 2014 (Figure 1). Therefore, we divided the period into two phases: 2000 - 2006 (Phase1) and 2007 - 2014 (Phase 2). The number of papers and authors in each period were 74 and 265, respectively, in Phase 1, and 72 and 256 respectively (41 being published in both phases). There was no significant difference between the number of articles and the number of authors in each periods. Most of the authors are presumed to be doctors as per the names on the paper.

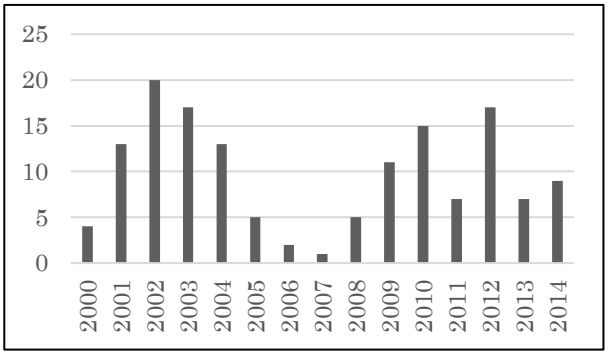

Figure 1, The number of paper per year

Source: Prepared by author.

2. Networks in both periods

The networks of authors in the two periods were defined. The contours were drawn using an m-slice technique in networks based on the method proposed by DeNooy et al. (2005). The following is an example of an m-slice. When there are five articles (paper A is single-authored, papers B, C, D and E are multi-authored) and seven authors (Table 1), Figure 2 may be drawn.

Table 1. Five papers and seven authors

Paper A	1
Paper B	2, 3
Paper C	2, 3, 4
Paper D	3, 4, 5
Paper E	6, 7

Source: Prepared by author.

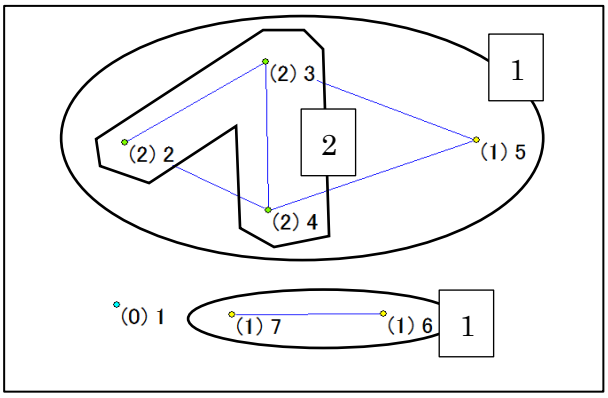

Figure 2. The relation of seven authors

Source: Prepared by author.

In Figure 2, numbers within the curve line are the number of times of co-authorship (n). Authors of papers B, C and D are connected in the big oval of Figure 1. In that oval, there is no joint work experience, yet authors 2 and 5 can connect through authors 3 and 4. Thus, it is possible to draw two networks and an isolated vertex of one person using the m-slice technique.

The respective authors of Phase 1 wrote a total of 74 papers and 72 in Phase 2, drawn from these networks using the aforementioned method. As a result, 35

networks were formed for Phase 1, and 31 for Phase 2. When one regards as the number of the persons who form the network, it becomes clear that a dominant network of Phase 2 is of a larger scale than that of Phase 1 (Table 2).

Table 2. The composition of members of the top three networks

	2000 - 2006	2007 - 2014
1st place	25	48
2nd place	16	21
3rd place	15	17

Source: Prepared by author.

There is no significant difference in the result of the m-slice in phases 1 and 2 (Table 3). The result of m-slice in both phases were a minimum value of 0 and maximum of 9.

Table 3. Result of the m-slice in two phases

m-slice	Number of authors of Phase 1	Number of authors of Phase 2
0	4	7
1	197	188
2	47	52
3	14	2
4	0	3
5	2	0
9	3	4

Source: Prepared by author.

3. Interpretation of network

The insight was provided when I interpreted the network from using the information that got from the interview to the pharmaceutical company.

The interview brought an environmental understanding surrounding the treatment for Alzheimer's disease and the ideas of these researchers. The information obtained from the interview was helpful to understand the influence upon the diffusion of drug A from the list of 480 surveyed authors.

The network was divided such that a person supposed to be influential in the diffusion of drug A was might be included in more than one network or in none of them. As a result, the percentage of networks in which an influential person is included become the Phase 1 percentage, which is higher than Phase 2's (Table 4). Therefore, it appears that the cooperation of an influential person is necessary because of the uncertainty surrounding a new drug's sales. Figure 3 shows that drug A was diffused rapidly within the first 10 years (2000 through 2010). The information that reduces uncertainty and promoted the spread of drug A was considered in the papers included in Phase 1.

Table 4. Percentage of networks where a person influencing the spread of drug A was included

period	The number of network	percentage
2000 - 2006	17	49%(17/ 35)
2007 - 2014	10	32%(10/31)

Source: Prepared by author.

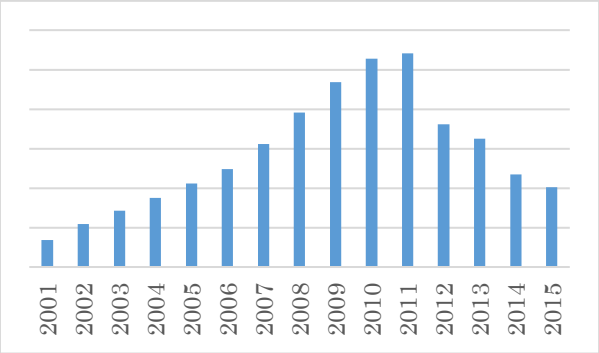

Figure 3. Sales trend of drug

Source: Prepared by author.

In addition, the structure of the top-three network, m-slice, and centricity of each network was considered, but we were not able to find any effective discovery about the diffusion of new drug.

(4) Features of the information regarding the diffusion of drug A: A qualitative data analysis

1. The data source and analysis methods

In this paper, three kinds of qualitative data were analyzed: keywords were given to each thesis, the paper title, and abstract. The keyword was given to each thesis by Ichushi service. For this reason, there is no problem that keyword for giving rules are different for each journal. The paper that appeared in *Japanese Journal of Geriatric Psychiatry* was used based on the title and the abstract. A total of 97 titles and abstracts of papers were used. The titles and abstracts of papers are analyzed using qualitative data analysis software NVivo 11. The keyword can be used to interpret data without using data software because keywords present in-depth classification. The keywords were arranged in the order of frequency and interpreted using information obtained from interviewing pharmaceutical companies.

2. Data Analysis and Findings

2-1.Keyword

A keyword consists of main heading and subheading, e.g., in case of "Alzheimer's disease (pharmacotherapy)," where "Alzheimer's disease" is the main heading and "pharmacotherapy" is the subheading.

The frequency order keyword of each period is compared in 2-1-1. Then, the keyword that appears in either phase is chosen and compared in 2-1-2.

2-1-1 Comparison of frequency of all keywords

In Phase 1, the first keyword was generic name of drug A; second, Alzheimer Disease; third, dementia. In Phase 2, in the first place was "Alzheimer Disease"; second, generic name of drug A; and third, "treatment outcome" (appendix A).

In Phase 1, there are eleven papers with keywords of generic name of drug A whose subheading is "pharmacology"; consequently, we can see that it is focused on research on this new drug.

In Phase 2, since there are papers to which subheading of "complications" is given to "Alzheimer disease" and papers to which subheadings of "adverse effects" are given to generic name of drag A, at this phase, it can be said that research is being conducted to improve the accuracy of medication results.

Although the keyword of "treatment outcome" did not rank within the third rank

in Phase 1, it is the third keyword in Phase 2. As can be seen from here it takes a long time to produce the result of treatment for Alzheimer's disease.

2-1-2 Comparison of frequency keyword (only in either phase)

In addition, keyword that are commonly given in the two periods are excluded, only keyword that are given only to papers in each period are extracted and analyzed.

In Phase 1, it is presumed that the relation between the administration of drug A to patient and the function of the brain is being studied, because keywords indicating names of a part of the brain and a disease occurring in the brain was seen.

With regard to keywords given to the paper in Phase 2, keyword related to adverse effects such as digestive system diseases and anorexia have come to be seen. This suggests that research on the results obtained by administering drug A "settled" to some extent, so it can be inferred that the interest of researchers has shifted to the adverse effects of next concern.

2-2. Title

The title of the thesis was separated in the Phase 1 and the phase and frequency words were picked out using a qualitative data analysis tool (NVivo 11). The characters and words were widely defined so that the frequency of their appearance was high (Figure 4). Words like Alzheimer, dementia, disease, type, name of drug A were established as prohibited terminologies because these words are general words frequently appearing in the papers on Alzheimer's disease.

Figure 4. Frequency word in the title in Phase 1

Source: Prepared by author.

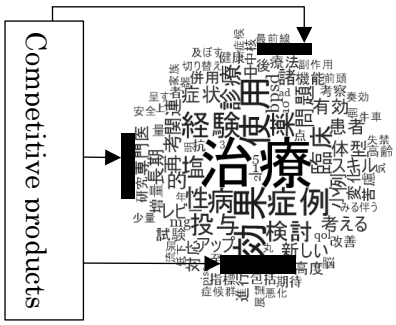

Figure 5. Frequency word in the title in Phase 2

Source: Prepared by author.

Comparison of figures 4 and 5 gave us the next discovery.

The word having the highest degree of frequency in Phase 1 was "medication "(middle of Figure 4). The context of the word–medication–was the report that facilitated beginning to prescribe drug A and the effect of the prescription of drug A, and consideration of whether drug A is prescribed. The context of the word "therapeutics" (the lower one of Figure 4) was the consideration of therapeutics

strategy and administration of drug affairs.

The word having the highest degree of frequency in Phase 2 was “therapeutics” (middle of Figure 5). The context of the word “therapeutics” was the effect of administration of drug to patient on disease. Additionally, the other Alzheimer’s disease curatives on market since 2011 are shown in Figure 5. The new drugs sold from other companies are competitors to drug A at the same time as these drugs are able to be used together. Therefore, some papers on switching from drug A to new drugs, other papers on the results of combined use with drug A have also been reported.

2-3 Abstract

Frequent terms of the two phases of the abstract were analyzed using a qualitative data analysis tool (NVivo 11).

The most frequently appearing word in Phase 1 was “group” (middle of Figure 6). The context of the word medication was the report that divided part of the data among treatment group and non-treatment group and analyzed the condition. The word that has the second highest degree of frequency in Phase 1 was “medication” (the lower one of Figure 6). The context of the word medication was reported, which is as a result of the patient who took drug A for the first time.

The word having the highest degree of the frequency in Phase 2 was “therapeutics” (middle of Figure 7).

The context of therapeutics was varied. The word having the second highest degree of frequency in Phase 2 was “group” (the lower one of Figure 7). The context of the word group was the article in which the patient’s data are classified by various factors (e.g., group to which the drug was given and group to which the drug was not given, high-dose group and low-dose group, young group and the over-80 group), and it was thus compared and examined.

Figure 6. Frequency word in the abstract in Phase 1

Source: Prepared by author.

Figure 7. Frequency word in the abstract in Phase 2

Source: Prepared by author.

(5) Finding and explanation for findings

From network analysis and qualitative data analysis, the following findings were determined about the doctor’s network of and the contents of the information created by that network during the period of diffusion of drug A period.

When the diffusion period is divided into two stages, in the Phase 1, many of the research group on drug A is participating specialists who are influential in the diffusion process. On the one hand, the reason is assumed that specialists were indispensable to the research group on the period where large uncertainty of drug A exists. On the other hand, in Phase 2, there are many groups that specialists do not participate in. In those periods, diversity within the research theme increasing is considered.

It was assumed that a research foundation was established during Phase 1, and various studies bloomed as a result of Phase 2.

The forgoing hypothesis about the transition of the above research contents was demonstrated in the result of a qualitative analysis. As a result of the qualitative analysis of the article dealing with drug A, the research carried out in Phase 1 was a research before the start of the administration of drug A to patient or immediately after starting its administration. In Phase 2, the following two points were clarified. One can see that research on comparing and combining competitive drug competitor and drug A is conducted. Secondly, in Phase 2, there are many reports of side effects. In short, the research accumulated in Phase 1 was the basis of Phase 2's research.

As mentioned (2)-2, information serving as a complementary asset promoting diffusion innovation has the strong characteristic a network externality. Therefore, it is necessary to acquire critical mass quickly when there is a competitive product. Because competitive product was not released at the time of release in drug A, it was not threatened by a competitive product. However, it is necessary to thoroughly inform doctors even when the products excellent.

In fact, according to *Nikkei Medical*, in the year when drug A was released, there is a description that points out that drug's "batting average" is 20%, that is, there was a tendency to underestimate. If a customer feels that the degree of product uncertainty is high, even if it is a superior product functionally, and even in the absence of conspicuous competition, building complementary assets called *user information* is necessary for products to diffuse widely.

Reference

Brown, J. S., and Duguid, P. (1991). Organizational Learning and Communities-of-Practice: Toward a Unified View of Working, Learning, and Innovation, *Organization Science*, 2(1): pp.40-57.

Coleman, J. S., Katz, E., and Menzel, H. (1966) *Medical Innovation: A Diffusion Study*: Bobbs-Merrill.Co., Inc.（小口一元/宮本史郎訳『販売戦略と意思決定』ラティス、1970）

Christensen, Clayton M. (1997). *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.* Boston: Harvard Business School

Press.（玉田俊平太監修/伊豆原弓訳『増補改訂版 イノベーションのジレンマ』翔泳社、2001）

de Nooy, W., Mrvar, A., and Batagelj, V. (2005). *Exploratory Social Network Analysis with Pajek, Cambridge*: Cambridge University Press.（安田雪監訳『Pajek を活用した社会ネット ワーク分析』、東京電機大学出版局、2009）

Lave, J., and Wenger, E. (1991). *Situated Learning: Legitimate Peripheral Participation*, Cambridge University Press.（佐伯胖訳『状況に埋め込まれた学習：正統的周辺参加』産業図書、1993）

Moore, G.A. (1991). *Crossing the Chasm: Revised*, New York: Harper Business.（川又政治訳『キャズム』翔泳社、2002）

Nikkei Medical（1999）. Special report Arutsuhaima-byo ni Koumyoumie-hajimeta(Light at the end of the tunnel to treat Alzheimer's disease): 1999/06, pp. 76-81.

Rogers, E. M. (2003). *Diffusion of Innovations, 5th ed.*, Free Press（三藤利雄訳『イノベーションの普及』翔泳社、2007）

Teece, D. J. (1987). Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing, and Public Policy. In Teece, D. J. (ed.), *The Competitive Challenge: Strategies for Industrial Innovation and Renewal*, pp.185-219. Cambridge, MA: Ballinger（石井淳蔵他訳『競争への挑戦―革新と再生の戦略―』白桃書房、1988）.

Tsutsui, Mariko (2011). *Iyakuhinhukyu no Chishiki Manejimento* (Knowledge Management in Diffusion Process of Pharmaceutical Products). Tokyo: Japan HAKUTO-SHOBO.

Wenger, E., McDermott, R., and Snyder, W. S. (2002). *Cultivating Communities of Practice*, Boston, MA: Harvard Business Press.（野村恭彦監修/櫻井祐子訳『コニュニティ・オブ・プラクティス』翔泳社、2002）

Appendix A

Table of top three keywords

	2000～2006（74 papers）			2007～2014（72 papers）		
	Keyword	Sub Headings	Number pf time	Keyword	Sub Headings	Number pf time
1st	generic name of drug A(total 90 times)	therapeutic use	68	Alzheimer Disease (total 110 times)	drug therapy	56
		pharmacology	11		diagnosis	21
		adverse effects	10		complications	11
		No subheading	1		Prognosis	7
					diagnostic imaging	4
					radionuclide imaging	3
					rehabilitation	2
					Radiography	1
					genetics	1
					chemically induced	1
					therapy	1
					etiology	1
					prevention and control	1
2nd	Alzheimer Disease (total 78 times)	drug therapy	48	generic name of drug A (total 100 times)	therapeutic use	76
		diagnosis	8		adverse effects	20
		radionuclide imaging	8		pharmacology	4
		prognosis	6			
		complications	4			
		diagnostic imaging	3			
		No subheading	1			
3rd	Dementia (total 19 times)	drug effects	13	treatment outcome	No subheading	25
		complications	2			
		prognosis	2			
		No subheading	1			
		radionuclide imaging	1			

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