Two types of lead users in a model for the transfer of technology into households

— The development and diffusion of induction heating cookery —

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In this paper, we propose a multi lead users model for the transfer of technology into households through an empirical analysis of the development and diffusion of induction heating (IH) cookery. Even if big firms successfully develop a technology such as IH, a new cooking paradigm based upon a special cooking device or special recipes is necessary when introducing a new technology to households. We postulate that two types of lead users play crucial roles in the task: reasoning-based lead users with technological expertise contribute to the development of functionality; sensitivity-based lead users having little expertise contribute to diffusion by making product socially trendy and authentically attractive. When introducing advanced technologies such as robots that have not been successfully diffused into households, forming flexible networks between the multi lead users and other stakeholders becomes highly indispensable.

Keywords : Advanced technology, lead user, technology diffusion, social value, induction heating cookery

1 Introduction

Today, there are many households that are introducing induction heating (IH) cooking devices and changing the heat source in the kitchen from gas to electricity. The development of IH devices was initiated by major electric appliances companies mainly for cooking stoves, in the beginning of the 1970s, and was put to practical use in the early 1990s. In the commercialized product, food is cooked by the heat of the cooking utensil placed on the stove, of which the heat is induced by electromagnetic induction in which the electricity is passed through the coil inside the stove. Initially, the price of IH was 350,000 yen, which was way too high for household diffusion, but the price dropped to less than 200,000 yen in the late 1990s. As of 2008, over 10 % of households use IH.

In analyzing the introduction of IH innovation, it is important to note that the benefit cannot be gotten with IH devices alone. It is necessary to prepare an entire system for cooking (here this will be called the cooking system), such as purchasing the cooking utensils that can be used in IH, learning the cooking skills, and developing the recipe. While the IH devices were developed actively by major corporations, in the early 1990s utensils that could be used with IH were inadequate, and the development of the components of the cooking system started only in the stage when IH began to diffuse into the households. Today, various proposals have been made for the IH cooking system, and the effort continues to design a new system where IH becomes the dominant component among all necessary components (dominant design[1]).

Traditionally, advanced technology was developed mainly by major corporations and diffused into the households through the market mechanism. However, when an advanced technology is introduced, difficult problems develop in many cases. Even if a heat source is developed, supplementary components such as utensils, skills, and recipes, as mentioned above, become necessary[2]. In addition to the development of IH by manufacturers, users who are highly interested in the development and diffusion of IH from various positions become "lead users[3]" and develop the supplementary technology to promote diffusion of the technology to households. This paper looks at this process, and surveys and analyzes how various lead users each played roles in the process of introducing the advanced technology called IH. First, the routes by which each component of the cooking system reached the household and how they spread as part of the IH cooking system are investigated by the time-series analysis of the media information on the change in the cooking method. Second, we looked at the cooking method in which "frying is done by holding the silicon spatulas in both hands" while the frying pan remains fixed. This is a method that diffused along with IH, and who developed it and how this method was developed are analyzed. Based on the above analyses, the paper proposes a model that emphasizes the roles of various lead users when advanced technology is introduced to the household. Finally, what is needed to maximize the technological potential from a social perspective when introducing advanced technology into households will be discussed.

2 Existing studies

Humans have developed various artifacts over the history to

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realize the functions needed for living. The society evaluated the produced artifacts, and selected those with excellent performance and price. In addition, certain lead users responded actively to an artifact, improved it from his/her perspective, and proposed the redesigned artifact to society[3]. There are series of researches in engineering, economics, and business administration on the evolution and mechanism of artifacts[4]-[8]. The following section describes the works by Petrosky[6] who investigated "why there are four prongs on a fork," and David[9] who analyzed "how the typewriter keyboard arrangement became QWERTY."

In the case of forks, the failure of the current products or the shape that made it difficult to use led to improvement. When cutting the food and transporting it to the mouth, people did so using their hands and teeth in prehistoric age, and a knife was used when it was invented. Later two knives were used. One knife was used to hold the food and transport it to the mouth while the other was used to cut the food. The knife for holding and transporting the food evolved into a spoon, a two-prong fork, a three-prong fork, and then the current four-prong fork, as the deficiencies of the previous products were improved. What consists as deficiency differs by person and by situation, and therefore no perfect product exists. However, the diffusion in society occurred through development of manners used when people gathered for banquets and through books on etiquette. The form of the fork evolved continuously as the process was repeated. The users played important roles in the evolution of the fork.

In case of the keyboard, the keyboard arrangement was influenced by users who typed and by schools that provided typing lessons, in addition to the manufacturers that led the development. The keyboard of the typewriter created for the first time in the late 1860s was arranged in alphabetical order ABCD from the left, and later, different manufacturers employed various arrangements. While various arrangements coexisted, users started to compete for typing speed, and contest for typing speed and typing schools that taught shorthand appeared. There, touch-typing where one memorized the keyboard and typed without looking became the standard. Since everyone protested against changes in the arrangement that they learned, ultimately, the current arrangement that was the most familiar to most people was employed. The keyboard arrangement was selected to benefit the user communities such as contests and schools, and external influence beyond the market mechanism acted in this selection process[Note 1)].

3 Framework of this survey

The IH cooking system analyzed in this paper is composed of diverse supplementary components for cooking using IH, as well as IH heat source. To investigate who developed them and how this IH cooking system was developed, the following surveys were conducted.

First, a database was built by gathering media information (books, cooking magazines, fashion magazines, and television commercial messages (TVCM)) on IH cooking, and the time-series change was analyzed[Note 2)]. Specifically, time-series analysis of the photographs of IH cooking (267 books, 57 cooking magazines, 52 fashion magazines, and 64 magazine ads) and TVCMs of IH cooking (31 cases), with subject limited to frying pan cooking, was conducted for how the new cooking method using IH was introduced by the media from 2002 to 2008[Note 3)]. The information for the media survey is listed in Appendix A.

Second, interview survey was conducted to investigate who proposed the method and how the cooking method that appeared in conjunction with the introduction of IH was developed, and for what reason it diffused. Specifically, people who contributed to the development and diffusion of the cooking method were extracted from the media information, and interviews were conducted from May to November 2008. The information for the interviews is listed in Appendix B.

4 Time-series analysis of the IH cooking method transmitted through the media

In the IH cooking transmitted through the media, the method in which frying is done by holding the silicon resin spatulas in both hands, as shown in Fig. 1 photograph, was introduced for the first time in 2004. The novelty of this cooking method was as follows. First, the silicon resin spatula was used rather than a ladle, a wooden spatula, cooking chopsticks, or a turner that were traditionally used for cooking over heat. The silicon spatula is a silicon version of the rubber spatula that had been in use. It has been imported and sold in Japan since 1999. However, at the time, the awareness of silicon spatula in Japan was extremely low. Rubber spatulas could not be used for cooking over heat, and it was mainly used for confectionery

Fig. 1 Cooking method in which silicon spatulas are held in both hands.

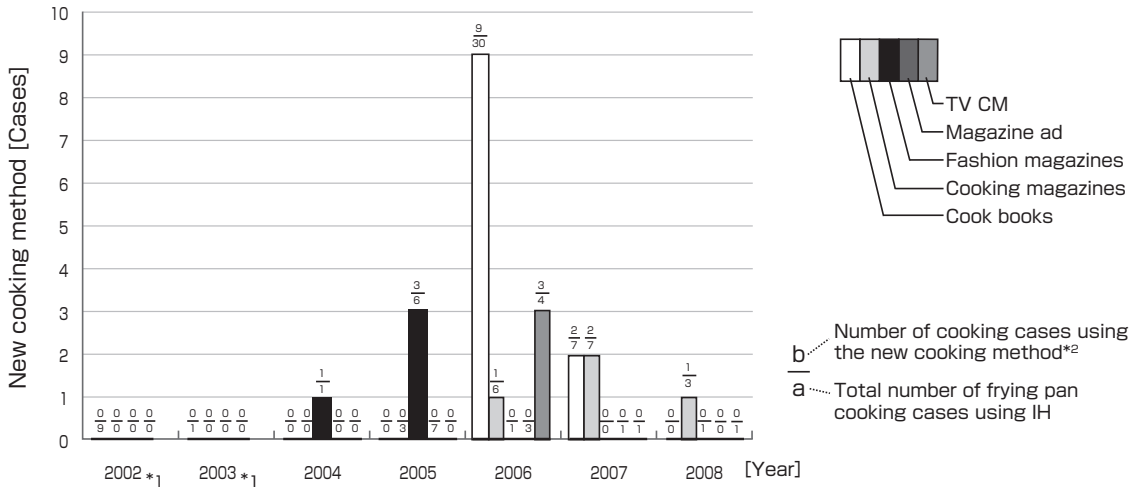
cooking. The silicon spatula could be used for cooking over heat since it is heat resistant to about 300 ºC. In IH cooking, the bottom of the pan becomes hot and frying takes place in the deep part of the pan, and spatulas must be used to scrape off the ingredients that adhere to the pan. Second, the method of using both hands to maneuver the cooking utensils was introduced as a new cooking method. When using gas, the pan had to be agitated so the ingredients would come in contact with the hot surface of the pan. In contrast, the bottom of the pan becomes hot in IH. There is no need to agitate the pan, and the tools are used to lift up and mix the ingredients. In IH cooking, the pan does not become hot if it is removed from the heat source, so it must be fixed and one does not touch the pan while cooking.

As shown in Fig. 2, the new cooking method was introduced in a fashion magazine in 2004 by cookery researcher W who studied the IH cooking method. The cooking method using silicon spatula was introduced for the first time in 2006 in books and cooking magazines, and there was increased exposure in the cooking magazines. Overall, the percentage of new cooking methods including two wooden spatulas and one silicon spatula, which were precursors of the two silicon spatula method, was about 30 percent and not overwhelming, but it was sufficient to gain social recognition. In contrast, the manufacturer's magazine ads showed strong intentions of providing correct technical information for IH against inappropriate ways of cooking, and there was no introduction of a new cooking method[Note 4)]. The information of the new cooking method was widely transmitted to prospective IH users mainly through fashion magazines where information flowed from lead users including cookery researchers, rather than companies manufacturing the IH cooking heater. For TVCMs, the all electrification sales promotion series by the Tokyo Electric Power Company (TEPCO) started in October 2004, and one of the versions aired in January 2006 featured a scene of mixing the ingredients with two wooden spatulas.

5 Development and diffusion of the cooking method in which frying is done by holding silicon spatulas in both hands

The result of the interview survey on the development of the cooking method is summarized as follows. First, the electric power company played a major role in the development of the cooking method in which silicon spatulas are held in both hands. TEPCO started cooking demonstrations by famous chefs at a cooking class held at the Ginza TEPCO Building in 1999. Measurements and recordings of the cooking were done to create the IH recipes, in hope that the professional chefs would present specialized cooking methods for the new heater. A cooking school coordinator N observed that chef Y of a famous Chinese restaurant held the wooden spatulas in both hands when he made fried rice. This frying method was positioned as the new "IH cooking method" to counter the claim that IH was unsuitable for Chinese cooking because one could not "agitate" the pan as the pan must be lifted from the heater to do so. In the TEPCO's TVCM aired on January 2006, there was a scene showing a boy making fried rice in an IH cooking school and he used two wooden spatulas to stir.

Second, a cookery researcher who studied IH cooking also played a major role. Cookery researcher W replaced the stove in her cooking school to IH in 2000, and decided to study IH cooking. She frequently exchanged information with aforementioned N about how to make fried rice with IH, and learned about the cooking method using two wooden spatulas. W immediately realized the problem where the rice adhered to the wooden spatula in this cooking method, and after experimenting to solve this issue, she found that the method of holding the silicon



*1 For TVCM, years 2002~2003 were not surveyed.
*2 New cooking methods include use of two wooden spatulas and one silicon spatula, that were used before arriving at the two silicon spatula cooking method.

Fig. 2 Changes in the new IH cooking method transmitted by the media.

spatulas in both hands worked optimally[Note 5)]. At the time, there was no cooking method using spatulas made of synthetic material for cooking over heat. However, W knew that the silicon spatula supplied as a sample by importer K was heat resistant, and she tested the silicon spatula instead of the wooden spatula and turner[Note 6)]. However, W was not satisfied with the existing product, and continued to study the silicon spatula that had optimal structure for IH cooking. As a result, the product developed jointly by Kai Corporation, a manufacturer of kitchen utensils, was announced in 2008 and was launched to the general market in April 2009.

Third, businesses that did not have knowledge of IH technology or cooking method played important roles. TEPCO promoted the "Switch the Design" Project under the concept to "propose a new lifestyle through electricity," and planned a "select shop" for IH products in the Ginza TEPCO Building. As a result of selecting a company while incorporating ideas from housewives, Flying Saucer (a division of Toko K.K.) opened a store on October 2005[Note 7)]. The company appointed S, a housewife, as the store manager and developed original cooking utensils as well as sold existing products. Food stylist C, a friend of S, proposed new ideas. Flying Saucer was already working on the development of silicon resin spatulas in 2004, and it started the seven color line-up adding black, navy, green, and brown to the red, yellow, and blue products that were already in the stores.

Next, the diffusion process by which the cooking method using the silicon spatulas diffused in society will be described. First, from the experience of developer W, her cooking method was initially not intended for the general public. The cooking method with silicon spatulas held in both hands was publicized in an article for IH fry cooking in a cooking article in a fashion magazine in 2004, as mentioned before. In the article on fry cooking in a cookbook for IH published by W in 2006, the method of holding a wooden spatula in one hand and a silicon one in the other was shown. Although two silicon spatulas were optimal, one was replaced with a wooden spatula for readers who did not own two silicon spatulas[Note 8)]. The silicon spatula for IH cooking developed by W was announced through the media for the first time in December 2008.

Second, Flying Saucer actively promoted the silicon resin spatula through the media since its launch. Rather than the cooking articles that were the subject of the time-series analysis of this research, the silicon spatulas were taken up in the goods articles of fashion magazines without much relevance to IH cooking. The focus was on the seven-color line up, and they were introduced as "colors that can be used by men in cooking" or "colors that match the interior decoration of the kitchen to create a comfortable place." The company developed an original Chinese wok for IH cooking in collaboration with TEPCO, and conducted a sales promotion by showing the wok with the silicon spatula. At the time, the silicon spatulas were not intended for IH cooking, and the combination of the spatula and the IH cooking utensil was quite coincidental. The reason the company thought of supplementing IH cooking with a silicon resin spatula was because it saw the scene where two wooden spatulas were used in the TEPCO TVCM that was aired at the time. A red silicon spatula was displayed with the wok in the show window of the Ginza store, and the booklet for the store carried a photograph of the ingredients being mixed in the wok with navy and brown spatulas in both hands. On the TEPCO's web CM, a famous chef was shown making fried rice using the wok and red silicon spatulas[Note 9)].

6 Proposal of a model for development and diffusion of the cooking system accompanying the IH technology

The progression of the cooking system accompanying IH can be divided into two stages of development and diffusion, as shown in Fig. 3. First, the cooking method where the wooden spatulas are held in both hands appeared almost spontaneously from 1999 to 2000. In the process of using the wooden spatulas, the silicon spatulas started to be used as new cooking tools. The second stage was after 2004, and the information on the new cooking system was transmitted through the media as the diffusion of IH progressed. Looking at the individuals and organizations that contributed to the development and diffusion of the cooking system, the development was led by the power company that promoted the diffusion of IH, and main roles were played by professional chef Y who cooked intuitively with wooden spatulas in both hands, cooking class coordinator N who saw that the two-spatula cooking method was unique to IH, and cookery researcher W who used silicon spatulas instead of wood. The diffusion was lead by the cookery researcher who provided IH cooking education with support from the TEPCO's sales promotion efforts for all electrification. Also, the sales promotion activities of the retailers as exemplified by Flying Saucer were transmitted to households through various media.

To consider the development and diffusion of the new cooking system, Table 1 compares the activities themselves, knowledge produced and transferred and the results of the activities with existing research for the individuals and organizations that led the development and diffusion. While the evolution of the fork was a cumulative process over a long time, the change in the IH cooking system was a discontinuous evolution brought on by advanced science and technology. As in the case of the fork, the household played a certain role as a user in the evolution of IH. Similar to the case of the keyboard, cooking tools and recipes that comprise the cooking system could be developed outside of the

company. As in the keyboard arrangement, external factors such as preferences of some users affected the development in addition to the market mechanism.

From the above investigation, the characteristics of the development and diffusion of the cooking method will be discussed. First, the development and diffusion of the cooking method that supplements IH innovation were not carried out by the major electric appliance company that was responsible for the technological development of IH. The advertisement by the electrical appliance company emphasized the point that the disadvantages of IH could be solved for consumers who were skeptical about IH, and there was no suggestion of a new cooking method utilizing the advantages of IH. The individuals who contributed to the development and diffusion were independent lead users who were not directly related to the power company or the appliance companies. They were not satisfied in simply accepting the existing cooking method like the general users, and actively offered suggestions for existing cooking utensils and methods. They were then supported by the power company, transmitted their suggestions to the household through the media such as books and magazines, and worked actively to develop and diffuse the cooking method.

Next, the motivations for the two types of lead users are considered. For lead users who developed the cooking method, the motivation was the intellectual curiosity for the IH function and the quest for a practical cooking style. They were interested in the fact that the values of electricity entered by the user and the temperature change in the pan were reproducible, and that the temperature in the pan could be maintained constant. In the course of experimenting with these functions in cooking, they found a new cooking method that took advantage of the property where the bottom of the pan became hot. The developer became curious about the IH technology itself, and approached IH from the perspective of "scientific cooking." This motivation led to the formation of an intelligent social infrastructure that stepped beyond profitability[Note 10]. The new cooking method was transmitted through the cooking articles in fashion magazines, but this was four years after the cooking method was discovered.

Table 1 Mechanism of IH innovation compared with the evolution of precursory artifacts.

	Petrosky Model [Petrosky 1992]	David Model [David,1985]	Cooking system accompanying IH technology
Example	There are four prongs in a fork	QWERTY keyboard arrangement	Cooking method in which frying is done by holding the silicon resin spatulas in both hands
Leader of development	Lead user	Manufacturer	Logical lead user
Leader of diffusion	User	User community	Sensible lead user
Driver of development	Improvement of defects in existing products	Realization of higher performance	Development of new cooking utilizing IH function
Driver of diffusion	Formation of manners (harmony with society)	Competition among users for typing ability	Match with social trend
Media environment that promotes diffusion	Books on etiquette, banquets	Typing contests, typing schools	Magazines, select shop (in the building of electric company), TVCM, Internet
Performance of diffused artifact	Certainly better than before	Not necessarily high	Provision of new social values

Looking at the motivation of the lead users who led the diffusion, the select shop exercised a sensible intuition for social trends. The seven-color silicon spatulas that they intuitively developed were highly acclaimed in the goods articles of fashion magazines in a manner that had nothing to do with cooking, such as "colors that can be used by men" or "colors that match the color of the kitchen." Such lead users were independent from the power company or the appliance companies. The fact that the period from 2004 to 2006 when the cooking method was transmitted to households through

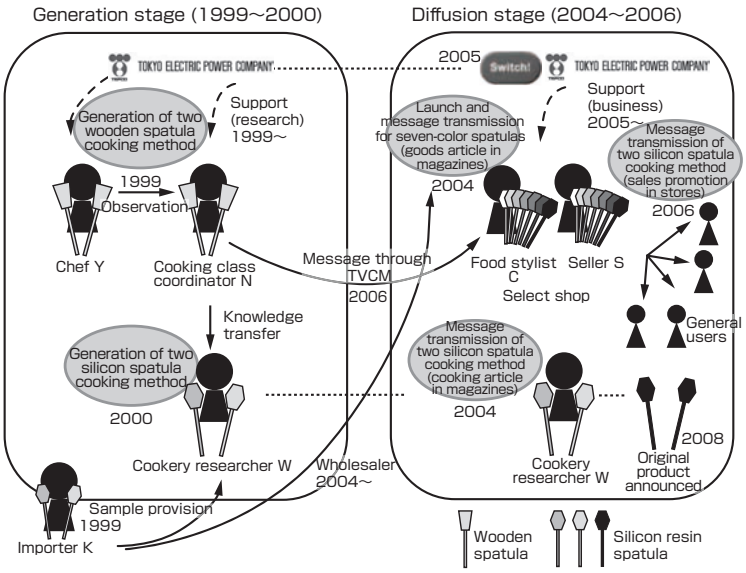


Fig. 3 Development and diffusion of cooking method in which frying is done by holding the silicon resin spatulas in both hands.

the media overlapped with the period of IH promotion by the power company was not by coincident. In fact, the select shop that served as a typical diffusion leader shared interest with the power company that was promoting all electrification. With such a background, the new cooking method was strongly pushed to households through the window of the store in the shopping district of Ginza as well as through the Internet.

From the above analysis, this paper proposes a model of the introduction of advanced technology to households through various lead users, as shown in Fig. 4. When introducing IH that was developed by a major electrical appliance company to households, the cooking method accompanying the IH played a major role. The development of the cooking method that fully brought out the technical potential of IH was done by "logical (reasoning-based) lead users" such as cookery researcher W who had specialized knowledge in the technology and cooking, and their goal was to maximize the function of IH for cooking. On the other hand, the diffusion of the new cooking method was promoted by the "sensible (sensitivity-based) lead users" such as S and C of the select shop. These users have excellent perception of the social trend. The simple combination of the advanced technology from the manufacturer and the cooking system that seek IH functionality may not necessarily result in a product that appeals to households, and may not lead to diffusion to homes. On the other hand, the cooking system proposed by sensible lead users who may lack the understanding of technology may produce attractive products that incorporate the social trend, and thereby promote the diffusion of the cooking system to households through the media. The flexible collaboration of diverse lead users contributed to the advancement of IH innovation.

7 Discussion

To introduce advanced technology to households, it is necessary to enable general users who do not understand the technology to appropriately use the product. As indicated by this study, the user cannot make fries only with the IH cooking heater developed by a company. A new cooking method must be developed by the logical lead user, and only when the supplementary components for IH cooking become available do the general users use IH at home. Moreover, the research indicates the possibility that the use of IH may spread to people who are not necessarily interested in cooking, as the users may be attracted to the element of the cooking system that reflects the social trend, such as the "color variations of the spatulas." How can we evaluate the fact that IH continues to diffuse even though the user is not conscious of the potential of the advanced technology?

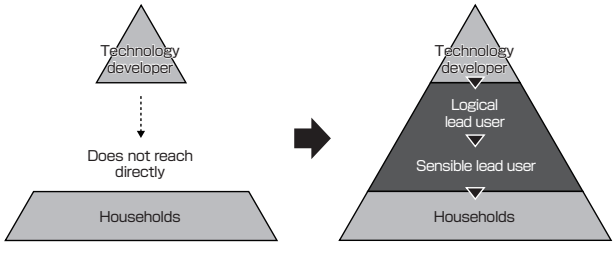


Fig. 4 Model of introduction of advanced technology to household through various lead users.

First of all, it is not easy to disseminate advanced technology to households. As shown by the case of household robots, even if advanced technology realizes wonderful functions, excellent performance alone will not ensure the introduction of a product to the households. For the potential product to be introduced to homes, it is necessary to organize the supplementary system for using the technology in households. As investigated in this paper, there are extremely diverse issues to be considered for a system for "using" advanced technology, such as how IH should be used in households, the safety of the IH cooking system, and environmental assessment (energy efficiency). The design-inspired innovation model that focuses on the product development by Apple Inc. states that the success of a product depends on the design that brings pleasure to the user[10], and the viewpoint of the user is an element that cannot be neglected. The supplementary system for using the technology at home must be designed to maximize the benefit the household user can receive in the context of social trends at that time.

The manufacturers, mainly of major corporations, develop the advanced technology itself. However, there is a limit in specialists designing the system for "using" the advanced technology. As Yoshikawa *et al* point out, even if the specialists mobilize all their knowledge of thermodynamics, surface science, and rheology pertaining to eggs, they may not necessary be able to produce good fried eggs[11]. In the case of the IH cooking system that is the subject of this research, the cooking system for "using" IH was created by fusing the cooking know-hows with advanced technology. This was accomplished by cooking specialists who sought "scientific cooking" independently from the corporations, and used their kitchens as laboratories. This indicates that by combining cooking practitioners with engineers, it may be possible to make a recipe for making good fried eggs. Also, it is important that the cooking specialist be an independent entity from the corporation. Pressure cookers and waterless cookers are now being used in general households after voluminous information had been supplied by cooking specialists. Therefore, for the advanced technology to be used in households, the autonomous participation of various lead users who specialize in "using" the technology is necessary.

Today, the importance of industry-academia collaboration that links science-technology and industry is widely

recognized. However, from the analysis of this research, to introduce advanced technology such as robots to the household, it can be seen that a social network composed of diverse lead users is needed in addition to academia and industry in order "to use" the technology. The model proposed in this research indicates the possibility that the household consumers can participate flexibly in the industrial activity using their practical knowledge. The model is expected to provide new research topics from the perspective of how to promote social innovation.

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Notes

Note 1) Recently, a powerful argument has been proposed that for the determination of keyboard arrangement, a corporate strategy to prevent entry of newcomers by the formation of a patent barrier instigated by a trust of major manufacturers played a critical role[12].

Note 2) The media information was determined as follows. For books, the books on cooking using IH cooking heater was selected visually among the books that contain "IH" in the title from the National Diet Bibliographical Database. For magazines, magazines that ranked within 5th place for circulation and were for readers 30 years old or above among "women's magazine" and "cooking and nutrition" categories were selected from the *Periodicals in Print in Japan 2008*. Magazines that contain articles on cooking using IH cooking heaters were selected visually for years 2005 and 2006 when there were highest amount of information on the IH cooking heater. For television CMs, all electrification TVCMs of TEPCO and Kansai Electric Power Company were selected.

Note 3) Even if there were several photographs, they were considered to be one data if they were for the same dish; even if it was one photograph or television CM, they were considered different data if there were different dishes. For magazines, advertisement and the text were separated; since the advertisements for cooking and fashion magazines were similar, they were jointly categorized as "advertisement."

Note 4) The IH cooking in advertisements were often for grill cooking, unlike in the books and magazines. Since IH could not be used with a grill, initially there were negative comments such as "you can't bake fish with the IH cooking heater." The grill on the IH cooking heater employs electrically heated wire rather than IH. Since the advertisements did not introduce any cooking method using new cooking tools, the figure in the graph is 0.

Note 5) W conducted experiments for a cooking method where mixing is done using two wooden spatula in her own kitchen, and observed that the rice grains got caught between the two spatulas, were squashed, and clumped together. To improve this point, she used two turners instead of wooden spatulas. However, the top edge of the turner was not perpendicular to the handle, and when held in both hands, the tips did not come together but crossed, and therefore the ingredients could not be held. She used the silicon resin spatulas instead of turners and found that mixing can be done with no problem.

Note 6) The import and sales of silicon spatulas were started for the first time in Japan by importer K who knew the high performance of silicon resin from his experience as a vacuum technology engineer. The product did not sell at all for the first three to four years, but the demand for the product rose from about 2004, and the sales for that year increased 2.7 times compared to the previous year.

Note 7) A "select shop" is a retail store that sells products of various brands selected by the sales clerk. Flying Saucer was a wholesaler of cooking utensils for professional use, but started handling products for household use in March 30, 2001, and S who was a housewife became the store manager.

Note 8) Developer W sought the silicon spatula form that was optimal for frying pan cooking using IH. The spatula designed and developed in collaboration with Kai Corporation was launched in December 2008.

Note 9) The TEPCO web contents released October 2006 include the photograph of famous Chinese chef, Mr. Ken'ichi Ching, stirring fried rice holding the original spatulas from Flying Saucer in both hands. (http://www.tepco-switch.com/others/ad/index-j.html)

Note 10) In IH, the pan itself becomes hot when the electricity is passed through the coil inside the stove, and the ingredients inside the pan are heated. Ignoring the variation of the resistance value of the metal of the pan, the power input and the heat value output of the pan will maintain a constant relationship. Also, ignoring the variation of the

quality of the ingredient, the power input and change of the ingredient will also maintain a certain relationship. In case of gas, the factors that determine the temperature inside the pan are complex[13]-[15].

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Authors

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Graduated from the Department of System Design Engineering, Keio University in 2000. Completed courses in Environmental Studies, Graduate School of Frontier Sciences, The University of Tokyo in 2002. Completed doctorate course in Human Environmental Studies, Graduate School of Frontier Sciences, The University of Tokyo in 2006. Doctor (Environmental Studies). Assigned to Assistant Professor of the Research Center of Advanced Science and Technology, The University of Tokyo in 2007. Currently studying innovations in advanced technology used in households. For this paper, worked on interview survey, media survey and analysis, and model proposal.

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Graduated from the Department of Economics, The University of Tokyo in 1977. Received Ph.D. from the University of Sussex in 1986. After working as SPRU Fellow and Senior Researcher of the National Institute of Science and Technology Policy, became Assistant Professor of the Research into Artifacts, Center for Engineering (RACE), The University of Tokyo in April 1993. Professor of the RACE in 1997. Professor of the Research Center of Advanced Science and Technology, The University of Tokyo since July 2001. Also, Professor of the Department of Advanced Interdisciplinary Studies, Graduate School of Engineering, The University of Tokyo from April 2007. In this paper, was in charge of model proposal and overall integration.

Appendix A

The surveyed books are listed in order of title, author, publisher, and publication date.

- *Seikatsu Jitsuyo Shirizu Benri Kino O Furu Katsuyo! IH Kukkingu Hita Kukkingu*; NHK Publishing; 2002.12.20.
- *Seikatsu Jitsuyo Shirizu IH Kukkingu Hita De Tsukuru Wagaya No Gochiso Reshipi*; NHK Publishing; 2003.11.20.
- *IH Reshipi Shu Katei De Dekiru Kobe Chuka Ryoriya-san No Aji*; Hyogo Prefecture Chinese Cooking Association, Hyogo Nutrition Cooking Confectionery School, and Kobe Branch of Kansai Electric Power Company; Asahiya Publishing; 2006.3.21.
- *IH Kukkingu Masuta Reshipi*; Masayo Waki; Kodansha; 2006.3.31.
- *Itsudemo Daredemo Oishiku Tsukureru! IH Kukkingu Hita Manten Reshipi*; Junko Takagi; Fuyosha; 2006.9.10.
- *IH Kukkingu Kihon No Reshipi*; Masayo Waki; Kodansha; 2007.12.1.

The surveyed magazines are listed in the order of magazine title, publisher, and publication period.

- *Okazu No Kukkingu*; TV Asahi Shuppan; Jan./Feb., 2000 ~ Oct./Nov. 2008.
- *Mrs*; Bunka Publishing; Jan. 2000 ~ Dec. 2008.

The surveyed television commercial messages are listed in order of advertiser, product name, and on-air period.

- Tokyo Electric Power Company; All Denka; 2005~2008.
- Kansai Electric Power Company; All Denka; 2005~2008.

Appendix B

The interviewed subjects are listed in order of name, company, and interview date.

- Yoshiki Ogino; All Electrification Business Promotion Division, Home Appliance Company, Panasonic Corporation; October 22, 2008.
- Hiroshi Kondo; Group Manager, Sales Planning Group, IH Cooking Heater Business Unit, Home Appliance Company, Panasonic Corporation; November 13, 2008.
- Izumi Hirota; Group Manager, Technical Group, IH Cooking Heater Business Unit, Home Appliance Company, Panasonic Corporation; November 13, 2008.
- Masaru Kita; Communication Group Manager, Sales Division, Sales Headquarter, Tokyo Electric Power Company; May 9, 2008.
- Ken'ich Morijiri; Director, Life Energy Design Center, Sales Division, Sales Headquarter, Tokyo Electric Power Company; May 11, 2008.
- Tomohiro Mizutani; Life Energy Design Center, Sales Division, Sales Headquarter, Tokyo Electric Power Company; July 15, 2008.
- Nobuko Sekikawa; IH Cooking Coordinator, Y.K. SNS Farm; July 15, 2008.
- Masayo Waki; Cookery Researcher, K.K. Trois Soeurs; June 27, 2008.
- Shuji Kato; President, K.K. Trois Soeurs; July 9, 2008.
- Hiromi Kawanishi; Y.K. Kawanishi; July 12, 2008.
- Miki Shimizu; President, Flying Saucer, Toko K.K.; May 1, 2008.
- Chizuko Shimizu; Director and Store Manager, Flying Saucer, Toko K.K.; May 19, 2008.
- Mieko Chiba; Food Stylist, Flying Saucer, Toko K.K.; July 14, 2008.

Discussion with Reviewers

1 Evidence for the discussion

Question and Comment (Motoyuki Akamatsu, Institute for Human Science and Biomedical Engineering, AIST)

The points that supplementary components is necessary for utilizing the technology, and that persons in certain positions act effectively to introduce advanced technology to households, are important for introducing the technology to society, and thus they match the scope of *Synthesiology*. However, the main thesis of the paper is somewhat unclear, and I feel there is not enough evidence.

Question and comment (Koh Naito, Center for Service Engineering, AIST)

Particularly in chapter "4 Time-series analysis…," please create a specific diffusion curve from the sales data, and draw a figure that shows how it is related to the major events.

Answer (Yuka Kubo)

I am aware of the insufficiency of evidence. I attempted to obtain cooperation from the appliance manufacturers and the cooking tool manufacturers to gather data for the sales of silicon resin spatula as well as for the actual state of IH cooking, but was unable to obtain those data. The sales data of the select shop were also undisclosed. Therefore, I conducted the analysis of household users from the information transmitted by the media. There was a huge variety of magazines, and while feeling regretful that a comprehensive analysis could not be accomplished, extraction was attempted as appropriately as possible.

This paper clarified that the cooking method unique to IH contributed to the introduction of IH to the household, and while the cooking method was diffused by sensible lead users, it was discovered by logical lead users. The logical lead users were able to discover a new cooking method because, while they were users, they were interested in the technology itself. I added revisions to express this point.

2 Sensible lead user

Question and comment (Motoyuki Akamatsu)

You mention that the cookery researcher is the logical lead user, while the select shop is the sensible lead user. The argument is clear for the cookery researcher, while it is unclear for the select shop. You wrote that the select shop is independent from the power company, but I don't think it is independent since it is located inside the TEPCO Building. Also you mention that the activity of the select shop is to respond to the social demand, but I don't think "participation of men in cooking" and "life surrounded by favorite cooking utensils" are general social demands. Also, it is written that "combining IH and silicon spatula was almost coincidental," and this means that the TEPCO CM played a significant role. From this point, didn't the power company function as a core diffuser?

Answer (Yuka Kubo)

As you commented, whether the action of the sensible lead user is a response to social demand is not clear in this analysis. It can be said that since the products born from the intuitive idea of the sensible lead user have been taken up several times in fashion magazine articles, they match the social trend as a result. I changed the description by using the word "social trend."

The select shop, which is a sensible lead user, has a store in the Ginza TEPCO Building through support of TEPCO, but TEPCO does not cooperate in development or selection of commercial goods. Although the TEPCO CM did show the cooking tools in both hands, it showed wooden spatulas, and I think it is important to note that replacing wooden spatulas with silicon ones was not an ordinary idea.

However, I do not think that it is coincidental that TEPCO supported a sensible lead user. In the process of setting up a select shop in the Ginza TEPCO Building, collaboration was done to find ideas that corporations cannot produce and to incorporate ideas from housewives. TEPCO did this intentionally to some degree. I added the point that housewives' comments were incorporated.

3 Contribution of women

Question and comment (Motoyuki Akamatsu)

The important point of the original manuscript is the "contribution by women," but in the framework of "logical lead users" and "sensible lead users," I don't think it is mandatory that the lead users are women. Of course, the two lead users were women in this case, but I think this was because the subject was cooking utensils whose primary users are women.

Question and comment (Koh Naito)

The paper discusses the importance of the role of sensible lead users who are sensible to the social demands of women. I think

this is an important point. However, there are descriptions such as "women as independent individuals" and "women who are in charge of cooking in homes," but I don't think the importance of the role of "women" is clear in the data and analysis of this paper.

Answer (Yuka Kubo)

One of the reasons the logical and sensible lead users contribute to the diffusion of technology from their positions is because the general users do not understand the content of the technology. I pointed out the contribution of women lead users because there are many technologies whose users are women who may not understand the technology. However, the roles of logical and sensible lead users who contributed to the introduction of IH to households can be played by men in non-IH cases. I removed the references that are limited to "women," and shall continue this research to demonstrate that the model applies to cases of other technologies.

4 Examples of other products

Question and comment (Motoyuki Akamatsu)

I think it will be helpful to readers if there are comparisons or discussion with other products. For example, pressure cooker may be used as another example for cooking utensils.

Answer (Yuka Kubo)

Unlike a microwave oven and a rice cooker that can be used by a user who has no skill, recipe, or tool, the user cannot benefit from an IH product alone. Similarly, for products that require supplementary components such as user's skill, recipe, and tools, various lead users are expected to contribute in diffusion, as indicated in this paper. For example, pressure cookers and waterless cookers were developed a long time ago, but information on cooking methods and recipes that optimize their functions are being transmitted by cookery researchers to this day. Recently, their users are increasing because there is a rising interest in reduced-oil cooking, and I think this is being accomplished through the contribution of lead users. I added the example of pressure cookers and waterless cookers in the discussion, and shall continue investigation of other case studies.

5 Perspective of innovation

Question and comment (Koh Naito)

On "IH innovation," in positioning it as an innovation, please describe which social value IH created when the technology appeared. I imagine that the appearance of the new cooking method affected the diffusion of IH because IH provided some new value to the user and it was not merely a technological replacement of gas.

Answer (Yuka Kubo)

The purpose of the generation and diffusion of the IH cooking system was to diffuse the value of "cooking that couldn't be done before" to society, as they were discovered when "used" by logical lead users. However, it was found that people who were not interested in cooking before or those who were simply interested in design were motivated to engage in cooking, powered by the intuitive idea of sensible lead users who contributed to the diffusion. Also, the social value of the IH cooking system is diverse including safety and environmental concerns. I added these to chapter 7.