Adoption of RFID Household-based Waste Charging System in Gangnam and Seocho in Seoul:Based on Technology Hype Curve Model

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ABSTRACT

Despite their various similarities, Seoul's' Gangnam and Seocho districts showed different patterns in the adoption of the RFID household-based waste charging system. Gangnam, one of the 25 wealthiest districts in Seoul, first adopted the RFID system in 2012, but decided abandon it a year later due to inconvenience, sanitation, budget limitations, and management related issues. Unlike Gangnam, Seocho, a largely similar district to Gangnam , started to implement the RFID system in 2015 and successfully adopted this innovation. In this paper, we explain the adoption behaviors of these two districts using a Technology Hype Curve Model with 5 stages. Unlike traditional technology adoption theory, the Hype Curve Model concentrates on the big chasm between early majorities and late majorities, which is a core reason for discontinuity in innovation diffusion. Based on our case study result, the early majority easily gave up adoption due to immature technological and institutional infrastructure. However, Seocho district, who waited until the deficiencies had been sufficiently fixed since late majorities, succeeded at incremental diffusion. Since its invention by Gartner cooperation, the Hype Curve Model has not received enough attention in academia. This paper demonstrates its explanatory power for innovation diffusion. Similarly, this paper focuses on the importance of institutional framework in the diffusion of innovation. Lastly, we compare the behavior of two local governments in supporting and diffusing RFID systems to draw relevant policy implications for innovation diffusion.

Key words: *Case Study, Chasm, Technology Hype Curve Model, RFID.*

1. INTRODUCTION

In Korea, the adoption of the RFID household-based waste charging system was chaotically and widely implemented after the Ministry of Environment strongly recommended 25 districts in Seoul City adopt an innovative RFID system. Especially Gangnam district, one of the wealthiest districts in Seoul, decided to adopt this innovation in 7 apartment complexes for the first time in 2012; however, the district gave up implementation after a year. In contrast, Seocho, a similar district in many ways to Gangnam, waited about 2 years for the technology to mature and thus had a successful diffusion. Using Technology Hype Curve adoption theory, we investigated why the early adopter, Gangnam, failed in successfully implementing the RFID household-based waste system and the late adopter, Seocho, succeeded.

When Rogers' first studied innovation diffusion in 1962, he mainly focused on agricultural innovation. According to his early study, the diffusion of innovation was encouraged by farmers' personal networks, due to the lack of Internet Communication Technology. For this reason, the adoption and diffusion of technology happened gradually from innovators to laggards. But, in today's era of on-line communication, the tendency of innovation diffusion is somewhat different than in Rogers' time thanks to the effects of internet and mass media. Instead of traditional innovation diffusion theory, [1] argued for the technology hype curve model, in which the diffusion of innovative technology can be seen in a discontinuous form, with chasms between the innovators/early adopters and late adopters. But, despite its relevance in describing the technology diffusion process, the Hype curve did not receive enough focus because of its lack of empirical evidence and its development by Gartner consultant group, rather than by academic scholars. We show the explanatory power of technology hype curve, in comparison to the traditional diffusion model, by presenting our study of two very similar districts in Seoul: Gangnam and Seocho. Although the technology hype curve model did not receive enough attention from scholars, as described above, its relevance in explaining IT technology adoption and diffusion should be excavated from a theoretical point of view.

Also, from the environmental point of view, it is important to analyze how relevant environmental policy is adopted and diffused. As can be shown in the previous literatures, relevant waste policy is closely related to not only public health and sanitary [2] but also to climate change [3]. Furthermore, as [4] pointed out, as more people start to reside in apartment complex with the rapid urbanization, governments should seek method to deal with waste dumped from densely populated area

as soon as possible. The newly invented RFID household based waste charging system is an appropriate tool to fulfill this goal. According to [4], the RFID system is a strong policy instrument in waste reduction because RFID system enables residents and local governments to charge waste charge in proportion to total amount of each household's waste emission. In other words, with the adoption of RFID system, the governments can reinforce unit-based waste pricing system by strengthen two radical premises of unit-based pricing system, 'polluter pays principal' and 'economic-incentive' [5].

Also, we would like to show how local governments in Seoul City lead innovation diffusion by supporting private sector and reducing administrative burden that levied to citizens. Especially we would like to explain how different perspective on innovation diffusion of two districts created different tales. As can be seen from [6] and [7], traditional technology diffusion theory mainly focuses on technological maturity or technological infrastructure, rather than on institutional infrastructure. However, institutional infrastructure, such as payment and incentive designs and evolving management processes, can be cores factor that drive smooth technology diffusion. In this sense, we focus on the role of central and local governments in innovation diffusion. The government can play a main role in establishing structures, especially when trying to introduce new policies that propose new ways of embedding operating systems. Specifically, as [8] pointed out, business and media lose their interest in innovations after the hype, so actors rely on government support to continue the development of their products. On the other hand, policy makers have an obligation to excavate the potentials of innovative technology and support it to be developed in a more complete form, despite any hype and disappointment. Also the Seocho Gu Government support apartment complex management office managers who actually accelerate innovation diffusion by reducing administrative burden. Also, levying administrative burdens to citizens can cause ineffectiveness in policy implementation. In this case, the local government of Gangnam let apartment complex management offices manage most of the problems that occurred during the adoption process of the RFID system for the first time in Seoul. The management offices not only had to manage the food waste system, but also answer local residents' complaints and deal with the negative side effects that inevitably occurred due to immature technology, such as illegitimate waste dumping. Giving too much work load to management offices caused a failure in a Gangnam that was trying to be an ambitious pioneer in trying innovation. In this sense, we stress the relevant role of policy makers based on tales of Gangnam and Seocho, not only in terms of reducing administrative burdens on citizens, but also in terms of supporting failed innovation by providing sound institutional supporting infrastructure.

Lastly, previous studies on the hype curve mainly considered the behavior or tastes of consumers, the demand side, although each stage of innovation contains both supply and demand [9]. But, as [10] and [11] pointed out, it is necessary to scrutinize both the supply and demand sides of stakeholders to evaluate the effectiveness of the hype curve from a macro point of view. Since in this case of RFID household-based waste charging system adoption the local government played both demand and supply sides simultaneously, it was necessary to consider the needs of both actors. In this study, we analyzed the cases of Gangnam and Seocho without limiting ourselves to either side.

2. LITERATURE REVIEW

2.1 Research Background: RFID and waste management

Radio Frequency Identification, also known as RFID has been used in various fields not only in private sector but also public sector [12] after its invention in 1886 by Hertz [13]. These days, many practitioners and scholars shed light on RFID technology to solve environmental problems in urban areas. Especially in Asian developing countries where governments face rapid urbanization, scholars focus on RFID technology to deal with environmental issue. For instance, Shanghai City government started RFID using waste management system to prepare Shanghai expo in 2011 [14], and the Ministry of Environment of South Korea introduced RFID system in the medical waste management in 2006 [15]. Not only developing countries but also developed countries such as EU or US also try to implement RFID technology in environmental policy. [16] and [17] introduce RFID using waste management system in EU and US.

Fig. 1. RFID machine Source: own

The South Korean government is the one who is eager to solve environmental issues using RFID technology. After the prohibition of waste emission was established by law in 2013, the importance of reducing the total amount of food waste increased. To reduce food waste, Korea's Ministry of Environment decided to adopt a RFID household-based waste charging system and invested almost 3 billion US dollars. Before the adoption of the RFID system, Gangnam and Seocho implemented a plastic bag system as a food waste throw away system. In this plastic bag system, local residents use relevant volumes of plastic bag from nearby markets and put the food waste in plastic bags to throw away. Unlike the plastic bag system, using and implementing the RFID machine system is complicated. First, the Gu government distributed to each household residing in apartment complexes a RFID tag embedded card. When each household touched the RFID card to the waste collection machine (see Fig. 1), the RFID reader recognized the user and gauged the amount of food waste based on the exact amount of waste the emitter disposed. A waste fee

was charged to the users in proportion to the food waste emission. The Ministry of Environment expected that innovative RFID method could reduce food waste because in RFID system, residents can check the total amount of food waste they emitted. Whenever local residents touch the RFID tag embedded card, the RFID machine automatically identify who the polluter is, and calculate the total amount of waste and waste fee charged, and show the result to the polluter. Exposing polluters to waste fee information charged to them can strengthen individual incentive design, which is a core theoretical background of unit-based waste charging system[1], and ultimately, it can reduce the food waste emission. As [18] pointed out, measuring individual performance based on exact information and data is the core premise of constructing individual incentive system. In this sense, the Ministry of Environment believe that food waste will reduce by adopting RFID household based waste charging system. But newly adopted innovation is more difficult to use when compares to former plastic bag system as described above. For this reason, there are local governments who hesitate to try innovation while local governments such as Mapo-Gu in Seoul are eager to use innovation.

Unlike the traditional technology adoption theory that stresses the effect of financial richness [20], Gangnam, one of the wealthiest districts in Seoul City, did not successfully implement this innovative system. As a matter of fact, Gangnam was the first district in Seoul to adopt the RFID system in 2012, but decided to give up and stopped implementing a year later. In contrast to Gangnam, Seocho, a similar district to Gangnam in many ways, adopted the RFID system in 2015 and diffused it incrementally in very successful ways. Where did these different tales of two cities come from? What factors cause this difference?

2.2 Technology Hype Curve Model

[1] introduced a Technology Hype Curve Model that shows the evolution of innovation technologies over time and uses changes in society's expectations to track the diffusion tendencies of ICT innovation [21]. The hype curve model was especially adopted in business and IT fields [22]. Today, the hype curve model is used as a theoretical frame for explaining the diffusion tendencies of induced pluripotent stem cells [23], hybrid automobiles [24], and stationary fuel cells [25]. Studies from science and technology fields show the potential of the hype curve model as part of a larger research agenda and its potential for influencing the innovation process [26].

Fig. 3 below shows a schematic form of the technology hype curve model. As we can see from Fig. 2, when Gartner first published hype curve model for the first time, the X axis of

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[1] The Unit-based waste pricing system can be defined in various ways, but most of the scholars consent that unit-based pricing system embeds 'polluter pays principal' and 'use economic incentives and the market system to minimize waste pollution' [4]. [19] defined unit based pricing system as 'mechanism that implements market mechanisms to provide economic incentives to decrease waste pollution'. In unit-based pricing system, since polluter pays waste charge in proportion to total amount of waste they emitted, the waste charge is used as economic incentive to encourage polluter to reduce waste.

the graph indicates the flow of time and the Y axis shows societal and media expectations of the emerging innovation. In this model of the technology hype curve, the Y axis originally represented social and media expectations [27], but it has been interpreted differently as the interest of experts in innovation technology [28], the risks and costs that must be considered when adopting innovation [29], and degree of innovation development [30]. The main purpose of the technology hype curve model is to prevent impetuous investment decisions based on the results of the first implementation of an innovation technology. Also, between peak of inflated expectations and slope of enlightenment, there is a trough of disillusionment stage, which is similar to chasm in Moore's model, innovative technology cannot be diffused continuously. Rather, the innovation experience discontinuous period, when lots of technological challenges born and dead.
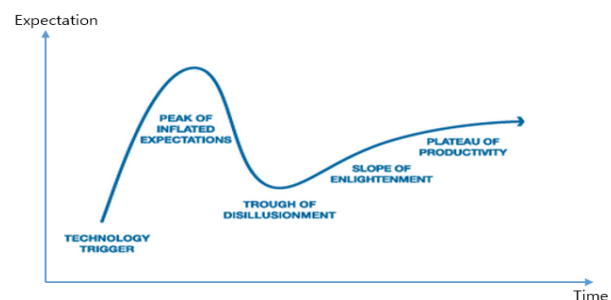

Fig. 2. Technology Hype Curve Model Source [1]

The hype curve model can be divided into five stages. The first stage is the technology trigger stage, when experts with abundant knowledge and interest begin to explore new possibilities for innovation [31]. In this period, professional researchers search for potential and possible advantages and disadvantages of a new technology [32]. However, they cannot give entrepreneurs explanations or evidence of the benefits of technology adoption. Next is the peak of inflated expectations stage. At this stage, there is still very limited information on the innovation technology, so there is little or no specific information on how and where to apply the technology. In the following trough of disillusionment stage, critical views on technology emerge, including examples of and information on failures. According to [33], the trough of disillusionment coincides with the Chasm that Moore suggested in 1991. So, innovative technologies are not adopted for a long time. The next stage is the slope of enlightenment. In this stage, the improvement and development of innovation bring new expectations and positive recognition of innovation to the early majority [27]. In other words, real-world experience and relentless trial and error leads innovation to evolve better forms. In the last stage, the plateau of productivity, not only experts, but a majority of society start to become aware of the benefits and advantages of an innovative technology. A mature innovation technology begins to be adopted widely in this stage. But, as [34] pointed out, the specific form and dynamics of the hype curve can differ from technology to technology.

Gartner's model has already been widely used in business and its explanatory power has been acknowledged [24], but

there is still a lack of verification and demonstration from an academic point of view [9]. [9] pointed out the lack of attempts to build a theoretical foundation of the hype cycle model. [35] also stressed the weaknesses of the hype cycle model, especially its vague definitions of the vertical and horizontal axes. As described above, the vertical axis of the hype curve represents expectations and visibility according to Gartner's original publication published in 1995. However, this definition differed from scholar to scholar. For example, in [25]'s analysis, the vertical axis was media attention, while [24] suggested that maturity of technology, consumer adoption, and maturity of institutional infrastructure also can used for the vertical axis of the hype curve. In this study, we used 'maturity of technological and institutional infrastructure' as the vertical axis, which can be radical factor to make concrete theoretical validation of the hype curve model

3. RESEARCH DESIGN

3.1 Case Selection

To do a comparison case study, we selected two of Seoul city's 25 districts (Gus). Like a county in the United States, the Gu is the basic unit of local government in Seoul City. Each Gu has its own authority to determine the time and specific method of waste policy implementation. Among the 25 Gus in Seoul, Gangnam and Seocho are the two wealthiest districts. As [36] and [37] stated, financial factors are the most important factors in innovative technology adoption. Because adopting and implementing brand new technologies requires additional costs, not only for purchasing machines but also training and educating organization members [38]. For these reasons, innovation technology is usually first adopted in wealthy organizations. Since Gangnam had no limitations in terms of budget, they were the first to decide to try the RFID household-based waste charging system in Seoul. As we can see from Fig. 4 below, Seocho Gu is right next to Gangnam Gu. These two districts have lots in common, but despite their similarities in financial status, location, area, and population, the adoption and implementation of Seocho Gu's behavior was different from that of Gangnam Gu. Unlike Gangnam Gu, which first implemented the RFID system but abolished it and regressed to the original plastic bag system a year later, Seocho made a more careful choice and did not adopt the RFID household-based waste charging system until 2015. While Gangnam used the RFID charging system, Seocho maintained the traditional plastic bag system.
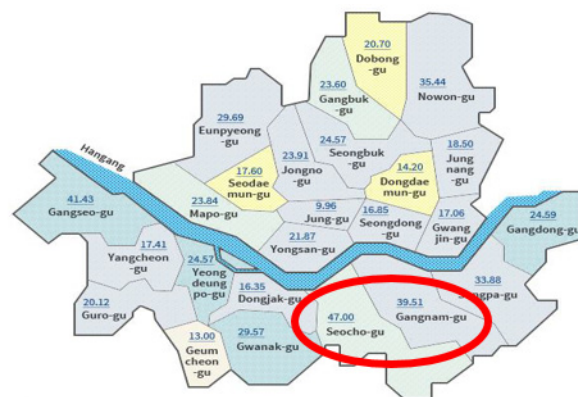

Fig. 3. Case Selection Source [39]

As can be shown in Table 1, Gangnam and Seocho have many things in common. The population of Gangnam in 2012 is 565,731 and the population of Seocho is 447,177. In 2012, the mean age of Gangnam is 40 and mean age of Seocho is 39.8. Also, Gangnam and Seocho are the two wealthiest districts among 25 districts in Seoul. Governors from conservative political party were elected in both districts in 2010 election.

Table 1. Comparison of Gangnam and Seocho Source [40]

	Gangnam	Seocho
Population	565,731	447,177
Mean age	40	39.8
Area	39.51	47
Financial self-reliance ratio	82.8	79.4
Political party of Governor	Conservative (Shin, Yeon-Hee)	Conservative (Jin, Ik-Cheol)

Out of several potential apartment complexes located in each district, both Gangnam and Seocho chose 7 apartment complexes as pioneers for implementing the RFID household-based waste charging system. All 16 complexes used a very traditional way of waste charging—a plastic bag system—before the adoption of RFID. Gangnam Gu first adopted the RFID system in 7 apartment complexes around early 2012.

Table 2. List of apartment complexes

	Gangnam	Seocho
RFID adopted Apartment Complex	Apartment 1_gangnam	Apartment 1_Seocho
	Apartment 2_gangnam	Apartment 2_Seocho
	Apartment 3_gangnam	Apartment 3_Seocho
	Apartment 4_gangnam	Apartment 4_Seocho
	Apartment 5_gangnam	Apartment 5_Seocho
	Apartment 6_gangnam	Apartment 6_Seocho
	Apartment 7_gangnam	Apartment 7_Seocho

As we can see from Fig. 4 below, Gangnam Gu first implemented the RFID system in February 2012 in 7 apartment complexes located in the district. But, about a year later, the Gangnam government decided to regress to the former plastic bag system, which it has kept up to now. In contrast to

Gangnam, Seocho did not adopt the RFID system, even after Gangnam gave up in May 2013. The Seocho government implemented the new technology in May 2015 in 7 apartment complexes located in Woomyon-dong, Seocho Gu, and tried to diffuse it throughout the district.

Fig. 4. Food waste charging system in Gangnam and Seocho

Table 3. List of Interviewees

ID	Age	Gender	District	Occupation	Years of experience
1	55	Female	Gangnam	Head of management office	1
2	58	Male	Gangnam	Head of management office	1
3	34	Female	Gangnam	Staff of management office	1
4	65	Male	Gangnam	Head of management office	1
5	46	Female	Gangnam	Resident	1
6	72	Female	Gangnam	Resident	1
7	54	Female	Gangnam	Resident	1
8	45	Male	Gangnam	Government official in Waste & Cleaning department of Gangnam	-
9	59	Male	Seocho	Head of management office	7 months
10	68	Male	Seocho	Head of management office	7 months
11	32	Female	Seocho	Staff of management office	7 months
12	38	Female	Seocho	Resident	8 months
13	62	Male	Seocho	Resident	6 months
14	64	Female	Seocho	Resident	7 months
15	38	Male	Seocho	Government official in Waste & Cleaning department of Seocho	-

3.2 Interviewees

We interviewed three types of actors related to RFID method adoption and implementation. The first type of actor was local government officials from Gangnam and Seocho districts. The local government plays an important role in the RFID adoption process. When the central government, the Ministry of Environment, recommend local governments adopt the RFID household-based waste charging system, each local government decided when to adopt and who would adopt the RFID system.

Also, they monitored opinions and reactions from residents and apartment complex management offices continuously to revise and develop the implementation. We interviewed government officials in the waste and cleaning departments in both Gangnam and Seocho Gu. In the field, apartment complex management offices control and administer most of the things. The apartment complex offices train and educate residents how to use the innovative technology, help them to become familiar with it, distribute RFID-embedded cards to each household, and ask local governments to redistribute RFID-embedded cards when residents lose them. To scrutinize the success and failure factors of both districts, we interviewed the heads and staff of apartment complex offices. Lastly, we also met residents who resided in RFID-adopting apartment complexes in each district to understand specific problems with the RFID system via their voices.

3.3 Interview Method and Process

In this study, as described, we interviewed 15 interviewees who reside or work in Gangnam and Seocho district. All interviews were conducted in Korean and semi-structured. We sent interview questions related to RFID waste pricing system

adoption before visit to guarantee time for to prepare interview when interviewing Government officials or apartment complex management office. On the other hand, in the case of interviewing residents, we visited each apartment complex and waited in front of RFID machine to catch and randomly select interviewees who came out to throw food waste away. Each interview lasted between 15 minutes to 60 minutes and some of them were recorded by voice recorder but the rest were written by hand because some interviewees were reluctant to record. After the interview, we summarize the interview and recorded. These organized interview records were used as resource of this qualitative study.

3.4 Case Study Design

We planned to compare the adoption behaviors of Gangnam and Seocho in light of the Technology Hype Curve Model in this research. Especially, we wanted to show how and why Gangnam, an early adopter of the RFID household-based waste charging system, failed through the technology trigger, peak of inflated expectations, and disillusionment stages. Also, we analyzed how Seocho, one of the early majorities of the

RFID system, fixed and revised deficiencies and started the enlightenment and plateau of productivity stages.

As we can see from Fig. 5 below, since Gangnam is an innovator and early adopter, they changed their system to the RFID system and experience the peak of inflated expectations through the disillusionment stage. With strong recommendation and support in the technology trigger stage from the central government, the Ministry of Environment, Gangnam district decided to adopt the RFID system in early 2012. Soon they found several deficiencies and problems, especially in comparison with the former plastic bag system. As a result, the residents of apartment complexes and the Gangnam local government overturned their decision a year later. Although similar in location and wealth to Gangnam district, Seocho took more cautious approach. Therefore, they waited long enough to solve the problems of immature innovation opened the 'slope of enlightenment' stage in May 2015. The Seocho government is planning to diffuse this innovation district-wide until the end of 2017.
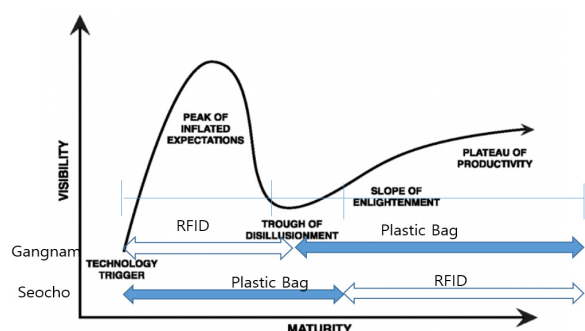

Fig. 5. Case study design

4. CASE STUDY RESULT

4.1 Technology Trigger and Peak of Inflated Expectations

As the total amount of food waste emission increased, the Ministry of Environment introduced and has stressed the importance of RFID household-based Waste Charging System for waste reduction since 2012. Therefore, the Ministry of Environment encouraged 25 Gus in Seoul city to adopt this new system as soon as possible [41]. Gangnam district showed huge interest about this new system. Ms. Shin, the head of Gangnam district who was elected in 2011, showed huge interest in highlighting the advantages of Gangnam as the most market-friendly, wealthy district in Seoul. Furthermore, as a passionate newly-elected head, Ms. Shin tried to solidify the pioneer-like image of Gangnam through adopting innovative technology such as RFID [42]. Therefore, Gangnam district adopted RFID technology not only in food waste unit-based pricing system but also in U-health service, by which residents could check their total amount of walking when holding RFID embedded cards [43]. As a result, with strong support and suggestions from Ms. Shin, Gangnam Gu decided to adopt the RFID system in 7 apartment complexes in 2012; she promised active promotion [44]. Both Ms. Shin, and local government officials in the Waste and Cleaning department expected effectiveness of the RFID system in reducing food waste.

Therefore, they planned to diffuse the RFID system district-wide until 2015, with strong support from policy decision makers.

4.2 Through of Disillusionment Failures: Gangnam Gu

Against the positive expectations of the impact of the RFID system on waste reduction, soon several deficiencies and failures were found in apartment complexes in Gangnam. As [45] pointed out, in the Trough of Disillusionment and Failure stage, pioneers who excavate the potential of innovation and implement it start to face disappointment because the early version of an innovation has lots of deficiencies. Naturally, users should either endure inconveniences or consider stopping the implementation. Gangnam, a pioneer in the RFID household-based waste charging system adoption, also encountered various problems, not only caused by immature technology, but also by a lack of institutional and cultural infrastructure. We discuss those problems more specifically below.

4.2.1 Gangnam Gu Governments

Several failures were found in the Gangnam case. The first type of failure can be explained from a macro-managerial point of view. As we already described above, local governments are in charge of macroscopic management, such as monitoring and controlling actors like residents, apartment complex management offices, pick up services, and RFID machine supply firms.

A year after first adoption of the RFID system, the Gangnam government found frequent breakdowns in machines due to moisture from food waste; residents asked the local government to fix the machines as soon as possible because food waste is notorious for its stinky smell. But, due to the immaturity of infrastructure to support innovation diffusion, there were two problems with procuring machine parts and fixing RFID machines. First, due to worsening of the small businesses that produce RFID food waste machines, it was difficult to supply machines or machine parts punctually, because lots of small businesses disappeared or went bankrupt. Moreover, since the Ministry of Environment did not standardize the size and figures of machine parts, the local government had to purchase completely new machines when machines were broken.

This problem naturally led to budget limitation issues. Not only were the early versions of RFID machines expensive, but the machines were not standardized, so the local government had to face serious budget limits in purchasing and maintaining the machines. Also, since the RFID system was first adopted in Gangnam Gu, there was a lack of information about how to use this system and machines, which meant the government needed to invest more money to educate and train government officials and local residents. Moreover, since local residents did not trust the effectiveness of the new RFID system, the Gangnam government invested more money to promote people's participation. Lastly, under the plastic bag system, each household paid food waste fees through purchasing plastic bags themselves, so there was no need for additional management costs. However, in the case of the RFID method, the Gu government had to collect the total amount of waste emissions

for each household and charge waste charges based on the quantity of waste emission. Therefore, there were additional administrative costs for collecting waste emissions, calculating waste charges, and sending bills to each household.

Also, when first adopted, the Gangnam government chose a prepaid system for charging. Specifically, the government deducted KRW 50,000 from local residents and gradually deducted amounts proportional to waste emissions from the KRW 50,000. But this prepaid system was found to be ineffective in reducing food waste because residents were insensitive to money that had already been spent. Furthermore, waste fees in the RFID system were lower than in the plastic bag system, so the effect of Pigouvian tax decreased. These facts led to an increase in food waste.

4.2.2 Apartment Complex management offices

The apartment complex management offices faced lots of difficulties in the innovation stage. First, since the internal structure of the early version of the RFID machines was complex, it was hard to clean the interior of RFID machines, despite strong demands from local residents, especially in summer. Also, the interviewees pointed out the insufficient capacity of RFID machines as a problem. Most traditional Korean food contains lots of water that caused frequent breakdowns of machines, because when people threw away food waste, water or moisture leaked into the machines. Moreover, since the early version of the RFID machines was too small to contain enough food waste because the machine production firm and the government did not recognize the exact amount of food waste emissions, since the local government could not collect data about waste quantities in the former plastic bag system. Soon, residents inevitably threw food waste outside the machines. For apartment complex management offices, this was not a simple cleaning problem but a serious management burden.

Since Gangnam Gu was the innovator or early adopter of the RFID household-based waste charging system, not only the Gu government but apartment complex management offices and local residents did not have enough information and experience to use it properly. Lots of people could not learn how to use the machines and soon many people found RFID machines an inconvenient way of waste emission. As a result, unauthorized food waste dumping frequently occurred, avoiding the surveillance of management offices. One manager from a management office reported a case of local residents throwing food waste by illegally exploiting lost cards.

Also, the elderly often could not properly use RFID cards because elderly people tend to have low digital literacy, as [46] and [47] stated. Also, elderly people felt uncomfortable when using the innovative RFID system because it was more complex compared to the former plastic bag system. For this reason, managers from management offices had to help elderly people often, which was an additional task and burden to managers. Moreover, people lost RFID cards frequently. If the card was lost, it could be reissued through the website of the Korea Environment Corporation in 24 hours. 24 hours can be a relatively short time, but in the summer season food waste quickly decays, so residents asked managers and management offices to borrow the master cards distributed from the Gu

government to apartment complex management offices. The managers found it hard to focus on other tasks because they had to help and monitor residents who wanted to throw away food waste. All these problems caused excessive work for apartment complex management offices.

4.2.3 Local Residents

Due to food waste with strong colors, such as Kimchi, the machines became discolored red. Sensitive residents found this hard to endure and asked management offices to clean the machines as soon as possible. But, since apartment management offices were responsible for all kinds of miscellaneous things, they usually had not enough time to answer immediately. For this reason, conflicts between residents and management offices rose in the process of requesting apartment managers regarding such cleaning problems. Cleaning problems occurred not only regarding the machines but also the surrounding environment. Since Korean people enjoy cuisines in broth such as soup, food waste often leaked during the transportation of food waste. Therefore, odors were often present in elevators, corridors, and stairs.

The residents of apartment complexes also raised a problem regarding convenience. In the case of the plastic bag system, it was only necessary to take away the bags on the way out of the house. However, when using the RFID method, it was necessary to bring the container back home after waste emission. Also, it was very inconvenient to carry a card every time. When the RFID card is put in the wallet, the card reader recognizes the RFID food waste card and transportation card at the same time. Therefore, it was necessary to take the transportation card out of the wallet. Because of this situation, the RFID card was often lost. Also, in the plastic bag system, the apartment complex management offices purchased bags and distributed them to each household. So, residents said that the plastic bag system was more convenient.

4.3 Slope of Enlightenment: Seocho

4.3.1 Seocho Gu Government

The Ministry of Environment eventually standardized the parts of RFID machines so it became easier to get new parts, even if small business companies went bankrupt or disappeared. Also, the local government chose suppliers with solid foundations so that they were able to minimize the possibility of bankruptcy. Furthermore, the Ministry of Environment and Seoul City government started to give local governments subsidies to purchase RFID machines. With the strong support from central government, the Seocho Gu government and local residents did not have to pay additional money to purchase machine when they decided to implement RFID system.

The Ministry of Environment and Seoul City government stated to give local governments subsidies for purchasing RFID machines. The central government fully supported the purchase of machines since 2013 to reduce the financial burdens of local governments. Since Seocho adopted the RFID system during this supported period, the local government did not have to arrange an additional budget to implement innovation.

At the beginning of RFID adoption, the Seocho Gu government did not choose a prepaid system. Rather than

repeat the same mistakes of Gangnam, Seocho let food waste emitters check the exact amount of waste emission every time waste was thrown away and set a monthly postpaid system. In this postpaid system, apartment complex residents pay waste charges after emission in proportion to the total amount of waste emission.

Also, to overcome the ineffectiveness of low levels of waste charge, the Seocho Gu government increased the food waste charge in the RFID system from KRW 60 per Kg to KRW 100 per Kg. In the former plastic bag system, in which citizens paid waste charges by purchasing plastic bag from nearby markets, plastic bags only cost KRW 60 per kilogram. But as [48] pointed out, low levels of a waste charge can be one of the most serious factors leading to waste policy failure. Seocho took a waste charge increasing strategy based on Gangnam's failure. Also, since the Ministry of Environment founded control towers to monitor and manage RFID food waste systems, it was easier for Seocho to collect food waste emission data from each household and levy waste charges.

4.3.2 Apartment complex management office

As for apartment complex management offices, the later version of the RFID household-based waste charging system was superior to the former version used in Gangnam Gu. First, with the adoption of the RFID system and foundation of a monitoring and managing organization, the Korea Environment Corporation, it became possible to gauge the exact amount of food waste emissions per month. So, RFID machines were developed in the direction of increasing capacities based on formerly accumulated data. The machines also developed to be easy to disassemble and clean inside.

Also, the government made an online card lost report system by which local residents can report and redistribute RFID tag embedded cards via by themselves. Since this brand-new way of reporting and redistributing does not have to go through apartment complex management offices, the management burden decreased. Besides, since local residents can report their lost cars immediately using their own PCs, the number of cases of misuse of a lost card by other residents also decreased.

To help people with low levels of digital literacy, the district office opened public hearings and training programs for local residents, including elderly people, to implement the RFID system easily. Also, for people without enough time to participate in public hearings or training programs, officials from the local government directly visited and explained the mechanisms of the RFID system. Additionally, the district government had a one-month grace period during which the innovative RFID system and former plastic bag system existed simultaneously to minimize confusion. Local residents communicated and interacted with each other to share information about the RFID system during this period, so the managerial burden of apartment complex management offices was reduced.

Also, the district government receives lost card reports and reissues new RFID cards through the government webpage in 24 hours, and also allows residents to visit the government office themselves to reduce the excessive work of apartment complex management staff. Since RFID cards can be redistributed quickly, residents can throw food waste away without help from management offices.

4.3.3 Local Residents

As RFID machines developed, problems related to sanitation were solved naturally. The Seocho Gu government selected small manufacturing firms who had matured the technology to make solid, convenient RFID machines. Before this evolution, local residents complained to apartment complex management offices about coloration and disgusting smells. But, in the later version of RFID machines, the distance between the cover and the metal bin in which emitted food waste was stored before collected by pick-up service was sufficiently extended. Also, inventors from manufacturing firms developed the machine covers to close as soon as possible, so residents do not notice disgusting smells when they throw food waste away. Furthermore, the small business firm changed the color of RFID machines from a light color to dark one, so residents do not notice discoloration of RFID machines.

In the early version of the RFID system, local residents had to bring a credit card size RFID card every time they want to throw waste away. To fix this inconvenience, the Seocho Gu government produce RFID card in a smaller size, almost as small as KRW 500 coin. This new RFID chip embedded card is small enough to hang on a mobile phone like accessories so that people can not only carry RFID card easily but also keep it safely not lost.

Also, the apartment management office provide plastic bag removal system right next to RFID machine. With this small innovation, residents in apartment complex simply take the plastic bag with the food waste, and then throw the plastic bag into the container located next to RFID machine. Through this method, local residents can take advantage of former plastic bag system and innovative RFID system simultaneously.

4.4 Plateau of Productivity

After the successful adoption and diffusion of innovation of Seocho, many of Seoul City's 25 districts started to consider adopting the RFID system. As described above, the RFID machine developed to be more convenient and clean, and the internal infrastructure, such as payment systems, public hearings, and support from the Central Government, were revised and increased. Also, positive news that food waste was reduced by almost 30 to 40% and the cases of apartment complexes where residents and staff were satisfied with the innovation were reported via mass media[2].

As a result, almost 1000 apartment complexes among the 2081 apartment complexes in Seoul City have started to adopt the RFID system partially or in whole since 2015. As of 2016, Gangnam is one of only two districts among the 25 that does not use the RFID household-based waste charging system. The

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[2] Joongrang Gu, one of the local districts located in Seoul City, reported they have reduced 40% of food waste during 5 months of experiment. The head of Joongrang Gu promised to diffuse the RFID system more widely. Not only in Joongrang, but the RFID household-based food waste charging system showed effectiveness in reducing food waste in Nowon Gu as well, where food waste has reduced by 30% from 2014.

Ministry of Environment strongly recommends local governments in Seoul adopt the RFID household-based waste charging system as key objective. Furthermore, the Ministry of Environment is trying to expand the scope of RFID system adoption to the whole country. As a result, local governments other than Seoul City, like Choongnam and Chollado, are implementing brand new waste charging systems now, and local areas that are not currently implementing RFID are also seriously considering the adoption of RFID with the strong financial support and strong recommendation of the central government[3].

5. DISCUSSION AND CONCLUSION

5.1 Summary of Findings and Implications

We analyzed the potential explanatory power of the Technology Hype Curve Model, especially regarding technology adoption. In other words, in contrast to the traditional technology adoption model introduced by Rogers, IT technology is never adopted continuously. Specifically, Gangnam district, an aggressive early adopter of the RFID system, implemented innovation for the first time in Seoul, but faced several difficulties in the implementation. First, the local Government had to endure frequent breakdowns of RFID machines and budget limitations because of insufficient standardization of machine parts and a lack of subsidies from the central government. Also, they faced problems with charging waste fees, such as the ineffectiveness of early versions of the prepaid system and additional administrative costs to collect waste emission data and send bills to each household. From the apartment complex management offices' point of view, the management of RFID machines and RFID-embedded cards were the most serious issues. Due to the complex inner structure of the early version of the machines, it was difficult to clean the inside, which naturally led to strong complaints from local residents. Also, since the capacities of the early version of RFID machines lacked data on waste emissions, illegal waste emissions increased because sometimes residents could not throw away food waste. Also, there were many cases of office staff helping residents throw away food waste because of low levels of digital literacy and high numbers of lost cards. They even had to help people report lost RFID cards to the local government and redistribute cards. The early version of innovation was not convenient for apartment complex residents either. Residents suffered from dirty surroundings and discoloration of machines that happened because of their complex inner structure. Also, unlike the former plastic bag system, it was inconvenient to bring plastic cans and RFID cards every time they wanted to throw away food waste. Because the Gangnam Gu Government could not solve all the problems they faced, they gave up to diffuse RFID method district wide a year later. Although Gangnam Gu gave

up to adopt, the central government, the Ministry of Environment did not give up to develop technology.

The early majority, Seocho, revised these deficiencies successfully and become an evangelist for RFID system adoption. First, the local government developed the capacity of RFID machines so that they almost never broke and never leaked liquids from food waste. Also, the Ministry of Environment standardized machine parts and started to support purchasing RFID machines financially by giving local governments subsidies. The Seocho Gu government also changed the payment design from a prepaid method to a postpaid method and increased waste fees[4] to maximize the effects of economic incentives. The management burden faced by apartment complex management offices also decreased. First, since the central and local governments developed RFID machines to be more convenient and clean, leaking liquid from food waste and illegal dumping of food waste due to a lack of capacity both decreased. Also, since the local government let residents report and redistribute RFID-embedded cards themselves directly via the local government website, there was no need to support local residents when they lost RFID cards. Also, because the local government provided education and training opportunities to people with low levels of digital literacy by holding public hearings and training programs, management offices did not have endure the additional management burden of answering local residents' needs.

We can draw several implications from this study. First, as many scholars in the innovation diffusion field, such as [35], have pointed out, the major weakness of the hype curve model is its weak theoretical background. In other words, as [51] pointed out, the theoretical background of the hype curve model is relatively weak because the hype curve model originated from business and marketing. Thus, the hype curve model did not have much chance to be seriously scrutinized. There is not only a lack of previous studies that have analyzed the effectiveness of the hype curve model [22], but also some empirical studies on its various limitations [24]. By comparing Gangnam and Seocho's cases, we find that the hype curve model can be adopted to explain innovation diffusion, despite the criticism that the hype curve model is a mere prediction without any practical evidence.

Second, we emphasize the relevant role of government in adopting innovative technology through policy implementation. The role of the government in innovation diffusion has not been sufficiently analyzed because innovation diffusion is first considered in business and marketing, where the *laissez faire* invisible hand is believed to be most effective. But, as we can see from the adoption of the RFID household-based waste

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[3] Kyonggi-do was chosen by the Ministry of Environment as one of the most successful local governments in reducing food waste using the RFID system.

[4] As [49] noted, generated environmental pollution can be reduced through a Pigouvian tax. If environmental damages, such as food waste emissions, can be measured exactly, and if waste charges are charged in proportion to the amount of emissions, a Pigouvian tax can control waste disposal behavior. But, the effect of Pigouvian tax has been controversial because it is hard to have perfect information about waste emission [50]. But when using the RFID household-based waste charging system, it is possible to monitor and trace the total amount of food waste emission in an easier way, thanks to innovative Internet Technology.

charging system, innovation implemented through policy is increasing. We have not only shown how central and local governments affect innovation diffusion by solidifying institutional and technological support, but we also given a theoretical explanation for this type of institutional support from governments in IT innovation diffusion.

5.2 Limitations

Although we aimed to draw objective theoretical implications from this study, there exists inevitable biases and limitations. First, we analyzed the case of 2 districts among Seoul city's 25 districts. We chose Gangnam district and Seocho district as the subjects of the case study for several reasons. First, Gangnam was the first district to adopt the RFID household-based waste charging system in Seoul but gave up a year later. Second, Seocho has many things in common with Gangnam, especially its wealth, which is one of the most important determining factors in innovation adoption, but Seocho waited several years to adopt and implement the system. However, since there are 25 districts in Seoul City, it is hard to generalize these results by using only the case of two districts. For this reason, it is necessary to scrutinize more districts' cases.

Also, the time span of this study was about 2 years, which can be relatively short for studying adoption behavior from the macro point of view. As of 2016, only 30% of apartment complexes have adopted the RFID system. For this reason, it is important to expand the time span when studying adoption cases, especially to check if the results drawn from this study describe a temporary situation or not. [24] stressed the importance of taking a relatively long period of analysis to examine the hype cycle. Moreover, as [11] described, there is possibility that the adoption of innovation is delayed after hype.

Lastly, according to recent newspaper articles, although Gangnam gave up implementing the RFID system due to several limitations of the early version of RFID machines and tax system, they are considering adopting RFID again[5]. [27] focused on innovators and early adopters and invented the hype curve model for early adopters who make investment decisions too quickly. In other words, what [27] intended was to make early investors avoid the risks of the early stages of innovation adoption. So, the behaviors of adopters after the plateau of productivity stage has not received enough attention. But as described above, the fact that Gangnam district is considering re-adoption of RFID implies that innovators or early adopters who fail in the early stage of innovation adoption can be potential customers again. Also, [51] described that, since there is a possibility of a second version of the hype curve after the original hype, it is necessary to analyze diffusion trends from a longer point of view. Further research should focus on the behavior of failed early adopters and innovators. Also, we suggest political and policy support from the Government for innovators who take the initial risks alone. In this study, we tried to explore the explanatory potential of the hype curve model using the cases from two cities, but future research should keep these limitations in mind to complete the tale.

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[5] Gangnam Gu government surveyed local residents to know tastes of residents and reconsider adopting the RFID household-based food waste charging system.

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