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Modification of Service Content for Evolution of Service Platform Ecosystems

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ABSTRACT

In platform ecosystems, the proper modification of goods provided could promote innovation and fulfill the need for diversity among consumers. However, most platforms in the service industry currently serve merely as intermediaries for existing services. This study aims to clarify how the function of a platform, which brings a modification of the content of services, contributes to the development of the platform ecosystem in service industries. The results of an agent-based simulation that imitates platform-based markets of a service industry reveal that the facilitation of changing the content of services could have negative effects for the platform ecosystem if there are no supportive functions. The authors demonstrate that two supportive platform functions contribute to successful modifications in service content the facilitation of customer involvement improves the sustainability of the ecosystem by increasing profits of platform users, and the support for capturing latent needs extends to the platform-based market.

KEYWORDS

Agent-Based Simulation, Customer Involvement, Labour-Intensive Industry, New Market Development, Platform Ecosystem, Service Innovation, Sustainability, Two-Sided Market

INTRODUCTION

In recent years, various business platforms have emerged. Specifically, this study focuses on service intermediation platforms (e.g., accommodation intermediating platforms such as Expedia and Hotels.com, sightseeing platforms like TripAdvisor, and restaurant booking platforms like Tabelog). Although there are various service intermediation platforms, these only do "intermediating." On the other hand, researchers studying platform-based markets in information technology industries suggest the significance of the role of platforms for the development of goods (products and services) and for the emergence of innovation in platform ecosystems. Although there is an accumulation of implications from previous research, platforms in service industries do not consider them. In platform ecosystems, such development and innovation can occur through the modification of the content of goods that utilize platform functions (or technologies). The authors believe that previous studies did not focus on the fact that service intermediating platforms provide functions to facilitate changing service contents provided by outside service providers. Thus, this study has the following research question:

Which platform functions can support successful changing of service content in platform ecosystems?

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In the following subsection, the authors review the literature on platform ecosystems and describe the research purpose.

Previous Literature on Platform Ecosystems and Research Purpose

Previous studies in the field of technology and innovation management have investigated their focal markets based on the concept of ecosystems (e.g., Adner, 2017; Jacobides, Cennamo, & Gawer 2018; Inoue, 2019). In particular, researchers have established the concept of a "platform ecosystem" (Gawer, 2014; Thomas, Autio, & Gann, 2014), which is also known as a platform-based business ecosystem and is regarded as one type of business ecosystem. The platform ecosystem consists of platforms as a system or architecture with a collection of supporting complementary assets (Gawer & Cusumano, 2014; Thomas et al., 2014). Among complementary asset providers, "complementors" produce complementary goods (products or services) for the platform (Boudreau & Jeppesen, 2015). A platform ecosystem can foster unlimited innovation through the participation of various organizations that hold several management resources as complementors (Gawer, 2014). A platform ecosystem also leads consumers with various needs to adopt the use of the platform (Ceccagnoli, Forman, Huang, & Wu, 2012).

Research on the platform ecosystem is mainly conducted for information technology (IT); platforms correspond to hardware or IT systems, and complementary goods correspond to software or applications (e.g., Inoue, 2019). Platform-based markets are not limited to the IT industry (McIntyre & Srinivasan, 2017). Nevertheless, most platforms in the service industry currently serve merely as intermediaries for existing services. In addition, the focus on platforms in service markets has only been on the intermediary function and its pricing (platform fee setting) (Clemons, Hann, & Hitt, 2002; Inoue, Takenaka, & Kurumatani, 2019; Kung & Zhong, 2017; Wang, He, Yang, & Gao, 2016; Zha, Zhang, Yue, & Hua, 2015). Thus, the viewpoint for modification of the service content with the platform has not been explored. In addition, most current service intermediary platforms, such as accommodation platforms, have not implemented this platform function.

Therefore, the purpose of this study is to clarify how the platform function of changing service content contributes to the development of the platform ecosystem. The authors believe implications from this study can contribute to helping future service intermediating platforms successfully develop service innovations in the ecosystem.

Research Approaches

This study focuses on the modification of service content in service intermediary platform ecosystems. The modification of such content by the platform function is not currently a widespread phenomenon. Therefore, this study conducts agent-based simulation experiments and constructs virtual service intermediating platform-based markets by logically and simply designing behavior and decision making of service providers and consumers. Based on these virtual markets, the authors tested platform functions that may be beneficial for the successful modification of service content.

MODIFICATION OF SERVICE CONTENT

Definition of Services and Service Modification

For the purposes of this study, the term "service" refers to the service of a labor-intensive industry. Several platform studies target "services" in a broader sense, but those explored herein need to be distinguished from similar usages, as described below. IT is another type of service. In some studies, the term "service" is used to express such factors as software, applications, and web services (e.g., Barrett, Davidson, Prabhu, & Vargo, 2015). Another type of service is the servitization of the platform (Suarez & Cusumano, 2009; Cenamor, Sjödin, & Parida, 2017). Servitization means that instead of pure product sales, products and services are integrated and jointly provided (Cenamor et al., 2017).

Features and examples of labor-intensive services are as follows. The characteristics of such services are intangibility, inseparability of production and consumption, heterogeneity, and perishability (Zeithaml, Parasuraman, & Berry 1985). Examples of such service industries include sales, hotels, food and beverages, transportation, telecommunications, finance, leasing, public goods, education, and health and social behavior (Miles, 2008).

Previous studies in service management have investigated service modification, and one of the major focuses of such research is service innovation. For example, Hertog (2000) proposed a four-dimensional service innovation model consisting of a new client interface, new service delivery system, and technological options. Victorino, Verma, Plaschka, and Dev (2005) classified service innovations by service type (regarding target customers), use of IT (regarding the digitization or maintenance of the information environment), and service customization (regarding the modification of service system or additional options). Berry, Shankar, Parish, Cadwallader, and Dotzel (2006) expressed the types of service innovations in a 2×2 matrix indicating whether it has a new core benefit or a new way of delivering such benefit and whether it must be consumed immediately on production. Referring to these previous studies, the authors summarize examples of service modifications in Table 1. Although the simulation does not express the specification of such modification, this study assumes the method of service modification is as it is in this table.

SUPPORTIVE PLATFORM FUNCTIONS FOR CHANGING SERVICE CONTENT

If platforms merely facilitated the modification of service content, service providers may find it difficult to develop new content to meet consumers' needs. To assist in the modification of service content, platforms could adopt additional platform functions. In this subsection, the authors identify two supportive platform functions as follows.

When a service is offered, an employee generally interacts with a customer. Therefore, customer involvement is emphasized in the development of new services (or service innovation). Failure to consider customers' needs in their entirety becomes a failure factor in service development (Dörner, Gassmann, & Gebauer, 2011). Increasing the amount of feedback from customers to the company and having them cooperate to create ideas and content generates incremental innovation (Cheng & Krumwiede, 2012; Gustafsson, Kristensson, & Witell, 2012). This behavior has a positive impact on corporate performance (Grawe, Chen, & Daugherty, 2009). The development of services inspired by customers makes ideas more creative and helps retain high user value (Magnusson, Matthing, & Kristensson, 2003). Although such involvement is important, it is sometimes challenging to grasp the customers' needs fully and adequately. As a solution, the platform owner can promote interaction between the complementors and their customers and can promote customer involvement in service development. Thus, this study considers a supportive platform function that facilitates customer involvement in service development:

Table 1. Examples of service modification

	Aspects of service detail	Aspects of service delivery
Service idea and concept	• Original food menu • Accommodation of customer input	• Stress-free service process • Comfortable hospitality system
Service type and target	• Opening of a high-class shop • Producing for the mass market	• Appropriate exterior, service design, and interface of web pages
New technology	• Availability of wireless internet connection • Novel customer experience with new technological innovation	• New technological transit system • Simplification of order with new electronic system
Customization	• Various lodging plans • Wide selection of food services	• Dedicated bus pick-up service • Improvement of accessibility for disabled people

Supportive platform function 1. Facilitation of customer involvement in service development.

In actual businesses, platform owners can suggest the development of new goods that capture the latent needs of consumers. As an example of a platform-based market, the video game platforms Nintendo Wii and Nintendo DS prepared innovative platform technologies for casual users and presented success stories for new software development to complementors (e.g., Subramanian, Chai, & Mu, 2011; Inoue & Tsujimoto, 2018a, 2018b). In the case of service intermediating platforms, the authors also observe some patterns for capturing latent needs and the development of new markets. For example, accommodation intermediary platforms could focus on foreign travelers and develop new markets. If the platform has a function that shows the existence of the latent needs of foreign customers and its market possibility, the service providers may be able to develop their services to fit the needs of new foreign customers. Thus, the platform owner can support capturing service providers' latent needs. Therefore, this study considers a supportive platform function that captures latent needs to assist in changing service content:

Supportive platform function 2. Support for capturing latent needs.

Simulation experiment

This study uses an agent-based simulation approach to explore the research question. This method simulates the behavior of actors (agents) that make up the social system and how they act to influence others (Harrison, Lin, Carrol, & Carley, 2007). The system is programmed on a computer and the agent attempts to reproduce the real exchange of relationships among the members by autonomously making decisions and interacting in the artificial environment (Fioretti, 2012). Some studies in the field of strategy and management also utilized an agent-based simulation approach (e.g., Huotari, Järvi, Kortelainen, & Huhtamäki, 2017; Kiesling, Günther, Stummer, & Wakolbinger, 2012; Zhang & Zhang, 2007).

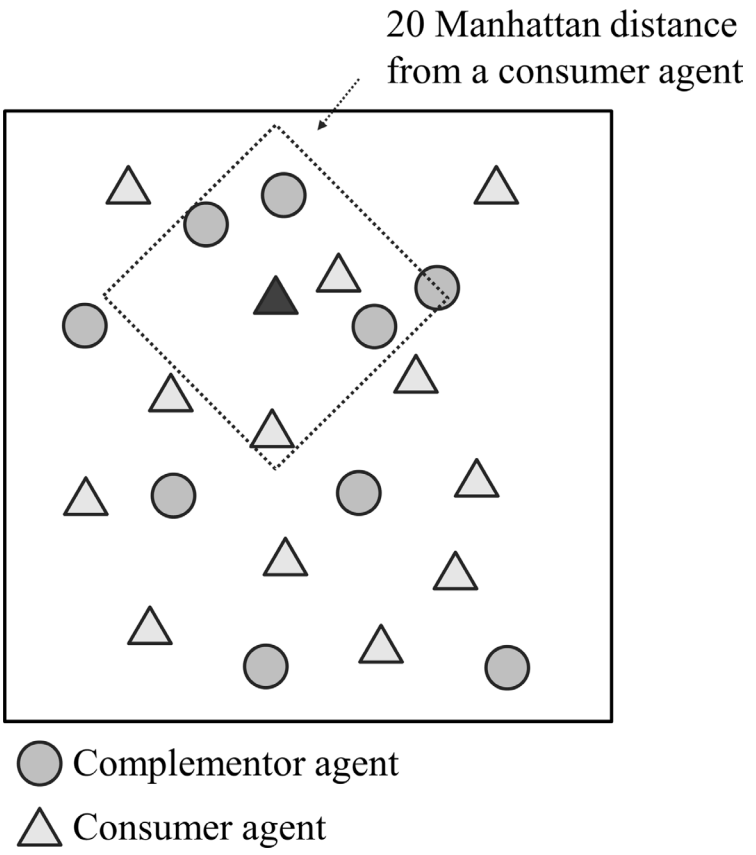
Simulation Overview

The proposed agent-based simulation system replicates the participation and transaction processes of complementors and consumers in the platform-based market of service industries. For simplicity, the study considers a case in which only a single platform exists without considering competition among platforms. There are three types of agents: a platform owner, complementors (service providers), and consumers. The structure of the simulated platform-based markets is "two-sided," where complementors and consumers interact via a platform. In the market, complementors provide (supply) services on the platform, and consumers purchase them.

Complementors provide services as complementary goods and have individual values concerning the price, quality, and content of their services. Consumers also hold individual preference (requirement) values for price, quality, and service content. Consumers purchase one service from the pool of services to maximize profit. The platform owner charges platform transaction fees for complementors and consumers. Complementors and consumers can decide whether to participate in the platform based on their (expected) profits.

When consumers and complementors use the platform, they can receive more options than they would under direct sales. To express this platform function, the present study assumes the following abstractive virtual space: (1) complementors and consumers are randomly arranged in a 100×100 two-dimensional map, (2) complementors and consumers each interact (through transactions and competitions) within the defined scope (within 20 Manhattan distance, and (3) participating in the platform enables participants to interact with all the other participants in the platform (not restricted by the limitation of 20 Manhattan distance). Figure 1 shows the conceptual image of the interaction range. The value of this Manhattan distance represents the effectiveness of the platform's intermediation function in comparison to direct transactions. When the value is zero, agents cannot interact with another side without the platform. On the contrary, when the value is 200, the platform's intermediating function is meaningless (as a robustness check, change in simulation results due to the value of the Manhattan distance, which is shown in "Discussion" and "Conclusion"). For simplicity,

Figure 1. Conceptual image of interaction range in the simulation



the study does not consider the reduction in utility due to distance. Figure 2 shows an outline of the simulation structure. Additionally, Figure 3 shows the simulation procedure. This simulation system is independently developed using R.

The aim of this simulation is to explore the research question according to one condition, which is assumed as one of the simplest settings. Therefore, the authors set the following premises. First, the distribution of agents' parameters (e.g., service price) are set to follow a uniform distribution. Second, each agent cannot change its parameters excluding service content. Third, the influence of price, quality, and content on consumers' profits are the same scale. Thus, many parts of this simulation are restricted for simplicity. Investigation of parameters based on real-world examples is recommended for future research.

Agent: Platform Owner

Platform owners acquire profit based on the number of transactions and the price of complementary goods by charging platform fees on the transactions between the complementors and consumers. In this simulation, the platform owner does not make autonomous decisions and actions through simulation steps. Their profit is calculated as the sum of profits from the transactions, expressed as the product of (sales volume of complementary goods) $\times$ (price of the goods) $\times$ (sum of the fee for complementors and the fee for consumers). Therefore, the profit $v_{j,t}$ of a platform owner j during period t is expressed as:

Figure 2. Simulation structure

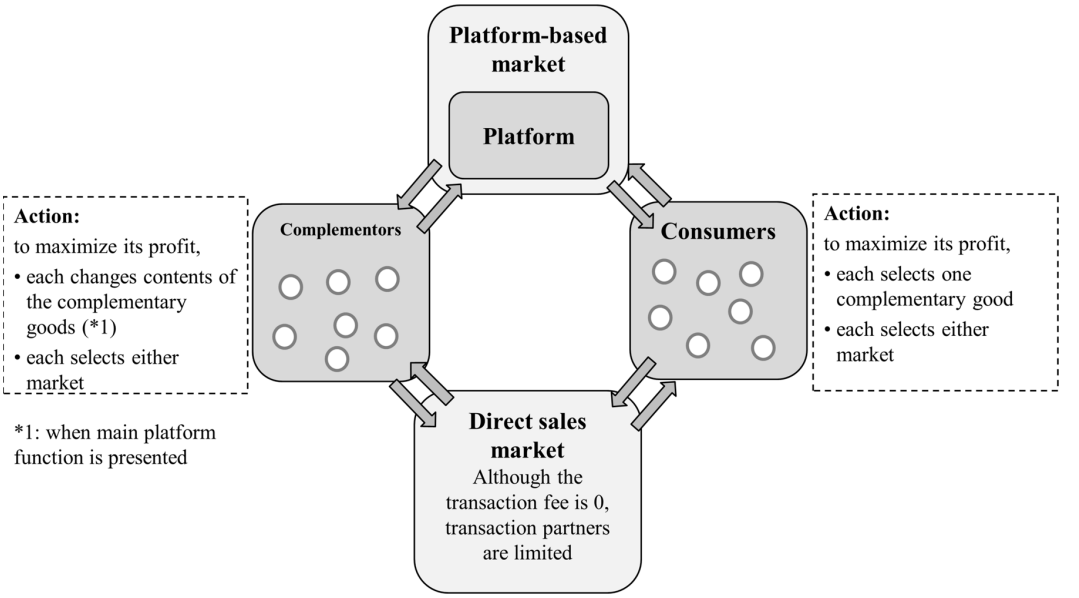
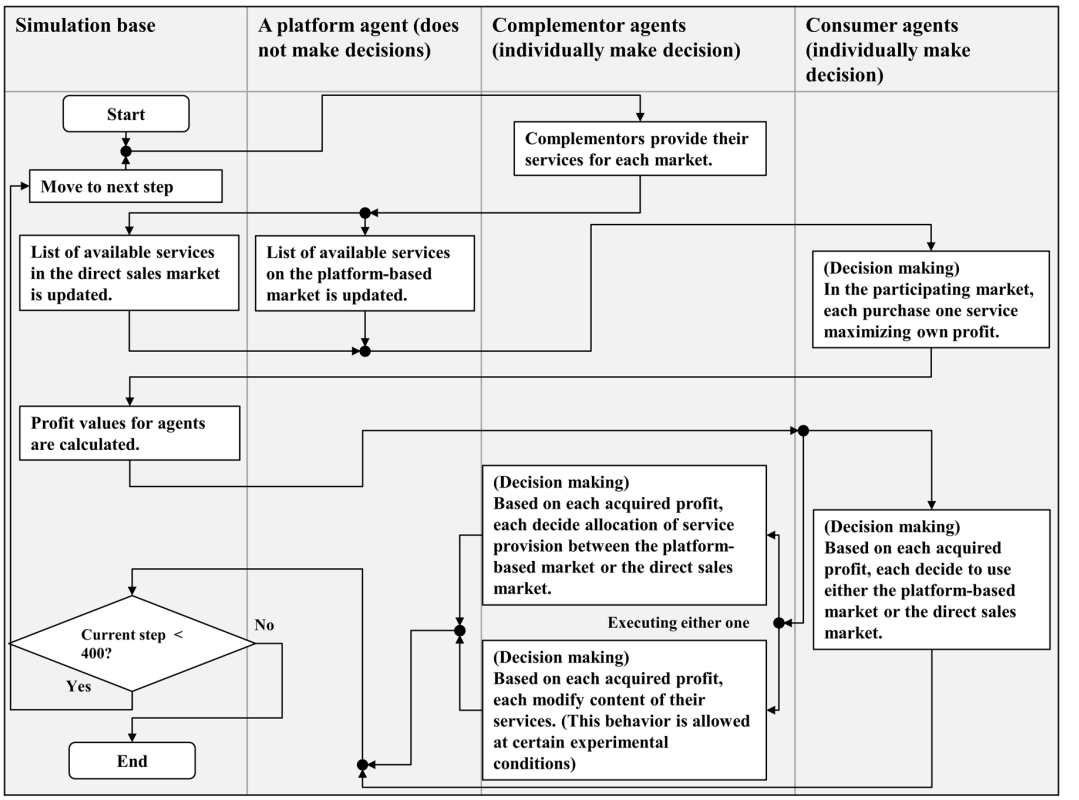


Figure 3. Simulation procedure



$$v_{j,t} = \left(r_{comp} + r_{cons}\right) \sum_{k}^{N_{comp}} p_k s_{k,1,t}$$

where, r_{comp} is the platform fee for complementors, r_{cons} is the same for the consumers, N_{comp} is the number of complementors, $p_{k,t}$ is the price of complementary goods provided by complementor k, and $s_{k,1,t}$ is the sales volume of these goods on the platform during period t. For simplicity, the authors do not consider the cost functions of a platform owner. Additionally, the platform fees are neutrally set as $r_{comp} = r_{cons} = 0.05$ since the analysis of the influence of the platform fee is not the objective of this study.

Agent: Complementor

The complementor earns a profit when consumers purchase the complementary goods that they provide. Each complementor has individual values for the price, quality, and content of its complementary goods. Since there is a correlation between price and quality of actual services, this relationship was also set in the simulation. However, since this study considers the variation of price and quality among agents, complementors have competitiveness depending on the balance between price and quality. Therefore, complementors, who have low competitiveness, will compete for matching between service content and consumer needs by changing their content. The parameter settings are as follows:

- **Price p_k:** a uniform distribution between 5 and 10. In the real world, the value of variable representing price is determined based on several factors including quality and market situations. Additionally, the value of price can also influence quality and market situations. For simplicity, this simulation sets the price p_k as the basis and sets the quality q_k based on p_k. Since service price does not generally become free, the lowest value was not set as zero (= 5).
- **Quality q_k:** expressed as {($p_k - 5$) + individual difference (uniform distribution within ± 1.25)}. The authors set the individual difference to express the dispersion of competitive power. A complementor that provides high quality at a low price is regarded as having a large competitive advantage. Fixed cost c_k is expressed as $c_k = q_k \times n$, which is dependent on the quality.
- **Content $\boldsymbol{f}_{k,t}\left(= \boldsymbol{f}_{k,t}^1, \ldots, \boldsymbol{f}_{k,t}^8\right)$:** eight values within a range of 0 to 10. $f_{k,t}^1$ to $f_{k,t}^4$ correspond to existing needs, and $f_{k,t}^5$ to $f_{k,t}^8$ correspond to latent needs. For simplicity, the sum of the eight values is always constant (= 10). The initial value is assumed to follow a uniform distribution, subject to the values for new need ($f_{k,t}^5$ to $f_{k,t}^8$), and is set to 0.

The profit of the complementor is calculated as sales profits minus the platform transaction fee and fixed cost. The profit $v_{k,t}$ of complementor k during period t is calculated as

$$v_{k,t} = p_k \left\{ s_{k,0,t} + \left(1 - r_{comp}\right) s_{k,1,t} \right\} - c_k,$$

where, $s_{k,0,t}$ is the sales volume of direct sales, and c_k is the fixed cost that exists regardless of whether the complementary goods are purchased. Each complementor provides four services, that is, maximum ($s_{k,0,t} + s_{k,1,t}$) = 4.

The complementor autonomously determines whether to provide complementary goods to a platform. Procedures are as follows: (1) complementors can choose whether to sell their complementary goods directly to consumers or make transactions via the platform; (2) the expected sales volume corresponding to each of their conditions is estimated from the sales performance of the previous step; and (3) the manner of goods provision is decided based on whether the expected profit is higher when using the platform than when not using it. Here, to avoid local optimization, random selection is adopted with a probability of 0.1. Following Inoue and Tsujimoto (2018b), if the complementor is inexperienced in participating in a platform, the expected sales volume on the platform would be estimated based on the participation size of complementors and consumers considering the indirect network effect and the band-wagon effect. The value is calculated by applying the platform participation rate of complementors and consumers (from 0 to 1) to the expected sales volume if the complementor is inexperienced in participating in a platform.

In the simulation, complementors also modify the content of their services and this is described in section of Simulation specifications.

Agent: Consumer

Consumers benefit from purchasing complementary goods (services). Each consumer has individual price requirements, quality requirements, and preferences (content requirement) for complementary goods. The parameter settings are as follows:

- **Price requirement $\boldsymbol{p_i^D}$:** corresponds to the price p_k of complementary goods and is uniformly distributed between 5 and 10.
- **Quality requirement $\boldsymbol{q_i^D}$:** corresponds to the quality q_k of complementary goods and is expressed as $\{(q_i^D - 5) +$ individual difference (uniform distribution within $\pm$ 1.25)$\}$.
- **Preference (content requirement) $\boldsymbol{f_i^D \left(= f_i^{D1}, \ldots, f_i^{D8}\right)}$:** corresponds to the content values $f_{k,t}$ of complementary goods and is comprised of eight values between 0 and 10. f_i^{D1} to f_i^{D4} correspond to existing needs, and f_i^{D5} to f_i^{D8} correspond to latent needs. As with the content values of complementary goods, the sum of f_i^D is a constant value (=10). Although these values are set as uniform distribution, the simulation assumes these are influenced by three types of consumers. The first type focuses on existing needs and refers to consumers whose needs can be satisfied by the service content of the current market; values of f_i^{D5} to f_i^{D8} are multiplied by 1/5. The next type of consumer has some needs that can be satisfied with the service content of the current market; weights are not added. The type who focus on latent needs refers to consumers whose needs cannot be satisfied by the current market's service content; values of f_i^{D1} to f_i^{D4} are multiplied by 1/5. After these procedures, the preference value f_i^D is modified as the sum of f_i^D is a constant value (= 10).

Consumer profit is calculated using the consumer's own price requirements, quality requirements, and preferences (content requirement), as well as the price, quality, and content of the selectable complementary goods. The profit of consumer i during period t is calculated as

$$v_{i,t} = \left(p_i^D - p_k\right) + \left(q_k - q_i^D\right) + \left(\sum f_{i,k,t}^{diff} + \alpha\right),$$

where, p_i^D is the price requirement of consumer i of a complementary good, q_i^D is the quality requirement of consumer i for a service, $f_{i,k,t}^{diff}$ is the degree of satisfaction of consumer i with the content of complementary good k, and α is a normalization constant. The degree of satisfaction $f_{i,k,t}^{diff}$ for the content of complementary good k for consumer i is calculated by the difference between the content values $f_{k,t}$ and the preference values f_i^D. When the difference between each corresponding dyad (e.g., $f_i^{D1} - f_{k,t}^1$) becomes 0 or greater, the numerical value is set to 0 as the need has been satisfied. Therefore, the range of $f_{i,k,t}^{diff}$ is from -10 to 0. $f_{i,k,t}^{diff}$ is standardized for the profit calculation so that the condition in which half the needs are satisfied is defined as neutral and set as $\alpha = 5$ (i.e., profit satisfaction with content ranges from -5 to 5).

Consumers act in random order at every simulation step and purchase one complimentary item that yields the highest profits among the options. Consumers cannot purchase specific complementary goods such as those already purchased by other consumers or whose profit is less than 0.

Consumers also decide whether to use the platform. In addition, consumers' decision making is based on the expected profit. The procedure is as follows: (1) consumers can search for complementary goods by using the platform or through their own effort (direct sales market), (2) the consumer then estimates the expected profits in the two situations of platform use and no use based on profits or previous steps in each market, and (3) the consumer selects the course of action with the higher expected profit. If the consumer cannot purchase complementary goods, a sufficiently smaller value than the usual profit level is given to the consumer. When the consumer has no experience in participating in the platform, the expected profit is 0. Here, to avoid local optimization, random selection is adopted with a probability of 0.1.

Simulation Specifications

Platform Functions

This study set one "main platform function" and two "supportive platform functions." The main platform function is the promotion of modification of the service content. When this function is present, the complementors participating in the platform have the option to modify individual values concerning the content $f_{k,t}$ of their complementary goods (services). For simplicity, a complementor cannot modify the values for the price and quality of its complementary products.

The first supportive platform function is the facilitation of customer involvement. When this function is presented, the platform notifies a complementor of certain customers' needs according to the values of their preferences. The complementor then can take advantage of this information and modify the service content accordingly. The second supportive function is support for capturing latent needs. When this supportive platform function is presented, the complementors participating on the platform can capture the latent needs of consumers to modify the content of their services.

Service Modification Behavior of Complementors with Platform Functions

When the main platform function exists, complementors can modify their content values. Complementors modify the value of the content to maximize their profits. When the complementor modifies the content values in the previous step, profit decreases, and the content values are restored back to the value before the modification. The complementors can either modify their content values or choose whether to use the platform during a single round. The selection probability of each action is 50 percent. When a complementor decides to modify content values, it has two options: to refer to the service contents of competitors (other complementors) or to preferences of customers (consumers who use their service). However, the latter is only adopted when the supportive function of customer involvement is facilitated. The selection probability of whether to refer to competitors or customers is assumed to be 50/50. When a complementor refers to competitors in deciding to modify the content, it

follows either one of two competitive strategies: imitation of competitors (Lieberman & Asaba, 2006) or differentiation of their positioning (Porter, 1996). The specification for each strategic behavior may use either an imitation or differentiation strategy. For the imitation strategy, one content value is randomly selected and is changed by ± 1 to approach the complementor that has the highest profit within the scope of interaction. For the differentiation strategy, one content value is selected at random and changed by ± 1 in a direction that is differentiated from the other complementors within the scope of interaction.

If supportive functions are presented, complementors' behavior for content modification is influenced. First, when a supportive function of customer involvement is present, complementors bring the content values close to the preference values of the customers. The complementor calculates the average value of preferences of customers who purchased its complementary goods, randomly selects one content value, and changes it by a maximum of ± 1. Second, when a supportive function of capturing latent needs is presented, the complementors can modify the value of latent needs (f_i^{D5} to f_i^{D8}). The modification procedure is the same as that of existing needs (f_i^{D1} to f_i^{D4}).

Experimental Conditions

There are two types of complementors in the simulation setting: those who use imitation strategies and those who use differentiation strategies. Furthermore, there are three types of consumers: those who focus on existing needs, those who focus on latent needs, and those who focus equally on both. To make the numbers of each type of consumer uniform, the authors run a simulation with 180 consumers and 90 complementors (360 complementary goods provided). To encourage content modification among complementors, the authors set the number of complementary goods to twice the number of consumers. The endpoint of the simulation is set as 400 steps, and the average value of the last 50 steps is taken as the simulation result. The simulation results are executed for 50 trials each.

To explore the research question, simulations are performed under the following conditions. In experiment 1, the authors test the base setting wherein the complementors do not modify their service content. These base settings reflect the current service intermediating platforms. In experiment 2, the authors test the effects of the main platform function. In experiments 3-1 and 3-2, the authors test each of the effects of supportive platform functions 1 and 2. In experiment 4, the authors test the effects of the combination of two supportive platform functions. These specifications are summarized in Table 2.

The authors define three evaluation indicators for platform ecosystem development:

(a) The transaction share on the platform
(b) the service purchase rate of consumer agents in the market
(c) the total profit of agents in the market

Table 2. Specifications of experiments

	Main PF: Modification of service content	**Supportive PF 1: facilitation of customer involvement**	**Supportive PF 2: capturing latent needs**
Experiment 1	Not presented	Not presented	Not presented
Experiment 2	Presented	Not presented	Not presented
Experiment 3-1	Presented	Presented	Not presented
Experiment 3-2	Presented	Not presented	Presented
Experiment 4	Presented	Presented	Presented

Note: PF = platform function.

The transaction share on the platform represents the degree of participation and usage of the platform. Since the total number of consumers in the simulation is constant, the service purchase rate of the consumer in the market corresponds to the market size. The total profits of the market represent the degree of social surplus.

Simulation results

Figure 4 represents a typical example of the simulation results. To demonstrate patterns of convergence, these figures represent the results for 1,000 steps. To improve visibility, the authors calculate the mean values for 50 steps. Each value is converged on about 50 to 350 steps. The values are vibrated after the convergence.

Figures 5, 6, and 7 represent the simulation results for the transaction share on the platform, the service purchase rates of consumers in the market, and total profit in the market, respectively.

First, the results of experiment 2 show the effects of the main platform function (changing service content) without supportive platform functions. Compared to the results of experiment 1, the introduction of the main platform function causes the evaluation indicators to decline. The means of the evaluation indicators from experiments 1 and 2 are as follows: platform transaction shares are 0.78 and 0.67, service purchase rates of consumers are 0.53 and 0.51, and total profits are 68.8 and 9.39. Accordingly, on the premise of the settings of this study, the following proposition was suggested.

Proposition 1: Facilitation of changing the service content could have negative effects on the platform ecosystem development without supportive functions.

Second, the results of experiment 3-1 show the effects of supportive platform function 1 (facilitation of customer involvement). Although the introduction of this function improves the evaluation indicators more than experiment 2, these are still worse than experiment 1. As the comparison between experiments 1 and 3-1, the means of the evaluation indicators are as follows: platform transaction shares are 0.78 and 0.73, service purchase rates of consumers are 0.53 and 0.51, and total profits are 68.8 and 45.3, respectively. Accordingly, on the premise of the settings of this study, the following proposition was suggested.

Figure 4. Typical example of a simulation result

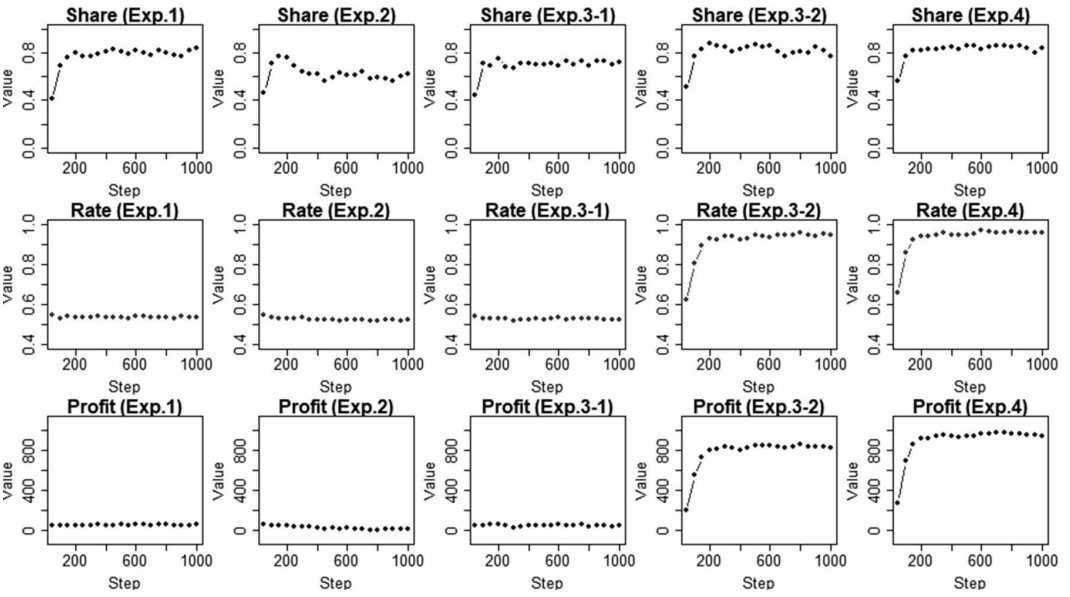


Figure 5. Results of transaction share on the platform

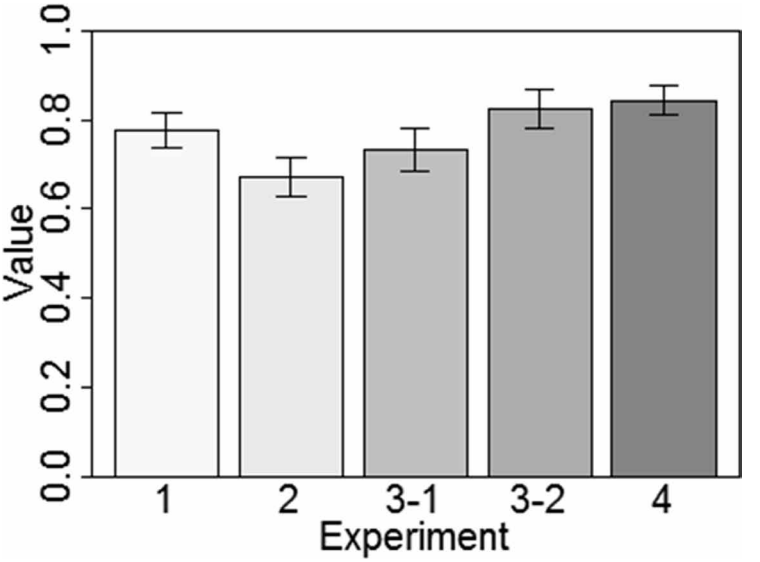
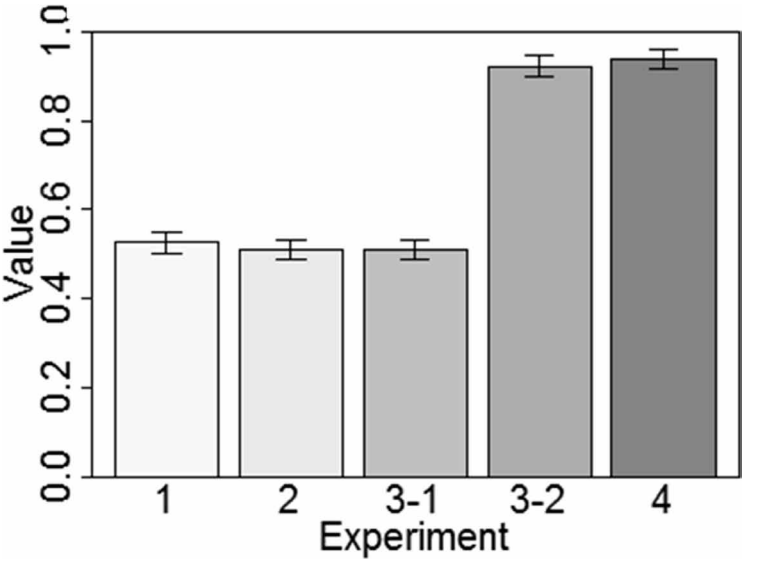


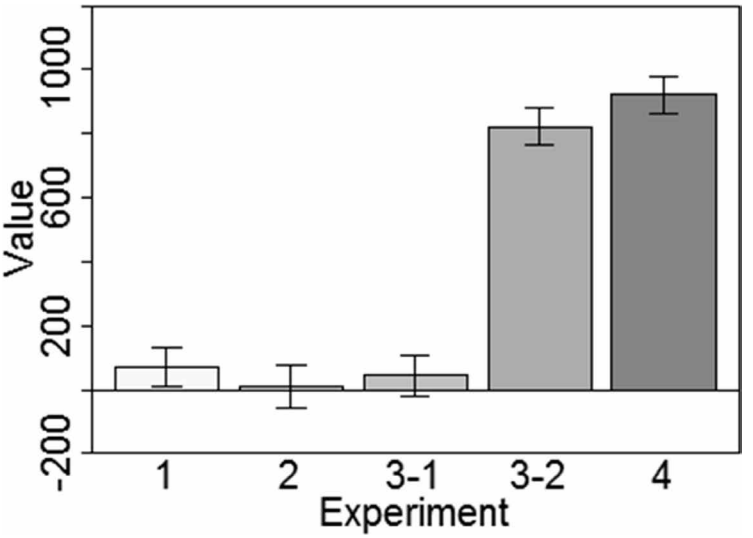
Figure 6. Results of service purchase rate of consumers in the market



Proposition 2: The facilitation of customer involvement for changing service content could have positive effects on platform ecosystem development; however, this effect is not sufficient for platform ecosystem development.

Third, the results of experiment 3-2 show the effects of supportive platform function 2 (capturing latent needs). Compared to the results of experiment 1, the introduction of this function drastically improves the evaluation indicators. The means of the evaluation indicators of experiments 1 and 3-2 are as follows: platform transaction shares are 0.78 and 0.82, service purchase rates of consumers

Figure 7. Results of total profit in the market



are 0.53 and 0.92, and total profits are 68.8 and 820.4. Accordingly, on the premise of the settings of this study, the following proposition was suggested.

Proposition 3: Capturing latent needs to support modification of service content could largely have positive effects on platform ecosystem development.

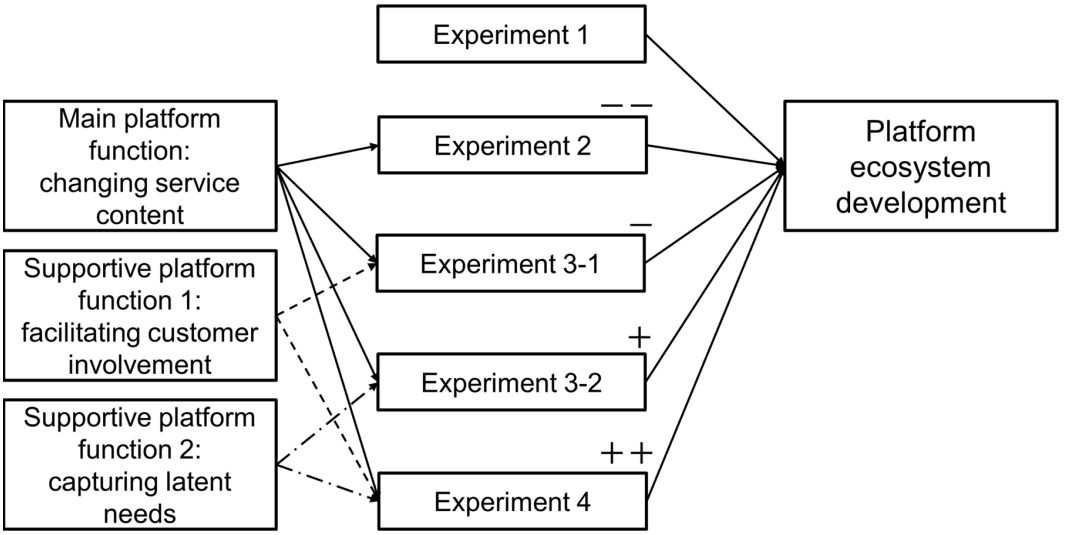
The results of experiment 4 show the effects of the introduction of both supportive platform functions. This was found to be the best setting in comparison with experiments 1 to 3-2. As the comparison between experiments 3-2 and 4, the means of the evaluation indicators are as follows: platform transaction shares are 0.82 and 0.84, service purchase rates of consumers are 0.92 and 0.94, and total profits are 820.4 and 921.2, respectively. Remarkably, although the evaluation indicators of platform transaction shares and rates of consumers are almost the same between experiments 3-2 and 4, the total profits of experiment 4 clearly increased compared to those of experiment 3-2. Accordingly, on the premise of the settings of this study, the following proposition was suggested.

Proposition 4: The introduction of both supportive platform functions could improve the profits of platform users, even if the number of platform users reaches the maximum.

DISCUSSION AND CONCLUSION

Using a simulation of platform-based markets in service industries, this study tested the effects of changing service content on platform ecosystem development. Figure 8 conceptually summarizes the findings. The simulation results reveal that the facilitation of changing the content values of complementary goods may have a negative effect if undertaken without supportive mechanisms. A decline of the platform ecosystem occurs if the platform focuses only on existing needs and facilitates the development and modification of complementary goods, as with IT platforms. For a platform ecosystem in an existing service industry, the introduction of this type of platform function leads to increased competition in the market, which in turn disproportionately increases the sales among complementors. An IT platform ecosystem would not have this problem since the market in IT platform ecosystems is newly generated, but that of the service platform ecosystem is not. Therefore, the design of strategies for platform owners to capture latent needs is crucial for the development of platform ecosystems with service development.

Figure 8. Conceptual summary of findings



This study revealed that the platform's facilitation of service modification could not improve the platform-based markets without supportive functions. However, this result can be influenced by the starting values of content in the simulation. For example, when the relationship among all complementors including values of content is in Nash equilibrium, they will not modify their service content. As another example, when matching between service content and all consumer needs are perfect for all complementors, complementors do not need to modify their content. Thus, the results of this study could be changed by the assumed initial situation of the market.

Notes: (−) or (+) symbols represent a decrease or increase, respectively, of evaluation indicators of the platform ecosystem development in comparison with experiment 1; this expression is conceptual. The number of symbols does not correspond proportionally to the values of the evaluation indicators. Actual values are shown in section of Simulation results.

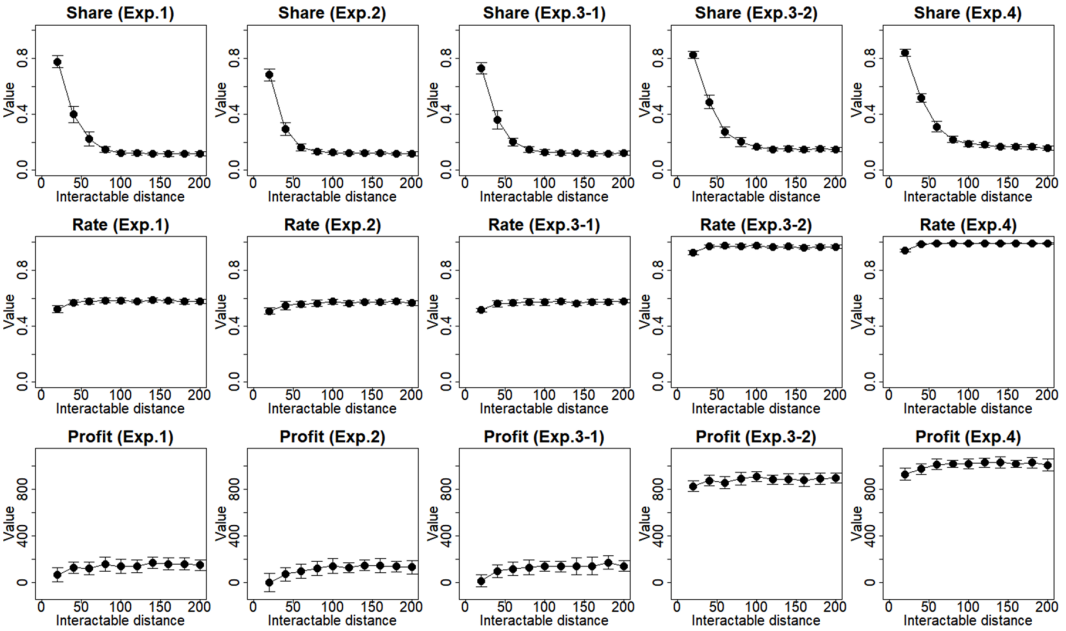
Robustness Check: Influence of Interaction Distance among Agents in Simulation Results

Figure 9 shows the change in simulation results depending on the interaction distance (value of Manhattan distance) among agents. Although the results revealed that the platform transaction share on the platform decreases as the interaction distance increases, other indicators (service purchase rate of consumers in the market and total profit in the market) are constant or increase slightly. About these results, the authors considered the following process: (1) some complementors provide a part of (not all) their services on the platform and use the platform functions to modify their service content, (2) other complementors imitate these improved service contents without using the platform. Thus, in the range of the simulation settings, the authors confirmed that the platform functions could contribute to the ecosystem regardless of the interaction distance, which confirms the effectiveness of the intermediating function of the platform.

Implications

Business platforms currently form their own ecosystems. A platform ecosystem can foster unlimited innovation through the participation of various complementors (Gawer, 2014). It also leads consumers with various needs to adopt the use of the platform (Ceccagnoli et al., Forman, Huang, & Wu, 2012). These are realized when complementors utilize platforms' technologies or

Figure 9. Change of simulation results depending on the interaction distance among agents. The X-axis represents the value of Manhattan distance.



functions to develop their goods. However, this study focused on the fact that this is common in IT platform-based markets but not in-service platform-based markets. In this context, the current study strengthens the stream of research on platform ecosystems by examining service development in service intermediating platforms.

This study considered two supportive platform functions for modification of service contents. The first is the function for the facilitation of customer involvement. Previous researchers suggest that customer involvement is significant for service development (Dörner, Gassmann, & Gebauer, 2011), service innovation (Cheng & Krumwiede, 2012; Gustafsson, Kristensson, & Witell, 2012), and corporate performance (Grawe, Chen, & Daugherty, 2009), particularly in the service sector. The second is the function for capturing latent needs. Platform ecosystems can facilitate complementors to explore new markets and can support the modification of content of complementary goods (e.g., Inoue & Tsujimoto, 2018a, 2018b; Subramanian, Chai, & Mu, 2011). In the case of service intermediating platforms, the platforms can support complementors to capture latent needs to develop new markets. The simulation results revealed that these two supportive platform functions can lead to a successful modification of service content. Although individual functions of customer involvement may be insufficient, a combination of functions for customer involvement and latent needs can generate higher profits in the ecosystems. The increase in participant profits on the platform also contributes to the sustainability of the platform ecosystem (Inoue et al., 2019). Thus, the results of this study theoretically and practically contribute to platform-based markets.

LIMITATIONS AND FUTURE RESEARCH

This study has several limitations. First, for simplicity, the authors assumed that all complementors could utilize platform functions equally. In the real world, the degree of utilization of the platform function depends on the capability of each complementor. Future research could focus on how complementors utilize platforms to develop new services. Additionally, entry of platform owners as

complementors and their influence (e.g., Wen & Zhu, 2019) could be also investigated in terms of service modification.

Second, to emphasize the influence of modification of service content, this study did not consider changes in price and quality. Future research could develop a simulation that includes changes in service price and quality with consideration of endogenous decisions of complementors.

Third, since this study could not acquire a sufficient dataset to conduct statistical analysis about the modification of service content in service intermediating platform-based markets, an agent-based simulation approach was adopted. However, as shown in this study, since this type of platform ecosystems are promising, an increasing number of practical examples will be available in the future. Therefore, future research could investigate the modification of service content on actual service platforms.

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