https://doi.org/10.20965/ijat.2018.p0459

Paper:

Equilibrium Analysis of Service Ecosystems for Labor-Intensive Services Using Multi-Agent Simulation

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[Received October 18, 2017; accepted March 16, 2018]

The value of a service system should be evaluated using multiple indicators, such as company profitability, consumer satisfaction, or employee satisfaction to realize an ecosystem in society. This study examines the mechanisms of service systems with a multi-agent simulation model consisting of a company, employees, and consumers based on game theory. The proposed model is intended for a basic service business in which employees provide services to consumers directly based on their skill. In this model, first, a company player sets the price of a service and salary of employees. Then, employees decide whether to acquire resources, such as skills, with their efforts (costs) to satisfy either consumers' needs or not. Then the employees acquire their profits (equivariant of satisfaction) not only from acquired salary but also from the reflection of consumer satisfaction. However, consumers have their needs structure, as gain tables, and decide whether and from whom to purchase. A consumer's profit is calculated using his/her satisfaction with the service provided using a certain employee and the price paid for the service. Based on the model proposed above, we conducted a multi-agent simulation where company, employee consumer players make decision to maximize their own profits. From the basic simulation results, two convergent patterns are acquired according to the initial values of price and salary. In the second simulation, the heterogeneity of consumer needs is considered in the model based on questionnaire survey results on actual consumer behaviors related to hair salons ($n = 2472$). With a factor analysis of 13 questionnaire items on lifestyles, four lifestyle factors are extracted. Based on the survey results, consumer players of four types are introduced into the simulation to analyze which services are selected in the service system. Through the simulation, four convergent patterns are acquired. In those patterns, consumers of different types are included according to the types of services. With those results, this paper presents a discussion of the design of a new service ecosystem through the comparison between acquired convergent solutions and existing business models.

Keywords: service engineering, multi-agent simulation, lifestyle, equilibrium analysis, service ecosystem

1. Introduction

Service industries have been expected to fulfill roles not only for economic growth but also for human quality-of-life (QOL) maintenance [1]. For example, Japan's changing population structure and growing labor shortage are expected to impose difficult challenges upon many service companies to continue their businesses that used to function well. Accordingly, new service businesses have been created continuously to adapt to such social changes. Nevertheless, they often confront tradeoffs or dilemmas in different aspects for the value of services including efficiency, quality, consumer satisfaction and employee satisfaction [2].

The service system is often expressed as a triangle including a company, employees, and consumers, as illustrated in **Fig. 1** [3]. Maintaining existing service systems demands attention not only to the company, but also to employees and consumers. For example, although Japan reportedly has higher standards of service quality than other countries, as in the restaurant industry [4], the high turnover rate and the decline of employee satisfaction might depress service quality and reduce QOL. Therefore it is important to support service providers to re-design existing service systems more sustainable. We define "service ecosystem" as a sustainable business model in which the profits of company, employees, and consumers are balanced. We believe that a computational model must be found based on actual data for the analysis of service systems and for the design of more sustainable service systems.

Service-profit chain theory [5], proposed by Heskett et al., is a well-known model showing that increased employee satisfaction positively affects consumer satisfaction, eventually improving company profitability. The Service-profit chain theory might explain many best practices of actual services. However, the mechanism of actual service systems can be expected as more complex:

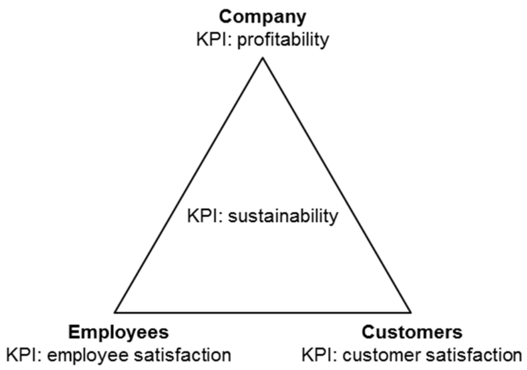

Fig. 1. Service triangle and key performance indicators (KPIs) [3].

models should include bilateral interactions among companies, employees, and customers. Therefore, numerous tradeoffs and dilemma mechanisms might exist in terms of profits of these players. Accordingly, companies sometimes confront difficult challenges in the re-design of existing service systems. Some researches verified the relationship among consumer satisfaction (CS), employee satisfaction (ES) and company profit by using actual survey data [6–8].

In addition, many previous researches are qualitative, such as service triangle and Service-profit chain theory. In order to analyze service systems, quantitative discussion is also needed.

Against that backdrop, this study aims to propose a computational model in which the equilibrium of a service system could be acquired through the interaction among players. According to previous researches, obtaining equilibrium includes methods such as game theory, experiments with human subject are multi-agent simulation, etc. are considered as a method for obtaining the equilibrium [9, 10]. In this study, by using both game theory and multi-agent simulation, we replicate a service system in which companies, employees, and customers mutually interact through their decision-makings.

We constructed a service model uniquely by reference to previous research on customer behavior model [11, 12]. or service provider model [13]. We also introduce some findings from earlier studies of employee satisfaction and consumer satisfaction in the model [14]. Although details of the model are discussed in the next section, the model especially introduces bilateral relations between CS and ES. In this model, consumer satisfaction can enhance employee satisfaction. In addition, the model includes the essence of the Service-profit chain model. ES can increase service quality and thereby increase CS. We analyze the service system mechanism using a multi-agent simulation as a basic model. Then, we consider the heterogeneity of consumer needs for services. We conducted a questionnaire survey of the lifestyles and daily behaviors on use of hair salon with 2472 female consumers. Based on the survey results, we construct heterogeneous agents in the model and conduct a simulation to analyze the mechanism closer to the real world. Finally, based on the simulation results, we present discussion of how service ecosystems can be maintained.

2. Model

2.1. Model Outline

The model includes three kinds of players, as presented in **Fig. 2**, the company, employee, and consumer. Each player makes decisions to maximize their own profit. The decision-making proceeds sequentially by a company, employees and consumers. In consideration of the service mechanism concept, this model regards the process of servicing as mere matching between employees and consumers.

A company player (H) manages the business: the player chooses a service price at which service is provided to consumers, and a salary paid to employees. Employee players ($E \equiv \{E_1, E_2, \ldots, E_m\}$) provide services to consumers. Before service provision, employee players have opportunities to acquire resources, denoted by $R \equiv \{r_1, r_2, \ldots, r_n\}$, which are abstracted with skills or knowledge. Employee players actively acquire resources at the expense of efforts to offer better opportunities for service provision. Consumer players ($C \equiv \{C_1, C_2, \ldots, C_l\}$) receive services from employee players in exchange for paying the service price to a company player.

2.2. Formulation of Each Player's Profit

Based on a general formulation in economics, we formulated each player's profit. Player profits of each type are calculated after all decision-making has concluded. First, the company player decides price (p) and salary (s) to maximize profit. The company player's profit (Π) is described with the formula below.

$$\Pi = pQ - sm \qquad (1)$$

Therein, m represents the number of employee players. Q represents the number of services that consumer players received. Eq. (1) shows that the company player's profit is calculated as the sales and the salary amount.

Secondly, each employee player decides which resources to acquire to maximize the player's profit. In other words, the employee players could acquire more opportunities for providing services to customers by acquiring adequate resources. The employee's profit is formulated to reflect the consumer's satisfaction that the employee has attained. In the model, an employee players' profit is calculated as the amount of salary, the efforts to acquire resources, and the level of reflection of the consumer satisfaction. These factors are based on earlier findings reported in the literature. By conducting a questionnaire survey answered by 150,000 employees, the authors demonstrated that employee satisfaction is divisible into four elements: satisfaction with (1) "leadership," (2) "job meaningfulness," (3) "team environment," and (4) "job terms" [14]. Particularly, satisfaction with "job meaning

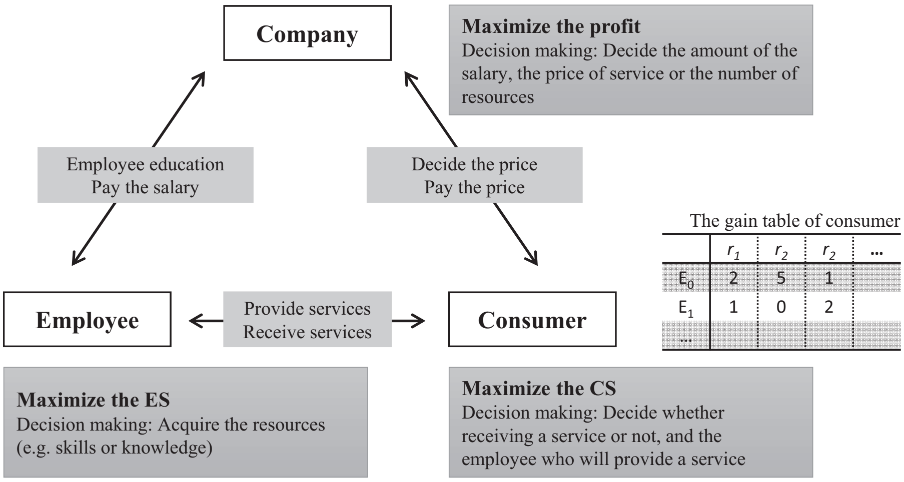

Fig. 2. Model overview.

fullness" and "job terms" are directly related to satisfaction with their own jobs. Satisfaction with "job meaning fullness" might be enhanced by customer satisfaction through service provision. Additionally, satisfaction with "job terms" is related mainly to the salary. Consequently, employee k's profit (π_k) is calculated according to the formula presented below.

$$\pi_k = s + \sum_{j=1}^{l} \frac{CS_{jk}}{Cap_j}\sigma_{jk} - \sum_{j=1}^{n} r_{jk}c_j \quad \dots\dots \quad (2)$$

In that equation, l stands for the number of consumer players, n signifies the number of resources, σ_{jk} denotes whether consumer player j received the service from the employee player k, or not, with a binary value, and c_j signifies the effort of acquiring resource j. In addition, CS_{jk} stands for customer satisfaction that consumer j receives from employee k, Cap_j is the maximum number of services each employee can provide in every simulation step, and r_{jk} is a binary value denoting whether employee k has resource j, or not. The amount of consumer satisfaction with services varies among consumers. Concretely, each consumer acquires CS calculated with the player's own gain table represented as **Table 1**. CS is defined as the sum of the values in the gain table responding to the employee player's resources. For example, if a consumer player's gain table is **Table 1** and employee player 0 (E_0) has r_1 and r_2, then the CS of the consumer player is calculated as $2+5=7$.

Thirdly, consumer players obtain profits from receiving a service after paying its price. Consumer players make decisions about whether to receive a service or not, just as the employee player from which the consumer player receives the service. Consumer player i's profit (u_i), when receiving the service from employee k, is described as the formula presented below.

$$u_i = \begin{cases} CS_{ik} - p \\ 0 \quad \text{(in case of no use)} \end{cases} \quad \dots\dots \quad (3)$$

Equation (3) means that the consumer player's profit is determined by consumer satisfaction with employee k and the price of service in the case of selecting employee k.

Table 1. Image of the consumer player's gain table.

	r_1	r_2	r_3	$\cdots$
E_0	2	5	1	
E_1	1	0	2	
$\vdots$				

3. Basic Simulation with Normalized Consumer Players

3.1. Setting

To find convergent solutions and to discuss a better service system, we conducted multi-agent simulations using the service model presented in the previous section. Players of each type can predict a future projection and change the player's behavior under a simple behavior rule. Through this simulation, the emerging responses among players are expected to end up reaching a certain kind of equilibrium.

Player behavior is modeled after a very simple rule: the values of parameters are changed one by one to improve profit. The company player can change price or salary one-by-one (not change or change ± 10 values) at each step within the range of the pre-determined maximum and minimum values. For example, if the company player predicts that raising the salary increases their profit, then they raise salary by one level. Similarly, employee players can change the resources at every step. Employee players decide to acquire a new resource set to adapt to the customer needs based on the previous results of service to the same customer. However, in cases where the employee player provides no service in the previous step, the player changes the number of resources randomly at the next step. Moreover, if the employee player regards

Table 2. Maximum and minimum value of price and salary.

	Value
Price maximum	80
Price minimum	10
Salary maximum	110
Salary minimum	70

Table 3. Gain table of consumer player 1.

	r_1	r_2	r_3
E_k $(k = 1,2)$	40	40	0

Table 4. Gain table of consumer player 2.

	r_1	r_2	r_3
E_k $(k = 1,2)$	0	40	40

Table 5. Gain table of consumer player 3.

	r_1	r_2	r_3
E_k $(k = 1,2)$	40	0	40

the service price as too high for the consumer player, then the player decides not to acquire the resource. After the decision-making of employee players, consumer players make decisions about choosing the employee player from whom the service is provided to maximize the player's profit.

As the first approach of the simulation analysis of service ecosystem by examining a simple situation. We assumed that there was one company player, two employee players, and three types of four consumers each, for a total of twelve consumer players. Regarding the company player, we set the maximum and minimum value of price and salary, as shown in **Table 2**. In Japan, the price for a haircut is estimated between \$10 and \$80 in many beauty salons [15]. The average daily salary to employees of beauty salons might be about \$90 [16]. For employee players, we set the number of resources as three, the effort to acquire one resource evenly as 20, and the maximum number of services each employee can provide respectively in every simulation step as in a day, as six. For the consumer player, each player's gain table was set as shown in **Tables 3–5**.

To explore the whole solution space and to consider the dependence of simulation results on the initial condition, we conducted simulation trials on all combinations of initial conditions from the minimum value to the maximum one with the interval of 10. In other words, 40 ($= 5 \times 8$) initial values exist. At the first step of simulation, each employee player decides a main target consumer with equal probability ($= 1/3$) and obtains resources to increase consumer satisfaction. The number of simulation steps of each trial is 100. The outputs presented in the following parts of this paper are the average values of 30 trials.

3.2. Results

Table 6 exhibits results of trials conducted with different initial values. Each table cell includes averaged values of company profit (upper), ES (middle), and CS (lower). We found two main patterns of convergent solutions. In the blue initial condition area, results roughly converged to pattern 1. In the orange initial condition area, results converged to pattern 2.

However, the values of ES and CS in convergent pattern 2 differ slightly because of some mismatches between employee and consumer players attributable to limited matching opportunities. Details of convergent solutions for respective patterns are presented in **Table 7**. **Fig. 3** shows simulation examples of two trials converging to patterns 1 and 2.

3.3. Discussion

Comparison between two convergent patterns in **Table 7** shows that the social surplus is higher in pattern 2, which means the sum of company profit, employee profit and consumer profit. However, in this pattern, the consumers' profit results in 0 because both consumer satisfaction and the price of the service are equivalent. In this simulation, only the company player can change the price and salary step-by-step based on complete information of customers' and employees' behaviors in previous steps. Therefore, the company player is expected to be dominant in this simulation model. Consequently, pattern 2 is probably a theoretical Nash equilibrium solution because company profit is thought to be the maximum. Although it is unimaginable in the real world that a company knows CS or ES completely in advance, phenomenon of this kind can arise in actual services when a company providing competitive services is dominant in a market.

However, company profit, employee profit, consumer satisfaction of pattern 1 are lower than those of pattern 2. Nevertheless, consumers gain some profits because their satisfaction is higher than the price. This situation could occur because of the initial conditions of salary and price in this simulation. Company players can only change price or salary incrementally at each step. Therefore, another equilibrium might be acquired wherein the initial salary is lowest or where the initial price is too high in comparison to the salary.

In this simulation, all simulations produce only two patterns. However, other convergent patterns might emerge in the different settings of simulation model, such as the way a company makes decisions.

Additionally, this simulation includes numerous limitations compared with actual service systems because it assumes information completeness, purely rational decision-making, the number of players, the number of resources, the value of cost to acquire resources and an ideal distribution of consumer needs as described in the gain tables. In particular, consumer needs are directly related to CS. Therefore, as the next step, we conduct another simulation in which the diversity of customer needs is considered in the simulation.

Table 6. Results (company profit, average of ES, average of CS) of trials with each initial value.

Salary \ Price	10	20	30	40	50	60	70	80
70	300 114.4 64.9	300 115.1 65.7	300 114.9 65.4	300 114.6 65.1	300 114.5 65.0	300 114.3 64.8	300 115.0 65.6	300 114.8 65.3
80	300 114.7 65.2	300 114.6 65.1	300 115.1 65.7	300 114.9 65.4	300 115.0 65.6	740 130 80	740 130 80	740 130 80
90	300 115.3 65.9	300 115.1 65.7	300 114.8 65.3	300 114.9 65.4	740 130 80	740 130 80	740 130 80	740 130 80
100	300 114.7 65.2	300 114.3 64.8	300 115.1 65.7	300 115.0 65.6	740 130 80	740 130 80	740 130 80	740 130 80
110	740 130 80	740 130 80	740 130 80	740 130 80	740 130 80	740 130 80	740 130 80	740 130 80

Table 7. Details of two patterns of convergent solutions.

	Pattern 1	Pattern 2
Price	40	80
Salary	90	110
Social surplus	833.2	1000
Company profit	300	740
Average of employee profits (=ES)	114.8	130
Average of consumer profits	25.3	0
Average of consumer satisfaction	65.3	80

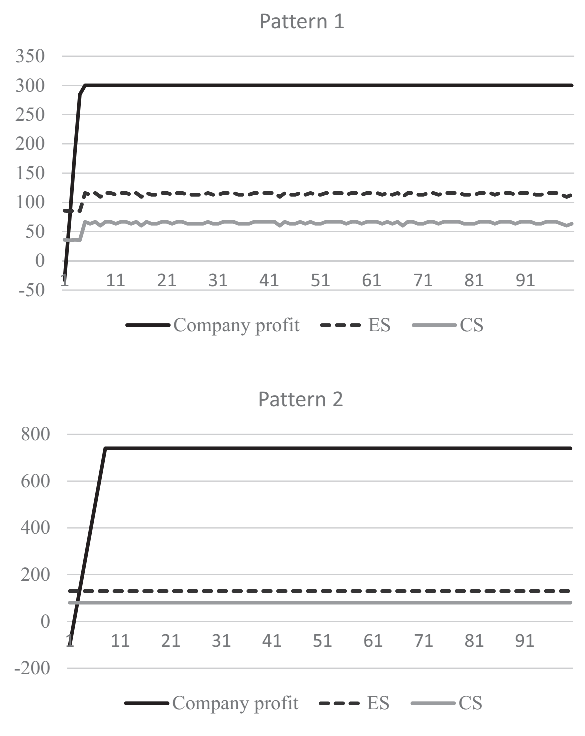

Fig. 3. Examples of trial trajectories.

4. Simulation with Heterogeneous Consumer Players

4.1. Lifestyle Analysis

As a second approach of the simulation analysis of service ecosystem, we assume an actual hair salon service. As a preliminary survey, based on an earlier study [17–19], we administered a questionnaire survey of lifestyles to Japanese consumers who use hair salons. By conducting factor analysis of 13 selected question items for all participants (2472, female), we extracted four factors of lifestyles related to their patterns of hair salon use. For the factor analysis, we employed maximum-likelihood method and Promax rotation with Kaiser normalization. The factor scores, or Bartlett scores of respective factors for participants were normalized to 1, 2, 3, 4, or 5. The top 20% highest factor participants are rated as 5, and the average 3. As results of lifestyle analysis, four factors were extracted from consumers: (1) active life, (2) anxious about daily life and health, (3) planned and economical consumption, and (4) conscious consumption (**Table 8**).

Based on the factor scores of customers, we divided consumers into two groups: high factor groups (top 40%) and low factor groups (lower 60%). **Fig. 4** shows that consumers with high active life factor or high conscious consumption factor tend to be willing to pay more for hair salon services. Further analysis of the survey results show that the function required for beauty salon services differs depending on consumers' lifestyles. For example, consumers anxious about daily life and health factors or high planned and economical consumption factor tend to emphasize basic functions such as cutting. However, consumers with a high conscious consumption factor tend to be willing to pay for keeping themselves beautiful. Consumers with high active consumption factor tend to desire beauty experiences. Based on those results presented above, we introduce the diversity of customer types in the following simulation setting.

Table 8. Lifestyle factor.

Lifestyle factor	Characteristics of lifestyles	Factor 1	Factor 2	Factor 3	Factor 4
Active Life	Open to new experiences	0.785	−0.012	0.022	−0.096
	Extroverted personality	0.743	−0.050	−0.048	−0.116
	Inclination to try new or reputed items	0.531	0.165	−0.079	0.150
	Satisfaction with everyday life	0.322	−0.401	0.011	0.178
Anxious about daily life and health	Anxious about health	−0.138	0.566	0.074	0.088
	Emotionally unstable	0.164	0.505	0.038	−0.168
	Inclination to waste money	0.131	0.389	−0.288	0.097
	Busy, less free time	0.139	0.276	0.165	0.036
Planned and economical consumption	Scrupulous personality	−0.043	0.091	0.713	−0.033
	Maintain a household accounts book	−0.034	0.022	0.383	−0.019
	Love cooking and housework	0.178	−0.094	0.324	0.160
Conscious consumption	Choosing items that are good for health even if they are expensive	−0.109	−0.034	−0.052	0.785
	Conscious about beauty care	0.239	0.154	0.126	0.308

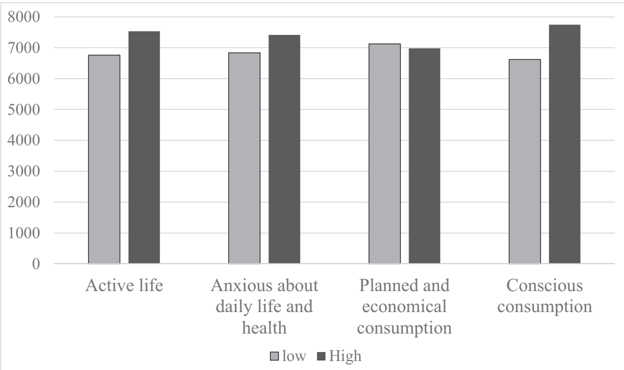

Fig. 4. Actual expense for hair salon (Japanese yen) of consumers with different lifestyle factors.

4.2. Simulation Setting

Based on the questionnaire survey results above, we introduce consumer players of four types. **Tables 9–12** respectively present gain tables for those four types. We consider r_1, r_2 and r_3 as resources to achieve the hair salon functions discussed in the previous section: r_1 denotes a skill for basic haircut, r_2 represents a special skill for beauty conscious customers, r_3 denotes a skill for customers who want to enjoy the beauty salon experience.

For this simulation, we assumed that there is one company player, two employee players, and forty customer players (ten consumers for four lifestyle types). The maximum number of services each employee can provide respectively in every simulation step was set as ten.

In contrast to the basic simulation described in the previous section, consumers are more numerous than the available supply of services in this simulation setting. We set this condition because we want to investigate which consumers and services are selected through the simulation. Other settings related to the company player and employee players are same as those of the basic simulation.

Table 9. Gain table of consumers with high active life factor.

	r_1	r_2	r_3
$E_k\ (k=1,2)$	20	20	30

Table 10. Gain table of consumers with high anxiousness about daily life and health factor.

	r_1	r_2	r_3
$E_k\ (k=1,2)$	30	10	20

Table 11. Gain table of consumers with high planned and economical consumption factor.

	r_1	r_2	r_3
$E_k\ (k=1,2)$	30	20	10

Table 12. Gain table of consumers with high conscious consumption factor.

	r_1	r_2	r_3
$E_k\ (k=1,2)$	20	40	20

4.3. Results

Table 13 presents results from trial combination of the initial value of salary and price. Each table cell includes averaged values of company profit (upper), ES (middle), and CS (lower) through 30 trials.

Through simulation with forty initial conditions, we found four main patterns of convergent solutions as color coded in **Table 13**. In the blue area of **Table 13**, simulation results converged to pattern 1. In the red area, they converged to pattern 1 or pattern 2. For the white area, they converged to pattern 1 or pattern 3. With the orange area, they converged to pattern 3. In the green area, they converged to pattern 4. Details of convergent solutions

Table 13. Results (company profit, average of ES, average of CS) of trials with each initial value.

Salary \ Price	10	20	30	40	50	60	70	80
70	460 82.2 32.2	460 81.2 31.2	446.7 81.0 31.0	406.7 78.9 28.9	400 77.8 27.8	400 78.6 28.6	413.3 79.0 29.0	406.7 78.7 28.7
80	460 82.3 32.3	460 81.7 31.7	482.7 87.5 37.5	820 103.4 53.4	820 103.2 53.2	820 103.1 53.1	820 102.9 52.9	820 103.1 53.1
90	820 103.2 53.2	820 103.3 53.3	820 102.9 52.9	820 103.0 53.0	820 102.8 52.8	820 103.0 53.0	820 102.8 52.8	820 103.2 53.2
100	820 103.1 53.1	820 103.3 53.3	820 103.5 53.5	820 102.7 52.7	820 102.6 52.6	1180 125 75	1180 125 75	1180 125 75
110	1180 125 75	1180 125 75	1180 125 75	1180 125 75	1180 125 75	1180 125 75	1180 125 75	1180 125 75

Table 14. Details of four patterns of convergent solutions.

	Pattern 1	Pattern 2	Pattern 3	Pattern 4
Price	30	40	50	70
Salary	70	70	90	110
Social surplus	660.5	400	1166.9	1530
Company profit	460	260	820	1180
Average of employee profits (=ES)	81.8	70	103.0	125
Average of consumer profits	1.8	0	3.0	5
Average of CS (only service users)	31.8	40	53.0	75

related to each pattern are presented in **Table 14**. **Fig. 5** presents the average number of users of each lifestyle in each convergent solution. **Fig. 6** presents examples of trial trajectories converging to each pattern. The time required for convergence differs depending on the initial value difference.

4.4. Discussion

Table 14 shows the details of four patterns of convergent solutions. First, all players' profits (equivalent of social surplus) are the highest in pattern 4. However, in this pattern, the lifestyles of consumers who receive services are limited. As shown in **Fig. 5**, only consumers with high active life or high conscious consumption factor can receive services. In this pattern, two employees acquire all types of resources. Therefore, selected service could fulfill the needs of all consumers. However, only two types of consumers could purchase it because it is too expensive for them. Pattern 4 is probably a theoretical Nash equilibrium solution because the company is dominant and their profit is thought to be the maximum. Although a company can acquire complete information related to consumer needs and behaviors in this simulation, phenomenon of this kind could occur in the real world. If a company knows the needs of a particular consumer well, they could exclusively provide a service that meets those consumer needs.

Consequently, only conscious consumption type consumers use the service in pattern 2. Comparing pattern 1 and pattern 2, the average price and CS of pattern 2 are higher than those of pattern 1. However, social surplus, company profit and average of employee profits are lower than those of pattern 1. In pattern 2, the number of users becomes half of the other convergent patterns because services are chosen only by consumers with high conscious consumption. This result implies opportunity loss because employees' acquired resources are limited. Acquired resources were specialized to r_2, such as, a special skill required for beauty-conscious consumers. However, if beauty salons specialize in the function of r_1, for instance, beauty salons emphasizing basic haircuts, then consumers with high anxiety about daily life and health or planned and economical consumption factor use services more often. The equilibrium solution might converge to pattern 1. Actually, in pattern 1 and 2, employee players acquired only single resource. In patterns 1 and 2, there were seven combinations of acquired resources for two employees.

Finally, pattern 3 includes all types of consumers. Both company profit and ES are the second highest among all patterns. Each employee player acquired two resources out of three resources. There were nine combinations of acquired resources for two employees. Although consumer profit is still low, this pattern is interesting from business viewpoint. In actual services, many companies might seek adaption to the consumer needs of as many types as possible even if such adaptation entails higher cost. Therefore, they must seek a feasible solution under consideration of many factors including profitability, CS and ES. In this context, pattern 3 might be the most balanced and sustainable service system.

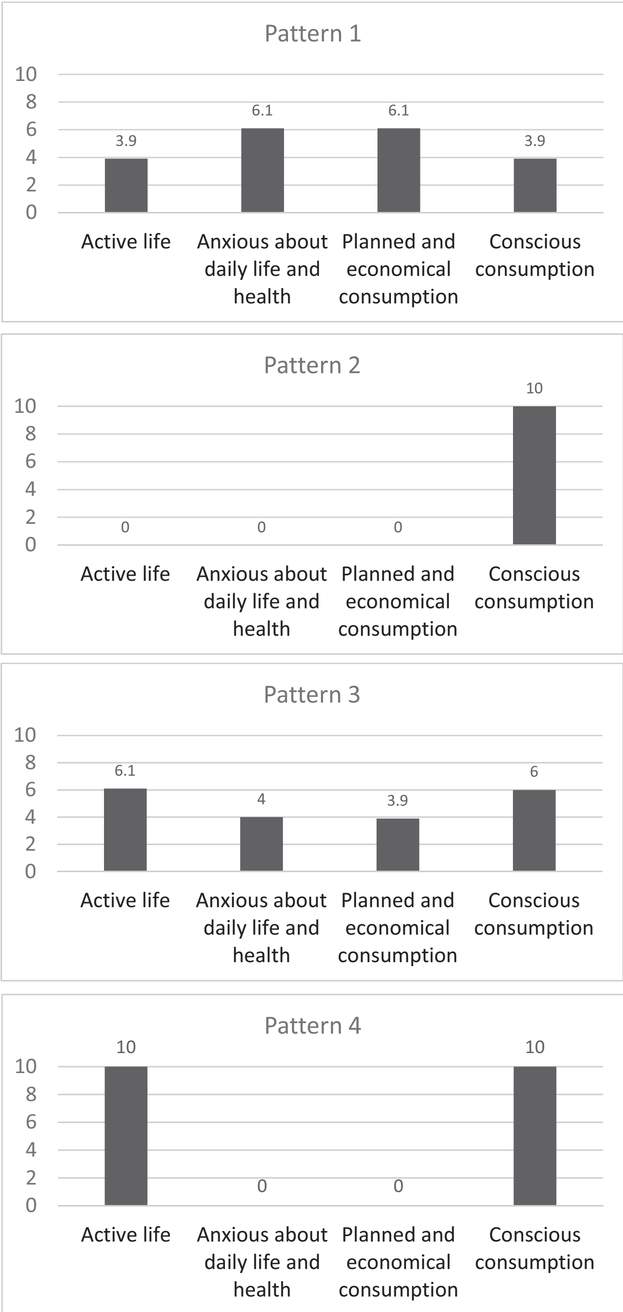

Fig. 5. Number of users for each lifestyle.

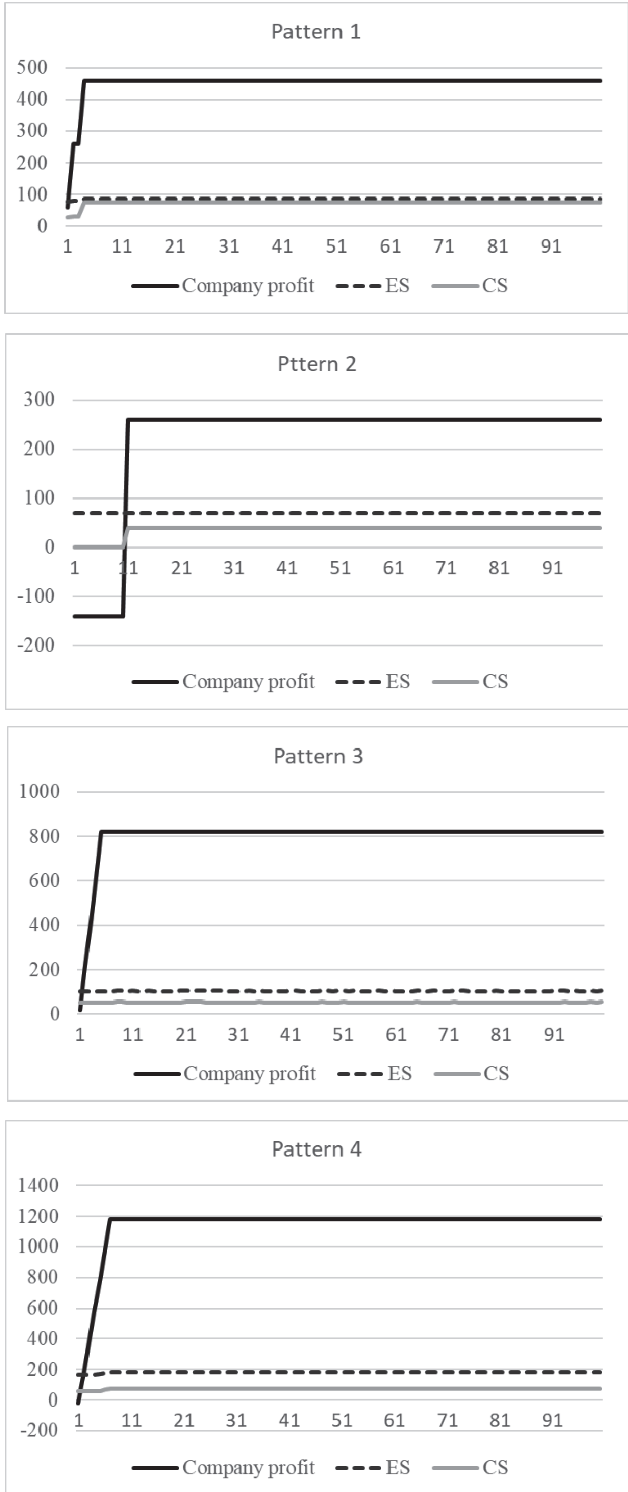

Fig. 6. Examples of trial trajectories.

Furthermore, although ES is less highlighted in manufacturing than services, adaptation to various consumer needs is a common issue in service and manufacturing industries. According to the progress of Internet of Things (IoT), manufacturers have acquired large amount of data on customer behaviors. Accordingly, mass customization [20], personalization, smart manufacturing [21], or product-service systems [22] are important issues for the adaptation to customers' heterogeneous needs from considering manufacturing costs and benefits for customers.

Also to note, by piecing together all acquired convergent patterns, those simulation results could be roughly consistent with the Service-profit chain theory. As ES increase, CS also increases except pattern 2. Moreover, higher CS results in higher company profit.

Although the simulation results of this study are limited in terms of their scope and number, they confirmed the importance having heterogeneity for consumer needs by investigating the relationship between acquired convergent patterns and included consumer types.

5. Conclusion

This paper presents an analysis of the service system mechanism with a multi-agent simulation based on game theory. The purpose of this study is to create a computational model to find the equilibrium for service systems through multi-agent simulation. The proposed model introduces some important previous findings on the relation between CS and ES to find feasible solutions that consider bilateral interactions among the company, employees, and consumers.

First, we conduct basic simulation with normalized consumer players. In this simulation, company, employee, consumer players decide to maximize their own profits. Consistent with the results of the basic simulation for normalized consumer players, two convergent patterns are acquired according to the initial values of price and salary. Although the company player should be dominant in the model, one convergent pattern is probably a Nash equilibrium solution because company profit is thought to be the maximum.

However, this simulation includes numerous limitations compared with actual service systems. In particular, consumer needs are directly related to CS. Therefore, as the next step, we conduct another simulation with consideration to the diversity of consumer needs.

Another simulation in which the diversity of consumer needs is regarded as conducted in the next step. This simulation assumes an actual hair salon service. Consumers of different types are introduced based on a questionnaire survey of lifestyle and actual hair salon use. Using a factor analysis of thirteen questionnaire items on lifestyles, four lifestyle factors were extracted. Based on the survey results, four types of consumer agents were introduced into the simulation to analyze which services the service system selects. Four convergent patterns were acquired through the simulation. In those patterns, consumers of different types were included according to the characteristics of services. As employee players acquired different resources (skills), characteristics of services and potential consumers changed accordingly. Moreover, results are roughly consistent with the Service-profit chain theory.

However, the proposed model still presents many limitations compared with actual service systems. For example, as the next step, bounded rationality of human, market competition among companies or technological innovation of services should be included in the model. In future studies, we expect to explore a decision support system of service design for actual business players. For this purpose, analysis of existing service businesses and synthesis of new services based on the computational model should be further integrated for future service engineering research.

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