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Service Engineering for Gastronomic Sciences

An Interdisciplinary Approach for Food Study

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Contents

Part I
Design for Value Creation

Chapter 1
Design for Value Creation

Tomomi Nonaka

Abstract This chapter addresses the value creation design of "food". Food has both the tangible characteristics of the food itself and the intangibility of its associated delivery processes. In designing food value creation, it is desirable to consider simultaneity, perishability, and heterogeneity as characteristics of services. Moreover, when designing food value creation, one must realize the three perspectives of customer satisfaction, employee satisfaction, and management satisfaction. To improve the added value surrounding food, one must positively analyze customer behavior, response to demand fluctuations, employee satisfaction, and link service profit chains. This chapter presents a description of analyses using customer and employee data at the realization site and food service system design.

In this section, food value creation design is discussed in consideration of the status and satisfaction of employees working at a food service provision site. Even in the same food service industry, widely various business forms exist, such as food service categories targeting restaurant service with cook–chill systems, restaurant service with cook–serve systems, and delivery of prepared food services. The effects of service characteristics such as intangibility, heterogeneity, simultaneity, and perishability vary depending on the business form of the food service and the characteristics of the service provided. Therefore, the importance of value creation design considering the type of food service, the characteristics of the provision process, and the external environment are described. In addition, food services are often labor intensive among service sites. The influence of employee feelings and conditions on the quality of services provided is regarded as important. This section introduces food value creation design that addresses employee satisfaction.

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1.1 Value Creation Considering Properties of Service

This section presents examination of design features for value creation in the food service business. Possible effects from properties of service such as intangibility, heterogeneity, perishability, and simultaneity are considered. Figure 1.1 depicts an outline in the food service business. For design for value creation in the food service industry, visualizing and capturing the energy consumption feature are executed as a first step. For energy management to create value, improving energy efficiency and managing energy peaks require several approaches. Improving energy efficiency is realized by reducing energy consumption per functional unit or its created value. It requires promotion of streamlining and/or reducing the input energy to be consumed.

1.1.1 Service Energy Efficiency

First, in considering value creation design, we examine the added value of food from the viewpoint of productivity. We discuss the improvement of value by improving productivity by taking energy consumption as an example among several productivity indicators. Toward the realization of a sustainable society, companies must conserve energy and natural resources. In the food service industry, which is part of the service sector, life cycle assessment (LCA) is currently expanding to address diverse product groups and production processes (Schau and Fet 2008; Bengtsson and Seddon 2013; Righi et al. 2013). In fact, LCA uses cradle-to-grave analyses of production systems to evaluate inputs and outputs in all life cycle processes from upstream to downstream of the systems. Schau and Fet (2008) states that food production has been much more energy-intensive because of industrialization. In the food service industry, in addition to the improvement of t operations aimed at improving efficiency (Shimmura et al. 2013a; Sill 1994), centralized efficient operations in central kitchens (Muller 1999; Kubo 1997), replacement of efficiency-enhancing equipment (Jyeshtharaj et al. 2011; Deng and Burnett 2000) and robots (Suzuki 2008) have been introduced for energy conservation.

In both manufacturing and service industries, reduction of energy consumption is necessary from the viewpoint of sustainability and global environmental protection.

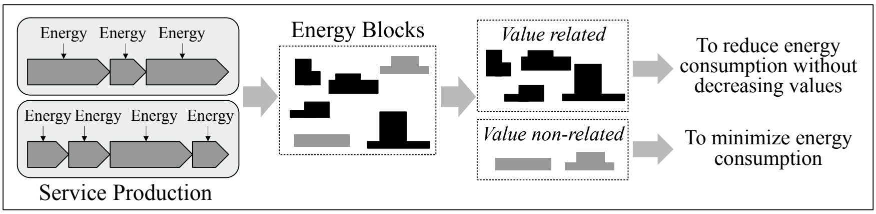

Fig. 1.1 Approach for improving service energy efficiency

Energy conservation is reducing the total amount of energy consumption necessary to create a certain value. The Energy Conservation Law in Japan calls for reduction in energy consumption intensity of more than 1% per year for businesses of a certain scale.

The energy consumption basic unit here can be set arbitrarily by the company. Generally, it often refers to energy consumption per unit production (amount), but in the manufacturing industry, the value of goods produced is fundamentally constant. Approaches typically aim at reducing the basic unit by increasing production efficiency. Other examples of denominator settings include one finished product, one intermediate part, product (part) weight, and product (part) length. However, in the service industry, the value provided is constant, considering its unique characteristics, i.e., "simultaneity," encompassing production and consumption, non-separation of products and processes, and "heterogeneity," encompassing receiver satisfaction.

By defining energy productivity as a service value maximization problem to maximize production per unit energy, it becomes possible to discuss service productivity from the viewpoint of energy consumption. Therefore, service energy productivity is defined as the quotient of the amount of input energy for the value created. Equation (1.1) presents an evaluation formula for service energy productivity (Nonaka et al. 2015).

$$\text{Service Energy Efficiency} = \frac{\text{Value Out}}{\text{Energy In}} \tag{1.1}$$

Service energy productivity can be improved through the following three approaches.

i. Decreasing the input energy in the denominator by increasing production efficiency
ii. Enlarging the effect by increasing value or increasing added value
iii. Decreasing the energy input to the denominator using methods other than increasing production

Figure 1.2 shows a service energy productivity improvement approach to reduce the input energy in the denominator using (i) and (ii) above. First, energy consumption is assumed to be classifiable according to whether it contributes to value by the production process; then energy consumption is modeled. For example, in the retail industry, energy consumption attributable to lighting and air conditioning in spaces where there are no customers or in areas where the store is not presented does not contribute to the value provided to customers.

Energy consumption associated with refrigeration for keeping food cooled is classifiable as contributing to value because product quality changes as a result of temperature adjustment. Energy that contributes to value requires an approach that reduces energy consumption without reducing value. Energy that does not contribute to value is necessary to minimize energy consumption. These approaches reduce the total energy consumption. Alternatively, the process is improved or reviewed so that

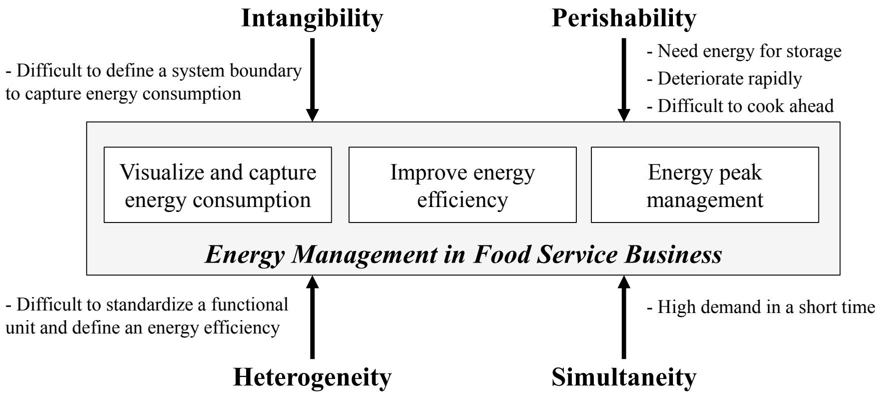

Fig. 1.2 Outline of energy management in the food service business (Nonaka et al. 2015)

the energy consumption peak amount that consumes large amounts of energy per time in a certain process is reduced.

1.1.2 Feature of Energy Consumption Considering Properties of a Service (Nonaka et al. 2015)

This section examines features of energy consumption in the food service business. It considers the possible effects attributable to properties of services such as intangibility, heterogeneity, perishability, and simultaneity. Figure 1.1 describes an outline of energy management systems in the food service business. For energy management, visualization and capturing energy consumption features are executed as first steps. Improving energy efficiency and managing energy peaks require several approaches. Improving energy efficiency can be realized by reducing energy consumption per functional unit or its created value. It requires promotion of streamlining and/or reducing the input energy to be consumed. However, energy peak management should consider not only efficiency but also how to operate and standardize energy consumption against demand peaks.

Intangibility: Distinction between goods and services in a tangibility continuum classification was discussed in an earlier report (Levitt 1981). In the food service business, a dish and related services are provided. The dishes can be regarded as tangible goods. Bebko (2000) reports that fast food retailing might certainly fit into the category of a differentiated good and service bundle that is attributable to a tangible food being offered with the food preparation and delivery service. Defining a system boundary is needed to capture and evaluate energy consumption accurately. Intangibility might make it difficult to set a boundary for the evaluation of service production systems.

Heterogeneity: In service provision processes, constant production of services is generally difficult to achieve. In a kitchen in restaurant service, service operations still entail many manual processes that create value (Shimmura et al. 2013b). An index of energy efficiency is generally evaluated by measuring the amount of energy consumption and its produced value. The heterogeneity of service might engender difficulty to define its produced value because of its lack of standardized functional units.

Perishability: Storage time of food is very short. In fact, food quality deteriorates rapidly in numerous cases in the food business. It is necessary to provide fresh cuisine to customers. Warm cuisine must be offered while warm; cold dishes must be served while still cold, so that a certain amount of energy is necessary for storage. Furthermore, difficulties of storing advance production inventories engender implementation of build-to-order manufacturing systems. A limited cooking operation can be implemented using batch production, which presents the possibility of affecting energy peak management and control of demand.

Simultaneity: A degree of simultaneity in food services is defined according to the location of consumption both spatially and temporally. Introducing a central kitchen system, batch production and production lead times can be regarded as influential factors.

Furthermore, large fluctuations in energy demand occurred because the restaurant service has high demand of the specific time slots at lunch and dinner times. High demand in a short time might cause difficulties for energy peak management.

Here, taking the cases of four food service businesses as examples, we consider relations between different business models, with different energy consumption and service characteristics. The four considered businesses are a restaurant with a cook–chill system, a restaurant with a cook–serve system, a delivery service, and home meal replacement.

In restaurants with a cook–chill system and a cook service system, customers order at a restaurant and eat there. In restaurants that have a cook–chill system, the cooking process is divisible into a central kitchen and restaurant, where energy can be consumed at each location. Energy input is necessary for transportation and storage processes. The cook–chill system, cook serve system, and delivery service run the main cooking process immediately after the customer order. Therefore, it should be inferred that simultaneity effects might be strongly affected.

In a home meal exchange service, the cooked process at the food processing plant is first implemented. Then the final cooking process is handled at the customer's home. The process is similar to the production of tangible goods. The description above explains that energy consumption in these four food businesses has effects caused by several characteristics and service characteristics related to energy consumption. Therefore, probably in the productivity improvement approach in food value creation, measures according to the characteristics of the service goods must be provided. Also, service characteristics according to the business model are necessary.

Here, value creation is divided into process design, planning stage and initial planning, and operational stages. Figure 1.3 portrays a conceptual diagram of production planning for value creation. In process design, the energy blocks input in each service

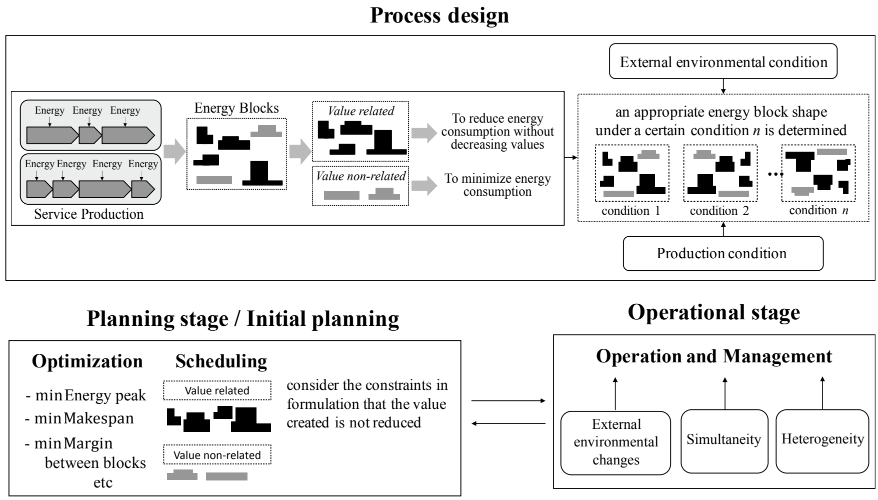

Fig. 1.3 Conceptual diagram of production planning for value creation

process are classified according to whether the process is related directly to value creation and whether the input energy contributes to value creation, or not. In energy input related to value creation, energy saving is attempted so that the value created is not reduced. However, an approach intended to minimize the amount of energy input that is not related to value creation is regarded as effective.

Next, based on classification results, an appropriate energy block shape is determined under a certain condition *n*. This problem defines the energy consumption time profile, i.e., the energy block shape, when processing is performed under certain external environmental conditions and production conditions. In the planning stage, a schedule is created using energy blocks under certain conditions found through earlier processes. In other words, the timing to execute a job that consumes the energy block is assigned to the time axis. The worker who performs the work and the equipment are assigned to the time axis. At this time, for the energy input related to value creation, we consider the constraints in formulation when creating the schedule so that the created value is not reduced. Subsequently, the derived schedule is used as the initial schedule. The plan is revised and updated according to environmental changes in the operation stage. Here, it is necessary to consider effects of heterogeneity, heterogeneity, and concurrency, which are the characteristics of services.

In addition, in labor-intensive processes, it is assumed that there might be a strong effect of factors unique to people involved in value creation and productivity improvement.

This can be regarded as the influence of heterogeneity on the service provider side. Therefore, the next section considers value creation that incorporates consideration of worker condition and employee satisfaction.

1.2 Value Creation Design Considering Employee Satisfaction

The importance of customer satisfaction in the service industry has been known for a long time (Bearden and Teel 1983). Studies have been conducted for evaluation of service quality and customer satisfaction (Taylor and Baker 1994; Sureshchandar et al. 2002), evaluation of waiting time, and major factors with which customers feel dissatisfaction (Luo et al. 2004; Shimmura et al. 2013c; Nonaka et al. 2014). Actually, customer satisfaction and service quality are closely related (Sureshchandar et al. 2002). In service value creation design, it is necessary to maintain or improve service quality and improve customer satisfaction while promoting efficiency. In the service industry, where production and consumption are performed simultaneously, the distance between employees and customers is short. Schlesinger and colleagues have proposed a "cycle of success" model that increases customer satisfaction by improving employee performance and by providing better service (Schlesinger and Heskett 1991). In the "Service Profit Chain (Heskett et al. 1994)" advocated by Heskett et al., the relation between employees and customers is expressed as a "satisfaction mirror". Then they influence each other. As a case study, many studies have evaluated the relation between employee satisfaction and service quality. For example, employee job satisfaction in banks (Reynierse and Harker 1992; Yoon et al, 2001) and hotels (Hartline and Ferrell 1996) is related to customers' perceived service quality. It has been shown to have a positive effect.

Especially in the service industry, for store services where employees provide services directly in contact with customers, the behavior and attitudes of employees are likely to be communicated directly to customers. In the restaurant industry particularly, many tasks require personal and manual work. The employee condition might strongly influence service quality.

Here, an overview of employee satisfaction research in the food service industry is presented. As a study in the food service industry, Bernhardt and colleagues have shown that positive correlation exists between employee satisfaction and customer satisfaction in fast food restaurants (Bernhardt et al. 2000). Koys conducted a questionnaire survey of employees and customers over multiple years. Results showed that employee satisfaction during the first year had a positive impact on customer satisfaction in the following year by multiple regression analysis (Koys 2001). In addition, Gazzoli et al. conducted a survey of 474 restaurants for employees and customers. Through covariance structure analysis, results demonstrated that employee empowerment and job satisfaction affect customer service perceived quality (Gazzoli et al. 2010).

The following sections introduce approaches that specifically examine employee satisfaction in the service profit chain. Here, when considering a value creation design that considers employee satisfaction, it is divided into employee satisfaction of two types according to the time constant of satisfaction. One is employee satisfaction related to job satisfaction over the medium to long term, which has been clarified by many studies through questionnaire surveys (Nonaka et al. 2016a). In addition, the section presents a description of short-term employee satisfaction that changes during the day or according to time.

1.3 Employee Satisfaction over the Medium to Long Term in Restaurant Services

Improving both employee satisfaction and service quality requires investigation of employee satisfaction and clarification of its structure. This section describes an analysis of employee satisfaction in restaurant services (Nonaka et al. 2016b). A Japanese restaurant chain in Japan was selected for analysis. The restaurant has employees of different types. Each employee must have specific skills and techniques in each context, depending on their position. Furthermore, service production in restaurants is done in a labor-intensive manner. Staff members working on the service floor provide services in direct contact with customers. In the kitchen, many manual processes create value for service operations. Therefore, staff working conditions can affect service delivery. A survey was administered to restaurant staff. Based on the results, an employee satisfaction model is proposed considering customer-oriented motives and contacts in the service delivery process. Correlation analysis and covariance structure analysis between kitchen staff, floor staff, laundry, and pantry staff are applied to the survey results, revealing differences in the satisfaction structure.

1.3.1 Questionnaire for Employee Satisfaction

Table 1.1 presents contents of the employee questionnaire administered to gather data to model employee satisfaction. The table provides an overview of question categories and question items. The questionnaire consists of two parts. The first group of questions investigates employee attributes. The second group is for employee satisfaction surveys. The questionnaire was administered with questions and free description questions using a Likert scale with question items accepting responses given at six levels: (1) strongly agree, (2) agree, (3) slightly agree, (4) only slightly agree, (5) disagree, and (6) strongly disagree. Paper question sheets were provided. Respondents completed the question sheets. The survey was administered as an anonymous survey.

Table 1.1 Outline of the employee questionnaire in a restaurant service

Question categories	Question items	Question type
Respondent attributes	Gender, Age group, Employee pattern, Length of working period at the current store, Length of continuous employment, Current working position, Experimented working position at the company	• Multiple choice question • Free descriptions
Ql: Work environment, viewpoint about work	*23 items [Q1-1–Q1-23] regarding;* Understanding of the company and workplace, Expectation of bosses and colleagues, Opportunity for challenging, Congenially employed, Good relationship with colleagues and bosses, Satisfaction with salary, Cooperation and collaboration with colleagues and bosses, Discretion, Satisfactory work, Pride in work, Understanding of their jobs by family (part of the items)	• Six level Likert question items
Q2: Work efficiency, service quality	*7 items [Q2-1–Q2-7] regarding;* Quality of dishes, Food preparation speed, Customer's reaction and satisfaction, Efficiency of work, Teamwork and collaboration, Staff assignment,Work environment (part of the items)	• Six level Likert question items
Q3: Relationship with bosses	*8 items [Q3-1–Q3-8] regarding;* Exact direction for work assignment, Advance directive, Work planning, Support, Complying with a request about shift schedule, Giving a goal for skill improvement, Listening to employee's voice (part of the items)	• Six level Likert question items

(continued)

Table 1.1 (continued)

Question categories	Question items	Question type
Q4: Philosophy, rules, and personal system	*5 items [Q4-1 – Q4-5] regarding;* Understanding of the personal system, Understanding of the work assignment and job rotation, Understanding of the batch production system, Understanding of the demand prediction, Understanding of the importance of collaborations	• Six level Likert question items
Q5: Education system	*2 items [Q5-1 –Q5-2] regarding;* Satisfaction for education system and its reason	• Six level Likert question items • Free descriptions
Q6: Attitude and motivation toward work	*8 items [Q6-1–Q6-8] regarding;* Interest in working for long period at the current company, Work fun, Desire to be more helpful at work place, Desire to enhance customer satisfaction, Interest in improving job skill, Continual awareness of providing good quality service (part of the items)	• Six level Likert question items
Q7: Interest in multi-skills development	*1 item [Q7]* About interests in increasing multi-skills	• Six level Likert question items

1.3.2 Questionnaire Design

Skills required for service production vary depending on the job type. This is especially true at labor-intensive service sites. For example, for a restaurant service, the cooking staff and the customer service staff probably differ not only in terms of their assigned work and required skills; the learning curve also differs greatly depending on the skill characteristics.

The skills to be acquired are defined herein as skills. The proficiency for each skill is defined as a skill. In the kitchen, there are skills of preparing ingredients, seasonings, cooking, dishing out foods, and so on. In catering, the items to be remembered differ depending on the target set, such as banquet dishes, luncheons, and regular menus. Therefore, the number of menus covered is a skill in itself. Additionally, how quickly and accurately it can be handled is regarded as a skill. Customer service requires skills such as guidance, order entry using a point of sale terminal (POS), banquet correspondence, and accounting. In this section, awareness of customer satisfaction, willingness to improve skills, and willingness to be a more skilled worker are examined so that differences in employee responsible duties, such as differences in customer contact and customer orientation (Homburg and Stock 2005) analyzed, can be considered. Differences, items to evaluate the degree of freedom and autonomy for work were set. The characteristic questions are presented below. As described in this paper, customer satisfaction is considered from the viewpoint of employees. It refers to customer satisfaction provided by services by which each employee can contribute through one's own responsible duty. For example, the staff members at the kitchen have a managing taste and control pace of cooking, the pantry and washing area has a speed of delivery, the set of dishes, the cleanliness of the dishes, the customer service is the attitude and smile at the time of customer service, and talking and serving dishes to customers in a timely manner.

- Relation between customer satisfaction and job type (Q1–22)
- Willingness to improve customer satisfaction (Q6–4)
- Service quality awareness (Q6–8)
- Willingness to improve work quality and skills (Q6–6)
- Willingness to increase skills and step up (Q6–7)
- Respect for your opinions (Q1–7)
- Self-discretion/self-judgment (Q1–17)
- Proactive proposals and problem solving (Q1–19)

The questionnaire was distributed at six stores; 128 employees responded to it. All segments of the restaurant staff were investigated, including both part-time and full-time workers in kitchens, service floors, washing places, and pantries. The percentage of respondents differed widely among age groups from teens to people in their sixties: 9% of people in their teens responded, 23% of people in their twenties, 9% of people in their thirties, 19% of people in their forties, 23% of people in their fifties, and 16% of people in their sixties. All teenaged staff members were part-time workers. Of the respondents, 31% were men; 68% were women. Results show that 26% of the staff worked in the kitchen, 18% in the washing area and pantry, and 50% on the service floor.

Many positive answers were given, suggesting high motivation for improving job skills, as observed particularly in the results of Q6-6 'Interest in improving job skill' and Q6-7 'Interest in increasing tasks which can be handled'. Both Q6-6 and Q6-7 received 89% positive answers, a categorization determined as the sum of (1), (2), and (3).

Next, we analyzed separate employee patterns that emerge when the staff is divided into different segments. Many positive answers including (1), (2), and (3) were received for the results of part-time workers and full-time workers. Similar trends with results across all segments are described above. A similar trend is apparent for both full-time and part-time workers in terms of motivation and emotion. In addition, full-time workers have a stronger motivation and deep understanding of strategy and rules than part-time workers have.

1.3.3 Correlation Analysis

We applied correlation analysis to evaluate the association between the two variables, which represent the respective question items. The analysis was applied for all combinations of question items, which are analyzed separately by respondent attributes. The questionnaire results of the six levels of Likert items are converted from the value of '1' to '6', which stand for (1) strongly agree, (2) agree, (3) slightly agree, (4) only slightly disagree, (5) disagree, and (6) strongly disagree. A value of $p < 0.05$ was inferred as statistically significant.

This section shows representative results with particular reference to three specific question items. The correlation coefficients among responses to questions Q6–2 are shown in Table 1.2. The question item is considered in reference to whether they might directly represent or influence employee satisfaction and customer satisfaction:

- $^{*}P<0.05$, $^{**}P<0.01$

As shown in Table 1.2, which presents correlation with Q6–2 and Q1–3 ($r = 0.581$, $p < 0.01$), and Q1–19 ($r = 0.586$, $p < 0.01$), only fair correlation was found in the segment of workers aged in their fifties and sixties. Aggressive policies providing the opportunity to propose, challenge, or implement improvement plans and problem resolutions have fair correlation, particularly for elderly workers. These policies might influence employee satisfaction of workers in their fifties and sixties more than other age groups. Actually, Q1-22 shows fair correlation with the kitchen staff ($r = 0.462$, $p < 0.01$) and service floor staff ($r = 0.559$, $p < 0.01$). Results illustrate that they might enjoy feelings toward contribution for customer satisfaction.

Correlation differences are visible according to segmentations. Particularly, the segment of current working position shows different trends of results.

1.3.4 Covariance Structure Analysis

Based on correlation between the questions in respective job categories shown in the preceding section and the role in customer contact and service production in each job category, a hypothesis of the employee satisfaction model is proposed in Fig. 1.4. Employee satisfaction (Gazzoli et al. 2010), consisting of motivation, job satisfaction, and empowerment, is not merely a one-way effect that affects service quality; it includes factors in service production systems that represent interactions with the structure and environment in which employees produce services. If a part of the service systems is changed, then it might affect employee satisfaction. We hypothesize that employee satisfaction engenders the next concrete action through the element of customer orientation. The behavior is an active behavior of the employees, as "I want to increase customer satisfaction," "I am always conscious of providing good service," or "It engenders the desire for skill acquisition and skill improvement." Here, in the service production system, they are necessary skills and other skills, and

Table 1.2 Correlation coefficients with Q6–2 (Do you enjoy your work?) and variables

Q6-2.	Do you enjoy your work?									
		Overall	Employment pattern		Current work position			Age gronp		
			Full time	Part time	Kitchen	Washing place and pantry	Service floor	10's and 20's	30 s and 40's	50's and 60's
Q1-3.	Do you have challenging opportunities ?	0.339**	0.471**	0.338**	0.269	0.493*	0.280*	-0.066	0.255	0.581**
Q1-8.	Do you feel that the company's mission and target give recognition to the importance of your own task ?	0.253**	0.607**	0.415**	0.237	0.663**	0.456**	0.222	0.400*	0.587**
Q1-13.	Do you feel the expectations of bosses and colleagues ?	0.327**	0.509**	0.428**	0.431*	0.352	0.425**	0.275	0.376*	0.583**
Q1-18.	Are common rules arranged for job processes ?	0.278**	0.444*	0.386**	0.564**	0.356	0.428**	0.116	0.568**	0.486**

(continued)

Table 1.2 (continued)

Q6-2.	Do you enjoy your work?									
		Overall	Employment pattern		Current work position			Age gronp		
			Full time	Part time	Kitchen	Washing place and pantry	Service floor	10's and 20's	30 s and 40's	50's and 60's
Q1-19.	Do you propose or implement improvement plans and problem resolutions actively ?	0.180*	0.330	0.288**	0.005	0.581**	0.284*	0.126	-0.076	0.586**
Q1-21.	Do you cooperate and collaborate with colleagues ?	0.239**	0.389*	0.497**	0.209	0.405	0.538**	0.373*	0.575**	0.491**
Q1-22.	Do you feel that your work leads to customer satisfaction?	0.366**	0.613**	0.409**	0.462**	-0.029	0.559**	0.299	0.613**	0.443**
Q6-1.	Do you want to work for a long period at the current company?	0.328**	0.792**	0.785**	0.812**	0.723**	0.800**	0.560**	0.875**	0.816**

(continued)

Table 1.2 (continued)

Q6-2.	Do you enjoy your work?									
		Overall	Employment pattern		Current work position			Age gronp		
			Full time	Part time	Kitchen	Washing place and pantry	Service floor	10's and 20's	30 s and 40's	50's and 60's
Q6-3.	Do you deire to be more helpful in the work place?	0.530**	0.709**	0.740**	0.598**	0.752**	0.706**	0.535**	0.659**	0.799**

**P<0.05, **P<0.01*

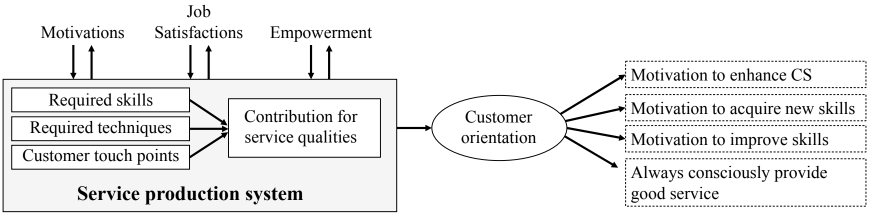

Fig. 1.4 Hypothesis model of employee satisfaction

customer contact points. Methods for contributing to service quality differ depending on the job type. The internal model of satisfaction is expected to vary depending on the job type in charge.

To verify the employee satisfaction hypothesis, covariance analysis was performed using the characteristic question group shown in "Questionnaire Design" in the preceding section and the question group, for which results differed for each job category in the correlation analysis in the preceding section.

For this analysis, "employee satisfaction" and "connection to customer satisfaction" are introduced as latent variables. Each question item is set as an observed variable. While examining the fit of the model, we verified the questions set for the employee satisfaction model structure and estimated the model. Results show the employee satisfaction models for each responsible duty depicted in Fig. 1.5a (cooking staff), Fig. 1.5b (floor staff), and Fig. 1.5c (pantry and washing staff). In the panels of the figure, small circles represent error variables, squares represent observed variables, and ellipses denote latent variables. The fit of the model was tested using RMSEA, NFI, and CFI values.

Next, the factor loading between the path connecting the latent variable "Lead to customer satisfaction" and "Motivation to improve customer satisfaction (Q6–4)" was high at around 0.8 for all three responsible duties. However, the factor load between "Motivation to improve work quality/skill improvement (Q6–6)" and "Motivation to increase skill/skill improvement (Q6–7)" was 0.93 higher than the observed variable. In contrast, the floor staff was only 0.56 for Q6–7 only; the staff at the bar and washroom was 0.92 only for Q6–7. These results were obtained probably because the internal model of employee satisfaction with the motivation from customer orientation to skill improvement and skill acquisition differs between the kitchen and other staff, where their technology is linked directly to service quality.

Consider the relation between the impression of the word "technical skills" and the staff members in charge of different tasks. Whereas cooking staff members tend to be highly conscious of skills, floor staff and pantry and washing staff might not place strong emphasis on skills. The floor staff and the pantry and washing staff are conscious of acquiring skills in the sense of learning work, but it is thought that the word "skill" is related directly to the work in charge and that it is difficult to imagine.

In addition, for customer service provided by the floor staff, the possibility exists that hospitality customer service that requires smiles and flexibility is not connected

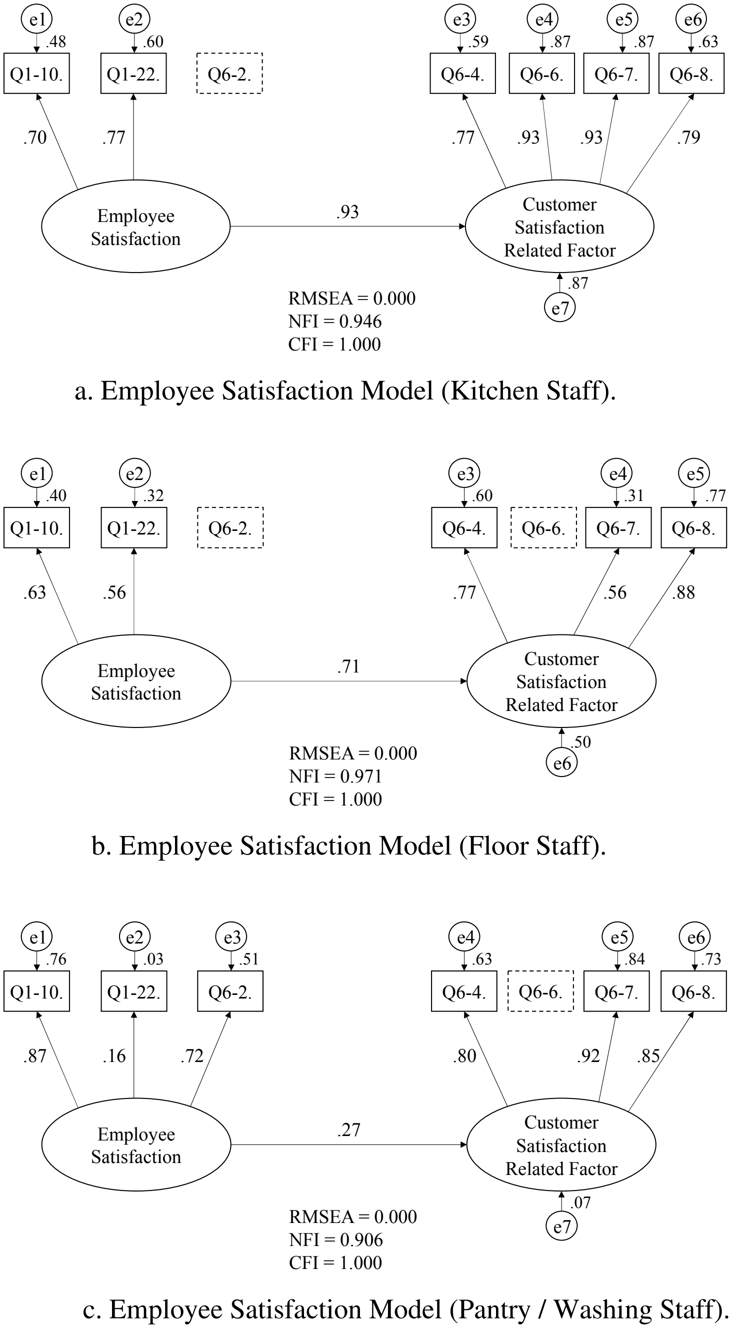

Fig. 1.5 **a** Employee satisfaction model (Kitchen Staff). **b**. Employee satisfaction model (Floor Staff). **c** Employee satisfaction model (Pantry/Washing Staff)

directly to the elements that can be acquired with skills and skills in the employee consciousness. Factor loading of 0.92 was strong only in Q6–7 in the pantry and washing area staff members. That result might derive from the fact that they have the desire to try to acquire widely various skills including other occupations resulting from other analyses.

Therefore, changing the job design based on the results described above might change and improve the internal structure of employee satisfaction for each job type. For the current job design, devising a way to allow staff to feel a customer's reaction in the kitchen and the pantry and washing staff with few customer contacts is expected to be effective. Additionally, it is possible that the consciousness structure of employee satisfaction of each job type will change by educating employees to make staff improvements and skill acquisition, and make them aware of the fact that skill improvement and skill acquisition contribute to service quality, and ingenuity related to their areas of responsibility.

Additionally, the consciousness structure of employee satisfaction of each job type might change because of education for staff improvement and skill acquisition with awareness of the fact that skill improvement and skill acquisition contribute to service quality, and ingenuity related to their areas of responsibility.

1.4 Employee Satisfaction in the Short Term

Regarding services for which production and consumption occur simultaneously, especially services for which employees face customers to create value, employee physical and cognitive ability and satisfaction can affect service quality. In such a scenario, the effects of employee status and employee satisfaction (ES) on quality and customer satisfaction (CS) are important. Most earlier studies dealing with ES and quality of service were conducted using questionnaire analysis. Many asked about medium-term to long-term satisfaction over a certain period from the time of questionnaire responses (Gazzoli et al. 2010; Judge et al. 2001; Iaffaldano and Muchinsky 1985; Harter et al. 2002). Survey results were analyzed using stratified data based on industry type, occupation type, etc. Nevertheless, few studies have examined details of work and work plans within the same profession (Nonaka et al. 2016a).

Employees are influenced by environmental factors such as demand fluctuation depending on the day or even during the day. Their feelings and attitudes might change. However, in studies presented in the preceding section, the standard or average satisfaction for each occupation was assessed, including those variations. Few studies have addressed effects of environmental factors on employee status and quality of satisfaction, either daily or during work.

This section specifically examines the effects of employee physical and cognitive skills, fatigue, and employee satisfaction (ES) levels on the productivity and quality of labor-intensive service systems. Short-term ES changes, productivity, and quality within the service production and delivery process are assessed (Nonaka et al. 2018).

Interaction with service systems is used to detect customer requirements, detect environments, modify task schedules, and update systems to clarify how employees adapt to and respond to environmental changes such as demand fluctuations. In addition, a proposed production planning game that simulates a service site is presented. In this game, employees work flexibly while adapting to changing service system demands and environmental changes. Employees produce products and services while mentally modifying and updating work plans. This game was designed using a restaurant service site as a use case.

1.4.1 Hypothetical Employee Satisfaction Model in the Short Term

In this section, restaurant services are considered as labor-intensive service sites. At such sites, employees need to adapt to demand fluctuations and respond to them. Moreover, advance preparation and efficiency are important. This requirement stems from the characteristics of the services that make up the restaurant services. Restaurant services might use a central kitchen, cook–chill system, or pre-cooking. However, it is common to start cooking after receiving customer orders. The restaurant is close to production and consumption areas. Both activities take place simultaneously. In addition, depending on the amount of demand on a given day, the amount of work might vary greatly with respect to labor input.

In the preceding section, we explained to target employees that differences exist in the internal structure of the employee satisfaction model, especially the customer-oriented specific actions and motivation pathways through ES. This condition is mainly attributable to different customer contacts depending on job functions. The survey examined the relation between ES and ES while confirming details of characteristics and work flows of each job process and task. The survey was administered via a questionnaire (Nonaka et al. 2016a) because it targeted average or standard ES. The hypothesis was that ES would change. We examined the change in ES over a one-day shift to investigate short-term ES.

Survey results show that the work performed by the employees comprised several processes and repetition. Each employee confirmed the demand forecast given by the store manager in advance, with information related to the shift plan and the staff composition, and made plans for preparation and setup for the assumed demand. They were not given a strict and detailed work schedule. Particularly, they established a detailed plan for preparation and areas for reserved guests to estimate work in advance. Furthermore, even after the start of the workday, we observed that the work priorities and task schedule were adjusted according to the status of orders, the overall work progress, and changing customer situations.

Here, if employees working at the service site can be represented as production facilities, it can be understood that "input," "output," and "sensing" are performed with flexibility and simultaneity. The inputs and outputs here are the materials required for production and the products produced. Employees sense the environment passively or actively. For example, passive sensing is given order data or a customer call. Active sensing, however, observes customers and seats and perceives fluctuations in demand based on visit and weather conditions. Employees update and modify their schedules and initialize their work schedules that are pre-assembled based on results of active and passive sensing in real time. Therefore, they sense changes in environmental order and change and adapt flexibly by capturing and updating environmental information, resulting in increased productivity.

At this point, by improving ES through a sense of accomplishment by improving productivity and achieving their own plan, or by being able to proceed as planned or feeling energized by deviations from expected demand, it is possible to improve productivity and quality. Figure 1.6 shows the hypothetical model of ES constructed considering these factors. In the figure, the component constituting the ES in the employee mental model comprises four elements. From the left, the four elements are time pressure (such as margin and impatience), work results (such as achievement and satisfaction), frustration (such as anxiety and discouragement) (Nonaka et al. 2018), and job satisfaction (such as enjoyment and fun). To verify this hypothetical model, a gaming simulation approach that simplifies and reproduces the operation in the actual service system for the purpose was adopted. The conducted experiment and the obtained results are presented in the next section.

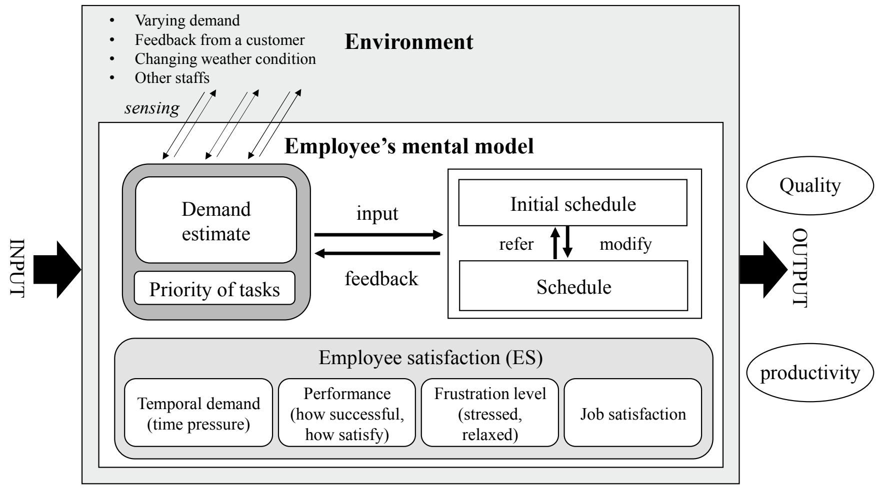

Fig. 1.6 Hypothetical model of employee satisfaction in the service delivery process (Nonaka et al. 2018)

1.4.2 *Employee Satisfaction Model Verified Using a Gaming Simulation Approach*

To elucidate short-term employee satisfaction, a triangular pyramid creation game was designed by simulating production planning in the service production process in restaurant services and labor-intensive service sites (Fig. 1.7).

In the game, for an order to arrive, the player manually creates and delivers triangular pyramids with paper using scissors and cellophane tape in a game format aiming for high score acquisition considering lot sizing problems. A triangular pyramid is designed in the game as an ingredient for a dish. The player is instructed that although it is permissible to start work and set up before ordering, quality will deteriorate over time from the start of work. The player is told, “Faster, freshly made, good quality triangular pyramids are pleasing to customers.” The player therefore recognizes that devising a production schedule that considers production LT, degradation degree, and quality is necessary to achieve a high score.

Demand forecast information is given to the player with different degrees of accuracy as the starting condition. Changes in productivity, quality, and ES are analyzed. Given the demand forecast information, the employee passively senses the information and corrects or changes the plan while mentally updating the assumed demand in real time. At this point, when very accurate demand forecast information is given, the difference between the assumed demand and the actual demand is small. In the demand forecast information with low precision, the difference between the assumed demand and the actual demand is large. A difference in productivity

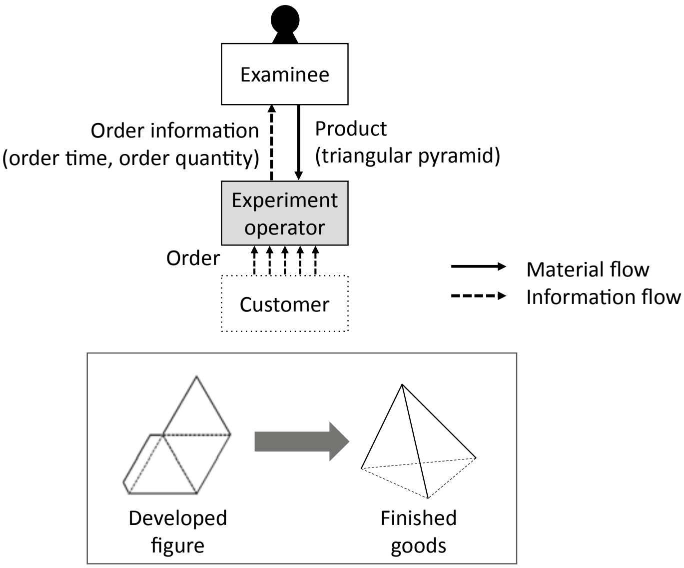

Fig. 1.7 Game outline

is assumed to produce effects on ES. The worker might reduce the operation time below the standard operation time in some situations. An example of the situations is that if the number of orders exceeds the production capacity of the employee or an order that diverges from the preliminary assumption arrives and the preparations and arrangements are insufficient. Reducing the time, however, lowers the quality even when completing the job on time. At this point, how employees deal with the tradeoff between quality and production lead time (production LT) is observed. The differences in quality and how productivity is achieved are analyzed.

In the game, the player uses scissors to cut the paper on which the development drawing is printed. Then a triangular pyramid is created by folding and taping the edges.The work itself is simple, but the degree of accuracy and task scheduling tends to influence the production quality. The player is given a sufficient number of sheets of paper as materials for producing the triangular pyramids. Figure 1.8 shows that the process involves first cutting the paper with scissors along the solid line in the developed view of the triangular pyramid and then creasing them along the broken line. Subsequently, assembly is completed by folding the overlapping parts and securing them with cellophane tape.

The triangular pyramid quality was evaluated based on the following five items: cutting of lines, no veering from lines, tape attached without any left over or protruding, laminations aligned perfectly for assembly, and proper tension on the side of the finished product.

The game flow is the following. After confirming the received order, the player formulates a production plan according to the order and creates a triangular pyramid. The player then delivers the triangular pyramid to the customer through the game operator as soon as all the sub-orders for an order are filled (Fig. 1.7).

Gameplay consists of three sessions with different demand conditions that are executed in some order. The conditions of three types are: high accuracy demand information (High), low accuracy demand information (Low), and no information (No). In fact, High shows the arrival time and number of orders, and Low shows only the total order quantity for the entire session. Order arrival time and order quantity are given as random numbers according to an exponential distribution and a normal distribution.

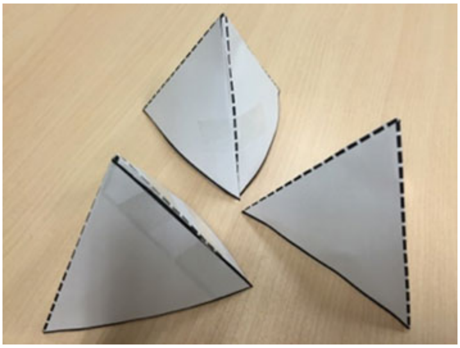

Fig. 1.8 Triangular pyramids created by one person with different quality

Game results are evaluated in terms of productivity, quality, ES, and CS in addition to the game scores presented. From the viewpoint of CS, the production LT of each order is evaluated against the quality and degradation scale described. The deterioration scale is obtained as the difference between the delivery time and the work start time: a higher value represents a greater degree of degradation. In addition, the number of orders in progress at the end of the game (disposal loss) and the number of undelivered orders are also evaluated. The provided quality is then calculated for each finished product, with each item assigned one point.

In addition, the player completes a questionnaire that evaluates "sensible production LT," "feeling of accomplishment," "feeling of impatience," "feeling of enjoyment," and "work efficiency" in ten stages following completion of each game session.

1.4.3 Experimental Evaluation

The proposed game was conducted using 18 college students as players. The time per session was assigned to players as approximately 10 min in three sessions per game. These three sessions were run under different conditions related to demand forecast information. For High, the order arrival time and number were given, but for Low, only the total order quantity for the entire session was given. There were nine orders per session, with two suborders per order on average, given as a normal distribution with a standard deviation of 1.5. Datasets of three types related to orders were prepared. Conditions were set for order datasets, session order, and forecast information by design of experiments so that players were not influenced by learning effects until they became accustomed to the work.

The average of the High quality scores was 2.46; the best score was that of High. The fastest average production LT, achieved with No, was 126.6, followed by 142.5 by High; then 158.8 Low. However, because No had the largest number of undelivered orders, the possibility exists that the value of the production LT might be small because they are not included in the calculation of the production LT. Conventionally, production LT and provided quality can secure a certain level of quality up to the threshold value before and after the standard operation time. However, for an order exceeding the production capacity that is hurriedly produced, a tradeoff exists between productivity and quality. The players planned the number of lots and the timing of job start while considering the assumed demand. At that time, highly accurate demand forecast information was useful, which is thought to have led to the high quality score and the speed of production LT.

Correlation was found between the quality score and the production LT and the subjective evaluation results for "enjoyment," "impatience," and "achievement feeling" were evaluated. The relation between ES and productivity and quality were analyzed (Table 1.3). Results show that, in the production "LT" and "impatience," moderate correlation was found for No because no demand forecast information was given. Therefore, it is easy for situations of unexpected or exceeded expectations to

Table 1.3 Results of correlation analysis

	High accuracy	Low accuracy	No information
Production lead time and product quality score	0.007	0.245*	−0.177
Production lead time and "impatience"	0.249**	−0.034	0.494**
Production lead time and "accomplishment"	0.012	−0.237	−0.030

*$p < 0.05$, **$p < 0.01$

occur. Furthermore, it is conceivable that impatience had an effect when recognizing that the production LT is longer. However, weak correlation was found for High. For High, no difference is likely to occur from expected demand. Consequently, a rush is made to make plans with little margin while understanding demand. For the factor leading to feelings of impatience, No and High might differ.

Quality of the triangular pyramids varied among individuals because of differences in player dexterity. However, considerable quality variation was confirmed even for a single player (Fig. 1.7). This inconsistency might result from the order being completed earlier and products rushed to completion, exceeding the acceptable range that guarantees quality before and after the standard operating time. The relation between these changes in quality and production capacity requires additional analysis.

For this study, an employee satisfaction model was developed to illustrate service provision processes along with a production planning game simulating the service site of a labor-intensive restaurant service. Subsequently, the influence of accurate demand forecasting information related to service quality and productivity was analyzed using the developed game. We analyzed the relation between ES and employee status and productivity and quality in a short term using the hypothetical model. A food value creation design was demonstrated to show employee status and satisfaction.

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Chapter 2
Analysis and Prediction of Customer Behaviors for Restaurant Management

Takeshi Takenaka

Abstract An important task for restaurant managers is the prediction of customer behaviors. A restaurant manager must predict the number of customers coming in several days in advance and prepare foods based on the estimated sales quantities of their products. Based on those estimations, the manager's most important job is purchasing foods and ingredients and preparing for the necessary staff members in advance. However, the job is not always easy for several reasons. An important task for restaurant managers is the prediction of customer behaviors. A restaurant manager must predict the number of customers coming in several days in advance and prepare foods based on the estimated sales quantities of their products. Based on those estimations, the manager's most important job is purchasing foods and ingredients and preparing for the necessary staff members in advance. However, the job is not always easy for several reasons. This chapter discusses the problem structure of restaurant management related to customer behaviors. Then it presents some research examples for demand forecasting and menu design through analysis of customer behaviors using big data. Moreover, it describes the customer satisfaction mechanism based on survey data and presents discussion of how service productivity can be enhanced based on customer behavior characteristics.

2.1 Restaurant Management Problem Structure Related to Customer Behavior

First, if a restaurant is always full of customers with reservations, and if there is only one menu determined by the restaurant, then it is expected to be quite easy for an experienced manager to estimate the necessary foods or adequate labor input in advance. In other words, a manager does not need so-called demand forecasting.

Nevertheless, most restaurants welcome non-reserved customers if they have sufficient seats and allow customers to choose products from a menu book to any degree

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the restaurant can accommodate such customers. Additionally, a restaurant cannot control when such non-reserved customers enter the restaurant. Accordingly, it becomes difficult for a restaurant manager to estimate the exact number of customers and product sales for each time period of a day.

Figure 2.1 illustrates the basic problem structure of the restaurant manager's decision-making and performance indicators appearing as results of the manager's decision and other factors. The first difficulty arises from uncertainty in the estimation of the number of customers for a day. In practice, restaurant managers usually predict the number of customers for a day based on past data considering the day of the week or season. Additionally, they must consider external factors such as weather, temperature or special events near the restaurant. However, the mode of demand forecasting is often based on the manager's experience and intuition rather than on a scientific methodology. Therefore, the authors have developed a demand forecasting method for service providers including SMEs based on service engineering, as introduced in Sect. 2.2.

On whatever way of demand forecasting, a restaurant manager must make decisions about food purchases and the necessary labor input of kitchen or hall staff to serve meals to customers adequately. Consequently, those decisions lead to direct or indirect managerial indicators. If a manager estimates the number of customers as much less than the actual number, then the manager might reduce the labor input of staff members. As a result, labor productivity, which is often expressed as the total sales per staff, per hour will be higher than usual. Although it is apparently

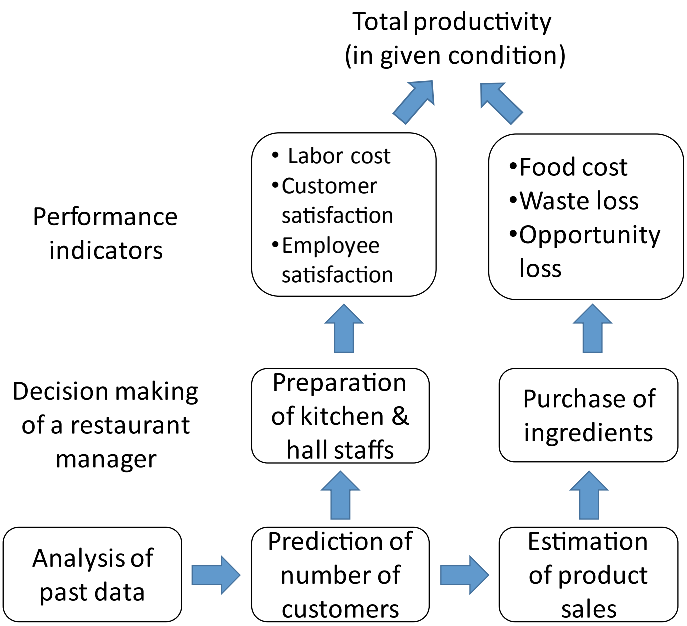

Fig. 2.1 Basic structure of a restaurant manager's decision making and performance indicators

good from the viewpoint of labor cost, it might also entail other negative results such as a decline of customer satisfaction because of increased waiting times or delay in serving dishes. Moreover, employees would be exhausted and complain about staff shortages. What is worse, overworked employees might not provide sufficient services or hospitality to customers. Poor services might result in losing repeat customers. However, oversupply of labor input based on overestimated customers can simply cause increased labor costs.

Estimation of product sales can be more difficult than that of the number of customers for restaurant managers because customers of various types choose from a menu on the table based on their preferences or health conditions. Accordingly, managers might try to prepare sufficient foods to satisfy various customer needs without a shortage of products. However, it can engender loss of foods because fresh foods spoil easily. Therefore, another difficulty derives from the constraints of food inventory control.

In fact, how can we predict various customers' choice of foods? A method often used in restaurant or retail industries is to calculate the share of customers who purchase a product among all customers. The figure is sometimes called the Purchase Index (PI) value in retail or restaurant service industries, especially in Japan. For instance, when 1000 customers out of all 10,000 customers who visit a restaurant in a certain period bought product A, the PI value of A is 10%. However, this method only considers the average probability of all customers and does not explain which types of customers purchase the product. Additionally, in the restaurant industry, because it is still not popular to introduce Customer Relationship Management (CRM) systems that can record the purchase history of all member customers, it is difficult to know the repeat rate of each product. Accordingly, the PI value cannot explain why 10% of all customers purchased the product. To elucidate the meaning behind the PI value, one should know a customer's decision-making processes and customer types who chose the product.

Figure 2.2 presents customer processes related to choosing products in a restaurant. Customers have various motivations to come to a restaurant related to their preferences for foods, experiences with a restaurant or similar type of other restaurant, or feeling of the day. Because repeat customers know the restaurant, they have expectations about products and services. Therefore, they sometimes do not need the menu book for choosing their favorite products. However, it is difficult to know first-time customers' expectations for the restaurant. Some customers might happen

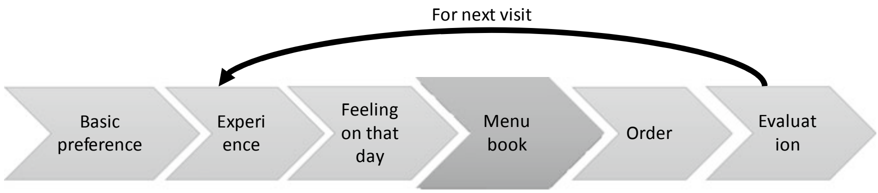

Fig. 2.2 Customer decision-making processes in a restaurant

to visit a restaurant with no expectations. Other customers might choose a restaurant based on information from the internet. In either case, a menu book might strongly influence first-time customers' choice of products.

Against that backdrop, a study example of how a menu might influence customers' decision making is introduced in Sect. 2.3. Moreover, a discussion of how one can ascertain various customers' needs and satisfaction at restaurants using technology is presented in Sect. 2.3.

2.2 Demand Forecasting

As discussed above, the number of the customers for a day is a fundamental measure for service industries, including restaurants, to infer customer demands. However, customer behaviors can be influenced by many environmental factors such as the calendar, the day of the week, weather, time, area, promotion or nearby events. Therefore, it is reasonable to understand customer arrival behaviors in terms of environmental factors.

The authors have developed a demand forecasting method using aggregate purchase data and environmental factors as "causal data" (Takenaka et al. 2011a, b). Using this method, one can specifically investigate common factors underlying customer behaviors as causal data. This method estimates the numbers of customers using more than 50 parameters with a multiple regression model including stepwise selection of parameters. Figure 2.3 presents an example of estimation results of the number of customers for a restaurant. In this case, the averaged accuracy of the model is 87.7%; 20 parameters are selected using stepwise selection of parameters,

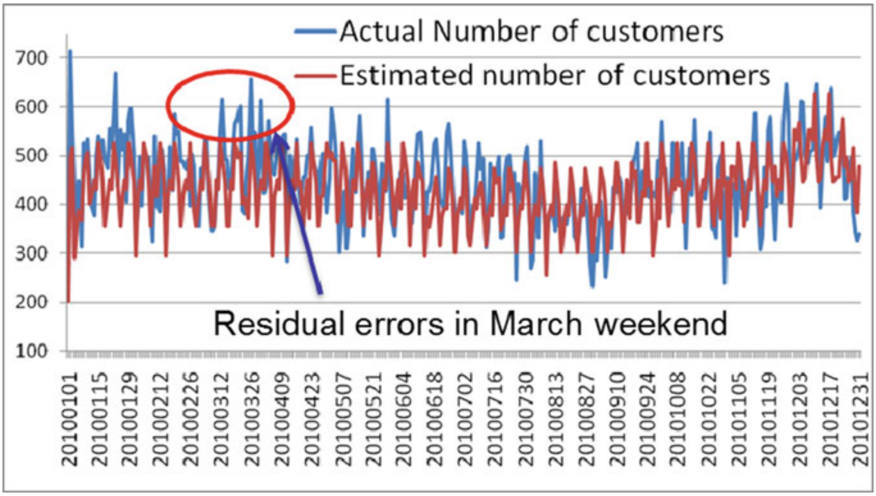

Fig. 2.3 Estimated number of customers for a restaurant

Table 2.1 Parameters and their respective multiple regression coefficients (n = 3500, Izakaya = 2500, Japanese restaurant = 700 and other type restaurants)

Constant term	353
Friday	172
Sunday during big holidays	154
Saturday	144
Jan. 3 (new year holiday)	143
Holiday during successive holidays	137
Weekday before holiday (except Fri.)	124
Holiday	121
End-year party season	103
Wednesday	98
Sunday	93
Thursday	76
Tuesday	60
Jan. 1 (new year holiday)	−289
Christmas Eve	−151
End of the year (3 days)	−150
Last day of holidays	−74
New year party season (Weekday of early Jan.)	−63
Rainfall exceeding 10 mm	−59
Max. Temp. over 32 °C	−52
Max. Temp. 27–31 °C	−39

as shown in Table 2.1. Using this table, they can readily estimate the numbers of customers according to environmental factors.

Using this method, one can construct a basic model for customer behaviors. The model includes some important measures that can be compared with other shops' models, as explained below.

(a) Accuracy of the model: The coefficient of determination (r^2) represents the model reliability using a prepared causal dataset. We can also calculate the model accuracy using a cross variation method.
(b) Selected parameters from the causal dataset: It is important information which parameters were selected using stepwise method because those factors have strong effects on customer behaviors. Moreover, the coefficient (number of customers according to each parameter) represents the size of the effect.
(c) Residual errors: Fig. 2.3 shows some residual errors, especially on some days. It is important to devote attention to which day such errors occur. We can sometimes find underlying factors except for causal data that are selected using the model.
(d) Variation of customer behaviors according to environmental factors: customer behaviors are not stable even on the same day of the week for instance. Variation

according to environmental factors can be an important measure, especially for comparison of stores of a chain or of an area.

Using demand forecasting models, one can compare standardized coefficients (coefficient divided by constant term) of constructed multiple regression models for many stores. Effects of factors can differ according to the characteristics of trade areas or customer needs. Especially, day-of-the-week effects vary according to the store location. Through those analyses, for example, area managers of a chain can realize differences of circumstances among restaurant stores.

Figure 2.4 presents a comparison of standardized coefficients (coefficient divided by constant term) of multiple regression models constructed for five restaurants. Effects of factors differ according to the trade area characteristics. Especially, day-of-the-week effects vary according to the restaurant location. Through those analyses, for example, area managers of a chain can realize differences of circumstances among restaurant stores.

As introduced above, the authors used a multiple regression model to predict customer numbers or sales because we think it is helpful for managers to know the causal factors in a quantitive manner. However, many other forecasting methods exist, such as the Box–Jenkins (ARIMA) model, Bayesian network model (Lasek et al. 2016) or other machine learning methods (Tanizaki et al. 2019). Recently many commercial software and cloud services using machine-learning methods for demand forecasting are also available. By those services, users can input many parameters related to day of the week, weather, events or other information without verification

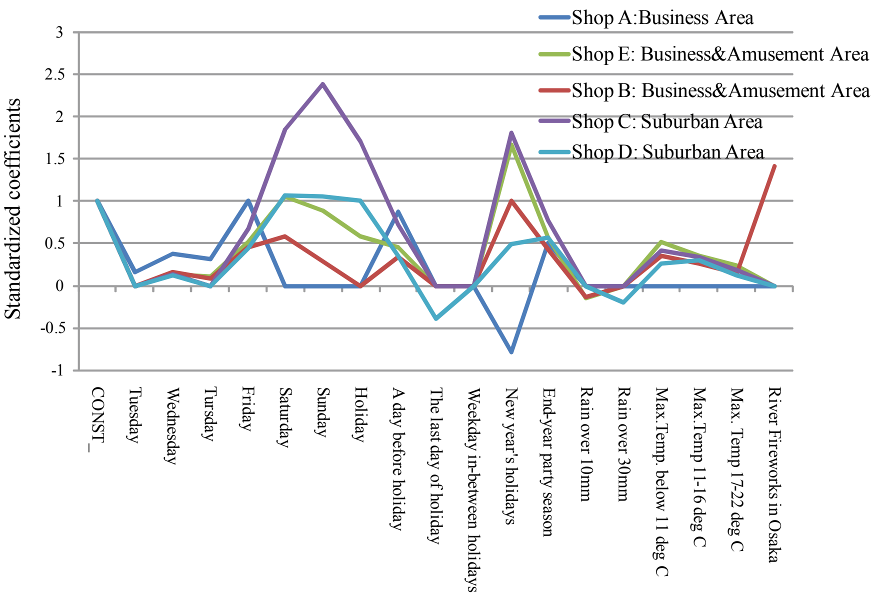

Fig. 2.4 Standardized coefficients of constructed multiple regression models for five restaurants

of each parameter. Although we actually confirmed that the accuracy of forecasting using machine learning with many unverified parameters is sometimes better than our method introduced above, it remains unclear how much each parameter affects the sales or number of customers because the constructed models are often too complicated for humans to understand. Acquired models using machine learning are sometimes a black box. When constructing a demand forecasting model, it is most important to choose adequate parameters considering that some parameters can have mutual multicollinearity. For example, because humidity and the amount of rainfall might have multicollinearity, we should verify those parameters carefully in advance. Moreover, effects of events on sales should be verified considering other factors. It is useful to check the degree to which sales have increased with a particular event using past data considering other factors such as the day of the week. Through those verifications, restaurant managers might have additional scientific hypotheses.

2.3 Customer Choice of Products and Menu Design

Customer choice of products in a restaurant is affected strongly by the menu book design. The menu book is an important touchpoint that provides various information about products and which gives messages from the restaurant to customers. Many variations exist in menu books, such as simple lists of dish names and prices, lists with pictures, or unprogrammed menus with recommendations or pop-up messages from restaurant.

Customers' choices of products are greatly affected by pictures of products, the position on the menu, recommendations, and prices. One major factor affecting customers' choice is expected to be the position of products on a menu book. Although a famous story of menu design is that the customer's eye movement often starts from the upper right to other positions on the menu, it might be not so simple in actual cases of restaurants (Bowen and Morris 1995; Yung 2012) because menu design varies according to countries and cuisine. Figure 2.5 shows a menu book of a Japanese cuisine restaurant chain. The number of the figure shows the sales rank of products included in each area of the menu book. Table 2.2 shows actual sales of products in each area in a certain period. Results show that product sales on the upper area of the menu book were greater than in the middle or lower areas.

However, many other factors such as the product name, picture, price, and pop-up recommendation can also affect customers' product choices. Therefore, the analysis above is insufficient to elucidate the effects of the menu book on the customer choice of product as an experiment. If one wants to verify factors in a scientific way, one must prepare some variety of menu books that use the same products with different layouts, although such experiments might not be easy for actual restaurant companies. A possible means of verifying various effects of the menu book on customer choice is the comparison of product sales made before and after changes of a menu book. Actually, many restaurant chains change their menu book seasonally.

Fig. 2.5 Product sales according to menu position. Number shows sales ranking of 6 areas

Table 2.2 Product sales by position

Upper left (9 items): 1816	Upper right (9 items): 2012
Middle left (14 items): 1110	Middle right (5 items): 544
Lower left (15 items): 1318	Lower right (11 items): 1280

Therefore, the authors conducted an experiment (Takenaka and Shimmura 2010). Figure 2.6 shows two lunch menus of a Japanese restaurant chain which mainly provides pork cutlets (Tonkatsu). This restaurant chain changed the lunch menu on the table during summer–autumn on September 21, 2009. We used purchase data of five restaurant shops that used the same menu, two months in all before and after the

Fig. 2.6 Two seasonal lunch menus of a Japanese pork cutlet restaurant

change in menu. We analyzed the effects of the change on product sales. The total sales on those menus during the two periods were almost equal (16034 vs. 16047). Therefore, the numbers of customers for both periods can also be regarded as almost equal. Based on those conditions, it might be reasonable to compare changes in all sales of some products that appeared on both menus while considering the change in menu design.

Product A on Fig. 2.6, for example, is the top-selling lunch set, which is also the least expensive product (680 Japanese yen) on both menus. This phenomenon coincides with the popular hypothesis that the upper left is the best position to catch the customer's eye. However, with the change in menu, the sales of product A went down 21%, although the product remained the top seller in the new lunch menu. However, product B (two products with different volumes) is a regular pork cutlet product. The position on the menu of B changed from the lower right to the upper left. Consequently, the sales of B increased by 12 and 15%. Those results in the change of sales of products A and B might be affected by the menu position. However, we also find a change in sales of products even if the positions were almost identical. The sales of product C increased by 10% on the new lunch menu. Probably, this change occurred because the picture and font size became larger. In this way, one can discuss the effects of menu book design on customer choice using large amounts of purchase data.

Another interesting finding of this experiment was the change in average customer spending. A restaurant industry representative reported to the author that Japanese customers tend to consider average prices of products on the menu, although the assertion was not proved. If this supposition is correct, then customers might roughly calculate the average price by checking some products on the menu. Figure 2.7 extracts price information from Fig. 2.6. If customer eyes could be attracted by the upper part of menu, then they might perceive average prices of products lower in the left menu. Actually, the average customer spending amount changed from 825 yen (left menu) to 844 yen (right menu). Although this hypothesis should be investigated further, the price on the menu is also expected to include important information for customers to choose products in a restaurant.

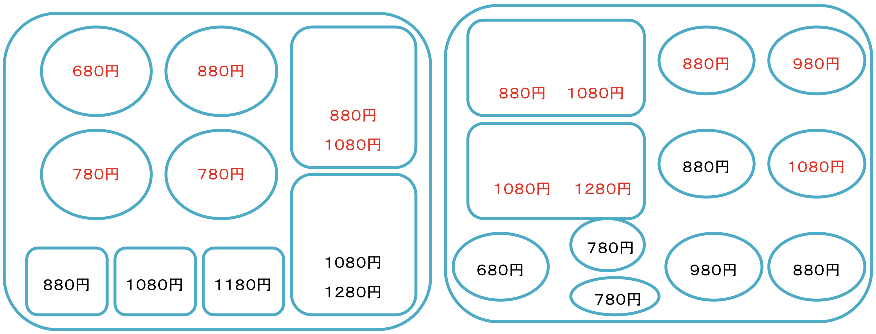

Fig. 2.7 Prices of products on two menus

2.4 Technology for Customer Contact

As discussed above, the menu book can strongly influence a customer's choice of products. However, other important problems persist even if we understand how customers choose products from a menu. Many customers, especially new customers, choose products based on their expectations rather than their experiences. Therefore, even a best-selling product is not necessarily the most satisfying product. Moreover, for modeling of customer needs and behaviors, one must consider the diversity of customer preferences and the reasons underlying customer satisfaction.

Against that backdrop, we introduced an interactive device using a tablet computer for customer contact. It recommends products and elicits data related to customer needs and satisfaction through natural interaction (Takenaka 2012, 2013). Figure 2.8 portrays screenshots of this device. The left panel shows promotion of some products. The right panel shows a customer satisfaction rating for a product after eating.

Figure 2.9 shows customer rating results for some products of a Japanese restaurant chain. The products are best-selling products of the restaurant chain according to comprehensive purchase data. Customers' subjective ratings vary according to the product type. For example, product A is a dish that includes tofu. Over 50% people awarded it a "Gold Prize". However, further investigation reveals that the satisfaction felt by repeat customers and new customers might differ. Figure 2.10 shows the difference of rating for the product. This product is appreciated more by repeat customers than by new customers. Moreover, other data acquired using this device show that repeat customers choose this product more often than new customers do. Therefore, this product has the potential to enhance customer satisfaction.

As discussed above, it is important to verify customers' decision-making mechanism of choosing a product and their evaluation of it after eating. The gap separating high expectations and lower evaluation can result in disappointment. Moreover, repeaters' choices of products give great information to elucidate product value even if they do not evaluate products explicitly.

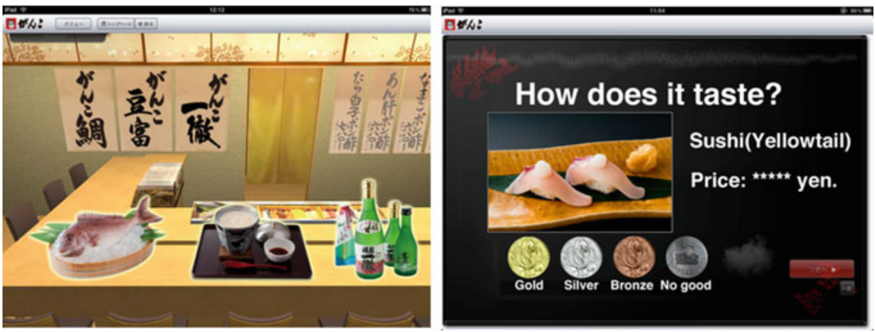

Fig. 2.8 Screenshots: promotion of products (left), customer satisfaction rating to each product after eating (right)

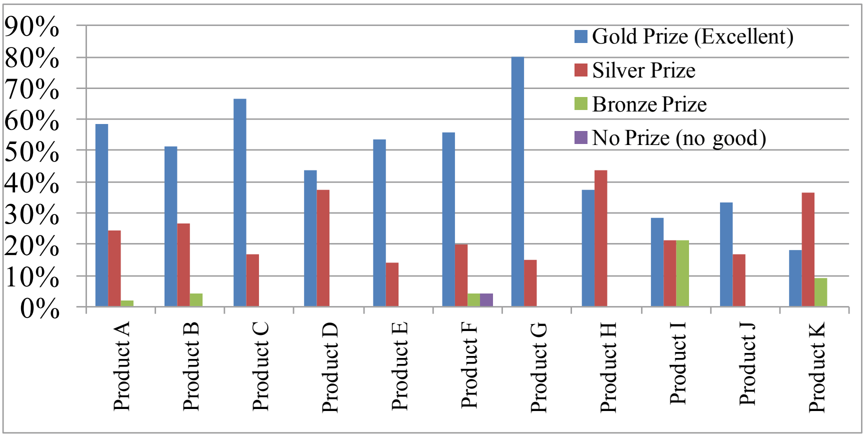

Fig. 2.9 Sample of customer ratings for hot-selling products of the restaurant chain

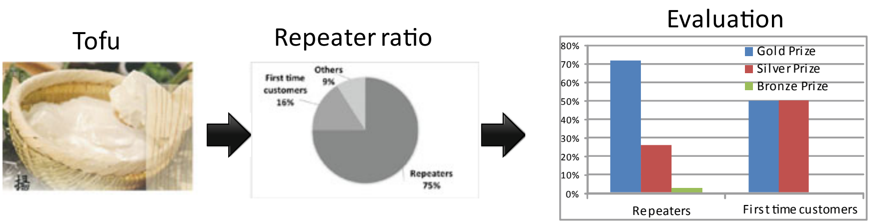

Fig. 2.10 Customer product ratings, comparing repeaters and new customers

2.5 Customer Satisfaction Mechanism

Earlier sections described how we can analyze customer behaviors based on data acquired at actual restaurants. For example, we can use purchase data combined with environmental data for demand forecasting, which is an important task for restaurant businesses. Moreover, it presents a research example of how one can verify the menu design effects for the customer's choice of products, combining menu design and purchase data.

However, it remains insufficient to elucidate customer needs and satisfaction because purchase data do not tell us why and which types of customers purchased those products. It is still not common in restaurants that each customer's behavior is recorded using membership systems, although recent rapid digital transformation including digital money might change the current situation in the near future. At present, it remains difficult for us to ascertain differences between behaviors of repeat customers and those of first-time customers. The research example of the customer contact device introduced in Sect. 2.4 highlights challenges to acquisition of customer feedback, including their on-site satisfaction.

Furthermore, customer satisfaction for a restaurant is not only affected by the quality of products (meals). Customers also evaluate other factors such as service quality, hospitality of staff members, and atmosphere of the restaurant including cleanliness. Overall satisfaction to a restaurant has often been represented by the willingness to revisit and willingness to recommend.

The authors have investigated those mechanisms underlying customer satisfaction to the restaurant based on large-scale mystery shopping survey data conducted by MS & Consulting Co. Ltd. A Structural Equation Modeling (SEM) method was used to analyze the relations among factors related to customer satisfaction. We used 3500 mystery shopping survey data of Japanese restaurants of several kinds including Japanese pub restaurants (Izakaya), family restaurants, and fast-food restaurants. We used many possible models through a trial and error process. Figure 2.11 presents a model that illustrates causal relations among factors related to customer satisfaction. We used some well-known measures of fit for the assessment of model fit, including Root Mean Square Error of Approximation (RMSEA) or Goodness of Fit Index (GFI). For this model, GFI was 0.923; RMSEA was 0.131. Most researchers concur that a GFI of 0.9 or more indicates good fit, although an RMSEA of 0.1 or more denotes a poor fit. Therefore, this model is not the best fit, but it can be a reasonable model.

As the model indicates, restaurant owners should enhance customer satisfaction to increase loyal customers who often revisit and recommend their restaurants to friends. For this end, not only satisfaction with products but also hospitality of staff members and atmosphere of restaurant including cleanliness are important. Moreover, continuous assessment of customer satisfaction based on behavior data and questionnaire survey data and long-term strategies to improve services are fundamentally important. Furthermore, it is important to consider customer diversity. CRM with individual customers will be more important for restaurants to survive and thrive in worldwide competition of restaurant businesses.

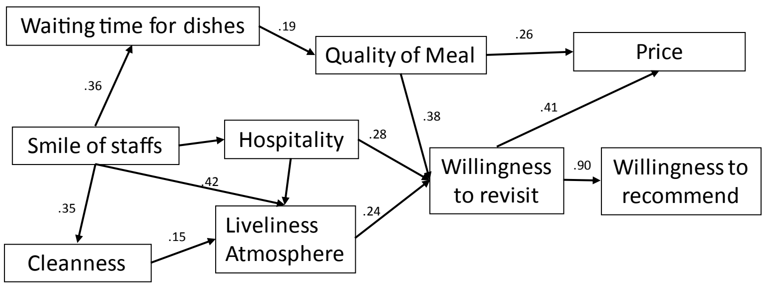

Fig. 2.11 Structure of customer satisfaction in restaurants

As introduced in this chapter, scientific methods based on actual data can help restaurant managers to create new services continuously based on changing customer needs.

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Chapter 3
Mathematical Modeling for Gastronomy Service Process

Takashi Tanizaki

This section describes a design method using operations research, especially simulation and mathematical optimization, for a gastronomy service system. Operations research is a study that provides an optimal operation method to a system. Operations research includes various methods such as linear programming, combinatorial optimization, queuing, and simulation. Therefore, it is necessary to use a suitable method for system characteristics and the design purpose.

In fact, because services have different characteristics from those of manufacturing, it is necessary to keep their characteristics in mind when designing service processes. Additionally, the value of services as a concept different from manufacturing must be kept in mind. We outline the characteristics and values of services. Then we describe mathematical modeling for gastronomy service processes.

3.1 Characteristics and Values of Services

Services have many characteristics (Murakami and Arai 2017). When designing a gastronomy service system, one must do so considering simultaneity and disappearance of the product along with the characteristics presented below.

(1) Intangible …Services have no physical form that industrial products have.
(2) Simultaneity … Services are consumed at the time they are produced.
(3) Heterogeneity … Recognition of service value differs depending on the person, time, and place.
(4) Disappearance … Services cannot be inventoried.

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As such, the design of services is inherently different from the design of industrial products that involve physical form. Industrial products are introduced to customers through design, production, transportation, and sales. After introduction to the customer, direct contact with the customer will occur. After an introduction to the customer, direct contact with the customer will occur and will be disposed of after utilization and maintenance. That is, the industrial products are designed using a product specification converted from the customer request based on the use-to-disposal process. No customer–manufacturer interaction exists at the production stage.

By contrast, with services, various interactions occur between the provider and the customer at the utilization stage. Therefore, when designing services, it is necessary to consider factors that have not been considered in the design of industrial products, such as locations where employees and stores are provided and storage yards. In service design, interaction between the service provider and the customer during the usage stage must be designed directly. In the design of engineering products, human decision-making is not the subject of design, but in service design, human decision-making comes into the subject of design.

Another important issue exists in service design: the issue of how to create customer value in the usage cycle. It is difficult to generally describe the relationship between service design and its value. Ueda et al. proposed differences in the value creation process (Ueda et al. 2009). Ueda et al. proposed a value creation model that classifies value creation processes into three classes based on the concept of emergent synthesis (Ueda et al. 2001) in production engineering (Fig. 3.1).

(1) Class I: Providing Value Model

The product/service provider and its receiver are defined independently. Their values (objectives) and environments are clear. The model can be described completely with a closed system. Optimization strategy is fundamentally important. In designing the gastronomy service process, what applies to this class is the case if the provider has

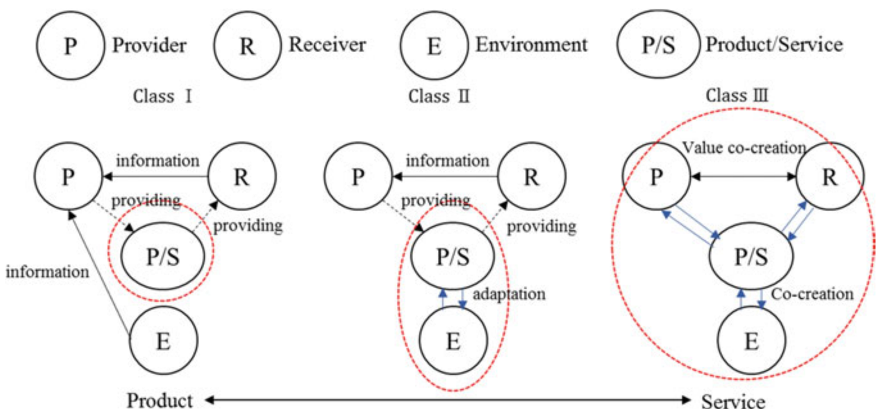


Fig. 3.1 Value creation models

a clear goal (e.g. improving customer satisfaction) and if the resources to achieve it can also be modeled clearly.

(2) Class II: Adaptive Value Model

The objective of product/service receiver is defined completely. However, the environment is changing and not predictable. Therefore, the model is to be an opened system. An adaptive strategy is therefore fundamentally important. In the design of the gastronomy service processes, what applies to this class is the case if a provider with a clear goal (e.g. improving customer satisfaction) and the resources to achieve it changed depend on environmental changes.

(3) Class III: Co-creative Value Model

The objective of the product/service receiver is uncertain even for itself. Therefore, the provider and receiver cannot be mutually separable. Value-co-creation by the provider and receiver is fundamentally important. In the design of gastronomy service processes, what applies to this class is the case in which the service is provided while listening for information related to preferences to improve the satisfaction of customers whose provider is not clear.

3.2 Mathematical Modeling for Gastronomy Service Process

There are various target fields in gastronomy service. Their methods and results for modeling differ depending on the target field. Even in the same target field, modeling differs depending on the class shown in Sect. 3.1 and the service type between the service provider and the service receiver. Because it is difficult to discuss gastronomy service process models in general, and because we are aiming at describing mathematical modeling, herein, we discuss what is often regarded as a design target.

Two service processes are discussed as modeling objects. One process is a service process of ordering, cooking, serving dishes, and payment in a restaurant. During this process, service providers (i.e. kitchen staff and waitpersons) and service receivers (i.e. customers) are associated at each service stage. This service process has the goal of reducing waiting times to improve customer satisfaction. A restaurant has many customers. Therefore, the actions of other customers can cause unexpected environmental changes. From the explanation above, this process is classifiable as class II. Another process is the modeling of staff scheduling based on the desired working hours of the restaurant staff. This scheduling problem has a clear goal of working time placement for staff to improve customer satisfaction. In addition, there are various restrictions (e.g. working hours of staff). This problem is classifiable as class I because the model can be described clearly. In the following, mathematical modeling for gastronomy service process is described using modeling methods and numerical examples for these two cases.

3.3 Modeling of a Restaurant Service Process (Tanizaki and Shimmura 2017)

This section describes modeling of restaurant service processes. In this model, let a waitperson be a service provider and let a customer be a service receiver. This service process deals with the process from a customer entering a restaurant to leaving after dining. Conditions of customers and waitpersons change in a restaurant hall while interacting. Figures 3.2 and 3.3 show the condition transition of customers and waitpersons. In conditions of customers in Fig. 3.2, Waiting for water, Waiting on an order, Waiting for dishes, Waiting for offers, Moving to the cashier, and Payment change to the next condition as a result of interaction with waitpersons. Regarding conditions of waitpersons in Fig. 3.3, all conditions change to the next condition as a result of interaction with customers. Queuing theory, which is one of the methods of operations research, is often adapted to modeling and analysis. Queuing theory is an effective analytical technique to use when a customer has a static relation with the waitperson. It is difficult to analyze service processes by which a waitperson and customer mutually interact and move at a restaurant. Therefore two-dimensional cellular automata (CA) are used to model customer and waitperson behavior. Next, we outline CA, the mathematical method used for this modeling.

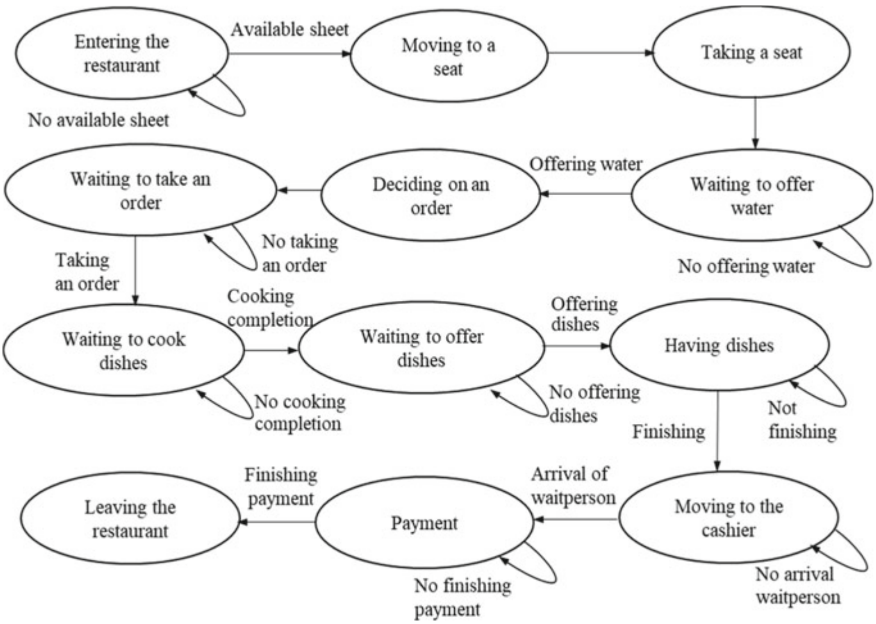


Fig. 3.2 Condition transition of customers

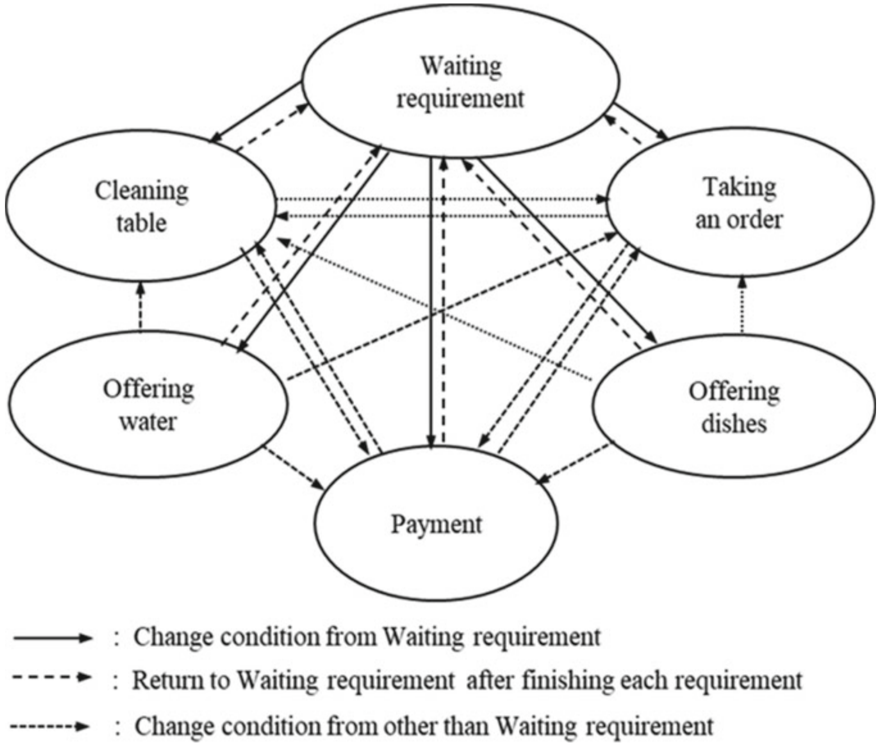


Fig. 3.3 Condition transition of waitperson

3.3.1 Cellular Automata

CA is automata with a cellular structure. It is a characteristic of CA that analysis objects are divided into the division domain called cells. Their overall behavior is expressed through interaction with neighboring cells (Katoh et al. 1998). Complicated aspects emerge even when simple rules are set. Therefore, it is a convincing analytical technique of complicated systems such as refugee flow simulation (Ohi and Onogi 2008). Regarding CA environments, CA can be one-dimensional or two-dimensional. Two-dimensional CA is applied for this modelling.

Two-dimensional CA are automata placed in a cell two-dimensionally (Fig. 3.4). The condition transition of the two-dimensional with neighborhood range r is described in Eq. (3.1).

$$C_{ij}(t+1) = f\left(C_{i-r,j-r}(t),\ C_{i-r,j-r+1}(t),\ \ldots,\ C_{ij}(t),\ C_{i,j+1}(t),\ \ldots,\ C_{i+r,j+r}(t)\right) \tag{3.1}$$

$C_{ij}(t)$: Condition of cell (i, j) at time $t(t,\ i,\ j$ are integer values of 0 or more)

Fig. 3.4 Eight cell coordinates centered around $\boldsymbol{C_{ij}(t)}$

$C_{i-1,\,j+1}(t)$	$C_{i,\,j+1}(t)$	$C_{i+1,\,j+1}(t)$
$C_{i-1,\,j}(t)$	$C_{i,\,j}(t)$	$C_{i+1,\,j}(t)$
$C_{i-1,\,j-1}(t)$	$C_{i,\,j-1}(t)$	$C_{i+1,\,j-1}(t)$

3.3.2 Modeling of Restaurant Service Processes Using CA

The modeling of restaurant service process using two-dimensional CA is described hereinafter. The planar layout of the restaurant is expressed by two-dimensional coordinates (i, j). This two-dimensional coordinate can be regarded as a cell (i, j) of a two-dimensional CA. The customer and waitperson condition is defined as the cell condition. Furthermore, the movement of customer and waitperson in a restaurant is defined as movement from cell to cell. As a result, the change and movement of the condition of the customer and the waitperson can be expressed by the condition transition of the cell. Letting C_m^v be condition v of customer m and letting p_l^u be condition u of waitperson l, then the condition $C_{ij}(t)$ of cell (i, j) at time t is described in Eq. (3.2).

$$C_{ij}(t) = \begin{cases} C_m^v : & \text{Customer } m \text{ in condition } v \text{ at cell}(i,\ j) \text{ at time } t \\ P_l^u : & \text{Waitperson } l \text{ in condition } u \text{ at cell}(i,\ j) \text{ at time } t \\ 0 : & \text{No customer and waitperson at cell}(i,\ j) \text{ at time } t \end{cases} \tag{3.2}$$

The location movement of the customer and waitperson is modeled as moving one cell at a time per unit time. The restaurant service process can be modeled as a two-dimensional CA with a neighborhood range of 1 surrounded by 8 cells around the central cell. As a result, the condition transition of cell $C_{ij}(t)$ is described in Eq. (3.3).

$$\begin{aligned} C_{ij}(t+1) = f_q^r(&C_{i-1,j-1}(t),\ C_{i-1,j}(t),\ C_{i-1,j+1}(t), \\ &C_{i,j-1}(t)\ , C_{ij}(t),\ C_{i,j+1}(t), \\ &C_{i+1,j-1}(t)\ , C_{i+1,j}(t),\ C_{i+1,j+1}(t)) \end{aligned} \tag{3.3}$$

f_q^r : A function that expresses that the cell condition transitions from q to r

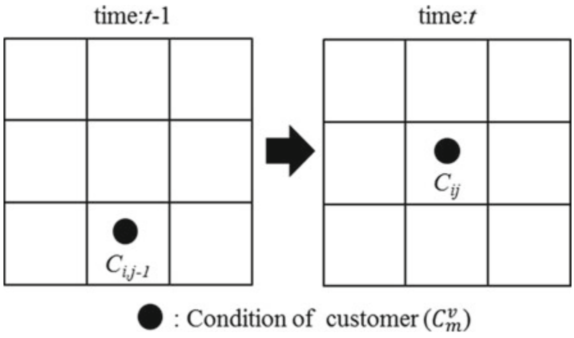


Fig. 3.5 Movement between cells

As an example, consider that customer m moves from cell (i, j-1) to cell (i, j) in condition v at time t-1 to t as shown in Fig. 3.4. This condition transition is described in Eqs. (3.4) and (3.5) (Fig. 3.5).

$$C_{i,j}(t) = f_0^{C_m^v}\left(C_{i,j-1}(t-1),\ C_{ij}(t-1)\right) \tag{3.4}$$

$$C_{i,j-1}(t) = f_{C_m^v}^0\left(C_{i,j-1}(t-1),\ C_{ij}(t-1)\right) \tag{3.5}$$

3.3.3 Application of CA to This Modeling

Condition $C_{ij}(t)$ of customers shown in Fig. 3.2 is expressed as follows using C_m^v:

C_m^1 : Entering the restaurant
C_m^2 : Moving to a seat
C_m^3 : Taking a seat
C_m^4 : Waiting to offer water
C_m^5 : Deciding on an order
C_m^6 : Waiting to take an order
C_m^7 : Waiting to cook dishes
C_m^8 : Waiting to offer dishes
C_m^9 : Having dishes
C_m^{10} : Moving to the cashier
C_m^{11} : Payment
C_m^{12} : Leaving the restaurant

Function to express condition transition of customers in Eq. (3.3) is expressed as follows:

$f_0^{c_m^1}$: Changing from null to Entering the restaurant
$f_{C_m^1}^{c_m^2}$: Changing from Entering the restaurant to Moving to a seat

$f_{C_m^2}^{c_m^3}$: Changing from Moving to a seat to Taking a seat
$f_{C_m^3}^{c_m^4}$: Changing from Taking a seat to Waiting to offer water
$f_{C_m^4}^{c_m^5}$: Changing from Waiting to offer water to Deciding dishes
$f_{C_m^5}^{c_m^6}$: Changing from Deciding dishes to Waiting to take an order
$f_{C_m^6}^{c_m^7}$: Changing from Waiting to take an order to Waiting to cook dishes
$f_{C_m^7}^{c_m^8}$: Changing from Waiting to cook dishes to Waiting to offer dishes
$f_{C_m^8}^{c_m^9}$: Changing from Waiting to offer dishes to Having dishes
$f_{C_m^9}^{c_m^{10}}$: Changing from Having dishes to Moving to the cashier
$f_{C_m^{10}}^{c_m^{11}}$: Changing from Moving to the cashier to Payment
$f_{C_m^{11}}^{c_m^{12}}$: Changing from Payment to Leaving the restaurant

Condition $C_{ij}(t)$ of waitpersons shown in Fig. 3.3 is expressed as follows using p_l^u

p_l^1 : Entering requirement
p_l^2 : Offering water
p_l^3 : Taking an order
p_l^4 : Offering dishes
p_l^5 : Payment
p_l^6 : Cleaning table

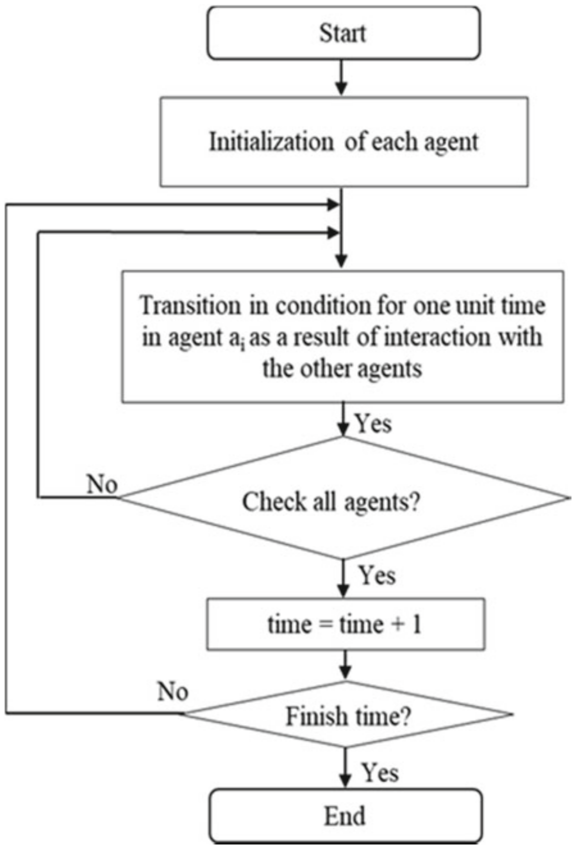
Functions to express the condition transition of waitpersons in Eq. (3.4) is expressed as follows:

$f_0^{p_l^1}$: Changing from null to Waiting requirement
$f_{p_l^1}^{p_l^2}, f_{p_l^1}^{p_l^3} f_{p_l^1}^{p_l^4}, f_{p_l^1}^{p_l^5}, f_{p_l^1}^{p_l^6}$: Changing from Waiting requirement to each condition
$f_{p_l^2}^{p_l^1}, f_{p_l^3}^{p_l^1}, f_{p_l^4}^{p_l^1}, f_{p_l^5}^{p_l^1}, f_{p_l^6}^{p_l^1}$: Changing from each condition to Waiting requirement
$f_{p_l^2}^{p_l^3}, f_{p_l^2}^{p_l^5}, f_{p_l^2}^{p_l^6}$: Changing from Offering water to each condition
$f_{p_l^3}^{p_l^5}, f_{p_l^3}^{p_l^6}$: Changing from Taking an order to each condition
$f_{p_l^4}^{p_l^3}, f_{p_l^4}^{p_l^5}, f_{p_l^4}^{p_l^6}$: Changing from Offering dishes to each condition
$f_{p_l^5}^{p_l^3}, f_{p_l^5}^{p_l^6}$: Changing from Payment to each condition

3.3.4 Multi-agent Simulation

Next, we move on to analysis of restaurant service processes. In restaurant service processes, customer satisfaction is related to various factors such as service waiting time, the deliciousness of dishes, and the hospitality of restaurant staff. An analysis of service waiting time that can be handled quantitatively is described in this book. Queuing theory is used conventionally for analyses of queue and waiting time (Takahashi and Morimura 2001). Queuing theory is effective for analysis when relations of service providers and receivers are static, as at bank counters. Like service processes of restaurants, it is difficult to analyze dynamic processes, such as restaurant service processes, where customers who are service receivers and waitpersons who are service providers interact and move to change the situation. In recent years, multi-agent simulation (MAS) has attracted attention as an analytical method of such processes. In actuality, MAS is a method to simulate the real world on a computer and to analyze the behavior of objects using multiple agents. Figure 3.6 shows that each agent acts independently and autonomously on the MAS, so the whole simulation can be executed through interaction with other agents and the neighboring environment. MAS can express human and organizational activities naturally. MAS can express human and organizational activities naturally, and because it is a simulation based on humans and organizations, it is readily applicable to simulate verification of events involved

Fig. 3.6 Overview of MAS flowchart



in decision-making (Nakanishi et al. 2003; Kawamura et al. 2003). Figure 3.6 shows the stepwise process for MAS. Within the system, all agents (customers and waitpersons) start by following a sequence of actions or conditions for transition, as shown through Figs. 3.2 and 3.3. If an agent satisfies a particular rule, it then moves to the next step to restart the process. After taking a dish, a customer moves to the cashier and leaves the restaurant. The system computes the overall time a customer stays in the restaurant. Then the process follows as in the earlier step. The simulation ends when the event queue is empty.

3.3.5 Case Study of This Method

As a case study of this method, an analysis of the seating arrangement of a restaurant is described. Restaurant A, for which the case study is conducted, is a restaurant specializing in pork cutlets in a restaurant street adjacent to the main station. Many restaurants exist in this street. When waiting for entering a restaurant occurs because the seat is full or no vacant seat exists for the number of group customers, there is a problem that the customer selects another restaurant without waiting.

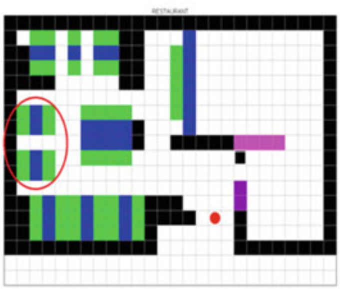
Therefore, using this design method, measures to improve the service process of restaurant A are examined. In other words, the service process of the restaurant hall is modeled based on an analysis of customer visit results. Using this model, the relations among the seat layout, the number of waitpersons, and customer queues are analyzed.

Figure 3.7 shows the seat layout of restaurant A. The maximum number of customers who can use this restaurant is 43; that of groups is 21. Three waitpersons serve customers. The method used to reduce the customer waiting time is the following.

(1) Shortening time to take orders and offer dishes of waitpersons.
(2) Shortening time to cook dishes of kitchen staff.

The purpose of service process design in this case study is (1).

Table 3.1 presents findings of the customer visit ratio at lunch time. As for the



Maximum number of customers: 43
Maximum number of groups: 21

Seat ratio for customers per group

Customers per group	1	2	Over 4	Total
Ratio (%)	62	5	33	100

Fig. 3.7 Seat layout of restaurant A

Table 3.1 Visit customer ratio at lunch time

Customers per group	1	2	3	Over 4	Total
Ratio (%)	76	19	3	2	100

number of customer ratio per group, one is 76%, two are 19%, and four or more are 2%. On the other hand, as for the seat ratio of restaurant A, a seat for one customer is 62%, and a seat for four customers is 33% (Fig. 3.7). Therefore, there is estrangement between the ratio of customer ratio per group and ratio of the seat. When a seat for four customers is used alone seat efficiency decreases because this restaurant does not allow customers from different groups to share a table. Figure 3.7 shows store improvement plan I, for which seats for one customer are increased, thereby reducing seats for four customers. It is difficult to extend a central seat in the facilities limitation of this restaurant. Therefore, Fig. 3.8 shows store improvement plan II of a realistic seat layout with the central seat as it is. Figures 3.7 and 3.8 show the ratio of the seats in store improvement plans I and II. The maximum number of customers who can use this restaurant decreases. However, that of customer groups increases by both Improvement plans I and II.

The purpose of this case study is the design of a restaurant model that decreases the number of customers waiting to enter the restaurant (waiting customers) by changing the seat layout and the number of waitpersons. Therefore, following (1), (2) are compared for existing restaurant, improvement plan I, improvement plan II to inspect restaurant improvement plan that is effective for the decrease in the number of waiting customers (Fig. 3.9).

(1) The number of waiting customers
(2) Seat-sharing ratio (= the number of seats customers using/total seats)

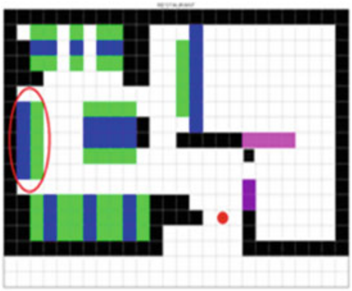
Results of a computer simulation using visit customer data for two weeks are shown. Figure 3.10 and Table 3.2 show the average numbers of waiting customers. Figure 3.10 shows that the number of waiting customers decreases both improvement plan I and improvement plan II in comparison with an existing store. Table 3.2 shows that the average number of waiting customers is 0.288 for the existing restaurant,

Maximum number of customers: 42
Maximum number of groups: 26

Seat ratio for customers per group

Customers per group	1	2	Over 4	Total
Ratio (%)	77	4	19	100

Fig. 3.8 Store Improvement Plan I



Maximum number of customers: 40
Maximum number of groups: 24

Seat ratio for customers per group

Customers per group	1	2	Over 4	Total
Ratio (%)	75	4	21	100

Fig. 3.9 Store Improvement Plan II

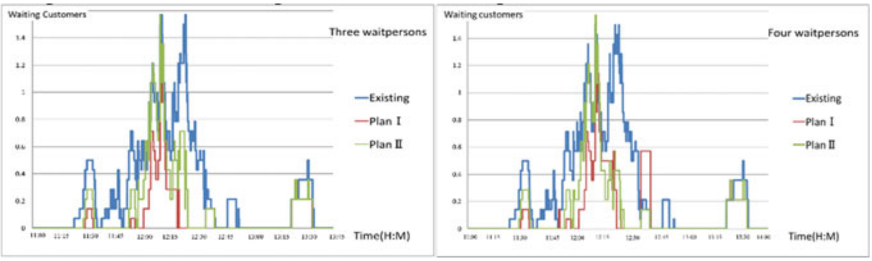


Fig. 3.10 Average waiting customers

Table 3.2 Average number of waiting customers

Waiting customers	Waitperson = 3			Waitperson = 4		
	Existing	Plan I	Plan II	Existing	Plan I	Plan II
Average	0.288	0.078	0.13	0.273	0.9	0.13
Peak	13	11	14	13	11	14

0.078 for improvement plan I, and 0.130 for improvement plan II in the case of three waitpersons. In other words, the average numbers of waiting customers of improvement plans I and II decrease in comparison with the existing store. The average number of waiting customers is 0.273 for the existing store, 0.090 for improvement plan I, and 0.130 for improvement plan II in the case of four waitpersons. The average number of waiting customers of improvement plans I and II also decrease as in the case of three waitpersons. The average numbers of waiting customers of three waitpersons and four waitpersons are almost equal.

Figure 3.11 and Table 3.3 show seat sharing ratios. Figure 3.11 shows that the seat-sharing ratios are lower for both improvement plan I and improvement plan II in comparison with existing stores. Table 3.3 shows that the average seat-sharing ratio as 52.8% for the existing store, 42.8% for improvement plan I, and 42.8% for improvement plan II in the case of three waitpersons. In other words, the average seat-sharing

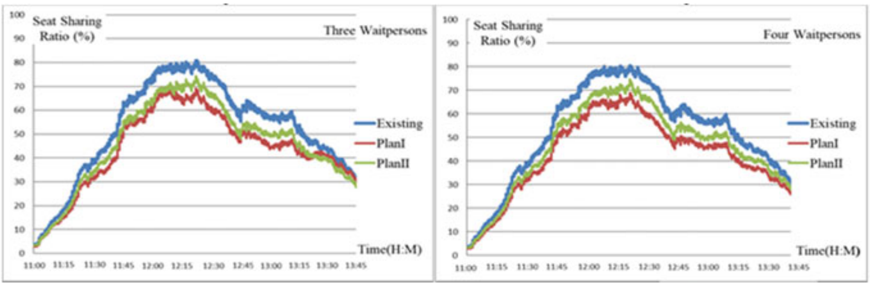


Fig. 3.11 Average seat-sharing ratio

Table 3.3 Average seat-sharing ratio

Waitperson	Existing	Plan I	Plan II
3	52.3	42.8	46.3
4	52.3	42.8	46.3

ratio of improvement plan I and II decreases in comparison with an existing store. The average seat-sharing ratio is 52.3% for the existing store, 42.8% for improvement plan I, and 46.6% for improvement plan II in the case of four waitpersons. The seat-sharing ratio decreases and the outbreak of waiting are controlled.

3.4 Modeling of Work Scheduling

This section describes the modeling of work scheduling based on the desired working hours of restaurant staff. Specifically, it is the modeling of a business process that decides the working hours of staff members working in a store. In this business process, when the objective and constraints for realizing the objective are clear (i.e. classified into class I), it can be modeled as an optimization problem. The following outlines the optimization problem required for modeling. It then describes the case of modeling.

3.4.1 Optimization Problem (Yagiura and Ibaraki 2001)

The optimization problem is generally formulated as follows:

$$\text{Minimize or Maximize } f(x) \qquad \text{s.t. } x \in F. \tag{3.6}$$

Therein, $f(x)$ is called an objective function; F is called a feasible region. F is a solution set satisfying the constraints. $x \in F$ is called a feasible solution, $x \notin F$

is called an infeasible solution. The objective function $f(x)$ is a function that takes a real number value or an integer value. The feasible solution that minimizes $f(x)$ is the optimal solution. Finding such a solution is the goal of the optimization problem. If F has a combinatorial structure, then Eq. (3.6) is called the combinatorial optimization problem. A number of algorithms have been studied to solve combinatorial optimization problems, and optimization solvers are also sold. Therefore, an optimization solver is useful to solve for this class of problems related to the gastronomy service process by modeling them into a combinatorial optimization problem. The following describes typical combination optimization problems.

(1) Traveling salesman problem

Given a set of n cities $V = \{1, \cdots, n\}$ and a distance $d_{ij}(i, j \in V)$ between cities i and j, after visiting all the cities exactly once, the problem is to find the shortest route by which a traveling salesman can visit each city and return to the starting point. This problem is expressed as shown as follows;

$$\text{Minimize} \sum_{i=1}^{n}\sum_{j=1}^{n} d_{ij}x_{ij} \tag{3.7}$$

$$\text{Subject to} \sum_{i=1}^{n} x_{ij} = 1, \quad j = 1, 2, \cdots, n \tag{3.8}$$

$$\sum_{j=1}^{n} x_{ij} = 1, \quad i = 1, 2, \cdots, n \tag{3.9}$$

$$x_{ij} = \begin{cases} 1: & \text{pass route between cities } i \text{ and } j \\ 0: & \text{not pass route between cities } i \text{ and } j, \end{cases}$$

$$\sum_{i \in S, j \in S} x_{ij} \geq 1 \ (S \text{ is the set of all partitions of } V). \tag{3.10}$$

Equation (3.7) shows that the objective function is to minimize the traveling route. Equation (3.8) shows that one incoming route exists for each city. Equation (3.9) shows that one outgoing route exists from each city. Equation (3.10) shows that there is at least one route connecting S and $\overline{S}$. This problem is applicable to determination of the optimal route when delivering goods to homes.

(2) Knapsack problem

Given a set $V = \{1, \cdots, n\}$ of n elements, each element j with size a_j, value c_j and size b of the knapsack. The problem is to determine the number of each element to be selected from V to maximize the total value, under the condition that the total size of the selected elements is less than or equal to b. This problem is written as follows;

$$\text{Maximize} \sum_{j=1}^{n} c_j x_j \tag{3.11}$$

$$\text{Subject to} \sum_{j=1}^{n} a_j x_j \le b, \tag{3.12}$$

$$x_j = \begin{cases} 1: & \text{Put element } j \text{ in the knapsack} \\ 0: & \text{Not put element } j \text{ in the knapsack.} \end{cases}$$

Equation (3.11) shows that the objective function is to maximize the total value of the element put in the knapsack. Equation (3.12) shows that the sum of the elements that can be put into the knapsack is less than or equal to size b. This problem is applicable to optimum loading when loading a truck.

(3) Generalized assignment problem

When n given tasks $V = \{1, \cdots, n\}$ are assigned to m agents $W = \{1, \cdots, m\}$, the problem is to minimize the total cost of the assignment. Also, cost c_{ij} and required resource amount a_{ij} when assignment task $j \in V$ to agent $i \in W$, and available resource amount b_i of each agent i are given. Each task must be assigned to one agent. The sum of resource requirements of assigned tasks cannot exceed the available agent resources. This problem is written as follows;

$$\text{Minimize} \sum_{i=1}^{n} \sum_{j=1}^{m} c_{ij} x_{ij} \tag{3.13}$$

$$\text{subject to} \sum_{j=1}^{n} a_{ij} x_{ij} \le b_i, \quad i = 1, \cdots, m \tag{3.14}$$

$$\sum_{i=1}^{m} x_{ij} = 1, \quad j = 1, \cdots, n \tag{3.15}$$

$$x_{ij} = \begin{cases} 1: & \text{Agent } i \text{ is assigned to task } j \\ 0: & \text{Agent } i \text{ is not assigned to task } j. \end{cases}$$

Equation (3.13) shows that the objective function is to minimize the total cost of assigning agent i to job j. Equation (3.14) shows that the available resource amount of each agent is less than or equal to b_i. Equation (3.15) shows that each job must be assigned to one agent. This problem is applicable to the optimal working arrangement of the store clerks.

(4) Integer programming problem

Given coefficients a_{ij}, b_i and c_j ($i = 1, \cdots, m$, $j = 1, \cdots, n$) and the set $J \subseteq V = \{1, \cdots, n\}$, the problem is written as follows;

Objective function

$$f(z) = \sum_{j=1}^{n} c_j x_j \rightarrow \text{Minimize or Maximize}$$

Subject to

$$\sum_{j=1}^{n} a_{ij} x_j \geq b_i, \quad i = 1, \cdots, m$$

$$x_j \geq 0, \quad j = 1, \cdots, n$$

$$x_j : \text{Integer}, \quad j \in J.$$

The integer programming problem has a general form. Therefore, most combinatorial optimization problems can be formulated into this problem. When the gastronomy service process problem is modeled as a combined optimization problem, it is started by formulating it as the problem above.

3.4.2 Modeling of Staff Scheduling

Determining the working day and time slot (hereinafter, working time) of staff in restaurants is an important task of the store manager. The staff scheduling problem in the gastronomy service is a problem of finding a working time that maximizes an objective function value (e.g., a customer satisfaction level) using a staff member's desired time as an input. At that time, it is necessary to comply with various constraints (e.g., the required number of staff and ability level by workplace, and the continuous working hours of staff). The store manager plans this staff scheduling, which is often planned without the support of a computer. Therefore, their workload is high. In the following, a typical staff schedule problem example is modeled based on some research results (Tanizaki et al. 2017; Nobutada et al. 2015).

The following is a viewpoint of modeling the work contents of the staff of the restaurant with generality.

(1) Components of the restaurant hall work are the workplace and work content.
(2) Attributes of the restaurant staff include wages, ability, desired degree for working day/time, and desired degree for workplace/content. The job position, which is an attribute of the staff member, is modeled as the ability and wages are its essential element.
(3) Staff member's ability is defined as "Possible" or "Impossible" for each workplace and work content.
(4) The desired degree for each time slot on each day of the staff member is "Permitted," "Not permitted," and "Desirable not to work." In addition, the working hours of staff members in a day shall be continuous.

(5) Set the minimum number of staff members to respond to customers according to work location and work contents in each time slot.

The objective function is generally set as the improvement of customer satisfaction. From the research point of gastronomy service process, the objective function is to improve customer satisfaction (*CS*), employee satisfaction (*ES*) and management satisfaction (*MS*). These three objective functions are modeled as described below.

(1) *CS* is modeled such that it improves by increasing the customer contact time of staff. Because *CS* will be improved further if staff members work for high-value work for customers, set a customer satisfaction factor for the workplace and work contents of staff members.
(2) *ES* is modeled such that it improves by increasing the working hours, workplace and work contents that desired by the staff members.
(3) *MS* is modeled such that it deteriorates by increasing staff working time because labor cost increases.

As one might expect, *CS* and *ES*, *ES* and *MS* are closely related. Many studies have been conducted on their relevance. (e.g. Heskett et al. 1997; Ugboro and Obeng 2000). This relation is discussed in another section. In this section, it is modeled as the three objective functions having a tradeoff relation. One must enter the desired working time for each staff member and decide their working time, places, and contents such that *CS*, *ES*, and *MS* become the highest. At that time, they must satisfy the minimum required number of staff and restrictions on the ability level of the workplaces and work contents where staff member can work and also satisfy the staff member's continuous working hours.

3.4.3 Formulation of a Staff Scheduling Problem

The staff scheduling problem can be formulated according to the following process. Prepare a working pattern set consisting of consecutive working hours of work desired degree 1 (= Permitted) and −1 (= Desirable not to work) for each staff member from each staff member's desired working time. At that time, ensure that the staff member's continuous working hour constraints are kept. From the working pattern set, decide the working pattern with the highest *CS*, *ES*, and *MS* under the condition that satisfies the constraints described above (Fig. 3.12). This problem can be formulated as a 0–1 integer programming problem by using 0–1 variables for the decision of the working pattern.

(1) Notation

m : staff member($m = 1, \cdots, M$).
d : time slot(day) ($d = 1, \cdots, D$).
t : time slot(time) ($t = 1, \cdots, T$).
p : workplace ($p = 1, \cdots, P$).

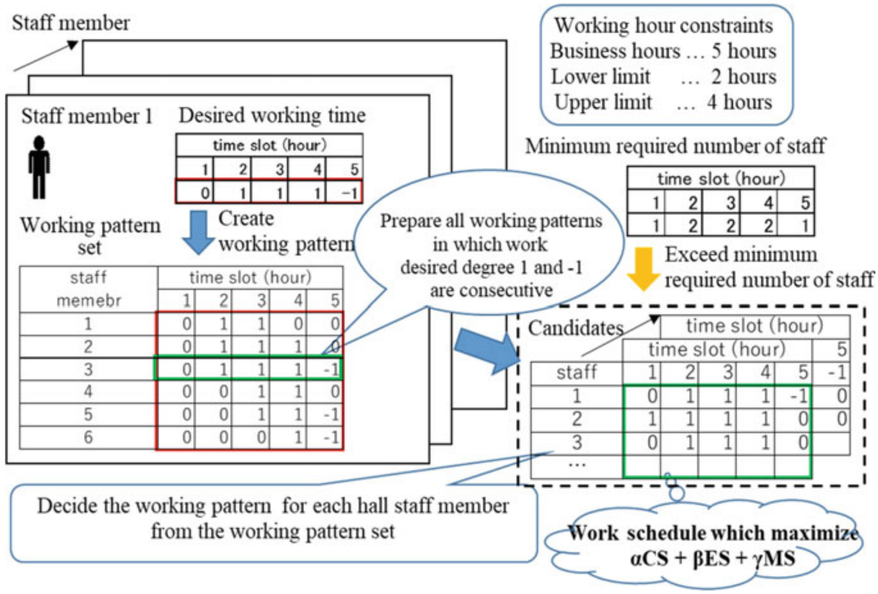


Fig. 3.12 Formulation of a staff scheduling problem

v : work content ($v = 1, \cdots, V$).
T_{max} : upper limit for working hours per day.
T_{min} : lower limit for working hours per day.
$k_{m,d}$: number of working patterns of staff member m on day d.
$K_{m,d}$: working pattern set of hall staff member m on day d

$$K_{m,d} = \{1, \cdots, k_{m,d}\}$$

$g_{m,d}$: working pattern $\left(g_{m,d} \in K_{m,d}\right)$.
$a_{m,d,g_{m,d},t}$: desireddegreeofstaffmember $m$onday d, time $t$and workingpattern $g_{m,d}$.

$$a_{m.d.g_{m,d},t} = \begin{cases} 1 : & \text{Permitted} \\ 0 : & \text{Not permitted} \\ -1 : & \text{Desirable not to work.} \end{cases}$$

$q_{m,p,v}$: desired degree of staff member m in workplace p and work content v.
$L^{\min}_{d,t,p,v}$: minimumnumberofstaffmembersonday d, time t, workplace $p$and workcontent v.
e_m : cost per unit time of staff member m.
$u_{p,v}$: customer satisfaction factor for the workplace p and work content v.
$x_{m,d,t,p,v}$: $0-1$integervariabledenotingwhetherstaffmemer $m$works ornotonday d, time t, workplace $p$andworkcontent v

$$x_{m,d,r,p,v} = \begin{cases} 1: & \text{Work} \\ 0: & \text{Not work.} \end{cases}$$

$z_{m,d,g_{m,d}}$: 0 − 1integervariabledenotingwhetherworkingpattern $g_{m,d}$ ofstaffmember m, onday d, isselectedornot

(2) Formulation

<Objective function>

$$\text{Maximize } \alpha CS + \beta ES + \gamma MS \quad (\alpha + \beta + \gamma = 1) \tag{3.7}$$

Equation (3.7) shows the weighted sum of *CS*, *ES*, and *MS* presented as

$$CS = \sum_{m=1}^{M}\sum_{d=1}^{D}\sum_{t=s.b.}^{c.b.}\sum_{p=1}^{P}\sum_{v=1}^{V} u_{p,v}x_{m,d,t,p,v}$$

(where $s.b.$ is the starting time and $c.b.$ is the closing time of business hours)

$$\tag{3.8}$$

$$\text{ES} = \sum_{m=1}^{M}\sum_{d=1}^{D}\sum_{g_{m,d}=1}^{G_{m,d}}\sum_{t=1}^{T} a_{m,d,g_{m,d},t}z_{m,d,g_{m,d}} + \sum_{m=1}^{M}\sum_{d=1}^{D}\sum_{p=1}^{P}\sum_{p=1}^{P}\sum_{v=1}^{V} q_{m,p,v}x_{m,d,t,p,v} \tag{3.9}$$

$$\text{MS} = -\sum_{m=1}^{M}\sum_{d=1}^{D}\sum_{t=1}^{T}\sum_{p=1}^{P}\sum_{v=1}^{V} e_m x_{m,d,t,p,v} \tag{3.10}$$

Equation (3.8) defines the *CS* value, which increases by $u_{p,v}$ if a staff member works at workplace p and work content v. Equation (3.9) defines the *ES* value, which increases by $a_{m,d,g_{m,d},t}$ if the hall staff member works in the "Permitted" time slot and decreases by $a_{m,d,g_{m,d},t}$ if the hall staff member works in the "Desirable not to work" time slot. Furthermore, it increases or decreases by $q_{m,p,v}$ depending on the desired degree of workplace p and work content v for staff member m. Equation (3.10) defines the *MS* value that decreases by e_m when staff member m works.

<Constraints>

$$\sum_{g_{m,d}=1}^{k_{m,d}} z_{m,d,g_{m,d}} \leq 1(\forall m,\ \forall d) \tag{3.11}$$

$$\sum_{p=1}^{P}\sum_{v=1}^{V} x_{m,d,t,p,v} = \sum_{g_{m,d}=1}^{k_{m,d}} a^2_{m,d,g_{m,d},t}z_{m,d,g_{m,d}}(\forall m,\ \forall d,\ \forall t) \tag{3.12}$$

$$\sum_{m=1}^{M} x_{m,d,t,p,v} \geq L^{min}_{d,t,p,v}(\forall d,\ \forall t,\ \forall p,\ \forall v) \tag{3.13}$$

$$\sum_{d=1}^{D}\sum_{t=1}^{T} x_{m,d,t,p,v} = 0 \quad \left(if\ C_{m,p,v} = 0\right)(\forall m,\ \forall d,\ \forall t) \tag{3.14}$$

$$T_{min} \le \sum_{t=1}^{T} a^2_{m,d,g_{m,t},t} \le T_{max}\left(\forall m,\ \forall d,\ \forall g_{m,d}\right) \tag{3.15}$$

Equation (3.11) shows that each staff member's working pattern for each day is the maximum one. Equation (3.12) shows that the staff member works in the desired time slot of the selected working pattern. Furthermore, the staff member works in one workplace and with the work contents in the time slot. Equation (3.13) shows that it is necessary to allocate staff member more than the minimum required number of staff members for the workplace and work content. Equation (3.14) shows that the staff member cannot work in workplaces and contents where there is no workmanship. Equation (3.15) defines the upper and lower limits of the staff member's working hours per day.

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Part II
Production Management for Value Realization

Chapter 4
Sensing of Service Provision Processes

Takeshi Kurata

4.1 Introduction

Comprehensive understanding and specific improvement of situations at service sites such as restaurants requires aggregation of big data related to Man, Machine, Material, Method, Mother nature (Environment), and Money (6 M) (Fig. 4.1) (Kurata et al. 2019a, b). Along with the popularization of internet-of-things (IoT) and artificial intelligence (AI), the realization of visualization or vision control, or 'Mieruka', has made steady progress in terms of tangible objects in 6 M such as facilities, equipment, ingredients, and cooked dishes.

Nevertheless, the development of Mieruka technologies and methodologies is still ongoing in terms of intangible issues in 6 M such as service provision processes and situations of service providers. Reportedly, a major disincentive is that information related to human behavior has not yet been obtained sufficiently. Japanese people spend around 90% of their time indoors, whether working or not (Shiotsu et al. 1998). In addition, restaurants that we specifically examine in this book are often occupied by indoor environments. Therefore, it is necessary to develop and use internet of humans (IoH) technologies, which are applicable indoors, including positioning technologies and human behavior measurement technologies. Collecting individual service provider data can be done easily in cases where the service process is repeated in a spatially limited area and in a short period of time. In many restaurants, however, moving in a relatively wide area and working are often combined. That combination poses a major barrier to data collection of each service provider. Therefore, it is crucially important to develop and use IoH technologies further for collecting data related to human behavior.

Accordingly, this chapter presents specific examination of measurement technologies of the service-provider-oriented part of 6 M (Man). First, we give an outline of

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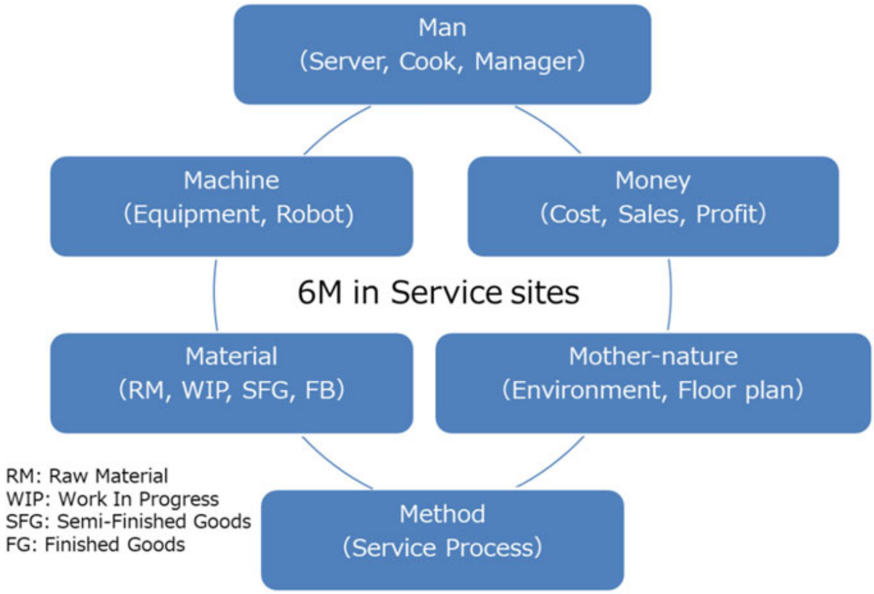

Fig. 4.1 6M (Man, Machine, Material, Method, Mother nature (Environment), and Money) in service sites

the concept of Lab-Forming Sites (LFS) and Site-Forming Labs (SFL) in association with the idea of a combination of Big data and Deep data (Pier Data) (Kurata et al. 2017, 2018). Next, we summarize IoH technologies including indoor positioning and action recognition. The costs and benefits of introducing IoH technologies at such sites are also explored.

4.2 Lab-Forming Sites and Site-Forming Labs

Figure 4.2 shows each technology and methodology in association with each phase of the service design loop (Takenaka et al. 2012; Kaihara et al. 2013), which consists of measurement, modeling, designing, and application. One can realize service-engineering based approaches for service improvement and innovation by utilizing technologies and methodologies for each phase of the service design loop as follows:

(1) Measure the behaviors of customers and employees and service/living environments (Tenmoku et al. 2011; Makita et al. 2013; Kato et al. 2016)
(2) Do As-Is comprehension for quality control (QC) circle activities (Fukuhara et al. 2013, 2014; Okuma et al. 2015)
(3) Do To-Be comparison for service operation planning (Myokan et al. 2016)
(4) Develop context-aware interface for service operation support

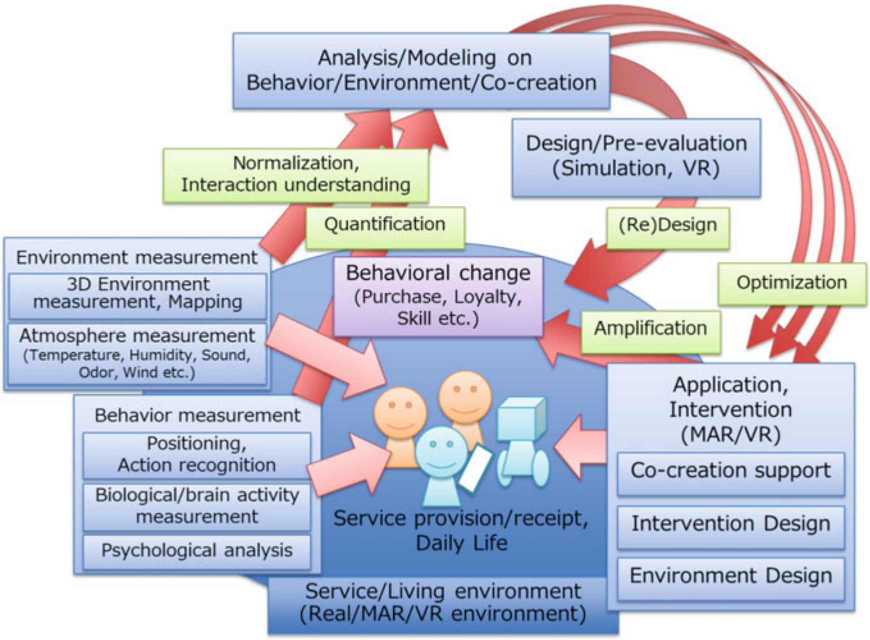

Fig. 4.2 Service design loop supporting human-centered co-creation

With the coming of IoT and IoH societies, approaches of those kinds, which we call "Hakatte Hakaru (Fig. 4.3)" in Japanese, are presumed to become more essential and ordinary.

There are two ways of realizing Hakatte Hakaru: Lab-Forming Sites (LFS) and Site-Forming Labs (SFL). To make these terms, we analogically used a term, "Terraforming," which designates the transformation of some planet such as Mars from its current environment to another environment that more closely resembles that of Earth so that we can live on the planet. We can illustrate what technologies are exploited for LFS and SFL in Fig. 4.4.

Fig. 4.3 Hakatte Hakaru: service design loop in Japanese

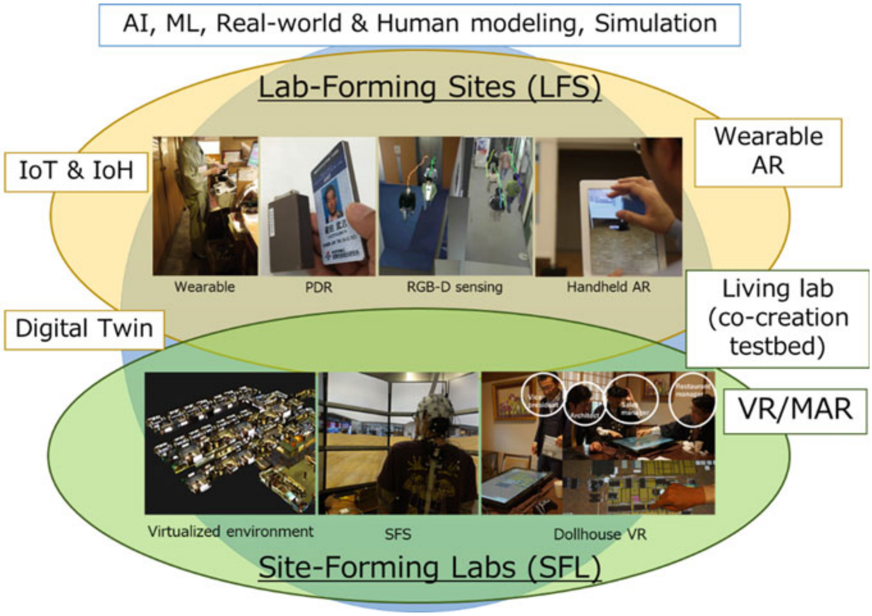

Fig. 4.4 Lab-forming sites (LFS) and Site-Forming Labs (SFL)

One can use LFS to transform real service sites into lab-like places for bringing methodologies in which hypothesis testing is conducted repeatedly by giving stimuli to service providers/customers and by observing the responses. Conventionally, it was not practical to realize such methodologies at actual service sites. However, the methods are finally coming into practical use by measuring service customers, employees, and service/living environments with IoT and IoH technologies including spatial computing for modeling and for comprehending actual service sites. At such sites, intervention is done with information provision using mixed and augmented reality (MAR) (Makita et al. 2014; Chang et al. 2015) or other interfaces and with physical actuation using robotic technologies (RT).

By contrast, one can use SFL to transform laboratories into real-site-like places for bringing subjects' behavior and experimentally obtained results closer and closer to those which are presumed to be obtained at real service sites. For that purpose, VR environments are often developed and used (Nakajima et al. 2012; Hyun et al. 2010; Takashi and Kurata 2014; Takeda et al. 2014; Hikaru et al. 2015; Yuta et al. 2018). Such VR environments should provide reproducibility of real service sites, but the extent of reproducibility depends on what one wants to explore. It is noteworthy that we can also use benefits available from VR environments in SFL: well-controlled environments and various measurements such as gaze, biological, and brain activity measurements.

4.2.1 Pier Data

Through LFS and SFL, one can acquire "big data" and "deep data". Big data can be collected on a daily basis without much effort, but it is difficult to maintain their quality. Moreover, the data are of limited types. No clear definition of deep data exists, but we consider for this work deep data have characteristics that supplement big data, such as high quality (including ground truth data), heterogeneity (including detailed motion, gaze, biometric information, and brain activity data), and the inclusion of subjective data (surveys and interviews). Deep data are used as training data for supervised machine learning, which is applied to recognize something from big data, or as basic information to enhance the qualitative understanding of the site. However, deep data can only be obtained in special circumstances such as sensing in a laboratory or at an edge heavy site, or by interviewing.

A pier has a structure in which the platform is supported by stakes, as in Fig. 4.5. It is similar to the structure in which deep data support big data. One can also assume that, typically, a so-called platformer is good at gathering big data. A so-called stakeholder with knowledge and know-how at each site can be good at gathering deep data. For these reasons, we call this combination of big data and deep data "Pier

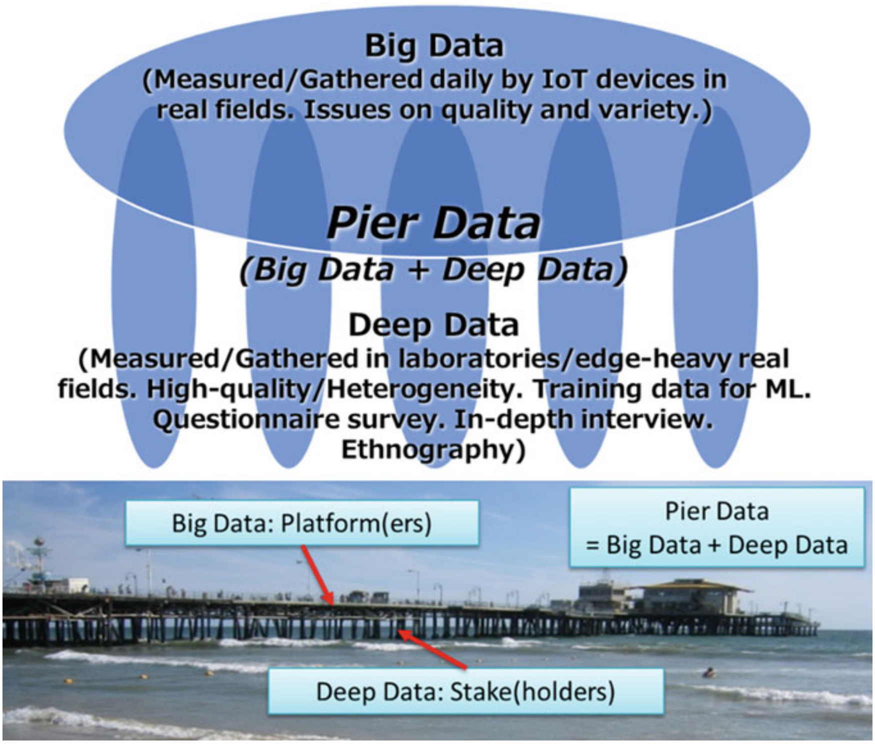

Fig. 4.5 Pier data: combination of Big data and Deep data

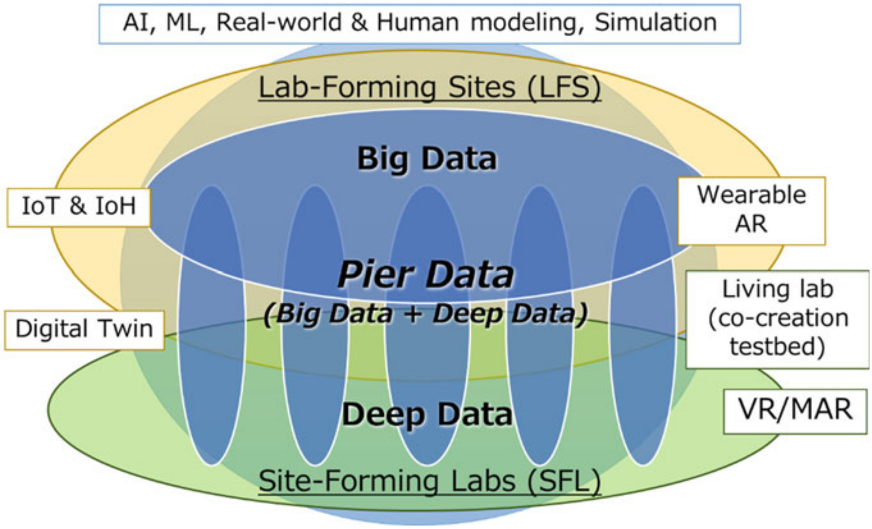

Fig. 4.6 LFS and SFL in association with Pier Data

Data". As shown in Fig. 4.6, one acquires mainly big data with LFS and mainly deep data with SFL. By making the pier data deeper and wider efficiently though LFS and SFL, it will be possible to understand what is happening in the real world comprehensively, especially at service and manufacturing sites for the improvement and innovation.

4.2.2 Research Cases of LFS and SFL

Although it might be difficult to conduct full-fledged research and development on LFS and SFL, many research cases have addressed the concepts of LFS and SFL with partial introduction and implementation. Table 4.1 presents studies conducted at AIST that are relevant to LFS and SFL.

Computer Supported Quality Control Circle (CSQCC) (Fukuhara et al. 2013, 2014; Takashi et al. 2015) was presented to facilitate As-Is comprehension and Before and After comparison on service provision processes in Japanese restaurants. In this case, employees' trajectories, point of sale (POS) and order entry system (OES) data were obtained from real restaurants on a daily basis. Restaurants' 3D floor maps were created interactively from a set of photographs (Ishikawa et al. 2013). Several indicators and indices were designed as work and skill evaluation. A Kaizen (improvement) plan was discussed while visualizing the obtained data, indicators, indices, and other information for improving service provision processes.

Table 4.1 Research cases of LFS and SFL in AIST

	Study Case	Measurement	Modeling	Design/ Pre-evaluation	Application/ Intervention
Lab-Forming Sites (LFS)	Maintenance service (MAR-based support)	User position and orientation, Target objects, Machine condition	Machines, Road environments	N/A	Computer-supported work
Lab-Forming Sites (LFS)	**As-Is comprehension and Before & After comparison on service provision in restaurants (CSQCC)**	Employees trajectories, POS/OES data, Real environments	Work indicators, Skills, 3D Indoor environments	Kaizen plan by discussion with visualization	Improved service provision
Lab-Forming Sites (LFS)	To-Be comparison of operation plans in warehouse picking	Trajectories of employees and carts, WMS data, Shelf layout	Picking work, Work indicators	Kaizen plan comparison by simulation	(Improved operation)
Site-Forming Labs (SFL)	Ethnography in a hotel (CCE Lite)	Trajectories of employees, Real environments, Interviews	Skills, 3D Indoor environments	N/A	N/A
Site-Forming Labs (SFL)	Marketing for product design in virtual stores	Trajectories/Gazes/Brain activities of subjects in VR, Real environments	Customer behavior, Indoor 3D environments	Product Design	(New product)
Site-Forming Labs (SFL)	**Restaurant floor planning with multi-stakeholders (Dollhouse VR)**	N/A	3D Indoor environments, Human body	Floor planning in collaborative VR	(Improved floor plan)

As described above, CSQCC is regarded as an example of LFS. "Dollhouse VR" (Hikaru et al. 2015; Yuta et al. 2018) is an example of SFL, which facilitates asymmetric collaboration among multiple stakeholders with two viewpoints: a top-down view using a large table-top interface and a first-person view using a head-mounted display. In this case, multiple stakeholders such as a restaurant manager, a sales manager, an architect, and an executive officer can discuss the rearrangement of a restaurant floor by moving tables and chairs in a virtual environment while using the Dollhouse VR system.

4.3 Internet of Humans

In various industries, and especially at restaurant sites, service providers' positions show strong correlation with the operation contents. Therefore, indoor positioning technologies are anticipated for greater use in service provision process analysis. If more microscopic motion data are obtained, detailed operational behaviors can also be analyzed. After summarizing indoor positioning technologies, the associated motion and operation recognition technologies are briefly introduced.

4.3.1 Indoor Positioning Technologies

One can readily find from Fig. 4.7 that technologies of so many different kinds exist for indoor positioning. The horizontal axis is basically a combined axis of the degree of error as an indicator of positioning performance and the area covered by a unit cost as an indicator of cost performance. Because those two factors have strong dependency in general, they are presented as a horizontal axis, as in this figure. The horizontal axis is divided into three categories. In this chapter, they are designated for convenience as "Macro-positioning", "Mezzo-positioning", and "Micro-positioning". The vertical axis presents system configurations that comprise "Stationary nodes only (SNO)", "Stationary and moving nodes combined (SMN)", and "Moving nodes only (MNO)".

With micro-positioning technologies, more precise position data is obtainable. However, micro-positioning technologies invariably have shortcomings. For instance, the MNO systems for micro-positioning such as mobile camera and Laser Rangefinder (LRF)/LIght Detection And Ranging (LIDAR) (Kuramachi et al. 2015) tend to consume more power than systems for mezzo/macro-positioning. Also, SNO systems such as millimeter-wave radar, surveillance camera, and LRF/LIDAR often

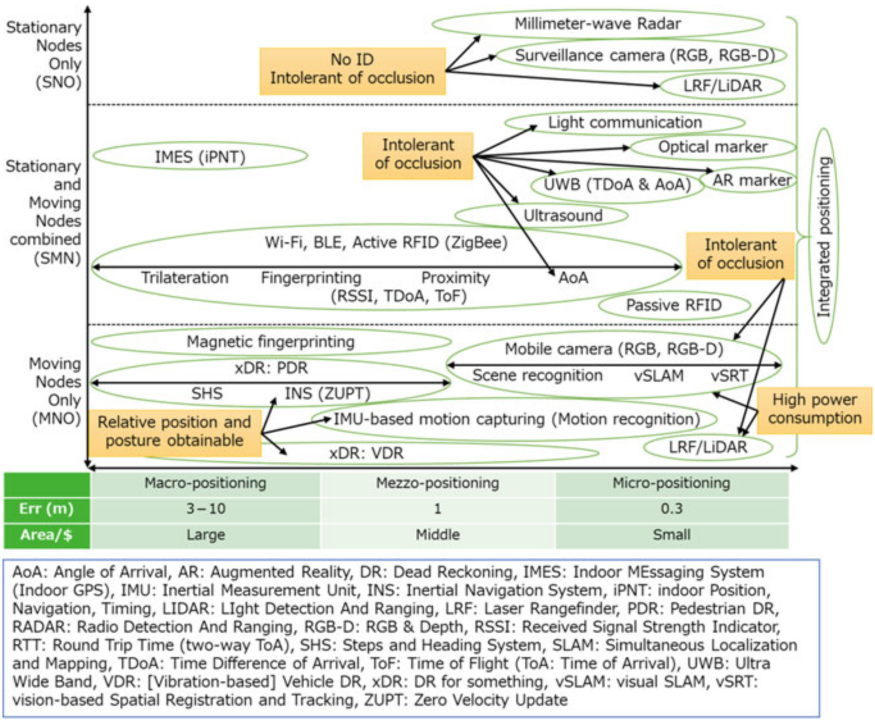

Fig. 4.7 Indoor positioning technology map

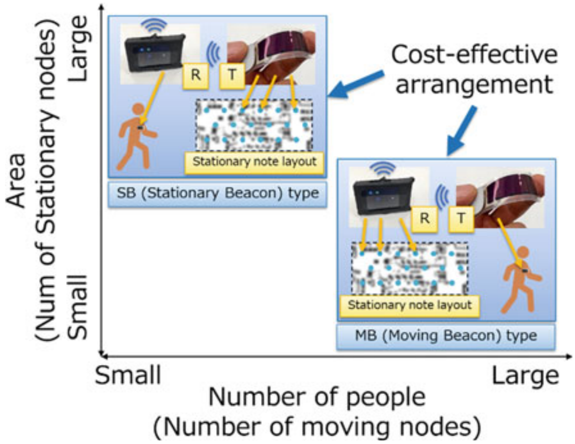

Fig. 4.8 Combination of stationary and moving nodes: SB type and MB type

have great difficulty in assigning or finding an ID for each subject. Moreover, they are not tolerant of occlusion no matter what they are micro-positioning or macro-positioning. Micro-positioning systems combining stationary and moving nodes such as light communication, ultra-wide band (UWB), ultrasound, angle of arrival (AoA) of a radio wave, and AR-marker-based methods also are not tolerant of occlusion.

The most popular system configuration is expected to be SMN. Figure 4.8 shows the cost-effective arrangements of stationary and moving nodes when we build SMN systems. In general, transmitters such as BLE (Bluetooth Low Energy) beacons and passive RFID (Radio Frequency IDentification) tags are much less expensive than receivers or transponders such as smartphones and IoT gateways. In cases with a larger area and fewer persons measured, it is better to choose transmitters as stationary nodes and receivers as moving nodes for reasons of cost. We designate such an arrangement as stationary beacon (SB) type, and the opposite arrangement as moving beacon (MB) type. The benefits and shortcomings of the SB type and the MB type are presented in Table 4.2.

4.3.2 Example of Indoor Positioning Systems

This section briefly introduces an indoor positioning system that we developed (Fig. 4.9) as an example of actual systems to ascertain their concrete shape. This system is categorized as an integrated positioning system (Ishikawa et al. 2011) consisting of Dead Reckoning for X (xDR) (Kourogi and Kurata 2003, 2014; Kohei et al. 2017), Received Signal Strength Indicator (RSSI)-based BLE positioning, and map constraints. The system has two features suitable for introduction into actual service sites. The first feature is that the system uses xDR, which includes pedestrian dead

Table 4.2 Benefits and shortcomings of SB and MB types

Type	SB	MB
Stationary node	Beacon (Small, Inexpensive)	Receiver/Transponder
Moving node	Receiver/Transponder	Beacon (Small, Inexpensive)
Positioning error	SB <= MB	
Positioning outside AoIs	Possible	Impossible
Remarks	Moving nodes can be used for measurement of orientation, speed, action recognition, human-machine interface, etc. Meaningful shape of trajectory.	Lower physical load for the users. Less need for battery charge/change of moving nodes.

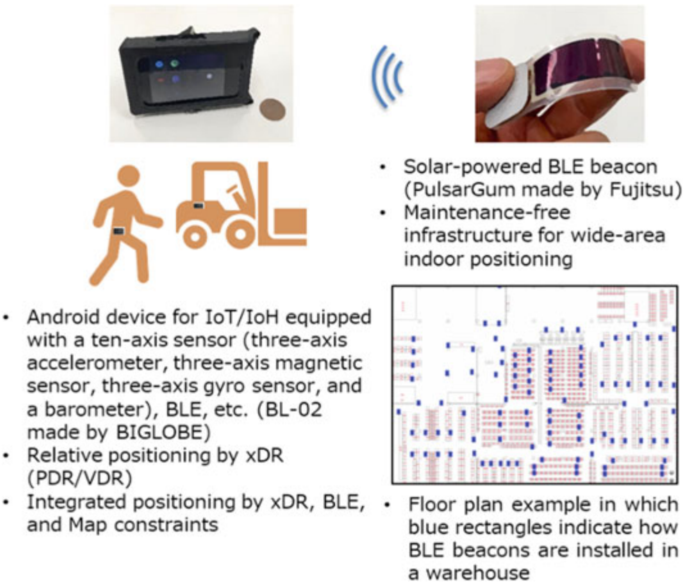

Fig. 4.9 Integrated indoor positioning system

reckoning (PDR) and vehicle dead reckoning (VDR) as methods of relative positioning. The second feature is that solar-powered BLE beacons are used as stationary nodes placed around the areas of interest (AoIs).

Although solar-powered BLE beacons are 2–3 times as expensive as typical battery-powered BLE beacons, the combination of xDR and BLE positioning makes it possible to reduce the number of BLE beacons to only a fraction of the number necessary for BLE positioning. A battery-free setup is possible without increasing initial installation costs. Additionally, a battery-free setup obviates battery replacement, greatly reducing operational costs. However, because this configuration inherently requires lighting as a source of energy harvesting, positioning performance must be sustained even at irregular time intervals of BLE signal transmission because of insufficient lighting.

Stationary nodes are naturally placed for covering AoIs. However, many flow lines or activities might occur outside of those expected areas. In some cases, such data are crucially important for service provision process analysis. Although BLE positioning leaves nothing to do, flow lines can be traced with xDR. As hardware for moving nodes, workers can use embedded modules or smartphones equipped with a nine-axis or ten-axis sensors, as described hereinafter. Also, because cameras are often difficult to bring in and install on site because of issues of cost, privacy of customers and mental load of employees, the system does not necessarily require vision-based positioning technologies.

4.3.3 PDR

The authors have been engaged in R&D related to xDR, and especially to PDR, since 2000 (Fig. 4.10). Fundamentally, PDR technology (Kourogi and Kurata 2003, 2014; Kohei et al. 2017) uses a group of sensors (commonly known as nine-axis sensors) that measure three-axis acceleration, three-axis angular velocity, and three-axis magnetism to estimate the sensor posture, as well as the travel speed and direction of a pedestrian carrying the sensors. One can estimate the pedestrian's relative location. Along with increasing demand for indoor positioning technologies including PDR from industries of various kinds, international indoor positioning competitions are becoming popular (Kaji et al. 2015; Katsuhiko et al. 2016; Lymberopoulos and Liu 2017; Ichikari et al. 2019). For instance, "xDR Challenge in industrial scenarios 2019" was designed to compare integrated indoor positioning algorithms developed by the respective contestants using real data from an actual restaurant site and a manufacturing site (Fig. 4.11).

For many cases in which a positioning system is to be introduced into an indoor service or manufacturing site, the cost of developing the physical and information infrastructure poses a barrier that raises questions about its cost-effectiveness. Although the introduction of indoor positioning is fundamentally important for LFS, cases exist in which the effect of its introduction must be represented solely as a monetary value. As a reference to R. Solow's productivity paradox, this situation can be

Fig. 4.10 History of xDR (PDR & VDR) research and development in AIST

Fig. 4.11 International indoor positioning competition called "xDR Challenge in industrial scenarios 2019"

called an indoor positioning paradox/dilemma. This paradox or dilemma, which does not occur using outdoor satellite positioning for free, can be eased using a relative positioning method such as PDR. An excellent example of it is indoor navigation by “DoCoMo Map Navi” (DoCoMo Map Indoor Navigation Area). A nine-axis or ten-axis PDR with a map (pedestrian space network data) and interaction with the user enable indoor navigation at about 600 underground shopping centers and subway premises across Japan (as of March 2019) without installation of a physical infrastructure.

Actually, PDR is classifiable into an inertial navigation system (INS) type, which estimates three-dimensional positions, and steps and heading system (SHS) type, which estimates two-dimensional positions (Harle 2013). The former method (Foxlin 2005) can provide highly accurate three-dimensional positioning without depending on how each person walks. It does, however, present some important limitations: because it is a method based on double integration of acceleration, it requires an accelerometer with easy calibration and high sensitivity. Also, the nine-axis sensor must necessarily be attached to the toe or shoe, where zero-velocity update (ZUPT) is possible.

We have been conducting research mainly of the latter type of PDR, the SHS (Kourogi and Kurata 2003, 2014). It is composed mainly of (1) attitude estimation, (2) estimation of the walking direction, and (3) walking motion detection and walking speed (pace) estimation. Relative to the INS-type method, it has fewer limitations related to the position of attachment of the nine-axis sensor and calibration of the accelerometer. However, although the SHS-type is less limited than the INS type in terms of attachment position, it does present some limitations of its own. For example, measurement with the SHS-type must be done in a stable condition by fixing a nine-axis sensor on the waist or chest, or by walking while holding and looking at the screen of a smartphone with a built-in nine-axis sensor.

The popularization of smartphones in recent years is highly anticipated for further easing limitations related to attachment or holding conditions. Estimation of walking direction is a fundamentally important technology for this purpose. The main methods that have been proposed are: (a) based on the Principal Component Analysis (PCA) of acceleration amplitude, (b) based on a Forward and Lateral Acceleration Modeling (FLAM), and (c) based on Frequency analysis of Inertial Signals (FIS) (Kourogi and Kurata 2014). According to a research report presenting comparative evaluation of them (Christophe and Valerie 2015), the method with FIS produced the best evaluation result overall.

The measurement range of an SHS-type PDR is limited to the ground and floor that are included in the map and floor plan. Estimation in the height direction is limited on the map and floor plan. In many cases, however, this height information is sufficient to obtain position information of customers, employees, residents, and others. Therefore, this limitation represents only a slight difficulty. As pressure sensors become increasingly accessible and accurate, a ten-axis sensor, which is a nine-axis sensor with a pressure sensor added, will also become more widely used. Attempts to measure the travel in the vertical direction using this ten-axis sensor (Kaji and Kawaguchi 2016; Kaji et al. 2016; Ichikari et al. 2015) have also been announced.

Whereas many other absolute positioning methods such as BLE positioning, in principle, provide a positioning result that is a set of independently obtained results, PDR generates a continuous trajectory. The shape and displacement (change of speed and angle) of this trajectory includes characteristics of the movement of the person being measured; it also allows measurement of the type and intensity of the movement. Therefore, it is more appropriate in some cases to consider PDR as a means to measure behavior rather than a positioning method (Makita et al. 2013; Kourogi et al. 2010).

4.3.4 Work Motion Recognition

If micro-level understanding of behaviors is required as in the analysis of hospitality in customer service and cooking, skills involved, etc., then the use of position data alone is insufficient. Inertial measurement units (IMUs) as in moving nodes for xDR, go beyond tracking position because they are also capable of capturing the type and size of motion, allowing for micro-level analyses of work motion and safety management by detecting falling movements. Figure 4.12 depicts three examples of work-motion capture systems.

Typically, 10–20 IMUs are attached all over the body, as shown in the left example in Fig. 4.12. Although this sort of setup is usually permitted for short-term collection of data, the time involved in attaching and detaching the system and its potential to interfere with work tasks make such a system unlikely to be adopted for long-term, everyday use. The system in Fig. 4.12-center is designed to reduce the number of IMUs to only five, thereby rendering it less cumbersome for workers and reducing hardware costs. In this case, a smartphone is placed inside the 'obi' belt as one IMU and also as a BLE receiver.

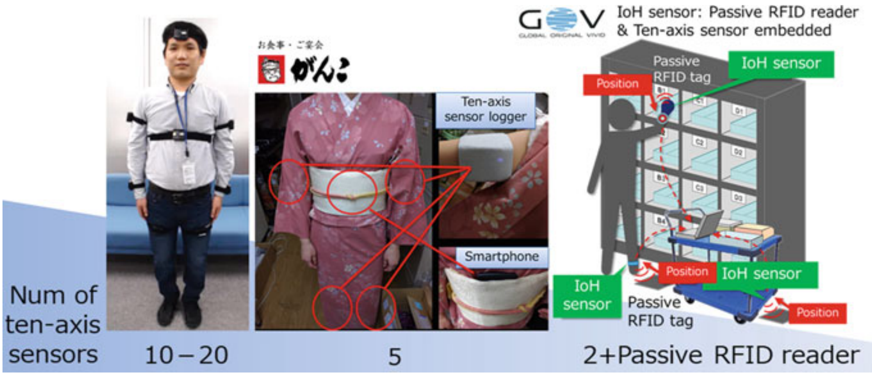

Fig. 4.12 Work motion recognition systems with different numbers of IMUs

Compared to a configuration by which IMUs are attached to the whole body, such configuration results in precision reduction of around 10–20%. The whole-body configuration provides the position and movement of each body part based on a skeleton model. In contrast, the partial body configuration, as shown in Fig. 4.12-center, means that some more detailed information related to work motion is missed. Then one must rely solely on local movement data from the available sensors. To address such difficulties, an integrated IoH sensor module with a wearable passive RFID tag reader (TECCO) and a ten-axis sensor module have been developed (Fig. 4.12-right). These devices enable the micro-level information lost in the decreased number of IMUs described above to be partially obtainable again by taking micro-positional data with an RFID tag reading. Thereby, improvement in the motion recognition precision can be expected.

4.4 Make Time Tangible

Generally, little objection arises to the importance of visualization associated with 6 M. However, regarding short-term data collection and one-time Before and After comparison as sufficient, using a single system sequentially at many sites to cut system acquisition costs, and not opting for continual long-term data collection simultaneously at many sites are common mistakes that can be made.

To shed light on these misconceptions, this section uses Fig. 4.13 to discuss some benefits of continual on-site measurement of data. The top and middle parts of the diagram show sites that are not collecting data continually, whereas the bottom shows a site that is. First, a common concern heard during on-site interviews is that workers are not used to their work being monitored, and that it will be difficult to

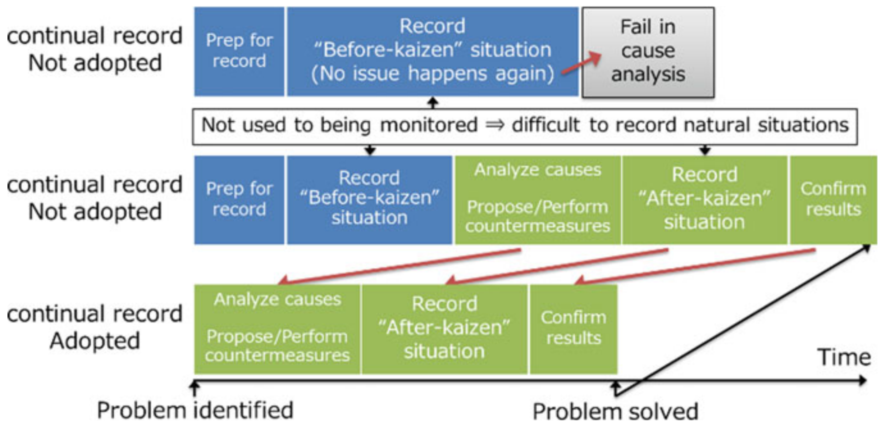

Fig. 4.13 Benefits of continual data collection

ascertain whether the resulting data reflect realistic and natural circumstances, or not. Continual data collection would allow such uncertainty to be dispelled.

One must consider how causes of found issues are analyzed and addressed. Typically (i.e., where continual data collection has not been adopted), the data collection system is only set up after a problem is identified, in which case one must wait for sufficient data surrounding the issue to be collected (a period that is designated as the "Before-data collection"). This waiting for collection creates a considerable time lag between the time when the difficulty is first identified and when its causes can begin to be analyzed and addressed. Furthermore, as presented in Fig. 4.13-top, if the exact issue of concern does not arise once again after beginning Before-data collection, then no data exist to analyze and identify causes.

Dashboard cameras in cars use accelerometers to detect incidents such as collision and sudden braking. They are able to keep records of such incidents for future use and for reporting of accidents. Similarly, with continual data collection at service sites such as restaurants, issues can be analyzed at any time, with seamless transition into data collection for confirming the effectiveness of solutions ("After-data collection"). In this way, issues can be addressed and remediated swiftly. This "Virtual Time Machine" concept (Hirose et al. 2004; Okuma et al. 2007) is expected to take root in more industry worlds in the future as 6 M visualization technology continues to develop and mature.

4.5 Conclusion

Even if large amounts of 6 M data could be gathered by IoT/IoH devices at real service and manufacturing sites, the data would not hold all the answers to elucidate the real sites comprehensively because big data in general entail issues of quality and variety. In-depth surveying such as retrospective interviewing can complement defects of big data. Nevertheless, such surveying invariably requires intensive effort with a high work load. In-depth surveying with subject screening (Nakajima et al. 2012) based on big data would alleviate the load. It would result in efficient surveying in terms of both breadth and depth. This idea is consistent with the idea of Pier Data. Demonstration of such a methodology at actual sites through further development of 6 M data collection and visualization technology including IoH technologies is a subject of our future work.

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Chapter 5
Systems Engineering Approach to Floor and Staff-Shift Layout Design

Nobutada Fujii

Abstract This chapter presents a description of layout design methods that include both spatial and temporal planning problems in service production and consumption. First, a brief introduction describes the proposed wider concept of service manufacturing systems, then layout planning methods of kitchen in a food-service industry and staff-shift planning method are also described as part of the wider concept. Kitchens in the food-service industry are labor-intensive environments. Their productivity depends on the flow of people and foods, such that traditional mathematical programming approaches are difficult to apply for optimization of kitchen facility layouts. In turn, planning work-shifts of staff members is also difficult in such complex kitchen environments because of the preferences and availability of the respective workers. A new facility layout planning method combining simulation and genetic algorithms (GA) is proposed. Simulations are executed to calculate the fitness of individuals in GA. Then, Combinatorial auction-based staff-shift layout design method is also proposed. Computational experiments are conducted to verify the effectiveness of the proposed methods.

5.1 Introduction

In the service industry, production, provision, and consumption are inseparable because of intangibility and extinction, which are specific to the service provided. Because of the inseparability of production, provision, and consumption, one must integrate manufacturing and sales. Feedback from consumers is incorporated directly into the production process. As a result, improvement activities are conducted at short intervals of hours and days at the production and provision sites of services, but to date such activities have largely depended on the experience and intuition of employees at the service sites; a novel approach is needed based on science and engineering (Sakao and Shimomura 2007). However, from the viewpoint of the manufacturing industry to date, production, provision, and consumption are separated because of

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the tangible and storable characteristics of the products provided. Consumer feedback is not directly brought to the manufacturing site. Probably it has been possible to realize efficiency using systems engineering approaches such as optimization and simulation. The concept of a service manufacturing system (Kaihara and Fujii 2012) has been proposed: it unifies the service industry and the manufacturing industry from the viewpoint of service creation, and integrates manufacturing and sales to reflect feedback from consumers to realize adaptive and robust service provision.

In this chapter, layout design approaches for kitchens in the restaurant industry are reported as one effort for service manufacturing systems by which a service industry can provide tangible goods. In restaurant kitchens, quality improvement through application of handmade skills by skilled workers is a key point of service quality; manual processing can not be omitted. Therefore, eliminating workers is difficult, leaving kitchens as a labor-intensive production base. In addition, these workers include not only full-time employees but also part-time workers, which can be a variable factor in production. The restaurant industry is not only susceptible to seasonal fluctuations and weather, but also to events such as hosting of nearby facilities. A difficulty arises in demand forecasting because numerous customers visit the store (Shimmura and Takenaka 2011). By producing high-quality foods while flexibly adapting to environmental changes inside and outside the kitchen as described above, customer satisfaction (Customer Satisfaction, CS) is improved and services are produced and provided. Employee Satisfaction (ES) and Management Satisfaction (MS) must also be improved simultaneously.

5.2 Service Manufacturing Systems

5.2.1 Rethinking Manufacturing from a Service Perspective

As an approach to service creation, the author aims to construct a service manufacturing system from the viewpoint of a manufacturing system. A service manufacturing system re-examines the production, provision, and consumption of products and services from the viewpoint of services; it does not construct or examine each stage of production and provision consumption independently, but instead links each stage to optimize the entire system (Fig. 5.1). Because the manufacturing industry to date has pursued economies of scale and scaling up, manufacturing and sales companies have become separate departments and companies, resulting in information circulation failure. That failure derives from difficulty responding to market changes as a result of excessive engineer-driven manufacturing without feedback. In the conventional service industry, service providers and consumers are all present at the service site. Therefore, the production and provision of services desired by consumers can be achieved by performing service production, provision, and consumption simultaneously. However, inefficiency attributable to handmade services represents an important shortcoming. The application of techniques cultivated by the manufac-

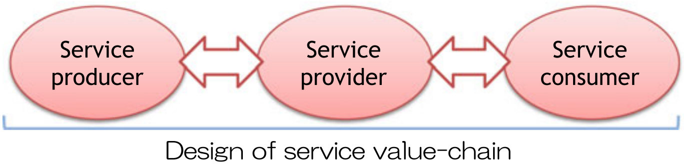


Fig. 5.1 Service manufacturing system concept

turing industry will enable efficient service production and provision support at the back-end, in addition to the introduction of independent service producers in pursuit of economies of scale. Based on the points raised above, the manufacturing industry and the service industry are no longer distinguishable based on the tangible nature of goods. Rather, the manufacturing industry and the service industry are handled in a unified manner emphasizing services using service-dominant logic (Vargo and Lusch 2004).

5.2.2 Service Value Creation Loop

Manufacturing system theory has been developed mainly in the manufacturing industry in the engineering field. In terms of service design, planning and operation, and production methods, the conventional methods of production systems are often applicable. They can contribute to productivity improvement of service industries that produce and provide tangible goods. However, simply bringing manufacturing techniques into the service industry is insufficient for high value-added services. The conventional design, planning and operation, and production methodologies must be reconfigured from the service user's perspective. Consumption theory related to service users is also necessary: service design theory that maximizes service evaluation by users reveals further demands and service planning and operation theory as a multi-objective optimization problem including various values of CS, ES and MS; rapid prototyping by integrating information service production theory promotes shift to actual production and realize value co-creation; service consumption theory maximizes the value perception of service users.

The key is to create value in the service manufacturing system by linking the four theories related to service manufacturing. The authors propose a service value creation loop (Fig. 5.2) to create service value. First, circulation of consumption theory, planning and operation theory, and production theory constitute a short-term loop. In consumption theory, after measuring data related to customer attributes and preferences in the store, the subjective utility of the customer is analyzed. Then the results are fed back to the planning and operation theory. Next, in the planning and operation theory, the production plan and process plan which maximize current customer satisfaction are determined and developed into the production theory. In

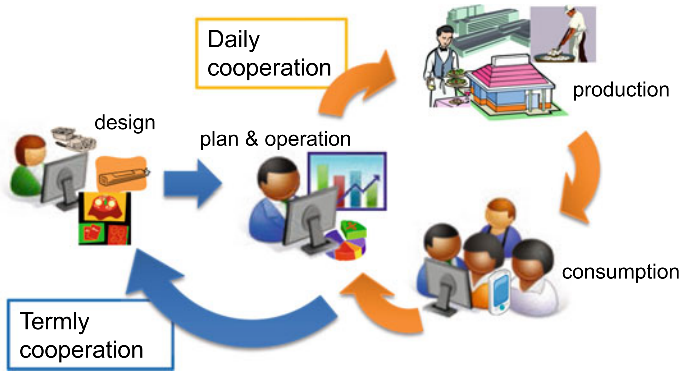
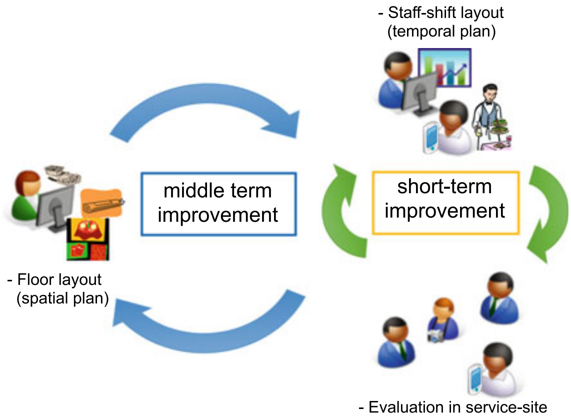


Fig. 5.2 Value creation loop in service manufacturing systems

Fig. 5.3 Short-term and long-term improvement loop in restaurant business



production theory, tangible goods to be supplied to stores according to the plan are produced efficiently while considering the labor of workers.

Next, a long-term loop including design theory is also possible. In design theory, the potential utility is modeled from the customer's subjective utility acquired in the consumption theory. A new menu and layout of the manufacturing site are designed as a new customer service, which is then developed into a plan and operation theory. By repeating these short-term and long-term loops, service production spirals upward. Service value creation is realized (Fig. 5.3).

In the following part of this chapter, the planning and operation part of the service manufacturing systems is introduced briefly to illustrate facility layout and staff-shift layout planning difficulties that arise in the kitchen. As the middle-term improvement loop, facility layout planning is considered, which can be understood as the spatial planning problem in the kitchen. A staff-shift scheduling problem is then addressed as a temporal planning problem in the kitchen, for which the duration and method used by each worker is planned for daily work.

5.3 Kitchen Floor Layout Design Using Simulation and Optimization

This section presents the facility layout plan of the kitchen as one way to improve restaurant industry productivity. In the restaurant industry, serving food is an important service. The kitchen for creating food (products) is the production site for services. Because the flow of products and workers which strongly affect the production efficiency of the kitchen presents a complicated trajectory and because it is difficult to evaluate them quantitatively, the facility layout has been created based on the experience and intuition of on-site workers.

Procedures for solving large-scale facility layout planning efficiently, include systematic layout planning (SLP) (Muther 1973), which is a traditional efficient framework for generating layouts, and combination optimization of discretizing manufacturing areas and applying facilities. A method exists to solve a facility layout plan as an optimization problem (Castell et al. 2004). Particularly, many studies use metaheuristics (Kochhar et al. 1998). However, when dealing with facility layout plans in combinatorial optimization problems, one must assume a static objective function. Because formulating a dynamic objective function that incorporates the flow of things and the flow of humans simultaneously is difficult, the method must be expanded. Therefore, in this section, the facility layout is optimized by combining genetic algorithms (GA) (Goldberg 1989; Holland et al. 1985) and computer simulation. This method can execute a facility layout plan by finding a layout plan as a combinatorial optimization problem and by incorporating a computer simulation into the calculation of fitness of individuals in GA.

5.3.1 Layout Design Method Using Simulation and Optimization

5.3.1.1 Target Floor Model

This study examines the facility layout including the waiting area of workers for the kitchen of a Japanese restaurant. Compared to the central kitchen, which was the subject of an earlier study (Fujii et al. 2013), the kitchen has the following characteristics.

- Products are created after receiving customer orders.
- The production floor is small.
- Created products are consumed immediately.

To place a facility in a small space, one must create a facility layout incorporating the facility size and orientation and the passage position. In addition, the product retention time is important because the products which are created are evaluated immediately by customers. To minimize the total residence time of products (the total residence time of all products ordered), a kitchen facility layout is created using simulation by GA.

5.3.1.2 Grouping Facilities

For cooking processes, facilities such as cupboards and refrigerators must be placed around the facilities that are actually used in the process. All are treated as a facility group. The location of the facility group can be determined by GA. Each facility is positioned relative to the facility group to which it belongs. Some facility groups do not include cupboards or refrigerators, but it might be desirable to place them near specific facility groups. Therefore, although not included in any facility group, by installing a corresponding refrigerator, cupboard, and moving to the facility group which performs cooking after passing through those facility, the arrangement of a facility that is not included in the facility group can be retained.

5.3.1.3 Overview of the Proposed Method

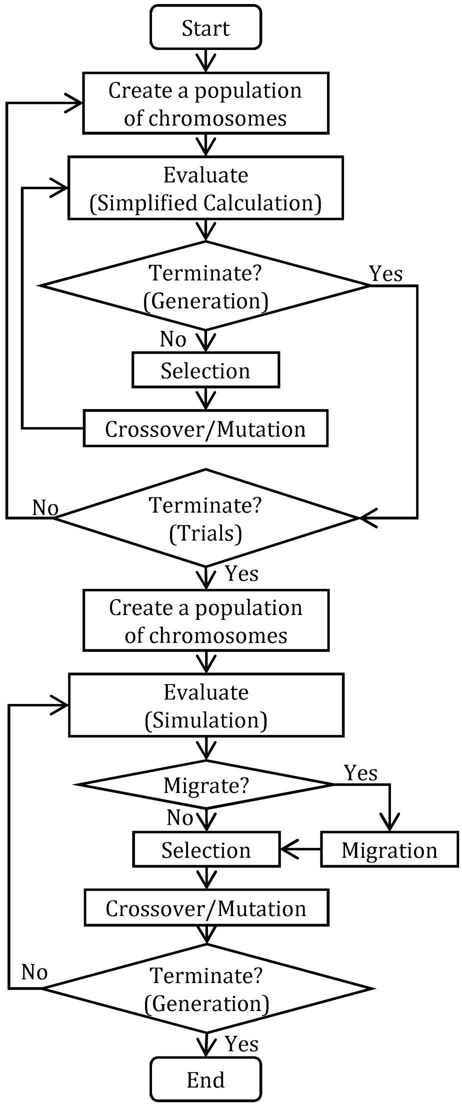
If all fitness evaluations are performed by simulation, then the computation time will be enormous. Moreover, it will be difficult to evolve a sufficient number of generations until the solution converges within a practical time frame. Therefore, the method for calculating the fitness of individuals comprises two stages, similar to the method used in an earlier study (Fujii et al. 2013).

In the first stage, a single population GA is run multiple times to create various individuals. The best individual in each trial is the initial individual in the second stage. Because individual evaluation by simulation in the second stage requires computation time, the number of individuals in the entire population in the second stage must be set smaller than in the first stage. As a result, a high probability exists that initial convergence will occur. Therefore, by application of a Distributed Genetic Algorithm (DGA) (Tanese 1989), which is expected to be highly effective in maintaining diversity in GA in the second stage, the initial convergence of the solution is prevented. The proposed algorithm is shown below. An overview is presented in Fig. 5.4.

Step 1 Creating initial individuals An individual that avoids duplication of location information is generated randomly as an initial solution.
Step 2 Individual fitness evaluation The fitness of an individual is evaluated using heuristic rules.
Step 3 End judgment Go to Step 4 if the number of generations has not been reached. Go to Step 5 if it has been reached.
Step 4 Genetic operation

Step 4.1 Select Select individuals to be left in the next generation according to the fitness of each.

Fig. 5.4 Algorithm of the proposed method



Step 4.2 Crossover Two individuals are selected randomly. Two-point crossover is performed at a certain rate while avoiding duplication of position information.

Step 4.3 Mutation For each, mutation is performed at a certain rate while avoiding duplication of location information.

Step 5 First stage end judgment Go to Step 1 if the predetermined rank has not been reached. Go to Step 6 if yes.

Step 6 Select individuals to be included in the second stage as initial individuals The best solution for each trial in the first stage is the initial individual in the second stage.

Step 7 Individual fitness evaluation Individual fitness is evaluated by simulation.

Step 8 Emigration decision Go to Step 10 if the number of generations has not been reached. Go to Step 9 if it has been reached.

Step 9 Immigration The best individual in each divided population is transferred to another divided population.

Step 10 Genetic operation

Step 10.1 Select Select individuals to be left in the next generation according to the fitness of each.

Step 10.2 Crossover Two individuals are selected randomly. Two-point crossover is performed at a certain rate while avoiding duplication of position information.

Step 10.3 Mutation For each, mutation is performed at a certain rate while avoiding duplication of location information.

Step 11 End judgment Go to Step 7 if the number of generations has not been reached. End if it has been reached.

5.3.1.4 Genetic Coding

Figure 5.5 portrays a schematic diagram of the genetic coding method. Figure 5.6 presents an example of the facility layout. Each individual holds the location information of each facility group and employee and the orientation information of the facility group. The location information is a discrete production area in a grid. The

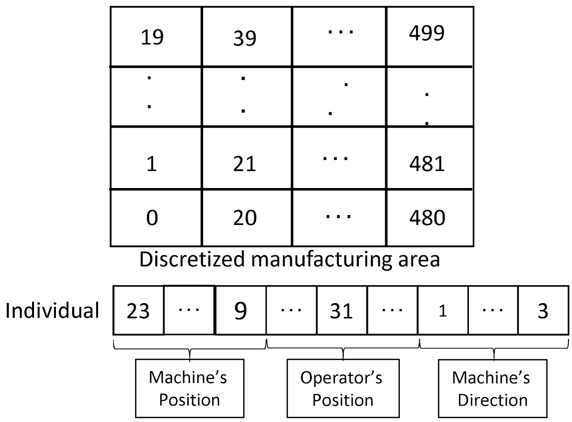


Fig. 5.5 Coding of individuals

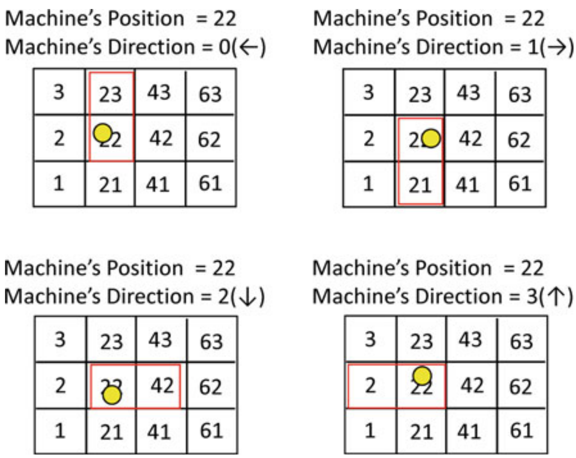


Fig. 5.6 Example of facility layout

divided sections are denoted by numbers, which designate the coordinates of the center of gravity of the facility group and the standby position of the employee. The orientation information of the facility group is assumed to indicate the four directions numbered as {0, 1, 2, 3}. In addition, the size is determined for each facility group. The facility layout is found uniquely by the location information and orientation information, as shown in Fig. 5.6.

5.3.1.5 Fitness Evaluation

As the first step, the total residence time obtained using heuristic rules is used as the fitness of the individual. Also, GA is executed for a predetermined number of generations. In the second stage, the individual created in the first stage is used as the initial individual. The total residence time obtained using simulation is optimized as the fitness of the individual.

Evaluation Using Heuristic Rules

Based on the following rules, the residence time for each order of each product is calculated. The sum is regarded as the fitness of the individual.

- The distance between facilities is calculated based on the facility center coordinates.
- Products with alternative facility and alternative employees are assigned with equal probability as facility and employees.
- Divide the total movement distance of the workers required to create the product by the movement speed of the workers to obtain the time required for movement. Then add the production time in each process to reduce the total residence time.

Because of facility and employee interaction that occurs in actual sites and simulations, the total residence time obtained using this method does not include waiting time.

Evaluation by Simulation

In the kitchen, product flow frequently occurs because of factors such as working workers and facilities in use. A simulation that can address the relation between facility and workers according to the flow of products and workers is executed. The total residence time is then derived and evaluated.

5.3.1.6 Feasible Solution by Neighborhood Operation

Each facility is arranged in multiple sections of the production area according to size. However, because the GA's chromosome includes only the position information and orientation of the center of gravity, a facility might be placed in the same position at the time of initial individual generation, crossover and mutation. For that reason, infeasible solutions might be generated. In that case, the operation searching neighborhood of the facility position is performed to avoid duplication of the arrangement section. Even if the layout does not overlap the facility, another facility might be placed around the facility, making it impossible for employees to use it. The actual store layout includes passages for workers to pass through. The passage is made by providing a section in which the facility cannot be placed in front of each facility. When avoiding duplication of facility, one must consider the passage.

Feasibility Check

Whether a chromosome created by genetic manipulation is feasible is determined by the following rules. Figure 5.7 presents an example of the feasibility check.

- Feasible (can be duplicated)
  - Employee placement area and aisle
  - Passage i and Passage j
- Infeasible (cannot be duplicated)
  - facility i placement and facility j placement
  - facility placement area and employee placement area
  - Facility i Surrounding Passage and Facility j Location.

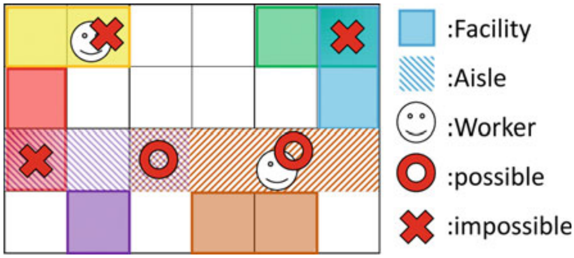


Fig. 5.7 Examples of possible and impossible positions

Neighborhood Search Rules

When making it feasible, the following rules are used to manipulate the vicinity of the facility position to create a layout that avoids being placed in a section that cannot be placed.

Step 1 Go to Step 2 if there are facilities and employees placed in the unplaceable section. End if it does not exist.
Step 2 Select one facility and employees placed in the unplaceable section.
Step 3 Set the search range to $N = 1$.
Step 4 Go to Step 5 if a section exists that can be placed in the range where the facility and employee selected in Step 2 is moved N. Go to Step 6 if not.
Step 5 Change the facility location information to the location found in Step 4. Go to Step 1.
Step 6 Set $N = N + 1$ and go to Step 4.

5.3.1.7 Diversity Metrics

In this study, to verify the maintenance of diversity and the transition of search, the standard for evaluating the diversity of the group is set. Here, group diversity refers to the degree of difference among individuals are in the obtained population. Diversity of the entire population, where P_i represents the percentage of individuals with the same locus as the total number of individuals N and individuals $i(i = 1, 2, \ldots, S)$, is obtained as information entropy $H(N)$ using the following equation.

$$H(N) = -\sum_{i=1}^{S}(P_i \log P_i) \tag{5.1}$$

The value of $P_i(P_1 + P_2 + \cdots + P_i + \cdots + P_S = 1)$ in the formula (5.1) is the number of individuals with the same locus as the individual $N_i(N_1 + N_2 + \cdots + N_i + \cdots + N_S = 1)$ given by the following equation.

$$P_i = \frac{N_i}{N} \tag{5.2}$$

Actually, $H(N)$ is $\log N$ if all individuals have different loci, and 0 if all individuals are identical. In this study, this value is normalized and evaluated in the (0,1) interval; H represented by expression (5.3) used as an evaluation index.

$$H = \frac{H(N)}{\log N} \tag{5.3}$$

5.3.2 Computer Experiments

5.3.2.1 Experiment Conditions

The kitchen facility layout is created using the proposed method. The experiment conditions obtained from actual store data and GA parameters are presented below.

- Number of employees: 12 (6 people working 10:30–16:00, 6 people working 16:00–23:00)
- Number of facilities: 55
- Number of facility groups: 20
- Number of products: 121
- Number of steps: 2–5
- Number of orders per product: 1–115 (total orders: 1080)
- Production floor size: 500 (Discrete floor to 25 $\times$ 20)

The movement speed and working hours of workers are fixed. Table 5.1 presents the product flow types. Facilities and employees that are producible for each product are determined, but the drawn flow lines differ. Production is performed using up to three facility groups. The facility groups used in each process are shown respectively in group 1, group 2, and group 3. Furthermore, the locations of the drink space and the washing place which do not affect the total residence time of the product are fixed.

Table 5.1 Production flow

	1	2	3
Product flow 1	A	B	Q
Product flow 2	E	D	C
Product flow 3	H	G	F
Product flow 4	R or S or T	I	
Product flow 5	K	J	
Product flow 6	H	G	L
Product flow 7	K	M	
Product flow 8	P	N or O	

- GA parameter (common to stages 1 and 2)
  - Selection method: Tournament roulette selection
  - Crossover method: Two-point crossover
  - Mutation rate: 0.01
- GA parameter (1st stage)
  - Number of individuals: 1000
  - Genetic manipulation generations: 20 000
  - Crossover rate: 0.5
- GA parameter (2nd stage)
  - Number of individuals: 100
  - Genetic manipulation generations: 150
  - Crossover rate: 0.6
  - Number of islands: 5
  - Emigration interval: 5
  - Number of migrants: 1.

5.3.2.2 Experiment Results and Discussion

In the second stage, the best value of the initial generation, the best value of the final generation, and the calculation time are presented in Table 5.2. The transition of fitness is presented in Fig. 5.8. The layout of the solution with best evaluation is portrayed in Fig. 5.9.

The vertical axis of Fig. 5.8 represents the total residence time. The horizontal axis represents the number of genetic operation generations. As the figure shows, the total residence time improved gradually as the generation progressed.

The layout of Fig. 5.9 shows that the facility used in the first step of the product flow presented in Table 5.1 is gathered around INPUT and OUTPUT. With this arrangement, while the facility in the first process is cooking a product that requires no employee restraint, the employee moves to INPUT and transports another product to the facility used for production. This configuration is thought to engender reductions in time. Among facility groups that can produce products that are producible in more than 100 orders, facility groups C, I, and L are located near INPUT and OUTPUT and move immediately when an order is placed. Because facility groups N and O are in an alternative relation mutually, they are regarded as located at a

Table 5.2 Experiment results

Best (1st generation)	Best (20,000th generation)	Avg.	S.D.	Avg. time (s)
1070213	478360	503650	12097	2896

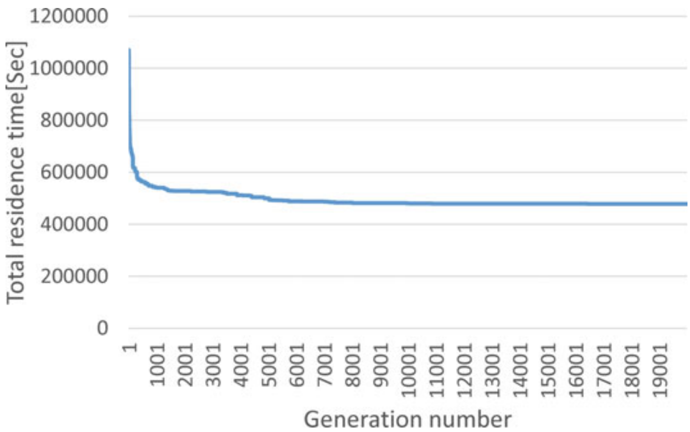
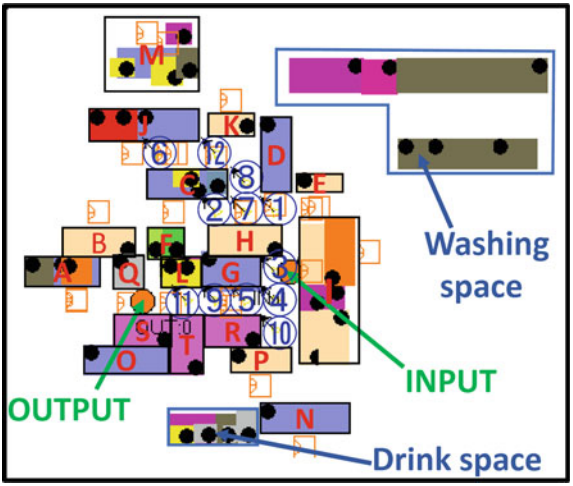


Fig. 5.8 Transition of fitness value

Fig. 5.9 Layout of best individual



position farther away from the described above three facility groups. Facility group J is placed in a separate compartment, despite the third largest number of products producible at 167. That placement occurs because the orders for 6 employees for product flow 7 and the 12 employees for product flow 5 using facility group J have as few as 17 orders. Therefore, they can concentrate on the work of product flow 5.

5.4 Staff-Shift Layout Design Using Combinatorial Auction

As described in this section, to improve resource input optimization and increase added value simultaneously, the goal is set to create an efficient staff-shift plan for employees in an intensive service site. The staff shift plan is made to determine when and what work each employee is responsible for. Various scientific and engineering methods have been studied to reduce burdens on creators in the field.

Constraints on personnel shift planning are classifiable into shift constraint conditions and staff constraint conditions: shift constraint conditions are conditions that secure the necessary personnel in each time slot; staff constraint conditions are individual requirements. The latter refer specifically to conditions related to the staff work style (Ikegami and Niwa 2001). In addition, the types of personnel shift plans are classifiable into work shift determinations, work content allocation, and both work shift determination and work content allocation, depending on the allocation target (Ikegami and Niwa 2003). The restaurant industry examined for this study is specifically Japanese restaurants. To date, shift scheduling was the only work shift determinations in earlier research (Fujii et al. 2015) for the hall staff of Japanese restaurants. The present study specifically examines the kitchen staff. The staff's concurrent duties are more severe than those of the hall staff. A staff shift planning method considering the concurrent duties is necessary. Therefore, in this study, a method of "both work shift determination and work content assignment" considering concurrent duties is proposed. Then it was evaluated using computer experiments.

In models proposed to date, when scheduling, the objective function is set as labor cost and a solution satisfying the shift constraint is obtained. Relax the constraints and find a solution that satisfies the shift constraints to the greatest extent possible if a solution that satisfies all the shift constraints cannot be found. This was based on the assumption that a solution existed. The assumption was made that the constraint was relaxed at the beginning of the search when the search space was limited. However, the current situation in the food service industry is the lack of personnel. Finding a solution that satisfies all shift constraints is difficult. Alternatively, a high probability exists that no solution exists. Therefore, this study is aimed at minimizing the shortage in each time zone and at minimizing the surplus personnel using the model (Tokunaga et al. 2015) as a reference.

5.4.1 Personnel Shift Planning Method Using Combinatorial Auction

5.4.1.1 Target System Settings

This study targets kitchen staff in Japanese restaurants where working hours can be set freely. The unit time is 1 hour. The tasks that can be handled vary depending on the employee. Multiple tasks can be performed concurrently. Precisely which operations can be combined is determined by the store structure: a so-called concurrent constraint. As a result, even if an employee can accommodate multiple tasks, whether or not they are useful concurrently must be based on the concurrent constraint. Each employee has a capability value for each job. Three levels of ability values exist: those available at a high level, those available, and those not available. In this way, one can express differences in employee capabilities on site. Each employee shall submit a desired work shift consisting of information of three types: available to work, impossible, and available to work but desire to avoid a time slot for a day if possible.

5.4.1.2 Application of Combinatorial Auction

In this study, a method based on combinatorial auction is proposed. A combinatorial auction is an auction in which multiple items (goods) that depend on value are simultaneously targeted for auction. The goods are allocated to the combination of bids with the highest bid value among the bids for the combination of multiple goods. The algorithm of the proposed method applying the combined auction is presented below.

Step 1 Maximize bid evaluation value Create a work shift for each employee that maximizes employee satisfaction.
Step 2 Create bid Assign a work position combination in charge for each work shift time slot obtained by maximizing the evaluation value, and create a bid in the vicinity. A bid is created in the vicinity of the bid that was awarded in the previous winner decision if the number of repetitions is the second or later.
Step 3 Winner determination The bid combination of each employee is determined so that the objective function value is minimized.
Step 4 End judgment Go to Step 2, otherwise end the process if the specified number of times has not been reached.

5.4.1.3 Definitions of Symbols

The meanings of the symbols used for formulation in the proposed method are represented below.

$i = \{1, 2, ..., I\}$: Employee number
$j = \{1, 2, ..., J\}$: Bid number
$d = \{1, 2, ..., D\}$: Plan period (days)
$t = \{1, 2, ..., T\}$: Plan period (hours)
$p = \{1, 2, ..., P\}$: Work position number
$q = \{1, 2, ... \{1, 2\}, \{1, 3\}, ...Q\}$: Concurrent restrictions related to a combination of work positions

$r_{p,q}$: 1 if work position p is included in work position combination q, and 0 otherwise

$c_{i,p}$: Ability value of employee i in work position p

f_q: Decrease rate of ability value when in charge of work combination q

w_i: Cost of use of employee i per unit time

$S_{i,d,t} \in \{-0.2, 0, 1\}$: 1 if employee i is in the desired work shift and time t on day d is "available"; it is 0 if not "workable", -0.2 if "can work but want to avoid"

LH_{min}^{day}: Lower limit of working hours per day

LH_{max}^{day}: Maximum working hours per day

LH_{max}^{week}: Maximum working time for one week

LD_{max}^{week}: Upper limit of working days per week

H_{rest}: Time that must be rested from the end of work until the next start of work

$N_{d,t,p}$: Capability value required for job p at time t on day d

$C_{d,t,p}$: Total ability value for job p at time t on day d

C^-: Total shortage capacity value during the planning period

C^+: Total surplus capacity value during the planning period

α: threshold

β: Correction rate discount rate

γ: Weight of objective function

$e_{i,j}$: Evaluation value of employee i's bid j

e_i^{max}: Maximum bid evaluation value for employee i

$\tau_{i,j,d,t,q}$: 1 if employee combination i is responsible for job combination q at time t on day d in bid j of employee i; it is 0 otherwise

$\theta_{i,j,d,t}$: 1 if employee i works at time t on day d in bid j of employee i; it is 0 otherwise

$\sigma_{i,j,d}$: 1 if employee i works on day d in bid j of employee i; it is 0 otherwise

$st_{i,j,d}$: Work start time on day d of employee i's bid j; it is 0 if no work exists on day d. However, $j = 1$ is set for the bid evaluation maximization problem.

$ed_{i,j,d}$: Ending work time on day d of employee i's bid j; it is 0 if no work exists on day d. However, $j = 1$ is set for the bid evaluation maximization problem.

$x_{i,j}$: The decision variable in the winner decision that represents 1 if the bid j of employee i is successful and 0 otherwise.

5.4.1.4 Maximizing Bid Value

Based on the desired work shift, create a work shift that maximizes the bid evaluation value for each employee. Solve the following $\{0 - 1\}$ integer programming problem and determine only the working hours so that each employee's satisfaction is maximized. Let e_i^{max} be the optimal value for each employee obtained using this problem. The formulation is the following.

$$\max \quad \sum_{d=1}^{D}\sum_{t=1}^{T}\theta_{i,j,d,t}S_{i,d,t} \qquad (\forall i,\ j=1) \tag{5.4}$$

$$\text{s.t.} \quad L_{min}^{day} \le \sum_{t=1}^{T}\theta_{i,j,d,t} \le L_{max}^{day} \qquad \left(if\,\sigma_{i,j,d}=1\right)$$

$$\sum_{t=1}^{T}\theta_{i,j,d,t}=0 \qquad (\text{otherwise}) \tag{5.5}$$

$$st_{i,j,d+1}-ed_{i,j,d}+24 \ge H_{rest}+1 \quad \left(if\ \ \sigma_{i,j,d+1}=1\right)$$
$$(\forall i, d=1,2,\cdots,D-1,\ j=1) \tag{5.6}$$

$$\sum_{d=1}^{D}\sum_{t=1}^{T}\theta_{i,j,d,t} \le LH_{max}^{week} \qquad (\forall i,\ j=1) \tag{5.7}$$

$$\theta_{i,j,d,t}=0 \quad \left(if\ \ S_{i,d,t}=0\right) \qquad (\forall i, \forall d, \forall t,\ j=1) \tag{5.8}$$

$$\sum_{d=1}^{D}\tau_{i,j,d} \le LD_{max}^{week} \qquad (\forall i,\ j=1)$$

$$\tau_{i,j,d}=1 \qquad \left(if\ \sum_{t=1}^{a}T\theta_{i,j,d,t} \ge 1\right) \tag{5.9}$$

$$\tau_{i,j,d}=0 \quad (otherwise) \tag{5.10}$$

$$\theta_{i,j,d,t}=1 \quad \left(if\ \ st_{i,j,d} \le t \le ed_{i,j,d}\right)$$
$$\theta_{i,j,d,t}=0 \quad (otherwise) \tag{5.11}$$

$$1 \le st_{i,j,d} \le T-LH_{min}^{day}+1 \quad \left(if\ \ \sigma_{i,j,d}=1\right)$$
$$st_{i,j,d}=0 \quad (otherwise) \tag{5.12}$$

$$LH_{min}^{day} \le ed_{i,j,d} \le T \quad \left(if\ \ \sigma_{i,j,d}=1\right)$$
$$ed_{i,j,d}=0 \quad (otherwise) \tag{5.13}$$

$$\theta_{i,j,d,t}, \sigma_{i,j,d} \in \{0,1\} \qquad (\forall i, \forall d, \forall t,\ j=1) \tag{5.14}$$

Expression (5.4) represents the degree of agreement between each employee's work shift and the desired work shift. The maximum value of employee satisfaction is obtained by aiming at the maximum. Also, (5.5) is a constraint on the upper and lower working hours of a day, (5.6) is a constraint that must rest more than the specified time before the next work, (5.7) is a restriction on the upper limit of working hours for one week, (5.8) is a restriction by which one can not work in the work impossible time period in the desired work shift, and (5.9) represents a restriction on the upper limit of working days per week. In addition, (5.10) is a constraint on the dependent variable $\tau_{i,j,d}$ and (5.11) is a constraint on work start and end times. Moreover, (5.12) and (5.13) respectively represent constraints on the dependent variables $st_{i,j,d}$ and $ed_{i,j,d}$. By solving this problem, one can obtain a work shift for each employee that maximizes employee satisfaction.

5.4.1.5 Creating Bid

Based on the bid of bid number 1 for each employee, create similar bids. The assigned work position combinations consist only of the tasks that each employee can accommodate. They are selected from the work position combinations which satisfy the concurrent work constraints. In addition, even if one work for multiple hours on the same day, it will be decided on a day-by-day basis to avoid changing the work position combination they are responsible for.

The first bid of bid number 1 is assigned randomly to ascertain which work combination is assigned to each employee's work shift is obtained by maximizing the bid evaluation value. From the second time onwards, bid number 1 is the bid that won the previous winner decision. To prevent the solution from worsening by creating a neighborhood, the bid with bid number 1 is not changed. Therefore, the new bid to be created is $J - 1$. The neighborhood search pattern for bidding is selected randomly from the following. At this time, satisfying the constraint equation for maximizing the evaluation value of the bid is necessary. The bid is discarded and new one is created if the created bid does not satisfy the constraint condition.

Working Hours

1. Select a day randomly with work. Increase the work start time by one hour.
2. Select a day randomly with work. Delay the work start time by one hour.
3. Select a day randomly with work. Increase the work end time by one hour.
4. Select a day randomly with work. Delay the work end time by one hour.
5. Select a day randomly with work. Increase the work start and end time by one hour.
6. Select a day randomly with work. Delay both work start time and end time by one hour.
7. Select a day randomly with work. Eliminate that day.
8. Select one day randomly without work. Add new work.
9. Select a day randomly with work. Remove the work on that day. Then select a day with no work randomly. Add new work.

Work in Charge

10. Select a day randomly with work. Change the work on that day randomly.

Working Hours and Assigned Duties

11. Select a day randomly with work. Set the work start time one hour earlier. Then change the work on that day randomly.
12. Select a day randomly with work. Delay work start time by one hour. Then change work on that day randomly.
13. Select a day randomly with work. Change work on that day randomly after the work end time is set one hour earlier.
14. Select a day randomly with work. Delay the work end time by one hour. Then change the work on that day randomly.

The reason for creating a pattern that changes only the working hours or the work in charge, or a pattern that changes both, is to improve search ability by increasing the number of solutions. Only one, pattern 10, changes only the work position in charge. In the computer experiment of this section, another pattern is selected as the other pattern so that the ratio of change in work hours and work changes is not excessively biased, the selection probability is set to triple rather than other patterns.

An additional constraint formula (5.16) is set up to prevent employee satisfaction that is maximized by maximizing the evaluation value of the bid from decreasing too much. Here, $e_{i,j}$ represents the degree of agreement with the desired work shift of the shift in bid j of employee i and represents employee satisfaction. By this additional formula, the greater the value of α, the higher the degree of agreement with the desired work shift, i.e., the work shift with high employee satisfaction.

$$e_{i,j} = \sum_{d=1}^{D} \sum_{t=1}^{T} \theta_{i,j,d,t} S_{i,d,t} \qquad (\forall i, \forall j) \tag{5.15}$$

$$e_{i,j} \geq \alpha e_{i,j}^{max} \qquad (\forall i, \forall j) \tag{5.16}$$

$$0 \leq \alpha \leq 1 \tag{5.17}$$

5.4.1.6 Determining Winner

The formulation for winner determination in this model is presented below.

$$\min \quad \gamma C^{-} + (1-\gamma)C^{+} \tag{5.18}$$

$$\text{s.t.} \quad \sum_{j=1}^{J} x_{i,j} = 1 \quad (\forall i) \tag{5.19}$$

$$\sum_{i=1}^{I}\sum_{j=1}^{J}\sum_{q|r_{p,q}=1} x_{i,j}\tau_{i,j,d,t,q}c_{i,p}f_q = C_{d,t,p} \quad (\forall d, \forall t, \forall p) \tag{5.20}$$

$$f_q = 1 - \beta\left(|q| - 1\right) \tag{5.21}$$

$$C^{-} = \sum_{d=1}^{D}\sum_{t=1}^{T}\sum_{p=1}^{P}\left(N_{d,t,p} - C_{d,t,p}\right) \quad \left(if\, N_{d,t,p} \geq C_{d,t,p}\right) \tag{5.22}$$

$$C^{+} = \sum_{d=1}^{D}\sum_{t=1}^{T}\sum_{p=1}^{P}\left(C_{d,t,p} - N_{d,t,p}\right) \quad \text{(otherwise)} \tag{5.23}$$

$$x_{i,j} \in \{0, 1\} \quad (\forall i, \forall j) \tag{5.24}$$

$$0 \leq \gamma \leq 1 \tag{5.25}$$

The decision variable in this problem is $x_{i,j}$, which represents 1 if the bid j of employee i is selected and 0 otherwise. The objective function is a weighted linear sum of the shortage and surplus ability values of the total ability value of the work for which each employee is responsible and the required ability value of each work in each time period set as a certain service can be provided. It is targeted for minimization. Also, (5.19) is the restriction by which only one bid can be selected per employee; (5.20) is the total ability value of each job in each time period. Furthermore, a formula exists for calculation from the seat of the correction rate according to the number of concurrent work positions. Expression (5.22) expresses the constraint on the insufficient ability value. Expression (5.23) expresses the restriction on the surplus ability value.

In this model, for larger γ, higher priority is assigned to the minimization of the shortage ability value. Smaller values of γ have priority assigned to the minimization of the surplus capacity value. Presumably, a greater deficiency value suggests lower quality of service and customer satisfaction, in addition to a greater labor burden on the employee and lower employee satisfaction. However, a larger the surplus capacity value is assumed to be associated with higher costs, extra labor costs, and lower management satisfaction.

5.4.2 *Computer Experiments*

5.4.2.1 Experiment Conditions

There are 24 employees. The planning period is set to 7 days × 13 hours. The number of jobs is set to 7. The employee satisfaction threshold α is set as 0.0. The correction rate discount rate β is 0.1. The number of bids is 50; the repetition number of combinatorial auctions is set as 100. Each employee's ability value and required ability value are based on actual data. IBM's general-purpose solver CPLEX12.6 was used to maximize the evaluation value of the bid and to determine the winner.

5.4.2.2 Experiment Results

Table 5.3 presents results of computer experiments with γ varied from 0.0 to 1.0. From Table 5.3, if $\gamma = 0.0$, then the shortage value in the objective function will be ignored. The ability value is the same as the total required ability value. The surplus ability value is 0. As the value of γ increases, the weight of the insufficient ability value increases. Also, the weight of the surplus ability value decreases. Therefore, the shortage capacity value decreases and the surplus capacity value increases. When $\gamma = 1.0$, the surplus ability value weight is 0. Only the insufficient ability value is reflected in the objective function, but the insufficient ability value does not become 0 in the second trial out of the ten trials. In other words, it was apparently difficult to find a solution with a deficit ability value of 0, irrespective of how great the surplus ability value could be.

When $\gamma = 0.9$ to $\gamma = 1.0$, the value of surplus capacity increased by about five times. If $\gamma = 0.9$, then the priority is low, but the surplus capacity value is considered. Therefore, the surplus capacity value can be suppressed to some degree, but if $\gamma =$ 1.0, the surplus capacity value is larger. However, the result is not reflected in the objective function. In fact, the insufficient ability value converges to a certain small value. If γ is slightly smaller than 1.0, then one can find a solution which reduces

Table 5.3 Experiment result

γ	Total work hours	Personnel expenses	Deficient capacity	Surplus capacity
0.0	0	0	555	0
0.1	170.9	201245	329.4	18.7
0.2	291.4	356860	221.2	41.1
0.3	353.2	452386	91.1	80.2
0.4	356.1	460128	72.5	88.3
0.5	372.5	482313	51.9	102.3
0.6	389.0	503800	34.0	126.0
0.7	404.7	520810	23.4	144.8
0.8	414.5	534627	14.1	170.2
0.9	436.7	566653	4.0	225.1
1.0	547.8	699788	0.16	1137.1

the excess ability value while maintaining the insufficient ability value. Probably, if one wants to reduce unnecessary labor input, then γ should be set to a value smaller than 1.0, even if $gamma = 1.0$.

5.5 Concluding Remarks

This chapter first presented a brief introduction about the proposed wider concept of service manufacturing systems, where both tangible goods and intangible services are regarded as integrated services. Then, a service value creation loop was explained by integration of service design, planning and operation, and production and consumption phases. As the implementation of the planning and operation phase in the restaurant business environment, short and long-term improvement loop was also described, with facility layout and staff-shift layouts as spatial and temporal planning problems on a kitchen floor.

The facility layout planning method of kitchen employed simulations and genetic algorithms for improving restaurant productivity, where the facility layout including facilities is not directly related to production using facility grouping. Results confirmed that the facility layout considering the product and worker flow was created. The effectiveness of the method was demonstrated using experimentally obtained results from computer simulations.

Staff-shift layout planning in the kitchen floor using combinatorial auction was proposed, where the objective function was chosen as a weighted linear sum of the deficit capacity and surplus capacity values. Computer experiment results were analyzed: results confirmed a tradeoff between insufficient capacity value and surplus capacity value and also confirmed that the weight can be changed by the value of γ.

Future issues include not only improvements of both facility layout planning method and staff-shift scheduling method but also integration of independent planning methods along the short-term and long-term improvement loops in the kitchen floor.

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Chapter 6
Design and Production Systems for Food Products

Takeshi Shimmura

Abstract Food has two characteristics: tangible and intangible. Customers evaluate the quality of food physically, judging the taste, texture, and arrangement. At the same time, customer evaluation is influenced by non-physical aspects such as the dining situation, tablemates, and dining space. To maximize value, food should be designed considering tangible and intangible aspects. In addition, quality, taste and seasoning of food depend deeply on the production method. They change with the passage of time. To realize designed food quality, production processes and methods should be designed based on an interdisciplinary approach, not only cookery science. This chapter discusses design and production theory for food.

6.1 Design Theory for Food

Traditionally, food is designed by skilled chefs. When designing food, they mainly define food tastes and cooking processes. Receipts describe the kinds and quantities of ingredients, flavoring, cooking processes, and arrangements. Food design mainly addresses tangible aspects. Is that optimal for food design?

Food value is a set relation between input and output. For instance, a consumer evaluating the value of sushi does not decide it based on sushi quality, but on the relation between quality and price. Moreover, sushi quality is decided not only based on physical quality, but also based on perceived quality, such as the dining environment and dining party members. Furthermore, the sushi price is not decided solely on the ingredient cost but also on the cooking process. Therefore, these four dimensions should be considered when food is designed. Figure 6.1 depicts a food design overview.

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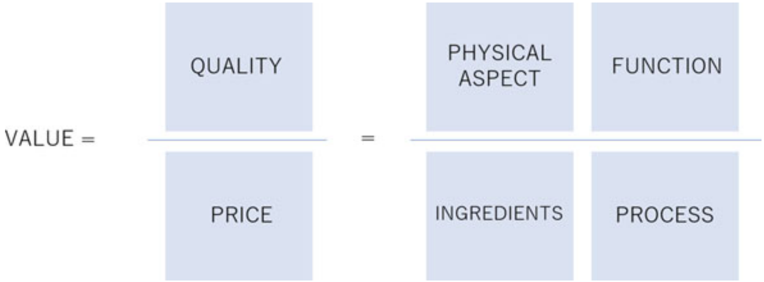


Fig. 6.1 Food design overview

6.1.1 Ingredients

Conventionally, food design emphasizes main ingredients, preparation, and seasoning. The symbol of design is the name of a dish. For example, "Roasted canard with orange sauce" gives an overview of the dish design.

When an ingredient combination is designed, it should be decided based on synergetic effect of "Umami", which derives from three amino acids: inosinic acid, glutamic acid, and guanylic acid. Humans feel that food tastes 7–8 times better if they eat a dish that contains plural amino acids, compared to single amino acids. This is so-called amino acid interaction. In addition, humans feel taste best if inosinic acid and glutamic acid are included 1:1. Furthermore, amino acid interaction is also good for health care because amino acid interaction will cut the usage of salt for dishes because salt is used to give food good taste. In fact, amino acid interaction creates good taste, therefore reducing salt necessity.

Traditionally, chefs find amino acid interaction through experience. For instance, the Japanese typical soup stock "Dashi" is made from "katsuobushi (dried bonito)" and dried kelp. Actually, katsuobushi contains inosinic acid; dried kelp contains glutamic acid. In addition, hamburgers contain beef and onions. Chinese steamed chicken dishes contain long green onions. These are also inosinic acid and glutamic acid combinations.

Although amino acid interaction is an important factor affecting the taste of dishes, amino acid information is not included on the receipt. Even if a kind of amino acid contained in ingredients is indicated on a receipt, the content amount is not given. If a food designer decides upon a combination and quantity of ingredients scientifically, then the kind and quantity of amino acid should be quantified. Currently, amino acid information for food design databases is not maintained sufficiently. Therefore, database formulation is an important mission for food design. Table 6.1 presents a sample of an amino acid database.

Table 6.1 Amino acid database

food categories	fiood	gultamic acid		inosine acid		guanylate	
seaweed	rausu kelp	2290～3380	2835				
	japanese kelp	1610～3200	2405				
	rishiri kelp	1490～1980	1735				
	hidaka kelp	1260～1340	1300				
	seaweed	550～1350	950	1～40	20.5	3～80	41.5
	wakame seaweed	2～50	26				
vegetable	tomato	150～250	200				
	dried tomato	650～ 1140	895			10	10
	green pea	110	110				
	lotus root	100	110				
	garlic	100	110				
	corn	70～110	90				
	soybean	70～80	75				
	fava bean	60～80	70				
	chinese cabbage	40～90	65				
	potato	30～100	65				

6.1.2 Processing

Whole cooking processes are discussed in Sect. 6.2. Cooking processing in the kitchen is discussed here. Cooking processes are divisible roughly into two functions: cutting and heating. Additionally, cutting processes are divisible into cutting (e.g., with a knife) and mashing (with a mill). Heating is divisible to heat transfer (baked foods), convection (simmered foods), irradiation (grilled foods), and microwave. Cutting processes are used to make eating easier, and for penetration of flavoring. Typically, Japanese traditional cookery is named "Kappou (katsu + hou)", where "katsu" means cutting, and "hou" which means heating. The purposes of both cutting and heating ingredients are to make food easier to eat and season.

Characteristics of cutting processes are physical actions. Therefore, physical structures of vegetable fibers and meat muscle, especially direction of the fiber lines and muscle lines should be considered when cutting. Processing methods should be chosen based on cooking purposes and dish characteristics.

For instance, two methods are used for root vegetable cutting: vertical cutting and horizontal cutting. Generally, root vegetable fibers run vertically. Therefore, vertical cutting does not cut the fiber line. As a result, vertically cut vegetables feel crunchy and remain moist because the fiber structure is not destroyed. By contrast, it takes a long time for seasoning agents to penetrate because fiber structure and walls are not cut.

By contrast, horizontal cutting cuts fiber lines. Horizontally cut vegetables feel soft compared to vertically cut vegetables because the fiber line is cut. In addition, horizontally cut vegetables drip vegetable juice. Thereby, they tend to lose freshness and moisture. By contrast, it is easy, and it takes a short time for seasoning agents to penetrate because vegetable juice drips easily.

Characteristics of heating processes are chemical action, whereas cutting processes are physical action. Therefore, chemical structures and characteristics of seasoning agents and ingredient cells are important for cooking process. For instance, marinating is traditional cookery. It is an essential function of marinating to exchange marinade building blocks and ingredient cell fluids. Adequate marination time is determined based on molar weight and salt density. For example, the sugar (sucrose/$C_{12}H_{22}O_{11}$) molar weight is 342.3 g/mol. That of salt (sodium chloride/NaCl) is 58.4 g/mol. Therefore, the sugar penetration rate is lower than that of salt because of the large sucrose molecule.

Furthermore, osmotic pressure is important for marination time decisions. If a fish is immersed in a salt marinade with 3% density, then the salt density of both fish cell and marinade are balanced. Thereby, the marinade-cell fluid exchange will be failure. As a result, seasoning agents do not perfuse. The taste of the marinated fish will be a light taste. The marinade density rate should be found based on osmotic pressure and the seasoning agent: salt, sugar, and vinegar density.

6.1.3 Physical Aspects

Physical aspects of dishes are the most typical factor for food design. Taste of a dish is a core factor for food quality, but humans eat and evaluate dish quality through the five physical senses, not only based on one's palate. For instance, if a customer eats a tomato-tasting spaghetti blindly, it would be difficult to judge a dish as tomato-tasting spaghetti even if one eats it. Perhaps a person could judge it as a noodle.

Visual information is an important factor. Therefore, food color, shape, decoration, and other such information are judged based on human visual affection. For instance, humans tend to evaluate red and orange food better in winter, and blue and green food better in summer because cool colors are symbolic of pleasant cooling sensations, and warm colors symbolize warmth. In addition, if a blue strawberry and red kiwi were served in their respective seasons, humans would tend to evaluate them as having good taste. Food color evaluation deeply depends on the eating experiences and knowledge of humans.

A sense of touch exerts influence on food quality evaluation because the food texture itself is an important factor affecting food quality. For instance, if a customer eats a damp cookie, the customer evaluates it as bad. If a customer eats a hard macaroon, it would be evaluated as bad. In addition, one evaluates the standards for food texture according to differences among ethnic groups. For example, European and North American ethnic people tend to evaluate crispy and hard foods better. By contrast, Asian people tend to evaluate tender and soft foods better. Humans evaluate food tastes by mouth, not only by the tongue. Buccal cavity nerves also feel and evaluate food quality. The criteria for judgment are decided based on ethnic eating customs.

Olfactory senses influence human food quality evaluation. As Fig. 6.2 shows, humans feel that foods taste strongly and clearly if they breathe and eat a food,

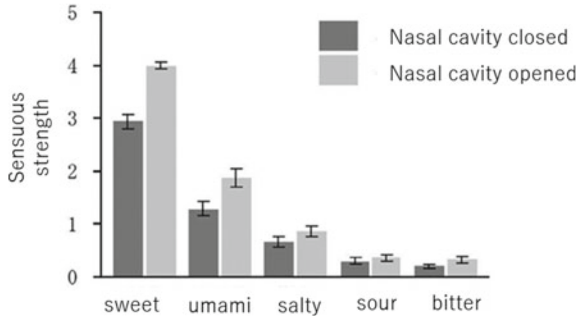


Fig. 6.2 Decorations of two types

compare to not breathing and eating. A typical example is that if a person gets a cold with nasal congestion, that person's sense of taste will be impaired or nonexistent. Human judgment for smell deeply depends on memory, especially while young.

6.1.4 Function

Since ancient times, the objective of eating was sustenance. As time went by, humans added functions for eating behavior. In other words, humans changed the definition of eating from eating to dining. The first impetus was communication among family and peers. Ancient people took risks of health and life chasing animals. Therefore, ingredients were a symbol of cooperation. People share food with hunting experiences. The second impetus was ritual. People think that food sacrifices and placement at altars are important for ritual observance and appeasing anger of the gods. In some cases, people share the food after offering it.

From the early modern period, people have incorporated dining as a way of life. For example, the Japanese aristocracy had parties celebrating their promotion and inheritance of family estates during the Heian era (AD 8C). In another case, people have parties for weddings in all countries. Along with that trend, people gradually establish traditions and codes for dining such as table manners and meanings of food. For example, abalone is a symbol of longevity. Seabream represents happiness in Japan. Dumplings are a symbol of money in China. Context has become an important factor of food design as well as physical design.

In modern times, food and dining design are full of context. Food designers make a food and dining concept before they design dishes and dining events. In that sense, food design resembles play-writing. For instance, when a dish is designed, a designer will consider the purpose of dining. If the purpose is a celebratory occasion, then auspicious ingredients such as seabream and abalone are applied. Auspicious dishes such as "Takiawase" (the phonetic equivalent of *much happiness* in kanji characters) are prepared in Japan. In addition, furniture, fixtures and dishes are chosen based on the concept. For example, red is a symbol of happiness in Japan. Therefore, red tablecloths and goblets are used in Japan.

Additionally, the dining environment is a factor affecting food design. If one eats a luxurious French course in a meeting room, the person might not evaluate it as excellent although it is truly fine food. Scripting is food design itself because dining is an experience, not merely tangible goods. Therefore, the dining environment should be designed based on a script. For instance, if one is dining at a Christmas party, a Christmas tree, decorations, and candles will warm the party. If a church is selected as the party space, then a customer psychologically evaluates the party as amazing.

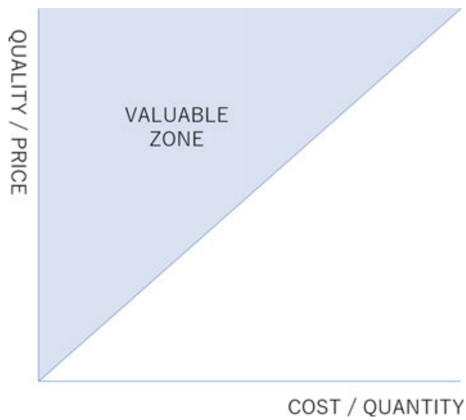
Naturally, the meanings of ingredients, color etc. depend deeply on ethnic considerations. Therefore, ethnic boundaries should be considered. For instance, red means happiness in Japan, but it is associated with funerals in South Africa. Furthermore, octopus is a symbol of happiness in Japan (the phonetic equivalent of *much happiness* in kanji characters), but it is a symbol of the devil in western countries. Today, food markets have become global. Therefore, food designerss should research ethnic customs, cultures, and creeds. In some cases, misunderstanding of ethnic considerations will give rise to serious mistakes. A well-known example is pork. It is a popular ingredient used worldwide, but devotees of Islam avoid it because of their religious beliefs.

6.2 Value Relations Between Price and Quality

The purpose of food design is to make consumers amused and happy. Nevertheless, people evaluate food value not only by quality but also by price. Therefore, food designers should think about "what is value for the consumer?" for good food design. Naturally, home meals have different aspects: health care, family affection, and so on.

Figure 6.3 depicts a simple value principle: a relation between price and quality. Food quality depends deeply on cost. It is a core factor for pricing. Costs include three factors: ingredients, labor, and budget. Naturally, if a food designer plans to

Fig. 6.3 Product value



create high-quality food, it is apparently expensive because of high cost. High-quality ingredients, skillful chef salaries, and exclusive dishes are more expensive. It is meaningless if the price of a dish A, with two-times higher quality than another dish B, is twice that of dish B. Food designers should realize valuable-zone foods, as depicted in Fig. 6.3.

There are two ways to realize valuable-zone food. One way is quality-oriented food. The other way is price-oriented food. In one case, if price and value are evaluated on a scale of 1–10, then quality-oriented food will be quality 8/price 5 (value = 13). The price-oriented food will be quality 8/price 5 (value = 13). In this case, if the average food value is defined as 12 (quality 6/price 6), then these 2 value-13-foods are more valuable than the average food.

During the twentieth century, the food industry intended to realize low price products through mass production systems because the mission of industry was to realize materialistic affluence. The challenge continues because hunger problems have not been resolved, but the core strategy of the food industry in industrialized countries has changed because of the maturity of markets and consumers.

6.2.1 Price

Price is described as a simple formulation of P (Price) = c (cost) + π (profit). Therefore, a price is formulated based on a balance between costs and expected profit levels. If designers intend to make a price plan, then they should define a source of value. As explained above, cost comprises three factors: ingredients, labor, and budget. If a designer intends to be differentiated through unique or valuable ingredients such as caviar and white truffles, ingredient costs should be emphasized. However, if a designer plans to be differentiated through advanced cooking techniques such as those of a Michelin three-star chef, there will be high labor-cost products. Furthermore, if a designer wants to be differentiated through costs, such as luxurious dishes or elaborate decorations, the main cost will be budgeted.

Ingredients are basic, constituting the origin of core value. For example, in the Japanese restaurant industry, the average ingredient cost is 30%, with a standard deviation (SD) of ± 10%. First, a designer chooses an average and SD. Subsequently, the designer plans individual food product ingredient costs. Generally, food or dishes requiring high skills will have low ingredient costs, and a popular food will have higher ingredient costs. An extreme example is that a Japanese famous restaurant chain company provides dishes with ingredient costs of 90% to maximize the total number of customers. That strategy brought them rapid growth in the restaurant market. Naturally, the average and SD of ingredient costs differ among countries and industries. Designers should assess them before planning a policy for ingredient cost design.

Approaches to labor costs differ among industries. Thereby, labor cost allocation should be decided by top management. If they design a business model without labor cost design, then the company will not be able to control costs. Total labor costs deeply depend on production systems. Fundamentally, the production systems of food manufacturers are machine-based and factory-based. Those of food service providers are human-oriented. Therefore, service providers such as restaurants, food retailers, and hotels spend large amounts of money for production (cooking) staff. By contrast, manufacturers such as food and beverage producers make expenses for depreciation of equipment. Manufacturers spend labor costs for R&D staff to produce unique foods and gain patents.

Budgets include two costs: fixed and variable. The main fixed costs are rent and depreciation. For retail businesses, rents depend strongly on the store location. The depreciation level is based on facilities, and the interior and exterior structure and decor. For food manufacturers, rent depends on the factory location for convenient distribution. Depreciation depends strongly on the main facility capacity. Retail store location and the interior decor are linked to food value because customers consume food at the site. Food designers should decide a fixed cost relation between cost and value. Variable costs of some kinds should be saved. Other costs should be regarded as risky investments that might be nonetheless necessary. For instance, utility costs should be saved for efficient energy usage. By contrast, plate and utensil costs are an important factor for food value. Therefore, cost expenses should be decided not based on cost savings, but based on food value creation.

6.2.2 Quality

Naturally, food quality is influenced by ingredient quality. In that sense, the food industry is a so-called material-based industry. If a food company uses low prices but aged ingredients, then the food will be a low-quality product. On the other hand, if a food company uses high prices and fresh ingredients, then the quality of the food will be good. In short, food quality is defined by the ingredient quality. As explained earlier, the purpose of food design is to realize a “valuable zone”. Therefore, the food designer should tilt the balance.

The first approach is cookery skills. If skillful chef cooks a food, then its quality will be better than that made by a poorly skilled chef. Of course, a skillful chef earns a higher income, so a food designer should consider that the chef’s skill will be leveraged or not. For instance, the average Japanese sushi chef earns 4 million yen per year. The average sushi dish price is 5,000 yen. A top sushi chef earns 15 million yen, but the price of fine sushi dining is 20,000 yen. Do you think that a higher labor cost realizes a “valuable zone”?

The second approach is processing methodology. Several methods exist for a chef to thaw frozen tuna: defrosted to room temperature, defrosted in a refrigerator, and lukewarm water. Thawing processes depend strongly on tuna quality because the tuna turns black if not defrosted carefully. To avoid black discoloration, the tuna temperature should rise rapidly from −10 to −3 °C. In addition, contents of nutrient composition depend strongly on temperature. For instance, the total fish vitamin content is determined by temperature. If a fish is stocked in a refrigerator (3–10 °C), then it will become rotten within a few days, soon becoming inedible. If a fish is stocked in a freezer (−10 °C), then the storage period is 2–4 months, with total vitamin B of 85–88% compared to day it was first stocked. If stocked at −20 °C, then the storage period is 5–10 months, with total vitamin B maintained as 90–100%.

A third approach is processing technology. The most illustrative example is heating. Traditionally, food is heated using water, fire, and oil used with a pot, griller, and oven. In recent years, convection ovens and vacuum machines have been developed for food manufacturers and retailers. The technology has rapidly improved food quality. Maintaining or controlling temperature is difficult for traditional heating. Especially, controlling the central temperature of ingredients is extremely difficult. As a result, foods tend to become stiff because of overheating when one seeks to avoid food poisoning caused by a lack of heating. If a convection oven is applied, controlling the core temperature of ingredients is easy: a cooking staff member needs only to set the core temperature with a controller. Then the machine automatically heats it and automatically stops heating to finish cooking. In addition, if vacuum cooking is applied, food quality becomes much better. Moreover, food becomes much safer. Characteristics of vacuum cooking are increased osmotic pressure achieved through high pressure. Traditional cooking takes a long time to give flavor by traditional heating because it is done at low pressures. Consequently, ingredients become stiff because of long heating times and high temperatures.

6.3 Process Management

Traditionally in food industries, processing means cookery by a chef. However, since the eighteenth century, cooking processes advanced rapidly because of technological development. For instance, a very early innovation was canning and bottling: preservation technologies. Some innovator developed food can and bottling. Then they became food manufacturers. Subsequently, they rapidly expanded the food market size. Another important technology is cold storage technology. Before that technology's introduction, food storage technology was mainly drying and salting. Naturally, drying and salting have some good characteristics; for instance, the price of dried abalone is very expensive because of rich amino acids. However, traditional stock methods basically changed ingredient characteristics. By contrast, cold storage technologies retain the original ingredient characteristics. In addition, freezing can enable maintenance of stock freshness longer, even for over a year.

These technologies introduction has led to food value chain generation. Before then, foods were fundamentally locally produced for local consumption because food was difficult to stock for long periods, excluding grains and dried foods, of course. Introduction of storage technology supported distribution of food over a wide area. In fact, the production area, distribution area, and consumption area form a food value chain. In other words, storage technology changed the processing system used by the food industry.

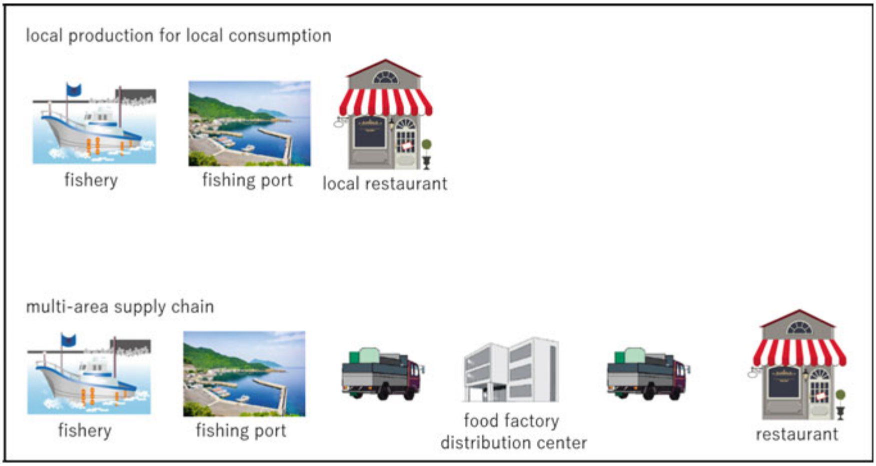


Fig. 6.4 Traditional and contemporary production models

Amazingly, food characteristics are similar to service product characteristics. Service products are difficult to stock. Therefore, services should be created or produced simultaneously with consumer orders. As a result, service production sites should be located near consumer locations. Therefore, food study for productivity innovation is a main field of service study because of their commonalities. Actually, food quality is determined by physical aspects, but also by emotional factors: human factors are core study objectives for service studies (Fig. 6.4).

6.3.1 Service Product Characteristics—Common Term with Food Contents

As explained, characteristics of food are similar to those of service products. This point has been studied mainly in the service marketing field for a long time. It has been concluded that four characteristics exist.

The first characteristic is intangibility. Material goods are tangible. Therefore, they can be stocked. They are easy to quantify. By contrast, services are intangible. They pose important difficulties to service providers. It is difficult to quantify service quality, to stock service, and to design it. Typical services are haircuts, medical care, and education. Fundamentally, services are not tangible goods but behaviors: cutting, examining, and lecturing. Therefore, service products are intangible. To be sure, service is associated with tangible products if it is served to a customer. For instance, aestheticians use scissors, doctors use auscultators, and teachers use textbooks. Similarly, food is a tangible product, but cooking is a behavior. Food quality is closely related to cookery.

The second characteristic is perishability. Material goods can be stocked because they are tangible. Thereby, manufacturers produce goods in a planned way and stock them in a warehouse. They can adjust demand–supply gaps by inventory control. By contrast, service itself is intangible. Therefore, it cannot be stocked. For instance, if a patient gets medical treatment, the medical treatment itself will pass out of existence, but the effects of treatment remain with the patient's body. If a medical services could be stocked, then a doctor could stock medical treatment services while idle. Then, if there are many customers, the doctor would only have to deliver it. Food is a tangible product, but if a consumer eats it, the food will vanish.

The third characteristic is simultaneity. Material goods can be stocked. Therefore, the production point time and consumption time can be divided. By contrast, services are intangible products. Therefore, they cannot be stocked or provided asynchronously. As a result, a service provider should create a service at the same time a customer orders it. For instance, an aesthetician should cut, a doctor should treat, and a lecturer should teach when a consumer comes to the service site. Food is a tangible product. Therefore, it is possible to stock it. However, food must be cooked at the time a customer orders it at a shop. Alternatively, a homemaker prepared food immediately before a family starts dining.

The fourth characteristic is heterogeneity. There are two heterogeneities related to service. One is that the customer has a subjective perspective for services. If a customer evaluates a service as good, another customer might evaluate it as bad. Moreover, even if a customer evaluates it as good, the customer might feel that it is bad another day. For instance, a customer who prefers long hair might prefer short hair suddenly. Evaluation of tastes typically changes day by day. If a customer with a full stomach eats a valuable dish, the customer might feel it is not tasty. The other heterogeneity is service product quality. Even the number one service provider can not create the same service products: hairstyles will differ to some degree every time a hair stylist cuts, and executions will differ every time a doctor operates on a patient. Food quality differs day by day, and even dish by dish. Even for factory-made food, tastes will change delicately because ingredients are natural objects.

6.3.2 Service Product Characteristics for Food—Different Points Among Industries

Figure 6.5 shows some typical food industries. The most typical and traditional food industry is a restaurant. At a restaurant, food is cooked simultaneously with the customer order. Therefore, restaurant food has qualities of simultaneity. In addition, specifications of food, such as quality, quantity, taste, and appearance vary from one dish to another dish because restaurant food is handmade. That is a typical characteristic for heterogeneity. Furthermore, it is difficult for a restaurant to stock dishes for a long time because long-term storage will bring quality deterioration. Although the point is not identical, perishability of service contents is similar.

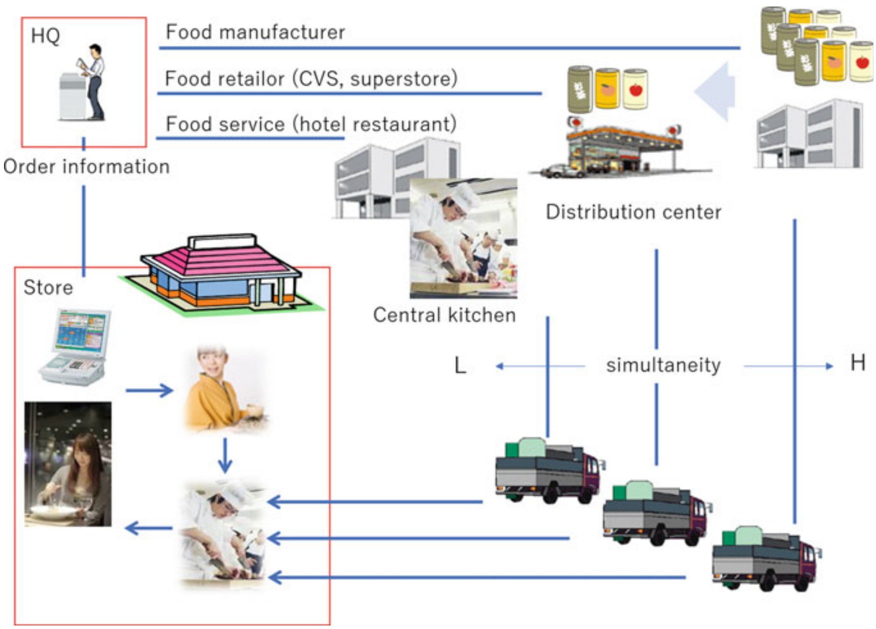


Fig. 6.5 Relation between the production system and simultaneity

By contrast, the retail food industry, such as convenience stores, has similarities, but some differences from service characteristics. For instance, at the CVS store, some foods are cooked at food factories. Other foods are cooked at a CVS store. Consequently, some CVS foods are simultaneous contents. The other foods are metachronous ones. Moreover, freshness dates of some foods are very long because of production methods (freeze, dried, retort-packed, etc.), and those of others are very short (fresh, store-cooked, box lunch, etc.). Some foods are available products, but others are perishable products,

However, food manufacturer products are similar to tangible goods. For instance, several food factories make products that are frozen, dried, retort-packed, and powdered foods, with very long freshness dates. Their characteristics are the same as those of tangible goods (available products). In addition, the quality of factory-made foods is almost, or completely, identical because these are factory made. That is a characteristic of material products (homogeneity products).

6.3.3 Trade-off Between Price and Quality

As 3-2 explains, service product characteristics are deeply linked with production systems of respective food industries. Generally, with hand-made based production systems such as those of the restaurant industry, service product characteristics are

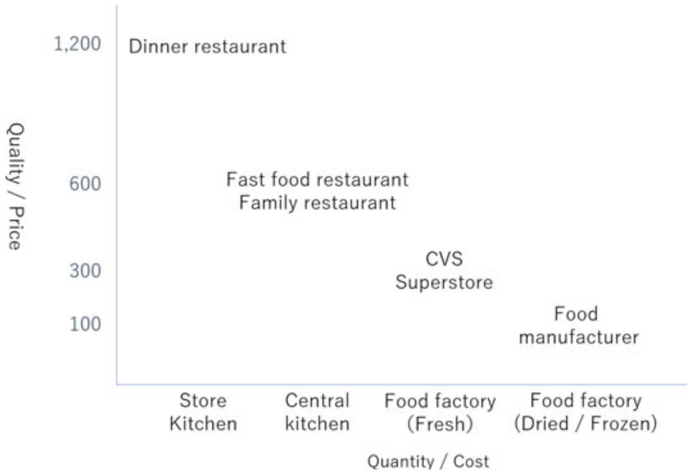


Fig. 6.6 Tradeoff between processing system and quality

accentuated. Moreover, among restaurants, fine dining and dinner restaurants are particularly prominent.

Figure 6.10 presents the relation between quality (price) and quantity among food industries. As the figure shows, quality and quantity share a so-called tradeoff relation: if a food company business is positioned on the tradeoff line, then the company can not differentiate itself from its competitors. In other words, the company can not realize a "valuable zone" (Fig. 6.6).

To realize a differentiating strategy, a food company should innovate processing systems for value creation. Is it possible to achieve a food that is quite fresh, does not drip, and which has a long shelf life for frozen live seafood? Is it possible to introduce more delicious ingredients? Two ways seem readily apparent. One way is to introduce individual technologies dedicated to serving a food industry. Recently, partial freezing and proton freezing technologies were developed and introduced to food industries. These technologies realize long-term storage for fresh food. They partly resolve the difficulties of simultaneity and perishability.

Another way is to construct a whole production system. For instance, if a global food manufacturer regards transport processes as aging processes, then the company can introduce a partial freezing transporter to optimize the ripening degree. Furthermore, the company changes the storage method from the refrigerator and freezer to a partial freezer and a proton freezer to realize a higher level cold chain.

6.3.4 Two Ways: Enhancing or Decreasing Simultaneity

An important factor affecting food industry productivity is production systems. Simply, if a food provider can stock food products, it can easily achieve full control of production planning by a food factory. The provider can easily fit a supply quantity to demand fluctuations. However, if another food provider can not stock it, it is difficult to control production planning. The company should cook food simultaneously with a customer order. Simply, the production method determines product characteristics (sententious/available product).

Industrial progress made by the food industry has occurred by virtue of production method development. The most traditional method was bottling. Since then, various methods such as freezing, retort, and vacuum-prepared foods, have been introduced.

Nevertheless, although these methods make it easy to stock food products, the food quality is not good compared to that of hand-made food, especially that prepared at a fine restaurant. For instance, retort curry is easy to stock for a long time, but its taste is not good compared to that served at a fine curry restaurant. In addition, factory-made and frozen sushi are easy to stock, but they have a bad taste compared to sushi dining. In other words, a tradeoff exists between preservability and food quality.

Is it possible to break through that tradeoff? Generally speaking, it is difficult, but not impossible. Conventional production methods used for food products are mainly to realize mass production, low-end production, and processing methods of denaturation (proteins become tight or cellulose is broken), freezing (breakdown of cell membranes because of water expansion), etc. The conventional methodologies have been accompanied by quality deterioration, but some innovative methods have been introduced in recent years.

One way is a physical approach. For instance, proton freezing can maintain food quality because it dramatically decreases drip. Usually, conventional freezing brings drip caused by cell membrane breakdown caused by water expansion. If water is frozen, then H_2O molecules become misaligned. Their overall volume increases. However, proton freezing controls molecular placement using magnetic attraction, electromagnetic rays, and flash freezing. Consequently, H_2O molecules stand in neat rows. The volume does not increase.

Another approach is a biological approach. For instance, partial freezing realize both lowering of food spoilage and of food aging. Conventional freezing can prevent food spoilage because it maintains temperatures of less than -18 °C. Food bacteria become motionless or at temperatures of less than 3 °C. However, as explained, conventional freezing brings drip, which is the cause of quality deterioration. However, partial freezing maintains temperatures of less than -1 °C. Under that environment, bacteria become motionless or dead, but food cells do not freeze because the congealing point of food cells is around -2 °C. As a result, partial freezing can prevent food drip and maintain good food quality. Moreover, partial freezing can keep almost 100% of moisture, which prevents food desiccation.

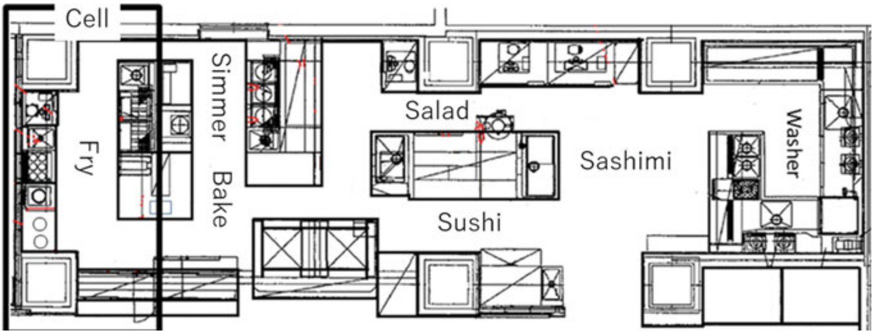


Fig. 6.7 Redesigned kitchen layout

6.3.5 Actual Example of Processing for Enhancing Simultaneity

Traditionally in a restaurant kitchen, each piece of cooking equipment is placed parallel in the kitchen so that a chef can also work in parallel with other workers. The system works well if a restaurant is busy because the division of labor increases efficiency, but if the restaurant becomes idle, the system does not work well because few orders are being made: all cooking position work loads decrease. If the restaurant resolves the problem, then they should change the processing system. Average work hours for the system are 137.3 h (SD = 16.2 h). The average sales per labor hour are 12.432 yen (SD = 2,374 yen). The correlation coefficient between work hours and sales was 0.42 ($p < 0.01$) (Fig. 6.8, left).

Figure 6.7 shows a restaurant kitchen layout. There are two kitchens: one is a large kitchen (existing layout); the other is a cell kitchen. If the restaurant is busy, then the large kitchen is operated because the kitchen is efficient while it is busy. However, if the restaurant becomes idle, the chef changes the processing system from that of a large kitchen to a cell kitchen. Then the chef cooks dish of all kinds there. Average work hours after introducing line and cell cooking were 116.0 h (SD = 12.2 h). The average sales per labor hour were 14.318 yen (SD = 1,898 yen). Also, the correlation coefficient between work hours and sales was 0.69 ($p < 0.01$) (Fig. 6.8, right).

6.3.6 Decreasing Simultaneity—Effects on Food Quality and Productivity

As explained in 3–3, recent technologies enable food providers to realize both productivity enhancement and quality improvement. In this chapter, concrete methods are explained.

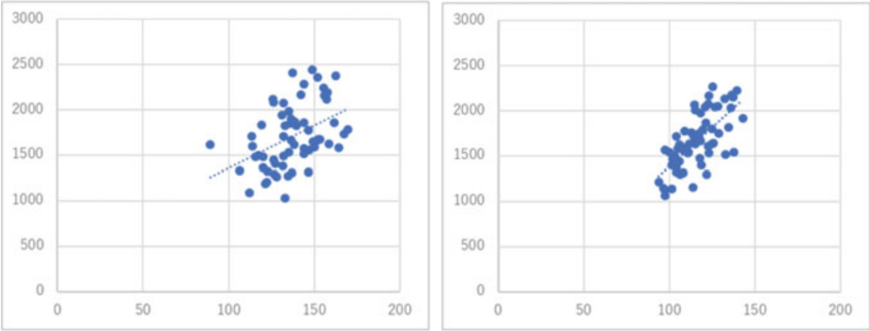


Fig. 6.8 Scatter diagram of simultaneity (vertical, revenue; horizontal, work hours)

For instance, partial freezing can enable stocking of ingredients and dishes and keep them fresh for a long time. For instance, if dashi (Japanese soup stock)-soaked boiled mizuna (potherb mustard) is stocked under a −1 °C environment, the color of the mizuna can remain a clear green for days. If soaked mizuna is stocked in a refrigerator, then the mizuna color will worsen the following day. Traditionally, restaurant chefs cook soaked mizuna every day to avoid color deterioration. Consequently, if a partial freezer is introduced, then it would be possible to change the cooking system from everyday cooking to batch cooking. Additionally, if Tessa (slimly sliced balloon fish sashimi) is cooked and stocked in the freezer, the sashimi taste will be good 2 days later because the inosinic acid contents increase because of aging. If a Japanese chef cooks Tessa on an idle day, for instance Thursday, and it were served on a busy day such as Saturday, then the restaurant could level the production capacity and satisfy demand fluctuation. In this way, storage technologies can change production scheduling and realize quality maintenance or even enhancement.

Furthermore, vacuum-assisted cooking, partial freezing, and a reheat warmer can change cooking processes more dramatically. Single introduction of partial freezing can change single-point cooking, but it can not realize multi-point cooking. If a central kitchen and a restaurant kitchen are connected by partial freezing temperature transportation, one can mass cook at a central kitchen by skillful chefs. Dishes can be transported to restaurant kitchens without quality deterioration.

Vacuumed cooking realizes multi-point cooking because it prevents contamination while food is transported. It also prevents food spoilage because of degassing air and sterilization. For instance, if a simmered fish is cooked, a head chef cooks the seasoning liquid and encloses it with a fish. The enclosed fish is boiled slightly to kill bacteria. Subsequently, the enclosed fish is preserved in a partial refrigerator. Then it is shipped out based on a restaurant order. During transportation, it is stocked in a −1 °C transportation car and then stocked in a restaurant store partial freezer. Up to this point, the fish is not simmered because cooling after heating brings quality deterioration. The day before serving, the packed fish are moved from the partial freezer to the reheat warmer. A reheat warmer is a combination of a refrigerator and convection oven. The function is switched by a timer. Several hours before serving, the reheat warmer starts cooking based automatically on a preset temperature and cooking time. It finishes cooking immediately before the customer eats it. Furthermore, a convection oven can control the core temperature of an ingredient. Therefore, the quality of simmered fish is better than that of pot-simmered fish. Because pot cooking can not control ingredient temperature automatically, food quality depends strongly on the chef skill. In this way, a food provider drastically changes their processing operations without quality deterioration.

6.3.7 Actual Example of Processing for Decreasing Simultaneity

Traditionally, chefs cook dishes every day to maintain food quality, especially before refrigerator introduction, because the food quality rapidly worsens immediately after cooking is completed. As explained above, a refrigerator can not stop quality deterioration because the interior temperature changes from 3 to 10 °C as a result of the defrost function. In addition, the humidity is 20% because the refrigerator is air-blast-quenching. As a result, dish quality is not best when the master chef does not work. In addition, the labor cost becomes high because cooking is done every day. At an actual Japanese cuisine restaurant, the average work hours for cooking every day were 72.5 h (SD = 9.4 h). The average sales per labor hour were 8.501 yen (SD = 1,607 yen). The correlation coefficient between work hours and sales was 0.79 (p < 0.01) (Fig. 6.9, left).

By contrast, introduction of a partial freezer in a restaurant resolved the difficulties, and realized both work-hour reduction and quality enhancement. The Japanese cuisine restaurant introduces a partial freezer. Also, the processing system was changed from everyday cooking to batch cooking. At the restaurant, the batch-cooking day is chosen based on the master chef work schedule and quality-keeping days by partial storage. The day was almost always a Monday or Thursday, avoiding weekends.

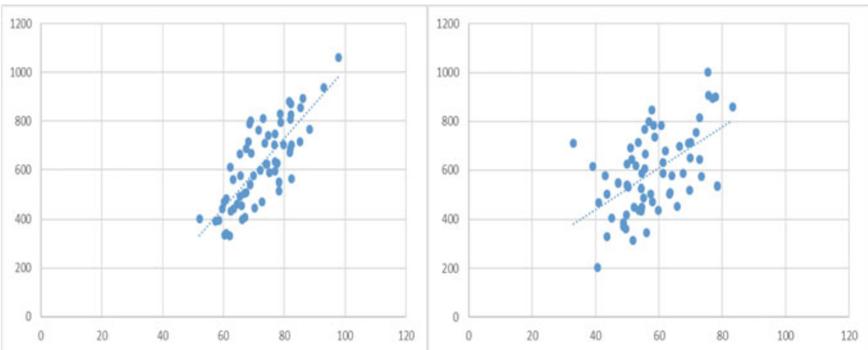


Fig. 6.9 Scatter diagram of simultaneity (vertical, revenue; horizontal, work hours)

After partial freezing introduction and under a batch cooking system, the average sales per labor hour were 10.302 yen (SD = 2,773 yen). The correlation coefficient between work hours and sales was 0.55 ($p < 0.01$) (Fig. 6.9, right).

In addition, the system improves dish presentation and cooking speed, as well as productivity and food taste. Dishes are cooked and dished-up while they are idle. The master chef checks presentation quality before they are stocked. Additionally, they have sufficient time for measuring. Therefore, food volume is the same as receipt-designed. Furthermore, the lead time for cooking becomes short because the cooking staff need not cook or dish-up pre-cooked food when they receive orders. It is important for the food provider to realize both high-quality food and a high-productivity site.

6.3.8 Design of Processing, Taste, and Cost

Traditionally, food quality and cost of manufacturing are regarded as having a tradeoff relation. Therefore, high-quality food cooked at fine restaurant is expensive. Factory-made, low-quality food is not delicious.

As explained above, multi-point processing is a breakthrough for food processing. Originally, the breakthrough was brought about by refrigeration technology. It can divide the harvesting area, processing factory, storage site, and consumption store. Furthermore, various new cooking technologies and food study can help food providers to overcome the tradeoff. They can entail cost breakthroughs along with quality tradeoffs.

Figure 6.10 presents three processing methods for simmered conger cooking: the first is high-end based on master chef cooking (traditional cooking model), the second is low end based on factory cooking (manufacture model). The last is optimization-oriented based on processing redesign (hybrid model). At the first method, live conger is delivered to ingredient quality in top condition. It is stocked in a live-box. When a chef cooks it, it is cut, filleted, and simmered with a chef-made seasoning liquid at a restaurant kitchen. Naturally, the dish quality will be good, but the cost for the dish will be expensive because of the master chef salary, live conger price, transportation cost, etc.

By contrast, a manufacturing model can minimize costs attributable to factory cooking and freeze storage. At the same time conger is harvested, it is cut by fishery port workers, frozen immediately, and stocked in a freeze warehouse. Frozen bulk fish are transported from the warehouse to a food factory for cooking. The factory is selected based on processing costs; invariably factories are located in less-industrialized countries. At the factory, the cut conger is washed with bactericidal agents, soda or salt, and simmered it with factory made seasoning liquid. Simmered conger is refrozen and stocked again in another freeze warehouse. The conger is re-thawed at a restaurant kitchen and is served to the customer. Naturally, the cost is cheap compared to chef-made simmered conger, but the conger dish has high quality.

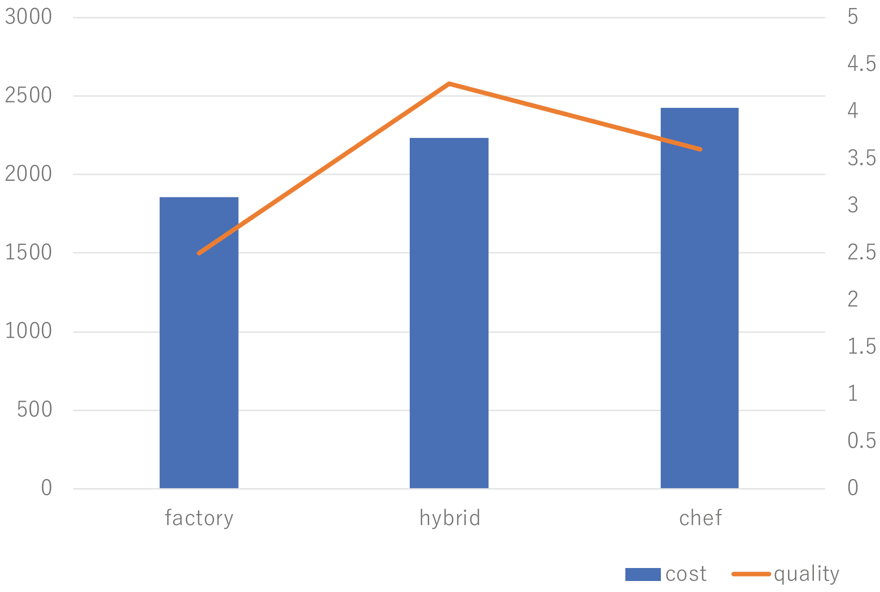


Fig. 6.10 Relation between price and quality (left axis, Yen; right axis; score)

By contrast, a hybrid processing model aims at realizing both high quality and reasonable cost. At the same time conger are harvested, they are cut by fishery port workers, vacuum-prepared, and stocked in a partial freezing warehouse. Stocked conger are transported from the warehouse to a restaurant, and are stocked again in a partial freezer. Similarly, at a central kitchen, the master chef cooks the seasoning liquid, encloses it, and transports it to the restaurant. In the restaurant kitchen, the conger are simmered using the master-chef made seasoning liquid by convection oven, and are served to a customer.

Figure 6.10 shows the relation between cost for the simmered conger and quality evaluation. Actually, the three processing methods are operated, with calculation of each production cost, and evaluation for each simmered conger quality by restaurant staff on an ascending scale of 1–5 (good = 5, bad = 1). The production cost for factory-based production is 1,855 Yen. That of chef-based production is 2,424 Yen. That of hybrid is 2,234 Yen. The average quality evaluation score for factory-based production is 2.5. That of chef-based production is 3.6. That of hybrid production is 4.3. Results indicate that the hybrid processing model is the most effective processing method.

Some reasons exist. One is inosinic acid maturing. Hybrid model conger shows an increased total of inosinic acid because partial freezing does not prevent maturing. By contrast, conger fish cooked by a chef are simmered simultaneously with chef fillet live conger. Therefore, the total inosinic acid is light. Another is the skill difference. To be sure, chef cookery is a high level, but a chef is a multi-skilled worker. By contrast, fishery port workers are single-skill workers, but conger-cutting skills are extremely high. A chef cuts a conger in 50 s, but a port worker cuts them in 7 s. Naturally, cutting costs are low, but the fillet quality is high when made by port workers.

6.3.9 Heterogeneity of Food

Naturally, food quality depends to a considerable degree on the provider skill or know-how. Especially in the food service sector, the trend is remarkable because food service is a human-based processing system. However, in this chapter, food heterogeneity, and food cost and value are discussed.

Fundamentally in a manufacturing industry, the parts price is highest at the point of purchase or production, and will become lower because of obsolescence or next-generation products. Additionally, if a manufacture has many inventories at warehouse, interest accrues for inventory capacity. In other words, inventory entails costs for manufacturers.

By contrast, for food producers, inventory has two meanings: cost and value. An example is aging meat. At the moment beef cattle are slaughtered, it is impossible to eat the meat because it is very hard. In addition, the meat is not delicious because it is not aged. The inosinic acid does not mature. If it is aged for weeks, then the meat has softened. The taste has become good because of aging. Actually, if the meet is stocked for years, then the meat will become very expensive. The other example is abalone. When taken from the sea, the price for live abalone is not so high (10$–30$). However, if it is dried and stocked in a good environment for dried abalone, the abalone will become very expensive (3000$–5000$). Correct storage used for aging can generate high value for food providers. Figure 6.11 shows a fat tuna example. The left picture shows the day tuna is filleted. The right one is that of 4 days later. As

Fig. 6.11 Aging tuna (left, after 2 days; right, after 4 days)

the picture shows, the tuna oil penetrates. The total inosinic acid content increases for 4 days.

Regarding the other meaning, heterogeneity is a crucially important point for food manufacturers because factory-processed foods also change quality dynamically. The most famous example is wine. When wine is bottled, the quality is not best because the wine has not aged. For years later, prices of some wines sour dramatically because of aging and supreme conditions. As discussed, food heterogeneity has two characteristics: one is a cause of low productivity; the other is a key for creating value.

6.3.10 Further Challenges for Design and Production Systems for the Food Industry

In this chapter, recent studies for food design and food production systems are introduced. Traditionally, foods have been studied mainly by individual study fields such as agronomics, bromatology, and cookery science. In recent days, the thought of "synthesiology", that complex research assignments should be studied not as a single research methodology but as plural and multiple research methodologies, has been introduced to penetrate various study fields. In the early twenty-first century, the service science, management and engineering (SSME) concept was introduced. Simultaneously the concept has been introduced to food study. The studies of this chapter are similar to cSSME studies because food characteristics are also similar to service product characteristics.

The title of this book "Service Engineering for Gastronomic Sciences" does not only mean natural sciences, but it encompasses social sciences and cultural sciences because food produces not only physical utility but also economic, social, and mental utility for human beings. Additionally, the meaning of "gastronomy" in this book does not mean cooking, cookery, and epicurean food, but instead means ingredients (material), cookery (production module), cooking system (supply chain), and food resources (resource management). Furthermore, gastronomy studies are aimed to resolving social research challenges such as pricing, inventory control, and food safety. Furthermore, intensive study has a relation with religion, ethnic, geology, and history.

However, this research field has kicked off during the last decade. Therefore, current studies are proceeding, or basic ones. Food studies are crucially important, addressing food shortage difficulties attributable to the population explosion, food security caused by political disunity, and health care difficulties caused by aging societies. In this field, new creative and innovative studies are anticipated.

Part III
Evaluation by Human for Further Value Creation

Chapter 7
The Intersubjective Valuation of Service

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7.1 Introduction

Value is a central concern for service, and practitioners aim to increase the value of their services. While customers seek high-value services, we know little about service value itself. In the case of products, we can design a product better in terms of its aesthetics, functionality, performance, and cost. However, services are comprised of more than products; specifically, we can increase value by creating better offerings—such as food, in the case of restaurants, and a well-designed space—but service is more than and differs from its offerings and environment.

In fact, design principles appear to differ between products and services. Regarding the former, we can make the products easier to use, less confusing to users, and aesthetically pleasing, or use human-centered design (Norman 2013; Stickdorn and Schneider 2011). In contrast, many services are designed to be difficult and confusing. For example, upscale restaurants sometimes intimidate customers unaccustomed to such establishments. Their menu lists are cryptic, and often written in professional jargon or sometimes in foreign languages. Further, customers must master many esoteric mannerisms. The food and drinks offered in upscale restaurants can be so subtle, nuanced, and norm-breaking that inexperienced customers cannot easily appreciate them.

If we cannot simply design services to be easier, more transparent, and aesthetically pleasing, then how should services be designed? We need a proper theoretical basis to answer this question. While no existing theory seems to offer a full answer,

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we can draw on some recent developments in service-related theory, or particularly service-dominant logic (Lusch and Vargo 2014; Vargo and Lusch 2004). This suggests that value is always co-created by the involved parties, which include both customers and service providers, as “the customer is always a co-creator of value” (Lusch and Vargo 2014, p. 15). This suggests that service cannot be considered on the traditional assumption of subject-object separation in which someone—such as a customer—is simply observing an object—the service—and subjectively judging its value. Service lies not in the individual, but in the transaction between these parties—hence, service can be considered “intersubjective” (Edvardsson et al. 2010; Helkkula et al. 2012; Löbler 2011; Peters et al. 2014; Yamauchi 2018).

We develop a theoretical perspective to explain service value by drawing on an empirical analysis of actual service practices. Specifically, we examine sushi bars in Tokyo and a classical restaurant in France. Our empirical analysis reveals that customers are often tested and pressured to exhibit their knowledge and skills, and illustrates the intersubjective nature of value.

7.2 Value of Service

7.2.1 Problems with Value

Value is said to be determined phenomenologically: “Value is always uniquely and phenomenologically determined by the beneficiary” (Lusch and Vargo 2014, p. 15). Therefore, no value exists in essence, but each person experiences and constructs value through his or her own perceptions. Namely, value is largely subjective depending on how the person perceives it. We need this phenomenological value to refute the supposition that value resides in goods, as phenomenology examines how things manifest themselves to humans, and not the things themselves. Naturally, the person does not have to be fully conscious of this subjective value, as the person experiences the value in their embodied act within a concrete, material situation, and not internally. Nonetheless, value is unique to the person and the situation the person experiences, and therefore, such value is said to be “idiosyncratic” (Lusch and Vargo 2014, p. 23).

This conceptualization of value is problematic in many ways. First, this value is simply inaccessible: Each person determines value on his or her own, and there is no way we can predict, estimate, or assess such value, as it depends on the individual. Thus, the value is as useful as it is random, and practically useless because regardless of what the service provider does, idiosyncratic value is determined elsewhere.

Lusch and Vargo (2014, 2016) anticipated this problem, and have since emphasized the institutional aspects of value (Lusch and Vargo 2014; Vargo and Lusch 2016). Value is institutional in the sense that it is not something arbitrary that can be determined only within ephemeral and contingent practices; it is determined in the social structures that produce and are reproduced by these practices. We can reasonably predict the value. Yet, how can we reconcile this institutionalized value and idiosyncratic value? Phenomenologists themselves have long struggled to explain intersubjectivity through subjective perceptions (Husserl 1950; Merleau-Ponty 2002).

The second problem is that while this value relies on the subject that faces an object, service cannot be an object. Service is defined as "the application of competences (knowledge and skills) for the benefit of another entity or the entity itself" (Lusch and Vargo 2014, p. 12). Thus defined, service is not something that we can count and compile. The service is "singular" (Lusch and Vargo 2014, p. 20), distinguished from "services" in plural, and the former cannot be a type of object that a person can easily confront and perceive. Therefore, it is too simplistic to suggest that a beneficiary can determine a service's value as if the subject can determine the value of an object.

7.2.2 Intersubjective Value

How should we consider the value of service? An important clue to answering this question is the claim that value is co-created. One person cannot unilaterally create value, as it is always collectively created by the parties involved, including customers. This principle stems from the assumption that service always involves a joint achievement among involved parties, and anyone participating in the service cannot simply receive the service, but actively constructs it. If this is the case, then the service cannot be reduced to any one participant, but rather resides between them. That is to say, service is intersubjective (Yamauchi 2018). Value is co-created when the service is jointly achieved.

Intersubjectivity can have many definitions; here, it refers to the social reality that is achieved among people through their interactions. Unlike phenomenologists, we do not need to begin with subjectivity to understand intersubjectivity, as we can begin with the interactions among people, and analyze how other people will present themselves to us. We focus on what happens between people and the actions they present to one another, which cannot be reduced to any of their cognitive intentions or internal sensations.

Intersubjective value can be understood in various ways. First, when we talk about a service's value, all participants are implicated in the service. They all jointly produce the service, and therefore, are inseparable from it. Subsequently, the service's value encompasses the value of the participants, who are inseparable part of the service. Therefore, each party must present and negotiate who he or she is.

Service providers in this intersubjective realm presenting high-value services cannot satisfy customers solely with high value, as these customers must ascend to that high value to value themselves as equal, if not higher. For example, patrons visiting an upscale restaurant may often experience anxiety or concern about their behavior.

This demonstrates that the individual's value as a consumer is relevant, and especially the extent to which they are experienced, knowledgeable, and sophisticated. A type of intersubjective struggle occurs in services in which value is co-created.

Second, value as an intersubjective achievement resides not in the perceptions of any one participant, but in the interactions between them. Therefore, we focus on how a person presents value to others and not what the person has in mind, as this is not accessible to others in the situation—nobody can read other's mind. What is presented to each other is the sole mechanism by which service is jointly achieved; this value is therefore only as presented, and does not exist elsewhere, such as in another consumer's perceptions. Subsequently, each person's perceptions relate to—but exist external to—the intersubjective value.

This presentation of value does not need to be conscious or verbal. Individuals affected by something often exhibit this affect through body language in general, and in particular facial expressions, postures, body movements, and tones of voice. Goffman (1961, p. 35) noted, "Although an individual can stop talking, he [sic] cannot stop communicating through body idiom; he must say either the right thing or the wrong thing. He cannot say nothing." This also means that the value presented is not always determinate, and we can often only guess what a particular body idiom means and sometimes misinterpret it. Nonetheless, people can function in most everyday situations without substantial problems, often by repairing any misunderstandings along the way. Therefore, value is achieved through such open interactions.

Third, we may need to evolve beyond the traditional notion of intersubjectivity given the recent "material turn" in the social sciences (Carlile et al. 2013; Pinch and Swedberg 2008), in which materiality is emphasized in an effort to decenter the sovereign human subject. This modernist thought on soverign human subject has been criticized for its emphasis on human subjects that can unilaterally constitute the world. Further, the agency of any human action cannot be reduced to the subject or its intentionality, but instead distributed among various other elements (Latour 2007). Consequently, we must examine both material objects and the humans implicated in service.

For instance, the upscale restaurant is not any arbitrary space, but is carefully designed. The menu is often cryptic in these establishments, and often no written menu is provided. The wine list is also obscure unless the customer has extensive prior knowledge. Employees exhibit formal behavior and everyone is properly dressed and performs their rituals well. Such material arrangements are consequential for intersubjective value. While customers can highly value these material arrangements as something non-quotidian and sophisticated, they are also tested regarding their sufficient qualifications to participate in this environment. In this sense, intersubjectivity in this scenario also involves materiality.

As this study aims to illustrate these ideas regarding intersubjective value through an empirical analysis, we will explain our empirical studies.

7.3 Research Design

We examine intersubjective value in two different settings: sushi bars in Tokyo and a classical restaurant in France. The restaurant setting is suitable for this study as it presents prototypical service situations. We began our research with sushi bars and discovered that the service value was intersubjective (Yamauchi 2018; Yamauchi and Hiramoto 2016). Nonetheless, this finding was often questioned, as sushi bars are highly culture-specific and an extreme case. Customers are typically intimidated by sushi bars, as customers must possess substantial knowledge of sushi to appreciate the service. Further, little guidance is provided, the chefs are not necessarily caring, and no prices are indicated—intimidating because of the uncertain final bill.

Therefore, we also chose to study service in another culture. France is considered as a country with one standard of service within the western world, with the restaurant as a service establishment invented in France just before the French Revolution (Spang 2000). This service form was then diffused to various other parts of the world, with French-style table manners as a global standard.

Our work draws on an ethnomethodological perspective (Garfinkel 1967; Sacks 1995; Schegloff 2007), as this is helpful in addressing such intersubjective value. Ethnomethodology seeks to explain how people work together to create social order in their activities. Essentially, social order is achieved by participants who understand one another although they cannot read each other's minds. Ethnomethodological research examines how participants themselves present their accounts of actions. One takes actions that are not arbitrary, but something intelligible; therefore, this perspective seeks to capture intersubjectivity.

We set up at least four cameras and several voice recorders in four different sushi bars to capture patrons' interactions; we also analyzed drink orders throughout. We chose traditional, high-end sushi bars in Tokyo, in which customers are seated at a counter across from the chef who prepares the sushi (Fig. 7.1). There are two different styles: *okonomi* and *omakase*. *Okonomi* is the "as you please" style; you order one sushi, the chef makes it, you eat it, and then repeat this. *Omakase* (or chef's choice) is

Fig. 7.1 A sushi bar

Fig. 7.2 The French restaurant

a newer style with a pre-prepared course. However, customers in this case are asked to order additional sushi after the course. Two of the four sushi bars we studied were *okonomi* and the other two *omakase*.

Among the various interactions between the service providers (chefs) and customers, we determined that order-taking was particularly noteworthy because customers presented themselves in these interactions, as our following analysis will demonstrate. Other interactions, such as serving food and drinks and some other general conversations, were less salient in this regard. We transcribed these interactions according to the standard system used in conversation analyses (Appendix).

Our analysis then examined wine-tasting practices in a classical restaurant in France, in which customers must present their knowledge and experience as with order-taking in sushi bars. Figure 7.2 illustrates one of the rooms we used, with interactions between the sommelier and customers videotaped and analyzed in detail. We installed cameras on tripods, both from a distance and on the table with a 360 degree lens; and voice recorders, both on the table and on the sommelier.

We observed the interactions involving these customers and either one professional sommelier or one professional *maître-d'hôtel* (head waiter). All the interactions occurred in French. The original French transcript is followed by an English translation in grey. All the figures containing participants are anonymized with an image filter.

7.4 Placing Orders at Sushi Bars in Tokyo

We begin with the following interaction that occurred just after the customers arrived and were guided to their seats. The chef (hereafter, "Chf") asked "What would you like to drink?" as the customers were seated. At this moment, no written menu was provided and no explanation was provided about this sushi bar and its offerings. These customers had not previously visited this establishment.

```
01 Chf U::m .hhh to begin (0.5) [What] would you like to drink.=
02 A1a                          [Yes-]
03 A1a =Mm::::(.)because it is <humid>: I'll have ddraft beer:
04 Chf >Let's go with draft b[eer<
05 A1a                      [Is dra[ft okay¿
06 Chf                             [>Yes it is<
        ((continues))
```

Responding to the chef's question, the customer (A1a) stammers, "draft beer," with prolonged end sounds for "beer." The customer looked down when responding, but looked up at the chef while prolonging the sound. This indicates that the customer was orienting his action toward the chef's feedback and presenting uncertainty in his action. In this case, the customer also prefaced this order item with the phrase "because it is humid," which demonstrates that he needed to qualify, rationalize, or justify his choice. Accepting this answer, the chef then responded, "Let's go with draft beer." The "let's" suggests that the chef chose to involve himself in this order, effectively presenting his agreement with the customer's choice.

Through this interaction, we can see that the chef asked the question rather abruptly without any clue. This question was challenging, although issued as if it were easy and benign. The customer then exhibited some uncertainty in his reply, which reflected the customer's experience. The chef then accepted the uncertain answer.

This can be contrasted with the next fragment at a different sushi bar. The same question is issued with the same timing; again, this is a first-time customer.

```
01 AS  What would you like to dr[ink
02 B3                           [Beer please
03     (.)
04 AS  As for beer (.) We have large and small [bottles
05 B3                                          [We↑:ll
06 B3  All right then a small bottle.
07     (0.2) ((AS nods))
```

This customer (B3) answers the server's (AS) question—in this case, the server approached and very concisely asked for a drink order with the same timing. In this case, the customer began to answer before the server's question ended, which demonstrates that he had anticipated this question. This answer reveals that the customer had some experience with sushi bars. This customer did not exhibit uncertainty, either. The consice answer "Beer please" without any prolonged sound or a glance back at the server.

The next fragment illustrates a case in which the customer (A3a) could not answer promptly, unlike the previous two fragments, and the chef provided some hints.

```
Chf What would you like to drink
              (0.5)
A3a We::ll uh::m (1.2) (........)[do you have
Chf                              [Ah beer,
A3a °un:°=
Chf =sake,
A3a Yes.
Chf U:m shochu.
     (0.4)
A3a °hum°=
Chf =a glass of (0.3) white wine or, champagne° `
[or something°
A3a                                           [huh:
A3a .hh uh:m <for me> beer(0.3)for beer how many kinds do
    you have
     ((continues))
```

A noticeably long 0.5 s pause occurs after the chef's usual question, "What would you like to drink?" The chef could recognize that the customer's answer was not forthcoming, and most likely the customer could not answer. The chef then provided some beverage examples as hints, such as beer, sake, and *shochu*. These hints indicate that the chef understood that the customer could not answer without assistance.

These analyses reflect general patterns in these conversations, as the service provider asks a question abruptly and without any clues when the customer is about to sit. Through this question, the service provider tests whether the customer can reply, as his or her answer clarifies the customer's experience. In this short, seemingly benign interaction, we observe that the customer is implicated in the service, and the customer's value—who he or she is—matters.

7.5 Wine Tasting in a Restaurant in France

7.5.1 Tasting Wine

We now examine how customers taste wine. When they order a bottle, tasting is required to approve the wine—they cannot refuse it unless it is corked, or a bad cork. Customers can also comment on the wine, or whether they like it. Whey they order a glass of wine, which is typically based on the sommelier's recommendation, customers can make more judgmental comments regarding whether they like it. In this tasting, the customers' knowledge and skills become salient.

Fig. 7.3 The sommelier staring at the customer

```
01 SOM Je me permets de vous faire goûter si vous voulez (.)
       I allow myself to make you taste if you want (.)
02     Chablis. ((inhale))(0.4) La cuvée Saint Martin du
       Chablis ((inhale))(0.4) The cuvée Saint Martin form
       the
03     domaine la Roche sur les millésimes 2016 madame
       domain La Roche on the vintage 2016 madam
04 CL2 Mer[ci
       Thank you
05 SOM    [Je vous en prie?
          [Please
       ((omitted))
11     ((SOM pours champagne to the next customer)) (11.0)
12     ((SOM looks at CLI2, Figure 3)) (4.0)
13 CL2 Ben oui il est bon. ((laughs))
       Well yeah it is good.
14 ALL clients (laugh)
15 SOM Vous avez vu je vous ai mis de la pression hein?
       Have you noticed I put the pressure on you isnt'it?
16 CL2 Ouais
       Yep
```

In this interaction, the sommelier (SOM) stares at the customer without saying anything (Fig. 7.3). The customer (CL2) notices this and responds. However, as soon as she says, "Well, yeah, it is good," she laughs and the other customers laugh as well. This laughter appears to suggest that the customer did not follow the rule by approving of the glass of wine, but instead had the sommelier wait. In this case, the sommelier's visible action of waiting for an approval pressured the customer. As many customers cannot perform the wine-tasting ritual naturally, the customer's unease is made salient in this case, although humorously.

Typically, the sommelier describes the wine before the customer tastes it, then presents the *etiquette* (label) and discusses the *cuvee* (batch), *domaine* (vineyard), and the vintage. In some cases, the sommelier pours wine for tasting without these explanations. In the following fragment, a customer tries to guess the wine.

```
           ((Other customers have already approved their glasses
           before two female customers))
 54 SOM    Mesdames.
           Ladies.
 55        (2.0)
 56 CL3    Très bien
           Very good
 57 CL4    Très très bien.=
           Very very good.=
 58 SOM    =Parfait  ((set the bottle back on the rolling table))
           =Very well
 59 CL4    <Ça aussi c'est, c'est un Bourgogne?>
           <this one too is, it is a Burgundy?>
 60 SOM    ((sees the CLI4 and leans in))
 61 CL4    C'est un Bourgogne?
           It is a Burgundy?
 62        (0.4)
 63 SOM    Pas [du tout.
           Not [at all.
 64 CL4        [Pas du tout. [(2.0) J'ai tenté!
               [Not at all.  [(2.0) I gave it a try!
 65 ALL                      [((laugh))
```

The sommelier prompted the two female customers to comment on the wine (line 54). The customers (CL3 and CL4) then approved their wines (lines 56 and 57). CL4 then guessed that her wine was Burgundy. The sommelier reacted to this with a frown, jokingly, and said, "Not at all" (line 63). The customers laughed. The sommelier then began to discuss the wine and added, "It is quite aromatic, which is why it gives rise to a bit of confusion with Burgundy wines."

Whether one can tell the difference is an important theme. We have consistently found this type of guessing in our dataset, as most customers could not tell or guessed in error, but this seems to be a part of the "game."

7.5.2 Behaving in a Proper Manner

Customers also orient toward the norms in a situation. In this kind of classical restaurant, customers presented their understanding that they should behave in a proper manner. In the following fragment, three male customers and one female customer were seated at the table. One of the male customers (CL3) ordered a bottle, but when tasting, he noted that the female customer (CL4) should taste it first (lines 6 and 7).

05 SOM à qui puis-je faire goûter? (0.4) le chab[lis?
to who may I have the wine tasted? (0.4) le Chablis?
06 CL3 [ah ben à madame? (.)
[ah wellto madam? (.)
07 hein pourquoi pas?(0.1) non? qu'est-ce t'en penses? hein
why not? (0.1) no? what do you think of it?
08 (0.3)
09 CL4 (bon bon) allez (2.0) cassons les codes (2.0) merci
go (2.0) let's break the codes (2.0) thank you
10 SOM je vous en prie
please
11 (9.0)(CLI4 tastes the wine)
12 CL4 ((nods)) [ouais]
[yeah]
13 SOM [(ça va?)]
[(alright?)]
14 CL4 trés bien
very well
15 CL3 ça se goûte?
is it tasty?
16 CL4 oui (0.2) ah ouais il est super bon
yes (0.2) ah yes it is super good
17 (4.0)
18 CL4 ouais (.) il est succulent ((smiles))
Yes (.) it is succulent
19 CL1 merci ((to SOM))
thank you
20 (4.0)
21 CL4 il est délicieux
it is delicious

When CL3 said CL4 should taste the wine, he tried to justify his act by saying, "Why not?" then sought approval from the female customer with "What do you think of it?" CL4 then accepted it, but commented, "Let's break the code," referring to the rule that the person who ordered the wine should taste it. At this point, they are both oriented toward the social code to which they should behave.

She first described the wine as "super good (*super bon*)" in line 17, then upgraded the expression to "it is succulent" (line 19). The "super good" is casual, while "succulent" is a more formal expression that is not commonly used; CL4 therefore corrected her first expression with one that is more proper. She then added, "Delicious," bringing an ordinary expression into the conversation and exhibiting three different behaviors: casual, formal, and ordinary.

This interaction reveals that customers orient toward a norm in both their rituals and manner. If a casual way of speaking is their quotidian reality, then they are performing a formal, specialized role. These customers' behaviors then indicate not only how they value themselves, but also how others evaluate them. Nonetheless, this is all done through humor; for example, CL4 smiled when she used an uncommon expression. These customers do not necessarily adhere to norms completely, but instead may distance themselves from them to some extent.

7.5.3 Presenting Negative Evaluation

Next, we examine a conversation fragment in which customers negatively evaluate glasses of red wine; they had ordered one fish and one meat course prior to ordering the wine. One customer at this table (CL1) performs the tasting ritual quite seriously, taking ample time with each step:

```
        ((SOM pours wine for CL2))
01 SOM  puis-je me permettre
        Can I allow myself
        (5.0) ((SOM pours wine for CL1))
02      on va goûter sur des (2.0) des belles Syrah sur les
        we will taste (.) beautiful Syrah on the
03      Saint-joseph la Cuvée du Papy de Stéphane Montez en
        20<15>
        Saint-joseph the Cuvée du Papy of Stéphane Montez in
        2015
04 CL1  du Syrah Saint-joseph? ((nods))
        some Syrah Saint-joseph?
05      (25.0) ((CL1&2 smell and look at the wine, Figure 3))
06      (4.0) ((CL1&2 drinks the wine))
07      (13.0) ((CL1&2 examine the finish))
```

The customers took some time to taste the wine while the sommelier waited, still holding the bottle (Fig. 7.4). These customers first observed the glasses of wine for only 25 s, then began drinking. This performance in front of the sommelier indicates the customers' confidence in scrutinizing the wine.

After more than 40 s of tasting, the customer (CL1) speaks, beginning with a general positive comment ("pleasant"), then an elaborate negative one ("a little bit young"). In this case, we can also observe that the general positive comment ("pleasant") was not highlighted using, for example, "very (*très*)," which typically occurs.

Fig. 7.4 Smelling and observing the wine

Fig. 7.5 Shaking head

((CL1 nods while shaking the head))
08 CL1 Tch oui? il est agréable
Tch yes? it is pleasant
09 SOM comment?
How's that?
10 CL1 il- il est agréable oui (.) j'aurais peu- un petit peu
it is pleasant yes (.) I would may- a little
11 mieux: si- il est peut être un petit peu jeune encore
better: if it is perhaps still a little bit young
12 peut être je sais pas non non?
maybe I don't know no no?

This evaluation was in fact anticipated by his shaking of the head (Fig. 7.5), which conveyed that the customer had more to say; this explains why the sommelier then issued a further "How's that? (*Comment?*)" to solicit more information. The customer took this as a solicitation for further elaboration of the negative impression in this case.

We omit the sommelier's response for brevity, but he essentially wants to propose something different and asks what the customer would prefer; the customer replies with a more elaborate explanation.

26 CL1 j'aurais peut être un petit peu plus:.(3.0) il
I would maybe a little more:. (.) it is
27 a un accueil agréable en nez mais: c'est vrai qu'en:
pleasantly welcoming in the nose but: that is true that:
28 (2.0) il a peu de mmm: peu de persistance en bouche ou
it has a little mmm: a little persistence in mouth or
29 quelque chose comme ça peut être j'en attendais
something like that maybe I was expecting perhaps
30 peut-être un peu plus derrière=
a little bit more behind

This customer suggests that the wine lacks “persistence in the mouth,” although it had a “pleasant welcoming (aroma) in the nose.” As he had expected something more in the wine’s finish, the sommelier then explains that he chose this less powerful wine to pair with the fish course:

```
31 SOM =d'accord. (2.0) c'est pour ça que je voulais
        okay (.) that is why I wanted to pair it with the
32      l'accompagner avec le poisson (5.0) ce coté sans trop
        fish (.) this side without
33      avoir de puissance justement
        having too much power precisely
```

This can be interpreted as an excuse, as the sommelier could not openly disagree with the customer, but simultaneously had to present himself as a skilled professional. Subsequently, the customer agrees with this assertion (“it will maybe pair well with the fish”), begins to concede, and ultimately agrees with the sommelier.

```
34     (2.0)
35 CL1 voilà
36 SOM Mais après [on peut on peut on peut
37 CL1            [effectivement vous avez raison [il va-
       that’s it (.) indeed you are right it will-
38 SOM                                            [no no non
                                                  [no no no
39 CL1 il va peut-être bien [aller avec le poisson
       it will maybe well pair with the fish
40 SOM                      [no no non quand je dis j'ai raison
                            [no no no when I say I am right it
41     c'est juste que- je vous dis ce que j'ai fait (.) après
       is just that- I tell you what I did (.) then
42     moi j'ai pa-pas forcément rai- raison j'ai pas la science
       I am no-not necessarily ri-right I don’t know everything
43     infuse faut pas:. vous inquiétez pas mais je peux essayer
       don’t. don’t worry but I can try
44     de vous faire goûter quelques chose?
       to make you taste something?
```

The customer aligns with the sommelier’s justification: “Indeed, you are right; it will maybe pair well with the fish.” The customers eventually decide to choose this wine rather than try something else. In fact, the customer began to smile when hearing the sommelier’s longer remark in line 12. The customer’s comment in line 37—“Indeed, you are right”—indicates that whether the sommelier is right is an issue in addition to the quality of wine, or specifically, the valuation of the sommelier himself is relevant.

In summary, we observe a more marked negotiation of value than in the previous fragment, as the customers performed a thorough tasting routine for over 40 s in front of the sommelier. The customer negatively evaluated the wine and conveyed his expectations of something with at least a better finish, which clearly indicated his extensive knowledge of wine. The sommelier conceded and suggested different wines, but also presented his own justification, which ultimately compelled the customer to become less confident.

7.6 Discussions

Our empirical analysis revealed the intersubjective nature of value. In sushi bars, chefs defined their service by posing a difficult question without any clue as if it were an easy one, as their customers should be able to easily answer this question. In a sense, the chefs were valorizing their service. Consequently, the customers could not simply evaluate the service, but needed to demonstrate that they were qualified for the service as defined by answering the question as if it were simple. However, many customers also presented impressions that they were not fully qualified through their body as well as their talk, while other more experienced customers could answer the question confidently.

The French restaurant scenario included a norm that customers should comment on the wines that they taste. Customers' knowledge was tested here; specifically, some inexperienced customers felt pressured to behave properly in performing the ritual and using sophisticated language. Alternatively, experienced customers could present themselves as more than simply qualified to participate in the service. They often meticulously performed tasting routines—which conveys that they know how to appreciate and judge wine—and made negative comments to demonstrate their knowledge.

We began with the question, "How can we explain the value of service when it differs from that of products?" A service is often designed to be difficult, intimidating, and aesthetically subtle, while products must be easy to use, empowering, and aesthetically pleasing. The answer to our question rests on the intersubjectivity of service, which implicates all participants who co-create value. The service's value encompasses the value of all parties, while the customer's value refers to whether the customer's knowledge and experience is sufficient to qualify for the service.

A service is designed to be difficult for users for two reasons: First, service providers must present the value of their services, and a valuable service should illustrate something that customers do not already know, as a familiar service is not perceived as worthy. Therefore, the service space and artifacts must not be simple or transparent, which is even the case for casual services. For instance, popular coffee shops use Italian words that most customers do not know; they present their service as non-quotidian and perhaps as authentic Italian espresso bar culture. Faced with this presentation, customers then must demonstrate that they are qualified for what they are not necessarily familiar with; hence, customers are pressured to present themselves.

Second, customers do not simply want to receive a high-value service, but also want to prove themselves and gain recognition. This can be observed in cases of experienced customers who present themselves as knowledgeable and serious about wine. However, other customers also orient toward this recognition when seeking to smoothly perform the ritual and use the proper language. These customers are all interested in how others perceive them.

7.6.1 Dialectic of Value

This recognition from others is at the heart of intersubjectivity, and we can formulate this using a Hegelian dialectic. Hegel's (1977) lord-bondsman dialectic illustrates that a person as a self-consciousness struggles with others because it seeks recognition from them. This is because when one's self-consciousness seeks recognition from others, it must present its competence, but this denotes a competence over others in the intersubjective relationship, negating the others. This person is in turn negated by others, creating a "life-or-death" struggle. In a service context, the service provider negates customers by presenting the value of the service that is typically beyond the customer's competence; the customer also negates the service provider by demonstrating their superior knowledge.

Hegel (1977) then explains that if one abandons this struggle, one becomes a bondsman to the other, who becomes the lord. At this moment, the lord can obtain the perfect recognition that he or she has sought from the onset, but this recognition is already meaningless because it is the recognition from someone subservient to the lord, rather than independent. The lord ultimately enjoys what the bondsman can produce. This leads to another moment that determines whether the bondsman can secure his own certainty given the material labor needed to produce objects, while the lord now depends on the bondsman.

This dialectic demonstrates that customers cannot obtain recognition from a subservient service provider; in other words, customers must be negated by an independent service provider, then seek to prove themselves. Only then can they achieve recognition. This is the reason why a service is often cryptic, obscure, and intimidating to customers: This struggle is a part of the service, and the customers are negated. If a service provider attempts to satisfy a customer, then the customer cannot be satisfied, as the service provider becomes subservient to the customer and his or her service is no longer valuable.

Nonetheless, this entire discussion is not necessarily firmly grounded in a Hegelian dialectic. In our case, the customer pays the service provider to serve him; this differs from the lord, who has total domination over the bondsman. In a sense, we repeat the same dialectic in capitalism: The customer becomes the master, but only while paying for the service. If the service provider seeks to satisfy the customer, it is not to serve the lord but to serve himself, and to profit from the customer. As this is principally a one-time relationship, it is therefore not binding: Strangers will meet briefly during the service, and will not meet again after (Callon 1998).

The service dialectic in our current highly capitalist society can be said to be a rather pure form of the dialectic, as we can assume that individuals who enter into this struggle are both free and independent—mutual recognition requires such free, independent individuals. A credible grand narrative no longer exists to allocate individuals within a given social structure; "each individual is referred to himself [sic]" (Lyotard 1984, p. 15). Individuals can—or must—principally make decisions on their own, but all simultaneously refer to themselves, as "each of us knows that our *self* does not amount to much" (Lyotard 1984, p. 15). Free, independent individuals are converted into atoms that must become secured by relating to others. Given this, we seek mutual recognition, and it is now upon us as to how we prove ourselves.

Serivce mediates a majority of social relationships in capitalism. In this situation where free individuals confront one another, the dialectic struggle works well but only to the extent that this is all part of a "game" (Lyotard 1984, p. 16). One seeks recognition only to profit; the struggle is far from "life-or-death." Therefore, the dialectic is repeated in such a way that once realized in its purity, the dialectic struggle is no longer what it aimed to be. The dialectic struggle we observed is a game in which individuals participate to seek mutual recognition. Eventually, this recognition is doubly dialectical; first, it is no longer meaningful when it is obtained from someone subservient, and second, it is only meaningful as part of a game.

7.6.2 Contradictory Designs

Value in this instance is intersubjective, as it lies not in one of the involved parties, but only between them. This value cannot be concentrated in a single place, or even in multiple places, and manifests only within the interaction. This does not mean that the value is not real, as value is not fixated within a person or an object, but it is performed (Dewey 1939; Muniesa 2011). Thus, we should discuss valuation as a verb, and not value as a noun. Our empirical analysis has revealed how such valuations are presented and negotiated in interactions.

The customer certainly has some judgment about a service, even when he or she does not express it. Even expressed appreciation of a service is not certain. While smiling and commending the service, he or she may then never return. This study's proposed intersubjective framework suggests that customers cannot simply express their thoughts, but their expressions are a part of their self-presentation. For instance, an upscale restaurant's aesthetic often forces customers to distance themselves from visceral reactions (Bourdieu 1984), and thus, the idea that we can understand customers' true evaluations is a myth. Whatever the customers express—or choose not to express—is a part of their performance. Similarly, asking for evaluations—such as through customer satisfaction surveys—is also a part of this performance; the customer can recognize that the service provider is interested in his or her evaluation, and this alters their relationship and the evaluation itself, rendering the service provider relatively subservient to the customer.

Nonetheless, we cannot ignore subjective judgment; in fact, service providers themselves orient toward customers' judgment, and the former assesses customers' actual satisfaction in many ways. By directly interacting with customers, sushi chefs have many opportunities to observe customers' reactions. Similarly, one customer in the French restaurant verbalized a positive comment of “pleasant,” but only while shaking his head, which prompted the sommelier to sense a problem and further clarify the customer’s judgment.

Therefore, it is important to understand that subjective value is also relevant, while a service’s value is inherently intersubjective. When the value is subjective, the subject separates from the object. In this framework, it makes sense to design the object to be easier for users, as there is no reason to render it to be more difficult and challenging. Subsequently, it is not relevant to ask who the subject is. As we observed, we must do the opposite when the value is co-created and therefore intersubjective: The service must be difficult. How can we reconcile these opposing design directions?

In a way, services must be designed to be simultaneously easy and difficult, although services are not inherently designed to be difficult for difficulty’s sake. Service is difficult because easy and familiar services are typically of no value to customers. Further, customers cannot prove themselves and become recognized unless they are not faced with the independent other, who is opaque to them. If the service is only difficult, without the opportunity for customers to prove themselves, they will simply perceive the service as meaningless. Therefore, the service’s design depends on its customers: it can be designed to be more difficult for highly knowledgeable customers who are prepared to engage in a struggle to prove themselves or those who want to see themselves this way. If customers are not ready, then the service must be designed to be somewhat easier.

Casual restaurants use written menus with foreign languages. For example, an Italian restaurant in Japan we studied had Italian words that few customers could understand. On the one hand, the service was designed to be difficult with such obscure language. On the other hand, the menu had substantial information to help customers make easier selections; each item was labeled alphabetically so that customers would not need to verbalize the unknown names. Similarly, popular coffee shops often use Italian words, such as “*grande*” or “*venti*” to denote cup sizes, yet the menu is made simpler with photos, and employees are friendly and willing to help customers. The design has both easy and difficult components. Alternatively, the high-end sushi bars and upscale French restaurant in this study were designed to be more esoteric and foreign.

Subjective and intersubjective value may be separated. For instance, customers may post anonymous reviews on such websites as TripAdvisor or Yelp! that appear to represent largely subjective judgments, or in which customers express their opinions without implicating themselves. Consequently, anonymous users may more easily post negative reviews, and negative reviews on these websites significantly affect businesses. Therefore, these anonymous review sites create a privileged vantage point for customers to make judgements from a safe distance, while in reality customers are implicated in participating in services and cannot maintain such a distance.

One common sense view is that customers can judge the value of a service as they please. This is understandable, as the subject-object separation retains a strong hold in modern life. Further, modernist thought has relied on sovereign human subjects that constitute and can change the objective world, which is stable and inanimate. As Heidegger (2002) demonstrated, the subject stems from an underlying basis, or *subiectum*. This was a way for the subject to secure safety and certainty by surrounding himself or herself with these solid objects, and particularly after modernity began by eliminating the gods and losing the transcendental center that used to give us certainty.

The shift from product to service coincides with the collapse of this modernist ideal; we can no longer trust either the value of objects themselves or the value of the subject that can dictate the objects' value. Currently, value is decentered as the subject is decentered. As value lies in the action and not in the thing, valuation as a verb should be considered. The value of service must also be understood in this historical context.

Appendix Transcription System

Symbols	Description
[	Point of overlap onset
]	Point of overlap outset
=	Connecting two lines represent no discernible silence between the lines
(1.2)	Pause in seconds
(.)	Hearable but not readily measurable short silence (less than 0.2 s)
.	Falling intonation contour, not necessarily the end of a sentence
,	Low rising intonation contour, not necessarily a clause boundary
?	High rising intonation contour
:	Stretched voice
Word	Stressed talk
°	Relatively quieter voice
–	A hyphen denotes a cut-off
> <	Relatively rushed or compressed talk
<>	Markedly slow talk
(word)	Parentheses around a phrase denote the transcriber's guess at what might be said
↑	Rising intonation shift
h	Exhaling
.h	Inhaling

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Chapter 8
Consumer Behavior for Information on Food Products

Keiko Aoki

Abstract Since a monetized economy has existed since pre-Christian times, it was already more effective in obtaining food than the barter system because of its system of payment. This purchase behavior has undergone a transformation from the development of information technology. For example, consumers used to buy food products with limited information from their own assessment or through package information such as price and producing area. However, in modern society, consumers have access to much more diverse information, such as assessments by others, and manufacturing processes. This chapter provides an overview of related studies on food purchase behavior influenced by information.

Keywords Consumer behavior · Information · Food products

Highlights

- Lack of clarity on whether sensory or non-sensory information has more influence on consumer behavior.
- Several previous studies imply that tasting with information, or high preference by a target group without tasting, has a greater influence on the value of food products than just information on the food product.
- Several previous studies imply that sensory information is effective before tasting if the information is negative, while non-sensory information is effective after tasting.
- Several previous studies imply that negative information has a greater influence on human behavior than positive information. However, some studies obtain the inverse result.

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First, we categorized food information into sensory information, consisting of intrinsic properties such as taste, food texture, and color, and non-sensory information, consisting of extrinsic properties such as production technology and branding (Jaeger, 2006). The perception of such information was categorized as neutral, unfavorite (negative information), and favorite (positive information).

Next, it needs to show willingness to pay (WTP) such as consumer's value in some environments and measuring methods for identifying food purchase behavior. As the environments, there are hypothetical and non-hypothetical conditions with tasting, which are defined as experiments without and with monetary incentives, respectively. Measuring methods mainly consist of three techniques: Stated preference methods as Contingent valuation (CV) method, discrete choice experiment (CE); Second price auction; Becker-Degroot-Marschack (BDM) Mechanism; Hedonic scaling. Each environments and methods are explained in Appendix.

From here, this chapter presents an overview for related studies on the type of information (description) that influences the WTP for food products. Table 8.1 provides a summary of previous studies mentioned below.

8.1 Sensory Information

8.1.1 With Tasting

Here, I introduce four previous studies investigated sensory information with tasting.

Lange et al. (2002) compared the effects of three types of information (blind tasting, information with or without tasting) in evaluating Champagne. They employed SPA in both within and between designs under the non-hypothetical condition and the scaling. Both results for SPA and the scaling showed similar results. Also they revealed that information with tasting was more effective than blind tasting.

Siegrist and Cousin (2009) investigated the order effect of tasting and written information. They presented the information such as sensory information perceived as negative or positive information by evaluating wine critics. According to the results, the group that received negative written information before the tasting gave lower ratings to wine than the group that received positive information. On the other hand, there was insignificant difference between the groups when this written information was provided after the tasting.

Seppä et al. (2015) investigated the sensory information in three rounds; visual round, in which the respondents actually saw the apples; taster round, in which the respondents actually tasted the apples; and the written information round, in which the respondents tasted the apples and felt their texture. The order changed in each treatment. The results revealed that tasting, written information, and higher frequency of tasting increased the value of the apples.

Lima et al. (2019) categorized tasting status into three conditions as blind tasting, expected, and informed. Blind tasting was defined that the respondents neither taste

Table 8.1 Summary of previous studies

Authors	Subjects	N	Goods	Condition	Tasting	Measuring	Design	Treatment
Sensory information								
Lange et al. (2002)	Residents	123	Wine	Non-hypothetical	Yes: Blind, Full	SPA Hedonic scaling	Between/ Within	-Blind tasting -Bottle (= expected without tasting) -full info with tasting
Siegrist and Cousin (2009)	Students	136	Wine	Non-hypothetical	Yes	Points (0-100)	Between	-No-information -Information before tasting -Information after tasting
Seppä et al. (2015)	Residents	118	Apple	Non-hypothetical	Yes	Hedonic scaling BDM	Between/ Within	-Appearance only -Appearance, written information and tasting -Appearance, tasting and written information
Lima et al. (2019)	Adults, Children	800	Grape nectar, Chocolate, Flavoured Milk	Hypothetical	Yes: blind, informed	Selecting one	Between	-Blind tasting -Expected -Informed

(continued)

Table 8.1 (continued)

Authors	Subjects	N	Goods	Condition	Tasting	Measuring	Design	Treatment
Alfnes et al. (2006)	Residents	115	Salmon	Non-hypothetical	No (actual)	CE	Within	Color (five colors)
Non-sensory information								
Ginon et al. (2009)	Residents	123	Baguettes	Non-hypothetical	Yes	BDM	Between	-General information only -General and health information
Botelho et al. (2017)	Residents	545	Pear, Apple	Non-hypothetical (in-fruit stores)	Yes	CV	Between	-Blind tasting followed by information (Place) -Tasting with provision of information (Place)
Hayse et al. (2002)	Primary food shoppers	87	Ham sandwich	Non-hypothetical	Yes	SPA	Between	Food irradiation: -Health negative information -Health positive information -Both information

(continued)

Table 8.1 (continued)

Authors	Subjects	N	Goods	Condition	Tasting	Measuring	Design	Treatment
Caporale and Monteleone (2004)	Residents	105	Beer	Hypothetical	No (video)	Hedonic scaling (9 point)	Within	-GMO brand -Organic brand -Traditional brand
Marette et al. (2008)	Residents: women (18-45)	115	Tuna can Sardines can	Non-hypothetical	Yes	Original methods	Between/Within	-No-information -Omega3 (positive information) -Mercury (negative information)
Chalak and Abiad (2012)	Residents	284	Shawarma sandwiches	Hypothetical (face-to-face interview)	No	CE: D-optimal	Between	-No-information -Food certification information (ISO, ServSafe)
Chen et al. (2013)	Residents	108	Beef steak	Non-hypothetical	No	CE	Within	-No-information -Advantage of technology -Disadvantage of technology

(continued)

Table 8.1 (continued)

Authors	Subjects	N	Goods	Condition	Tasting	Measuring	Design	Treatment
Uchida et al. (2014)	Residents	3370	Salmon fillet	Hypothetical	No	CE: D-optimal	Between	-Minimal information -FAO information + minimal -Science information (Worm et al. 2006) + minimal
Sensory versus Non-sensory information								
Aoki et al. (2010)	Students, Residents	562	Ham sandwich	Non-hypothetical and hypothetical	Yes:NH No:H (picture)	CE: D-optimal	Between NH and H, Within information	-Health risk (negative, positive) information -flavor information
Aoki et al. (2019)	Residents, Chefs	386	Rice	Non-hypothetical	Yes	CE: D-optimal	Between treatments, Within information	-No-information -Cultivation information -Other tasting ranking

(continued)

Table 8.1 (continued)

Authors	Subjects	N	Goods	Condition	Tasting	Measuring	Design	Treatment
Williamson et al. (2016)	Chinese grape wine drinkers	828	Wine	Hypothetical in the field.	No (picture)	CE: Orthogonal	Between	-Control (coffee's explanation) -Tourism -Environment -Safety -Tradition, -Tasting
Li et al. (2019)	Students	93	Coffee	Hypothetical	Yes	Hedonic scaling (9 points)	Between	-No-information -Subjective sensory information (profiles) -Objective sensory information (cultivation environment)

nor receive any information about the apples. Expected was defined that the respondents were given some information but did not taste. And informed was defined the respondents were given some information with tasting. The results found that information with tasting more effectively influenced than that without tasting.

Additionally, the results of sensory information show different trends when the tasting is by professionals such as chefs and sommeliers, and when it is by ordinary individuals (Kelley et al. 2001; Nestrud and Lawless 2008).

8.1.2 Sensory Information Without Tasting

Here, I introduce a previous study investigated sensory information without tasting. Alfnes et al. (2006) investigated value of salmons' color by presenting four different shades of red to respondents and giving written explanations of the colors. The respondents showed a willingness to buy salmons that were of intermediate shades of red. However, the study did not find the effectiveness of information statistically.

8.2 Non-sensory Information

8.2.1 With Tasting

Here, I introduce two previous studies investigated non-sensory information with tasting. Ginon et al. (2009) investigated health information on baguettes with and without general nutrition information and label information by using BDM. Also, in this study, the respondents tasted both before and after the provision of information. The results showed that label information is more effective and that the order of tasting is insignificant different.

Botelho et al. (2017) studied the order effects of tasting and written information effect on the food-producing area. The results revealed that provision of information after tasting was more effective than before tasting.

8.2.2 Without Tasting

Here, I introduce six previous studies investigated non-sensory information without tasting. Hayse et al. (2002) compared the effects of three health information on food irradiation of ham used in sandwiches as negative, positive, and both information by using SPA in non-hypothetical condition. The result found that negative information is most effective among information.

Caporale and Monteleone (2004) investigated the effect of information on manufacturing beer. They conducted four treatments such as (1) using genetically modified yeast; (2) with organic barley and hops, and (3) using traditional brewing technology; (4) no information (blinding). The results showed that it was better rating of the beer in giving information treatments compared to no information one. However, it was unclear which of the three types of provided information was more effective.

Marette et al. (2008) investigated the effects of health information on the selecting of tuna and sardine cans by using an original method in within and between designs. They compared the provision of negative information on the risks of mercury, positive information on the good effects of omega 3, and no information. In case of both cans, negative information was more effective than positive information.

Chalak and Abiad (2012) investigated the effect of information on food certification information on high risk shawarma sandwiches in Lebanon by CE in hypothetical conditions with a between design. Used information is quality management (ISO 9001) and safety (ISO 22000 and ServSafe). They found that the effects were better when information was provided, and that safety (ISO 22000 and ServSafe) information was more effective.

Chen et al. (2013) investigated the effect of information on new technology (vacuum packaging) of beef steaks by using CE. Used information was negative information (high price, possibility of faster decay), and positive information (freshness, long lasting taste, etc.). They found that having any information, regardless of the type, was more effective.

Uchida et al. (2014) investigated the effect of information for ecolabel salmon by using CE. They compared three kinds of information such as general information, information published by the UN Food and Agricultural Organization, and science information from science magazines. The results suggested that while science information was more effective in changing consumer behavior, in some cases, it might be most lowering the value that a consumer attached to it.

8.3 The Comparison Between Sensory and Non-sensory Information

8.3.1 With Tasting

Aoki et al. (2010) examined the effects of sensory and non-sensory information for ham with sodium nitrate both hypothetical and non-hypothetical conditions by using CE. Sensory information was defined that the food additive sodium nitrite enhanced flavor, which non-sensory information stated that sodium nitrite prevented botulism poisoning but maight be carcinogenic. Tasting was conducted in non-hypothetical condition only. The results found that the flavor aspect of sensory information under non-hypothetical condition and that the carcinogenic aspect of non-sensory information influenced the value of sodium nitrite under hypothetical condition, respectively.

Aoki et al. (2019) examined the effects of sensory and non-sensory information for rice in the non-hypothetical condition with tasting by using CE. Sensory information was defined the tasting rating results of Japanese chefs who stored manager class with over 10 years of experience) and residents. Non-sensory information stated rice cultivation methods. The results found that tasting with information was more effective than just tasting, and that the non-sensory information on cultivation leaded to a higher rating of rice than sensory information related to taste ranking.

8.3.2 Without Tasting

Williamson et al. (2016) compared the effects of sensory information related to taste information on wine vs. non-sensory information related to some information such as tourism information about the wine producing area, environmental information, food safety information, and cultural information about the producing area. They conducted it under virtual hypothetical conditions by using CE. They found that environmental information as non-sensory information and taste information as sensory information increased the rating of wine.

Li et al. (2019) compared the aroma, flavor, and body, such as taste information of coffee of the sensory information, and cultivator or growing environment of coffee as the non-sensory information. They used scaling. They found that sensory information related to taste was more effective in increasing preference for coffee than non-sensory information related to cultivator and growing environment.

8.4 Recent Trends

This chapter presents consumer behavior related to food by using the recent technological innovations, apart from researches on information mentioned above. The technology introduced here is eye-tracking (ET) technology, and we discuss the studies investigate the consumer behavior related to food using this technology.

Using CE and ET, Ballco et al. (2019) studied yogurt packaging, nutritional factors such as low sugar and low fat, suggesting that displaying such nutritional information on packages draws consumer attention to the product and may stimulate the urge to buy the product.

Siegrist et al. (2019) conducted a between design study by comparing displays of cereal using virtual reality (VR) versus displays in shops, to participants in a supermarket and found no significant difference. That is, the study suggested that VR has utility value.

8.5 Conclusion

This chapter classified researches on sensory and non-sensory information which affect consumers' food choice and summarized the experimental results in each information. The sensory information has significant impact on the food choice in the aspect of output such as taste, color, and texture. These factors are essential and robust effect. On the other hand, some non-sensory information has significant impact in the aspect of producing input such as organic, food additive, and health risk. Some of these information does not have significant impact in some foods. There is still needed to research the impact of this type of information. The most surprising thig is that there is still a few experiments which compare those information types. The result are sometimes inconsistent. To overcome this limitation, the authors advises readers to advance these field of study. To prompt this kind of study is to find out which type of information more affects the satisfaction of eating foods. That means, people decide the taste of foods by brains before tasting or tongue after tasting, which leads the collaboration of neuro brain research field.

8.6 Appendix

In the overview of related studies on information mentioned above, I explain environment and a way of measuring WTP. The methods presented in this chapter are also used in the food product sector for measuring WTP. A general description of each method is provided here. For more details, please refer to the respective references.

8.6.1 Environment

Normally, in the food sector also, the experimental environment is placed under non-hypothetical conditions and surveys are placed under hypothetical condition.

8.6.1.1 Experimental Economics

Experimental economics is a branch of economics that studies human behavior under an economic environment where the subjects are given monetary incentives. Therefore, the earnings depend on a result-reward due to decision-making mechanism. For more details, please refer to Friedman and Sunder (1994), Kagel and Roth (2016), Jacquemet and L'Haridon (2018), Holt (2019), and so on. In addition, in experimental economics, experiments are conducted not just in laboratories but also on the field. For details, please refer to Carpenter et al. (2005) and Banerjee and Duflo (2017).

Experimental designs consist of two types. One is a between design, which compares between groups. One merit of between-design is that results are non-personal, as it involves comparisons between different groups for a task. However, a demerit is that it may not be possible to deny the difference in results based on different individual attributes. The other is a within design, which compares within a group. A merit of the within design is that since the effects of a task are measured for the same individual, the results cannot be swayed by the individual attributes of the person. However, a demerit is that the results may be influenced by factors other than the task, as the target group may develop a learning effect. Therefore, researchers need to consider that they should employ between design or within design in their study.

Incidentally, it seems that people confuse experimental economics with behavioral economics. Both are similar in terms of exploring human behavior by offering monetary incentives, but both these branches differ at fundamentally essential aspects. A difference on the academic front is that experimental economics is a branch pursued by theoretical researchers while behavioral economics is pursued by people involved in empirical research. Experimental economics is a macro perspective as studying social systems, while behavioral economics is a micro perspective that closely observes the human behavior.

8.6.1.2 Survey

In the food sector, the use of hedonic scaling is common in surveys and for creating sensory profiles. Generally, 5 or 7 Likert-scales are often used in the studies.

8.6.2 Measurements

8.6.2.1 Choice Experiment (CE) Method

CE is a stated preference method (Louviere et al., 2000). Stated preference method is an approach to measure the value which is hard to price something such as services and risks. CE consists of alternatives with or without opt-out option and attributes describing these alternatives. Opt-out options mean not to buy in the alternatives mainly. Sometime opt-out options mean to keep condition such as status quo. For the effects of using or not using opt-out options, please refer to Kallas and Gil (2012). Several choice sets are created by setting the levels of ordinal scale or nominal scale for these attributes as example below. Respondents must choose one of the alternatives in each choice set as shown in Table 8.2.

Generally, the number of choice sets is based on full factorial design which is calculated the number of attributes and the levels. Since the number by the full factorial design is large to let respondents repeat their decision making, researchers often employ a fractional factorial design instead of the full factorial design because of reducing the number of choice sets. As the fractional factorial design, an orthogonal

Table 8.2 Example of a choice set

Alternative	Rice 1	Rice 2	Rice 3	Neither
Country of origin	USA	USA	USA	
Cultivation method	Conventional	Conventional	Organic	
Taste	Top 20%	Normal	Top 20%	
Fair trade	Non-Fair trade	Fair trade	Fair trade	
Price	100 Baht	200 Baht	300 Baht	
Which do you want to buy?		☑		

Source Aoki et al. (2017)

design aims to minimize the correlation between attribute levels, which an efficient design such as a D-efficient design aims to minimize all variances and co-variances of all parameter estimates. Hensher et al. (2015) write that the orthogonal design works well only in the case where a certain alternative is chosen in almost all choice sets. However, researchers need to consider whether they employ the orthogonal or the efficient designs. Before analyzing, the raw data set is created based on the choice sets such as example below (Fig. 8.1). Basically, first row is placed under variable names in the set. Figure 8.1 is inputted in vertical direction. For example, variables such as set and price which consist of assumed continuous figures are inputted them. On the other hand, variables such as alt and choice which are uniform such as corresponding or not are inputted as 1 if variables correspond, 0 if not. After finishing creating the set, researchers estimate models such as multinomial logit and random parameter logit by statistical software such as LIMDEP, STATA, SPSS. Consequently, WTP is calculated to identify the attribute with a higher value based on estimated coefficients. For methods to create the set, software and estimation models mentioned above, please refer to Hensher et al. (2015).

In CE, researchers often conduct in a hypothetical condition. For a further validity, a non-hypothetical condition is sometimes employed. Between hypothetical and non-hypothetical conditions may be different. That is called hypothetical bias, which WTP is higher in hypothetical condition than non-hypothetical condition (Murphy et al., 2005; Aoki et al., 2010; Hensher, 2010; Loomis, 2011; Penn and Hu, 2018). However,

set	alt1	alt2	alt3	niigata	sado	toki	price	choice
1	1	0	0	0	1	0	200	0
1	0	1	0	1	0	0	230	1
1	0	0	1	0	1	0	290	0
2	1	0	0	0	1	0	230	1
2	0	1	0	1	0	0	290	0
2	0	0	1	0	0	1	200	0
3	1	0	0	0	0	1	230	1
3	0	1	0	0	1	0	200	0
3	0	0	1	0	0	1	290	0

Fig. 8.1 Example of row data set. *Source* Author

a few studies do not indicate hypothetical bias (Carlsson et al., 2005; De-Magistris et al., 2013). Therefore, the results of the hypothetical bias have been mixed. To mitigate the hypothetical bias, cheap talk are often used in the CE though it is not always able to mitigate the hypothetical bias (Alemu and Olsen, 2018). As other bias, I introduce other bias, which is status quo bias in CEs (Meyerhoff and Liebe, 2009).

Incidentally, conjoint analysis (CA) is often confused. CA has many points in common with CE and was developed from psychology. Also CA is based on quantitative choices such as rating and ranking of the "Conjoint Measurement" theory (Krantz and Tversky, 1971). CA differs from it in many aspects, such as calculation of utility value. Louviere et al. (2010) describes this in detail.

8.6.2.2 Contingent Valuation (CV) Method

Similar to CE, CV is a stated preference method and is based on the theoretical framework Random Utility thory. CV has many formats; however, it requires respondents to directly express their willingness to pay such as examples below. While CV has its merit of multiple formats, it is criticized for the bias in the validity and reliability of the results (Diamond and Hausman 1994; Venkatachalam 2004). The relative merits of CV and CE are not yet known (Mogas et al. 2006). For classification of stated preference methods, including CE, please refer to Merino-Castelló (2003).

Example 1 (considered by author) This park contains many rare plants and living creatures that are documented in the Red Data Book. However, the number of visitors to the park has increased in recent years, making it necessary to establish a park design to preserve the rare species.

How much do you think you can pay for a park that preserves rare species? (   ) JPY

Example 2 (considered by author) This park contains many rare plants and living creatures that are documented in the Red Data Book. However, the number of visitors to the park has increased in recent years, making it necessary to establish a park design to preserve these rare species.

A. Per person expenses for the park to preserve the rare species is JPY 1000. Would you be willing to pay this amount? Yes/No
B. Per person expenses for the park to preserve the rare species is JPY 500. Would you be willing to pay this amount? Yes/No

8.6.2.3 Second Price Auction (Vickrey-Auction) (SPA)

In this auction, bidders simultaneously bid for an item, and the highest bidder gets to buy the item at the second highest bidding price. The auction invented by American economist and Nobel Prize winner in Economics, William Spencer Vickrey (1914–1996) is different from common first price auctions. In this auction, the highest bidder wins the auction but pays the amount of the second highest bid (or the minimum price offered by the seller if there is no competitors) and not the amount he/she bid him/herself. At present, this concept is being used in many auction markets, for example, Yahoo! Auctions. For more detailed, please see Krishna (2009) in theory and Lusk and Shogren (2007) in experiment, respectively.

8.6.2.4 Becker-Degroot-Marschack (BDM) Mechanism

This is a simple mechanism designed by Becker et al. (1964). The BDM involves random determination of price and any bid exceeding this price is considered as the winning bid. Therefore, there may be more than one winner.

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Chapter 9
School Cafeteria Experiments for Food Healthy Messages

Kenju Akai

La destinée des nations dépend de la manière dont elles se nourrissent (The destiny of nations depends on the manner in which they are fed).
Physiologie du goût—Jean Anthelme Brillat-Savarin

9.1 Introduction

This chapter focuses on salt, which is one of the minerals essential for humans to live. Salt—i.e., sodium—is a necessity for human survival. However, an excessive intake of salt can induce high blood pressure or hypertension. Hypertension is characterized by chronically high blood pressure, defined as systolic blood pressure >140 mmHg and diastolic pressure >90 mmHg according to medical guidelines. Hypertension causes cardiology and kidney disease (Intersalt Cooperative Research Group 1988). The onset of hypertension increases rapidly after the age of 45 years (Japan Preventive Association of Life-style related Disease 2015). The medical costs of hypertension in Japan increase tenfold for people aged 45 years and older. It increased to 41.17 billion yen from 3.79 billion yen. Therefore, learning how to reduce salt intake from an early age and making efforts to avoid excessive salt intake are important.

However, contrary to these health-related imperatives, salt is used abundantly in the food service and processed food industries. The World Health Organization (WHO) recommends 5 g of daily salt intake; however, it is difficult to adhere to this recommendation in Japan (World Health Organization (WHO) 2016). Since salt accentuates the flavor in dishes, we are starting to become desensitized to the good flavors of dishes with milder saltiness. In particular, soy sauce and miso paste are widely used in Japanese homes, increasing salt intake through cuisine based on these two condiments.

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The people of Japan have the high level of salt consumption in the world, followed by Thailand, Korea and Singapore, which are linked (HonKawa Data Tribute 2017). The salt consumption of Japanese people is conspicuously high. Though based on the author's hypothesis and not on scientific data, perhaps Japanese people's need for a high salt intake to supplement the excessive loss of salt from sweating in the hot and humid climate worsens the overconsumption of soy sauce and miso paste. Furthermore, highly selectively brand name rice tastes sufficiently sweet, which may encourage people to prefer their side dishes even saltier. Perhaps Japanese people have become salt addicts who cannot control their salt intake despite our best efforts.

In Japan, the first diseases that are the leading causes of mortality from non-infectious diseases and extrinsic causes for men is smoking and the second hypertension, while for women, the first is hypertension (Ikeda et al. 2012). Compared to the now ubiquitous warnings against smoking, programs promoting salt reduction to prevent hypertension are still in their budding stages in Japan.

In the United Kingdom, programs to reduce the intake of salt to prevent cardiology have been implemented at the national level. The UK Federation of Bakers Ltd has been committed to gradually reducing salt content in sliced bread to 10% (1.0 g) and has achieved that goal (The UK Federation of Bakers Ltd. 2019). This has lowered the rate of cardiology in the UK and cut healthcare costs by around 1.5 billion GBP (Action on Salt and Salt Awareness Week 2017). This case demonstrates the successful education of a population to provide accurate knowledge about a condiment quintessential to cuisine. The reduction of diseases and healthcare costs has resulted in a surplus, that is, new value for society.

In Japan, similar attempts to reduce salt intake have been made by the city of Kure in Hiroshima Prefecture (Kure city 2019). The Kure model is characterized by attempts to increase awareness of salt reduction and recommendations to reduce salt in the food industry including to restaurateurs, urging them to provide low-salt foods. Another noteworthy initiative is the use of seaweed salt. In general, 99% of common table salt is sodium. The largest obstacle in salt reduction is people's misconception that reduced-salt foods are less tasty. Thus, the method of using the ancient Japanese traditional *dashi* broth has been employed to overcome this shortcoming. Japanese cuisine is characterized by the use of seaweeds such as *kombu* kelp to add *umami* associated with sodium glutamate. This ancient knowledge gave birth to the idea of cooking seaweed with salt water during salt production to make seaweed salt. Seaweed salt contains a lower percentage of salt and higher percentage of potassium and magnesium, though exact proportions vary depending on the type of seaweed used. Furthermore, umami added from the seaweed deepens flavor while controlling salt content. Seaweed salt also has the benefit of a higher potassium to sodium ratio than common table salt. Potassium has the effect of cancelling out the hypertensive effects of salt, though bitterness increases when there are large quantities of this mineral.

The following section introduces the essence of economic experiments using university cafeteria meals with the aim of promoting salt reduction by using seaweed salt, as described above. However, while the name "seaweed salt" has a positive connotation and effect in serving food aiming for salt reduction, it can also have negative effects depending on the purpose. This will be introduced in Sect. 9.3 describing the first experiment. Section 9.4 describes the second experiment for the promotion of reduced salt meals. This chapter demonstrates how one food product, seaweed salt, can leave different impressions on consumers when introduced through different approaches.

9.2 Experimental Economics

The experiment uses a method based on experimental economics. Experimental economics is an academic system for which Vernon L. Smith and Alvin E. Roth received the Nobel Memorial Prize in Economic Sciences in 2002 and 2012, respectively. People were employed as participants to validate whether market principles function in reality as theorized to examine themes such as market turmoil, the collapse of the bubble economy, spectrum auction, and labor market matching. They are given a financial incentive toward goods and services—i.e., the utility of humans as theorized by economic theories—by providing them with rewards proportionate to the hypothetical money they earned in a pseudo-market. For example, the economic theory on market competition fundamentally assumes that individuals seek to maximize personal profit and does not account for relative interest between the individual and the other party, involving a sense of inequality, inferiority, or superiority to others. However, it is impossible to exclude the effects of such emotions from individuals in business, and in fact, these may significantly affect the dynamics.

However, the essence of experimental economics lies in creating a sterile experimental room where all other factors are conveniently excluded for the purpose of studying the theory. That is, the main purpose is observing how human economic behaviors converge to the theoretical conclusions by allowing participants to behave in conformance to the theory while in the experimental room.

In other words, the main purpose of experimental economics is to compare different features of a market to ascertain how it functions according to a theory based on a reward system aimed at personal gain, without awareness of others. This enables proving that a theory actually functions in the experimental setting, as long as the market functions according to the efficacies and reward systems defined by economic theories and humans are conscious of these. Conversely, it would show that if the market does not function according to the theory, there is some flaw or misconception in the theory.

If these things must be taken for granted, we might as well use agents programmed with a learning algorithm, not real humans, and conduct experiments on multi-agent simulations. In reality, however, humans act on psychological bargaining based on the amalgamation of cumulative knowledge and past experiences. Naturally, human participants of experiments act on such internal bargaining as well. Real-world experiments do not seek to forcibly eliminate external human factors, but investigate whether theoretical conclusions are reached, with or without them. Conversely, these human factors are eliminated in a multi-agent simulation. In other words, the two experimental methods can be compared to find which human factors distort the theory. As such, the two are in a complementary relationship.

Traditional experimental economics primarily sought to observe whether the evolution of an economy conforms to a theory as an endpoint of free human behaviors in the market by fixing utility, reward systems, and other conditions within the experimental setting to fit the theory.

Alongside these types of experiments developed others in which personal preferences and utility are not fixed, but which study them in detail. For example, these studies examined human choices such as whether humans behave fairly, and what kind of pay distribution system they prefer under a particular economic environment or system. These studies are influenced by psychology, and seek to define the functional type of essential human utility and preferences.

Specific studies that have explored people's sense of fairness include investigations of how the costs of labor should be divided under fixed work conditions if you were the CEO: whether to divide it completely equally, based on commission, or a combination of the two. These studies further investigate what styles of distribution are preferred by nationalities such as Americans or the Japanese, ethnicities, ideologies, and emotional and sex differences to explore human nature.

Behavioral economics is a prime example of an interdisciplinary area of studies between psychology and economics. Behavioral economics studies have experimented with and proven human satisfaction and utility systems unknown in previously existing economics, such as how the perceived utility of 1 yen differs dramatically between 1 yen in loss or gain. The core of this theoretical system is called the *prospect theory,* for which Daniel Kahneman won the Nobel Memorial Prize in Economic Sciences in 2002 and Richard Thaler in 2017. Compared to experimental economics, which emphasizes the establishment of experimental methods and theory testing or rebuttals, behavioral economics does not necessarily require experiments, but also uses surveys and other methods that can be validated statistically. Furthermore, it emphasizes establishing economics theories such as utility and behavioral patterns.

Behavioral economics has in recent years been increasingly used in medical research to encourage certain human behaviors. For example, smoking and alcoholism are issues of habituation. Analogous to preventive medicine that seeks to change human behaviors through medication is economics that seeks to change behaviors through financial, emotional, and systemic mechanisms called nudges. The two are in high affinity with one another as academic studies that seek to influence behavioral changes in humans.

In summary, experimental economics can be simply classified into the type in which several economic systems are compared with human wealth and monetary drives, and preferences for services are fixed in experimental settings. In the other type, the economic environment or system is fixed in experimental settings and various subject groups introduced into it to compare preferences between subject groups to explore human nature.

Thus, experimental economics has been evolving with the aim of validating human nature theorized under experimental settings to provide hints to economic planning in real society, and has been applied as such. However, it has always been questioned whether experimental results can be applied to economics in real life, given the dissociation between the simplicity of economic environments and complexity of the real economy.

This has led to the development of methods in economic experiences that take the experiments from sterile experimental rooms to the field—i.e., actual supermarkets and restaurants. An example is introducing the experimenter's intentions by changing the menu or pricing customers see in a restaurant, bringing in participants of various age groups and sexes to the restaurant, and observing what they order. In this case, participants are compensated, spending this to pay for their order from the menu.

Natural experiments take field experiments in economics one step further into an even more natural experimental environment. Unlike the participants of the above-mentioned field experiments who are invited and paid by the testers for their participation, they unknowingly participate in natural experiments. For example, the tester may increase or decrease the prices of two products alternately to observe the effects of price changes on sales in a supermarket. This may help identify the relationship between two products, such as the relationship between butter and margarine, which are two substitute goods. In other words, sales of one increases when the sales of the other drops. In addition, it can be tested whether it is more similar to the relationship between bread and butter, which are complementary goods, because the sales of one decrease when the other decreases. The participants are customers who have visited the store. The tester shuffles the prices based on a theoretical hypothesis, then rearranges the shelves accordingly. The rest can be observed through point-of-sale (POS) data that reflects customers' purchases.

This chapter introduces two natural experiments conducted by the authors. Study 1 validated how product names that seem compatible with the food at a glance may lower the value if it gives the impression that it is not good for health. Seaweed salt rice from Okinoshima island town, Shimane Prefecture is a premium rice grown through the salinity stress method, in which a solution of seaweed salt made by baking sea salt with umami-filled seaweed is sprayed in the growing stages. Compared to common rice, seaweed salt rice grains grow more robustly and have a stronger, more glutinous texture. It can be priced up to three times the price of the rice commonly used in the school cafeteria. However, the term "salt" can give a negative impression as people become more aware of the importance of reducing their salt intake. Therefore, seaweed salt rice was explicitly priced the same as common rice and served in a school cafeteria to compare sales. The purpose was to determine whether it appeals to consumers despite the promotion of salt reduction. Next, the methods of growing seaweed salt rice were promoted to observe changes in sales. This study was reported at the international conference of EuroSense in 2018 (Akai et al. 2018).

Study 2 was an experiment on reduced-salt menus for preventing hypertension that tested whether the seaweed salt meals encourage students' healthy food purchasing behaviors. It costs more to prepare a low-salt dish than non-low-salt one, so it is avoided by markets. However, there are other proposed reasons for the poor sales of low-sodium products, such as the presumed blandness and lack of flavor, which discourages purchases by all but the most health-conscious consumers. In general, the lower intensity of flavors of low-salt foods in Japan is enhanced by adding complementary umami from the broth of seaweed or fish. Thus, it costs more than it does to manufacture the same food the conventional way with normal levels of salt. Since this cost difference can never be eliminated in the market, it remains unsure whether low sales can be attributed to poorer taste or higher prices. Furthermore, the market for such products is small, making it prone to poor sales, which drives prices even higher, further exacerbating the effectiveness of promoting salt reduction.

Thus, the present study sought to use a university cafeteria as the field of an experiment in which reduced salt and non-reduced salt products were sold at the same price to observe the changing of sales volume of reduced salt meals. Participants were students who participated in the experiment unknowingly by eating their meals at the school cafeteria as they normally would. This study was reported at the international conference of Pangborn in 2019 (Akai et al. 2018).

9.3 Study 1 Experiment: Introduction of Seaweed Salt Rice in a University Cafeteria

9.3.1 Introduction

Okinoshima island town (shortly, Okinoshima) in Shimane Prefecture is home to the production of seaweed salt. It is made by cooking locally harvested seaweed related to kombu kelp called *arame* with seawater to produce sea salt. Rice has been produced in Okinoshima since ancient times. Specifically, the salinity stress method is employed, because the rice plants are exposed to seawater. In recent years, farmers in Okinoshima have been reviving and further developing their ancient traditional salinity stress farming method to improve the rice making process. Seaweed salt solution is sprayed on the rice plant over its growth processes. Rice produced in this method is sold as Okinoshima seaweed salt rice. It has been covered by television shows and other mass media and has enjoyed a surge in product visibility and boost in sales.

In the last two to three years, foods with the term seaweed salt have gained popularity. A convenience store chain sells seaweed salt fried chicken bearing the geographic name Awajishima island city, which is rooted in its status as a forerunner in the seaweed salt trend. The term seaweed salt suggests a wholesome and flavorful food product for a perceived value added, namely increasing the number of food products also named as such.

This study sought to explore whether seaweed salt is an appropriate name for rice. For Japanese people, rice is sweet, and the side dishes eaten with it are often quite salty. Thus, a name associated with salt is assumed compatible. This good match between salt and rice is likely accepted by the market, given that convenience stores sell salt *onigiri* (rice balls) that contain no other ingredients. Furthermore, in the hot and humid Japanese climate, consuming enough salt is important in the prevention of heat stroke. As such, salt should be associated with a good image.

However, it is questionable whether the widespread climate of low-salt publicity interferes with people's positive impressions of salt. Thus, this study sought to experimentally validate whether the word "seaweed salt" in the name "seaweed salt rice" continues to maintain its positive connotations and be accepted in the market.

9.3.2 Design

The experimental field consisted of the student group/university school cafeteria at Izumo Campus, Shimane University. The participants of this experiment, who did not know they were participating, are students and faculty of Izumo Campus, who are the users of the cafeteria. The faculties of medicine and nursing are located on the Izumo Campus, so the students who use the cafeteria are likely highly conscious about health.

Usually, seaweed salt rice is not served in this cafeteria. However, seaweed salt rice was served with the usual rice. The purpose was to provide information about seaweed salt to observe the sales of seaweed salt rice. The rice usually served is the Koshihikari variety produced locally in Shimane Prefecture. It is sold in 4 serving sizes: L: 360 g for 151 yen, M: 260 g for 118 yen, S: 180 g for 97 yen, and SS: 120 g for 75 yen.

Okinoshima seaweed salt rice costs approximately three times that of the standard rice served in the cafeteria. However, it was sold at the same price as the standard rice to be evaluated according to the name or brand. This was to avoid unconditional rejection based on the higher price, given that participants were students eating at their school cafeteria.

The experiment was conducted from June to December 2017, except in September, which was summer vacation, during which seaweed salt rice was not served.

The sale of standard rice was interrupted in the second week of October, when the students returned from summer vacation, to serve seaweed salt rice only. This temporarily forced all cafeteria users to select seaweed salt rice to create an environment that encouraged them to eat it as much as possible. Figures 9.1 and 9.2 show the original Japanese poster and English translated version used in the final stage of the seaweed salt rice campaign. These emphasized that the rice did not contain salt, and explained the stages of production of both the seaweed salt and seaweed salt rice. This final stage campaign was intended to examine whether a last-minute surge in demand for seaweed salt rice would occur. An example of a last-minute surge in demand is the increased sales of tobacco before increasing the tax rate or boost in general sales before increasing the purchase tax rate.

Furthermore, Study 2, which involved the low-salt menu introduction experiment, was conducted from October to December 2017. Therefore, as explained later, the latter half of this experimental period was affected by the other experiment.

Fig. 9.1 Japanese original poster

Fig. 9.2 English translated poster

In the last month (December), a survey form was placed in the cafeteria so that cafeteria users who ate the seaweed salt rice could voluntarily write their reviews of the rice. The survey comprised items on the sensory analysis between the standard and seaweed salt rice and their impressions of the seaweed salt rice. Respondents received a vegetable juice as a gift to thank them for participating in the survey.

9.3.3 Results

Figure 9.3 displays the volumes of weekly sales of seaweed salt rice and standard rice. It is normal for Japanese people to order rice with their main dish, given that rice is the staple crop in Japan. The figure shows that sales of seaweed salt rice were much lower than that of standard rice until October. Interestingly, the sales of seaweed salt rice did not increase, even when the sale of standard rice was suspended in the second week of October (10/9–13), forcing users to eat seaweed salt rice in

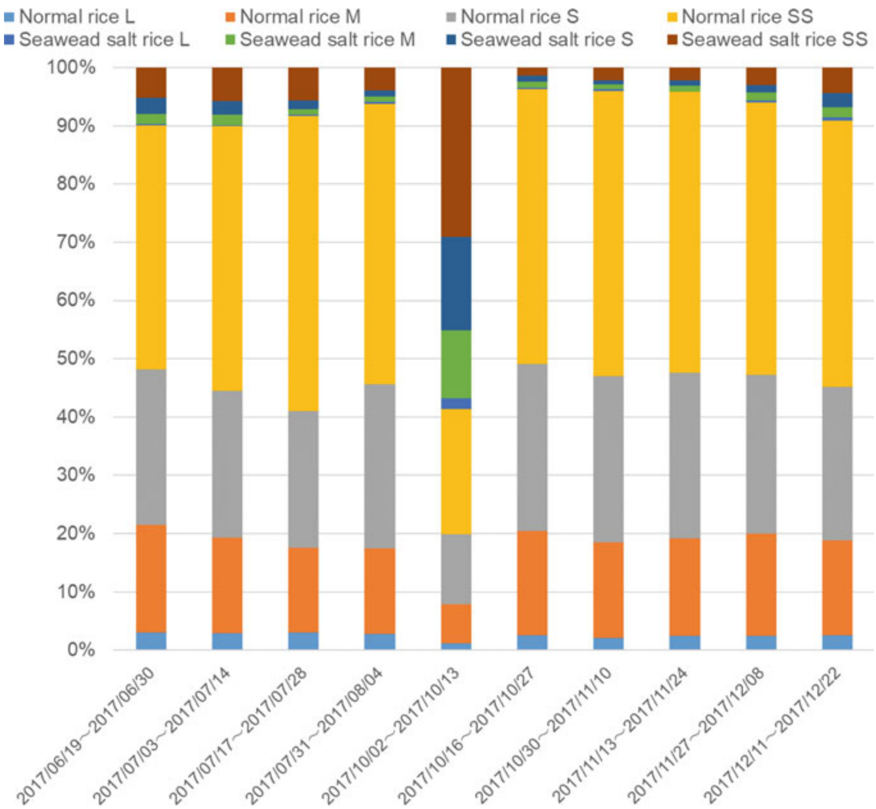

Fig. 9.3 Weekly consumption for each type of rice

the cafeteria out of lack of another choice. However, sales increased when the final seaweed salt rice campaign was launched on December 1 to inform cafeteria users that it contained no salt, and to clarify the steps of the production of seaweed salt and seaweed salt rice. This increase may be explained by two factors: the adequate conveyance of information on seaweed salt rice and a last-minute surge in demand.

These outcomes show that regardless of how delicious the rice is or how expensive it is in the general market, it does not necessarily translate to sales in the target market; in this case, the school cafeteria. Perhaps the value added in seaweed salt rice was counter-intuitively diminished by offering the two options at the same price. Furthermore, the second half of the experiment overlapped with the promotion of salt reduction in the school cafeteria (Study 2). Thus, the term "seaweed salt" may have evoked the negative impression that salt was mixed into the rice. This may be why sales in the second half of the experiment did not increase, despite a period in which standard rice was unavailable in an attempt to obligate the consumption of seaweed salt rice.

According to the survey, 35 of the 50 respondents answered that seaweed salt rice "seemed to contain salt. Figure 9.4 shows the sensory analysis of the results of the seaweed salt rice tasting. Respondents were asked to assess the rice on the axis of hardness (hard and soft) and mouthfeel (chewy and plain). Seaweed salt rice tended to have a harder, more substantial flavor according to the respondents, while standard rice was softer. However, the data were collected from a small sample, which was insufficient to demonstrate statistical significance. Even as students, they seemed to have noticed a difference from the rice they were accustomed to eating.

In recent years, the term "seaweed salt" is seen increasingly frequently, is increasingly visible, and used for many product names such as seaweed salt fried chicken and seaweed salt rice ball. However, we found that when the term is used not for processed food but for raw ingredients such as rice, consumers do not necessarily appropriately understand the meaning. This may be attributed to the fact that the term is often used for the processed products on rice. Thus, labeling a raw ingredient such as rice with the term makes it seem like a processed food with added salt.

In naming food products, it seems important to assess the meaning related to health and food a name adds, and conduct a market test, as we did in this experiment. Specifically, this is important for products in high competition with existing products to which consumers are already loyal, making brand switching less likely. In this case, it is important to have a striking or memorable product name that conveys a healthy image and stance or attitude as well as packaging or health data that explain these suppositions.

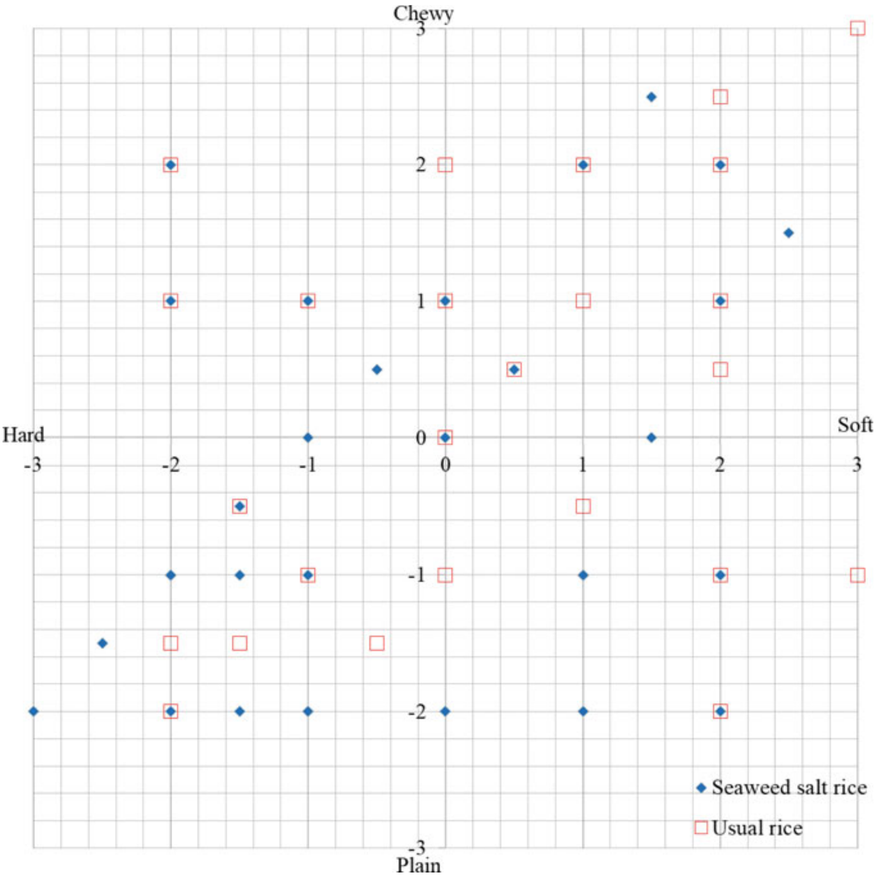

Fig. 9.4 Sensory analysis of rice type

9.4 Study 2: Low-Salt Menu Introduction Experiment in the University Cafeteria

9.4.1 Introduction

Seaweed salt has a good sodium-potassium balance and enables the production of low-salt foods by bringing up the umami of seaweed. However, low-salt menus come with a cost: higher costs of ingredients such as low-salt condiments translate to a higher price of the final product, leading to consumer avoidance. However, regarding the problem with low-salt foods, it is not clear whether this is truly because of a price issue or people's preconceived notions that low-salt foods are bland and not tasty. Food companies have also released various low-salt products in the market, but their sales are not good. They are also unsure about whether this can be attributed to the price difference or compromised flavor. Thus, in this study, a menu normally served at the student cafeteria and a low-salt version thereof were sold at the same price to study which had the higher demand. Furthermore, based on sales, it was tested whether reduced-salt foods were received well by young university students.

9.4.2 Design

The menu at the cafeteria at Izumo Campus, Shimane University was used. The two most popular dishes on the standard menu, namely pork and chicken, were selected as foods to be served with reduced salt. The first was *shio-buta-itame*, or salt-fried pork, and the second *karaage*, or fried chicken. These popular dishes recorded the top sales among dishes using the two meats served at the same time the year before. However, the salt-fried pork dish contained 2.9 g of salt and fried chicken 2.6 g. Neither contained unusually high amounts of salt compared to the salt content of other common dishes. To reduce the salt, that used in these dishes was substituted with seaweed salt. The seaweed salt used in this study is produced in Okinoshima, Shimane Prefecture and contains 35,000 mg sodium, 380 mg calcium, 340 mg potassium, and 960 mg magnesium per 100 g. Low-salt versions of other condiments such as soy sauce were also used to halve the amount of salt. The prepared low-salt dish was tried at a food tasting by ten physicians who work with hypertension prevention, such as those working in pathology at the faculty of medicine and in the departments of nephrology and family medicine. The salt-fried pork and fried chicken dishes contained 1.6 and 1.5 g of salt, respectively after reducing the salt, and were sold at the same price of 280 and 302 yen, respectively.

These dishes were routinely served, for example, salt-fried pork in the first week and fried chicken in the second week. The menu included photographs displaying both the regular and reduced-salt versions of the dishes. Figures 9.5 and 9.6 show the less salty pork and chicken meals.

In explaining the reason why a reduced-salt menu was introduced in the school cafeteria, it was not mentioned that this was an experiment. Rather, it was promoted as a limited edition special menu to promote salt reduction, and accompanied by an explanation of the importance of reducing salt in the cafeteria.

The purchase data was stored as POS data, which was used to compare sales.

9.4.3 Results

Figures 9.7 and 9.8 show the daily sales volume for each less salty food. Twelve servings of the reduced-salt pork menu and 16 servings of the reduced-salt chicken menu on average per day were prepared. On average, 85.7% of the prepared reduced-salt pork and 97.0% of chicken meals were sold.

Fig. 9.5 Photo menu of less salty pork meal

The results indicated that with the price being equal, the sales of reduced-salt foods achieved high level. Furthermore, the fact that it continued to sell out after its introduction showed that the students found the flavor acceptable. The majority of participants in this experiment were students who used the cafeteria; thus, they were sensitive to pricing. We found that as long as the price and taste were the

Fig. 9.6 Photo menu of less salty chicken meal

same, young people accepted reduced-salt foods. Since it is difficult to make low-salt eating a habit, it is recommended that it be promoted from an early stage to prevent hypertension. However, young people tend to rely on eating out, which can make their environment a difficult one in which to eat a low-salt diet. Therefore, it is important for the school cafeteria, which is responsible for university students' health, to introduce low-salt options to nurture a low-salt habit among young users before they enter their adult lives.

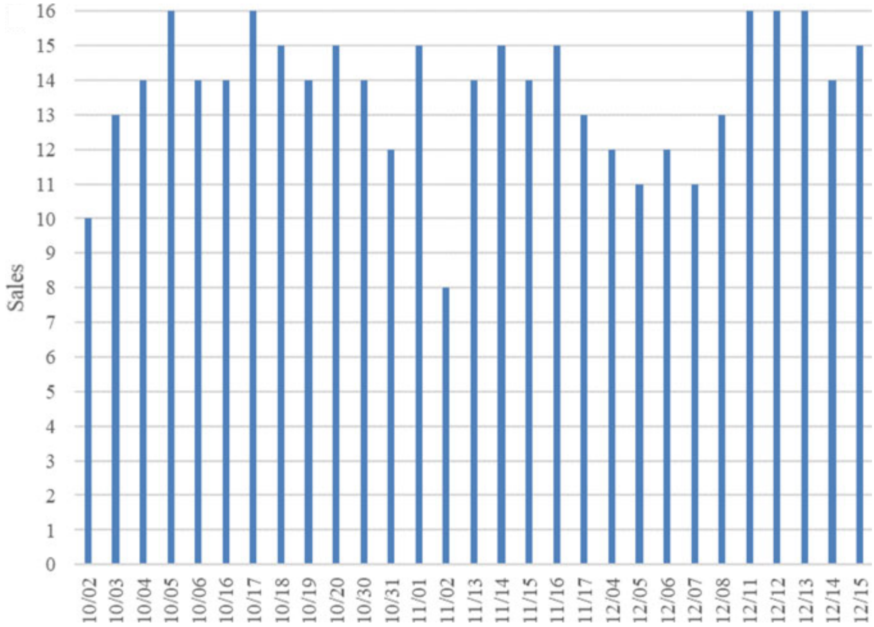

Fig. 9.7 Daily consumption for less salty pork and vegetables stir fry

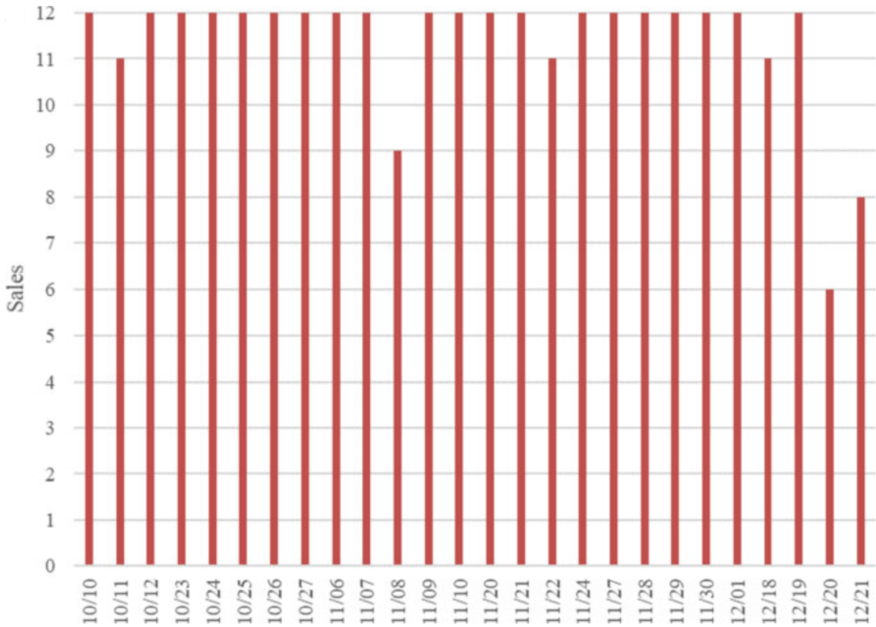

Fig. 9.8 Daily consumption for less salty fried chicken

However, it is very difficult to avoid the added costs of ingredients to develop reduced-salt menus. Thus, actualization through the efforts of the cafeteria is not realistic, and government subsidies and university support may be required. A simple method may be to dilute the soups of soup noodle dishes. Our observations of people with a high salt intake in Shimane University cafeteria revealed that they frequently ate noodle dishes. Relatively flexible ways to provide low-salt options such as offering the soups in noodle dishes in reduced-salt versions may therefore be an effective and familiar way to reduce the salt intake of young people.

9.5 Conclusions

This chapter introduced a natural experiment plan using experimental economic methods with the university cafeteria as the experiment field to introduce seaweed salt rice and reduced-salt meals. In the former, POS data were used to observe the changes in sales, and a survey tasting analysis and image analysis were performed. In the second experiment, POS data were used to observe sales.

There are several limitations to this study. First, neither experiment reflected the general market, because both were conducted in the university cafeteria. Furthermore, we would have liked to conduct the study by providing the reduced-salt dishes at a higher and lower price than the standard versions of the menu to study the demand for the reduced-salt menu as a substitute of the standard menu. However, this was not done, assuming that students would likely select the cheaper version. Other limitations include the emphasis on inferential discussion, and omission of statistical tests and estimations. Thus, there are limitations regarding the validity of the results as scientifically obtained data.

However, there are also benefits in using a school cafeteria as an experimental field. It is possible to conduct these experiments at any university as long as the cafeteria is willing to cooperate in the study. In addition, this model is applicable to other cafeterias as well, such as those at private companies and government offices. Conducting such studies in other universities and companies will enable more effective meta-analyses. Once there is large enough data, it will be possible to perform statistical tests to confirm the scientific validity of the results. This will lead to the more active promotion of salt reduction, and with time, to the actual reduction of salt in the diets of Japanese people.

Research related to food may seem difficult, because it seems hard to gain entry to the field and involves complicated procedures such as cooking and contracts with restaurants. However, the science of food studies involves experiments based on simple observation.

We hope this study provides useful hints for the future research of readers as an experiment conducted in the familiar setting of a school cafeteria.

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