Available online at www.sciencedirect.com
ScienceDirect
International Journal of Hospitality Management 27 (2008) 541–551
www.elsevier.com/locate/ijhosman

The interaction of major resources and their influence on waiting times in a multi-stage restaurant

Johye Hwang[a,*], Carolyn U. Lambert[b]

[a]Hotel & Restaurant Management Program, University of Missouri-Columbia, 220 Eckles Hall, Columbia, MO 65211, USA
[b]School of Hospitality Management, The Pennsylvania State University, 229 Mateer Building, University Park, PA 16802, USA

Abstract

The purpose of this study was to examine the impact of major resources on multi-stage waiting times and their interactions on waiting times. The simulation study showed that each resource influenced waiting for different service stages and that interaction among the multi resources occurred. The results implied that the simultaneous increase in the levels of two resources had a synergistic effect on reducing waiting times for some stages. However, for some resources, the simultaneous increase in the resource levels did not help reduce waiting times when the increase in one resource type overwhelmed the other resource's function.
Published by Elsevier Ltd.

Keywords: Capacity management; Waiting time; Restaurant resource; Simulation; Service quality

1. Introduction

Service quality is essential for the long-term success of service firms, as satisfied customers are a necessary component for a profitable firm. To attain the desired service quality requires the integration of the marketing perspective and the operations management perspective (Davis and Vollmann, 1990; Klassen and Rohleder, 2001). The marketing view emphasizes offering high quality service to attract more customers, which may increase revenue, but does not guarantee profitability while the operations management view emphasizes providing services in a cost efficient way, but lacks a revenue enhancing function. Both of these perspectives rely on the level of resource capacities available to meet appropriate service standards. Restaurants may lose customers when the desired capacity to provide their service is lacking and customers are forced to wait. Waiting lines negatively affect service quality and customer satisfaction (Corsten and Stuhlmann, 1998). Thus, managers need to recognize that the resource capacity impacts the quality of service perceived by customers and must be managed for restaurants to be successful.

Since restaurant customers arrive randomly and their arrival rates change with time, management must make dynamic decisions based on the unpredictable and variable demand. Also, restaurants utilize various types of resources. Although restaurant capacity is dependent on several types of resource components, most authors have focused on a single component, such as human resources (Field et al., 1997), seating configuration, (Thompson, 2002) or restaurant layout (Hueter and Swart, 1998). However, an integrated systems approach that captures all of the resource types in the front-of-the house and back-of-the house may be more effective. The integrated view permits capacity decisions to be made based on the whole system rather than on the performance of one part. Creating an integrated approach for capacity management would help restaurant operators compare various levels of restaurant capacities for efficiency and cost.

Resources of a service firm were categorized as physical facilities, equipment, and labor (Lovelock, 1992). Within a restaurant context, the categorization has been expanded to several types of interrelated resources, including employee, facility and equipment, customer, and technology (Sill, 1994). For long-term decisions, managers must determine

*Corresponding author. Tel.: 1 573 884 6184; fax: 1 573 884 6184.
E-mail addresses: hwangj@missouri.edu (J. Hwang), cul@psu.edu (C.U. Lambert).

0278-4319/$ - see front matter Published by Elsevier Ltd.
doi:10.1016/j.ijhm.2007.08.005

how large the waiting room, dining room, and kitchen should be and how many physical resources, such as tables and pieces of equipment, should be installed. For short-term decisions, managers must determine how many employees should be working in the front-of-the house and in the back-of-the house and what staffing levels are optimal during different dining periods.

Resource trade-offs can be considered when capacities are managed. From a marketing perspective, a capacity level which can meet all demands and ensure service quality is desired. However, system costs are always associated with service quality and an excess capacity is costly to the restaurant. On the other hand, a lack of capacity leads to the loss of customers due to poor service. Therefore, firms should maintain an optimum balance between the cost of having customers wait and the cost of providing capacity. Thus, the purpose of this study was to examine the impact of major resources on multi-stage waiting times and the interactions among the resources in their influence on waiting times. By identifying the relationships, the major types of resources can be managed more effectively.

2. Background

Capacity in the service sector has been defined as the highest possible amount of output that may be obtained in a specific period of time with a predefined level of staff, installations, and equipment (Lovelock, 1992). Jones (1988) illustrated what effective capacity management implied for both productivity management and quality management by using Flynn's (1986) three-stage model of production, delivery and consumption of services stages. By using the three-stage model, Jones explained that the effective management of capacity is "a performance target in its own right" (p.109). Second, Jones emphasized that effective capacity management has a mediating role in achieving the goals of both productivity and quality in terms of matching intermediate output and final output of the three-stage model. As a result, capacity management can lead to better performance in both productivity and quality.

Adenso-Diaz et al. (2002) emphasized the impact of capacity management on the quality of service perceived by customers by relating insufficient capacity to a lower level of attention to customer needs and therefore a lack of perceived quality. They also pointed out that the goal of capacity management is "to minimize customer waiting time and to avoid idle capacity, with the goal of attending to demand in time and in the most efficient way" (Adenso-Diaz et al., 2002, p.287).

2.1. Strategies for capacity management

Sill (1991) presented three capacity-management strategies in restaurants: adjusting capacity, using queues, and adjusting demand. Two strategies, adjusting supply and demand, were found to play an important role in managing capacity and influencing service quality (Armistead and Clark, 1992). In addition to a level strategy and a chase strategy, Armistead and Clark (1994) sequentially suggested a coping strategy. A coping strategy is needed when services run out of capacity to satisfy demand and when services are in excess of capacity within the time frame expected by customers. In contrast to the studies mentioned, Siferd (1990) emphasized the strong relationships between staffing and scheduling strategies and the capacity to serve customers. Siferd et al. (1992) again pointed out that staffing and scheduling strategies and practices are the most influential factors as customers and employees are involved in the service process.

From the service marketing point of view, Parasuraman et al. (1985) found that service firms identified fluctuating demand, an inability to mass produce, and a difficulty to calculate costs and control quality as major problems. In order to overcome these problems, service firms employed strategies such as pricing, advertising, personal selling, customer orienting, and strategies to cope with fluctuating demand. Of the management options listed by these authors, the five most commonly used were hiring part-time employees, scheduling flexible, working overtime, using cross-trained employees, and calling on potential customers to generate business. On the basis of whether or not an imbalanced situation is foreseeable, Shemwell and Cronin (1994) introduced demand management, supply management, intelligence enhancement, and risk reduction strategies to reduce the imbalance between supply and demand and to improve performance. They emphasized that disequilibrium situations lead to losses when demand exceeds capacity to serve or capacity is underutilized. A study by Klassen and Rohleder (2001) showed a comprehensive perspective for combining operations and marketing to manage capacity and demand in services. Furthermore, Klassen and Rohleder suggested that combining demand management and capacity management improved decision making and increased profitability of services when customers cannot be scheduled, such as in restaurants.

2.2. Customers' expectations of waiting experiences in restaurants

When customers enter a service system, they have specific expectations regarding an acceptable waiting time that leads to satisfaction (Taylor, 1994). Thus, the restaurant manager's goal is to provide an acceptable level of customer satisfaction by providing customers with acceptable waiting times. However, there is no absolute level of acceptable customer satisfaction. Customer satisfaction is relative depending on the context of the service operation. Davis and Vollmann (1990) stated that operators should provide a consistent level of customer satisfaction, which may result in a variable waiting time. In subsequent research, Davis (1991) attempted to develop a framework to find the optimal waiting time and the number of employees that fulfilled customer satisfaction goals and minimized the total cost. Based on the customer satisfaction scores, he found the relationship between waiting time and customer satisfaction and identified the proportion of customers who can be highly satisfied, moderately satisfied, and dissatisfied at a given waiting time.

Handheld technology has been advertised as the solution to increasing customer satisfaction by decreasing service wait time, however, no research studies were found to confirm this premise (Malison, 2003). Manion and DeMicco (2004) discussed the benefits of handheld technology that include speeding up the ordering process, staff communication with customers and other staff, and the payment process. Although the wait time for payment process was not found to be critical to the overall experience (Hwang and Lambert, 2005), the effectiveness of technology, such as handhelds, in reducing customer wait time and increasing revenue should be examined.

2.3. Capacity management performance measures

Sill and Decker (1999) identified capacity components in the service delivery process and measured the capacity usage in a casual restaurant. To manage capacity and demand concurrently, Kimes et al. (1999) developed a restaurant revenue management program to reduce the meal duration and the variability in the meal duration to increase revenue per available seat hour (RevPASH). They found that the high variability of meal times was due to personnel and procedural matters in front of the house. Thompson (2002) found that mean party size and restaurant size had an impact on the best table configuration. Hueter and Swart (1998) used simulation to determine the optimal labor hours required to provide desired customer service (three minute-waiting time) and used integer programming to determine the optimal allocation of labors to minimize labor cost at a Taco Bell restaurant. Fung (2001) developed a restaurant simulation model to determine the impact constrained resources had on waiting time and the turnover rate.

Although these studies focused on the particular capacity such as seating, labor, or front-of-the house process, they lacked an integrated view of capacity. Kimes et al. (1999) and Thompson (2002) measured performance based on revenue instead of customer satisfaction. Instead, customer expectations for service levels should be derived to identify capacity requirements. Identifying a service level that meets customer expectations, and achieving it by managing capacity is a way of improving customer service.

Performance measurements used in these studies were meal durations, turnover rate, waiting times, or revenues. For instance, Field et al. (1997) used the duration of meal time as a measurement of customer satisfaction. Kimes et al. (1999) assumed that reducing meal duration helped to maximize revenue; however, meal duration is also related to customers' desire to stay and is unlikely to be controlled by managers. Fung (2001) found that when meal duration could be reduced, the number of customers served would be increased, but he recognized that wait staff would need to be subtle to achieve this. Field et al. (1997) provided a convincing argument that turnover itself is not a sufficient measure of restaurant capacity. Consequently, creating an integrated approach to capacity management will help restaurant operators measure restaurant capacities and restaurant performances. The integrated approach demands that the solutions to the problem should be based on the whole system, not the performance of a part of the system. In the assessment of capacity measurement, customer satisfaction should be included because customers directly perceive and assess the operation's capacities.

Despite the difficulties in managing service capacity, capacity management should be valued as a method to connect productivity management and quality management, and enhance profits. Specifically, capacity management is critical for a successful business because it has a considerable impact on service quality perceived by customers.

Previous studies reviewed from the restaurant capacity management point of view made a significant contribution in advancing capacity management in the restaurant industry. However, as those previous studies focused on the particular capacity of a restaurant, they failed to capture an integrated view of capacity management. Furthermore, the studies overlooked customer factors in managing capacity and measuring performance of capacity management. Consequently, developing a tool for measuring restaurant capacities and performances becomes necessary from an integrated view of capacity management. At the same time, in the assessment of capacity measurement, the customer perspective should be included as customers directly perceive and assess the operation's capacities.

3. Development of model and hypotheses

A computer-simulated restaurant system was developed using data from a casual dining restaurant. The service-delivery process was simulated as a discrete event system using Microsoft C++.

3.1. Data collection and service model

A casual dining restaurant located in a city in a northeastern state in the United States was observed on a total of five typical Fridays and Saturdays between 4:30 pm and 11:00 pm in December, 2004. Data showed very similar patterns in the arrival rate and party size distribution. Information about the restaurant's resource capacities was obtained from the General Manager of the restaurant and the operation's reports. The service process (Fig. 1) included the following stages.

Greet: A host greeted the party on arrival at the restaurant. The host assigned the parties to each server

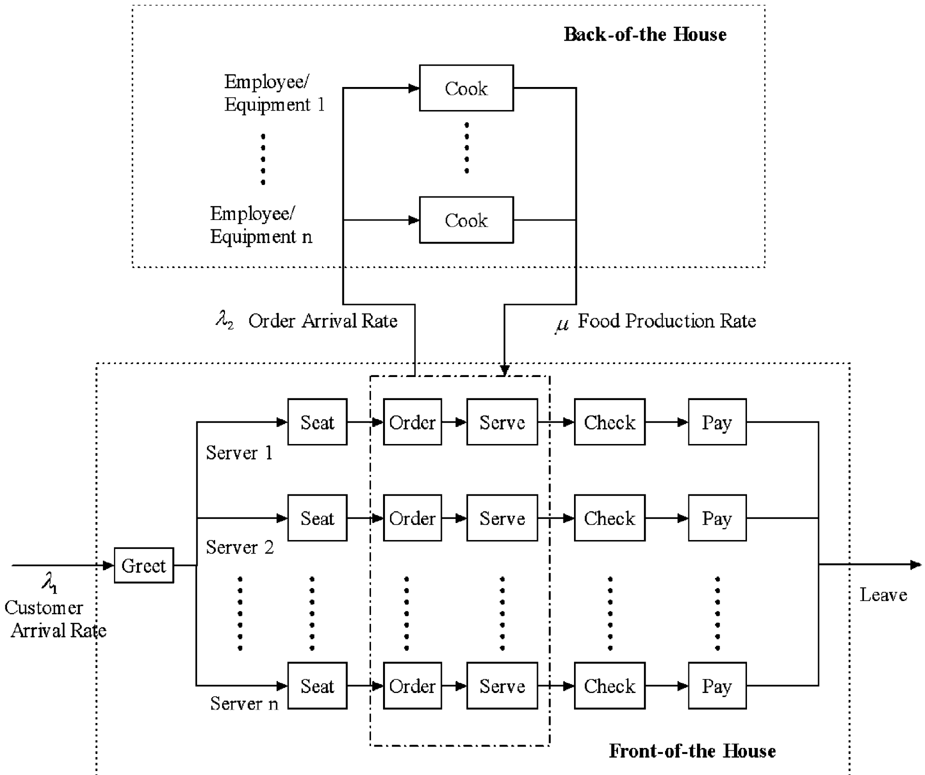

Fig. 1. Restaurant service-delivery process in simulation model.

with equal probability. However, when there was no available table in the server's section, the host checked the availability of the other server's tables. When there were available tables in other sections, the party was seated there. Otherwise, the party waited for any available table in any server's section. The restaurant did not allow any reservations. Balking (i.e. a party leaves without joining a queue) or reneging (i.e. a party leaves once they join a queue) behaviors were not captured in the arrival. In the simulation model, only the parties who stayed to be seated were included.

Seat: When a table became available, the party was seated by the host. After the host seated the party, he checked the next service needed from a list of pending jobs. The server arrives at the table, introduces himself or herself to the party, and takes the party's drink order. The party reads the menu to order their entree.

Pending event list (PEL) checking: The server first checked a PEL. If there was a job on the list, the server performed the job on the first-come first-served (FCFS) basis. If not, the server waited for a party's request for service.

Order: In this stage, the server arrives at the table with the drink orders and takes the party's order. Then, the server sends the order to the kitchen. After the server finishes taking the order, s/he checks the PEL list. Appetizers are not included in the order and serve processes in the study. If the entrée orders are taken in separate time fragments, those separate time fragments were added and used as one segment of order time.

Serve: When the food ordered was ready the waiter served the food to the party if s/he were idle. When the server finished the serving process s/he checked the PEL.

Check: Once the party finished eating, they asked for the check. When a server was idle, s/he brought the check. When the party received the check, the party placed the credit card on the table for further payment process.

Pay: The server picked up the credit card or cash from the table, processed the payment through the POS system, and brought the receipt for a signature or changes to the party. The party signed the receipt if necessary and left the restaurant.

3.2. Simulation input: analysis of arrival, party size, and service time

The arrival rate observed was time-dependent. Thus, the arrival of parties was modeled as a non-stationary Poisson process (Law and Kelton, 2000). To obtain an estimate of the arrival rate of parties, the dinner period was broken down into a number of subintervals [4:00–4:05; 4:05–4:10;…; 8:55–9:00). For each day, the number of arrivals in each interval was counted, and the arrival rates over the five days were averaged. The arrival rate in each subinterval was modeled as a Poisson process. The subinterval length, five minutes, was chosen because of the congestion nature of arrivals. If 15 min or more had been chosen as an interval length, the arrival rate would be too smooth and the congestion factor would be lost. A 5-minute interval was also supported in the study of labor scheduling by Thompson (2004). The party size data were very important in this study because different party sizes had different dining durations, and the number and the size of tables. The equipment capacity was sufficient for the entrees and vegetables. The estimated distribution of party size was included based on the observations. Service time distributions were obtained based on observation and used as input for the simulation model.

The simulation model consisted of each customer's waiting time at each stage of the process, and the capacities of the dining room and the kitchen. Based on the actual restaurant, the simulated restaurant had 184 seats; 16 two-top and 38 four-top tables. The number of servers and cooks in the simulation were also matched with the real system. These parameters were subject to change in the experimental study. Two four-top tables were allowed to be combined for parties of more than four.

3.3. Structure of restaurant simulator

As a discrete-event simulation, the next-event time-advance mechanism was used as the basic structure of the simulation (Law and Kelton, 2000). Corresponding to this mechanism, a future event list (FEL) was defined as the basic data structure for managing system dynamics. The restaurant operation in the simulation was controlled through FEL. For each action, the top event in the FEL checked the conditions for execution. If all of the conditions (i.e. the availability of server or table) were satisfied, the simulation processed the event and advanced its clock to the current event time. Otherwise, the events that could not be executed on time were pushed to the corresponding PEL of the server. The server checked his or her PEL for the next task after processing the current event. If the conditions for the next task in the PEL were satisfied, he or she processed the event. For those customers who could not be seated immediately at the arrival time point, a waiting line (WL) formed. In the simulation, WL and PEL were realized by the queue structure in a FCFS manner. This structure is depicted in Fig. 2.

The restaurant simulator is composed of the entities of customer, server, and restaurant. Each entity possesses the properties and behaviors. For example, the customer entity called *SimCustomer* defines characteristics such as party size, assigned server's ID, number of tables required, and current stage. *SimCustomer* also defines behaviors such as arrival and departure. The *SimEvent* defines the characteristics of all events associated with servers and customers (i.e. arriving, seating, ordering, serving, paying, leaving, and checking). *SimStore* defines the resources and service discipline/rules such as FCFS of the restaurant. *SimStore* also defines how the restaurant simulation operates.

3.4. Experimental hypotheses

Experiments were designed to test the following hypotheses to determine the relationship among resources.

H1:. The change in the level of one resource significantly influences at least one of the waiting times in the multi-stage service process given medium levels of the other two resources.

H2:. The simultaneous change in the levels of two different resources interacted at least one of the waiting times in the multi-stage service process given medium level of the other resource.

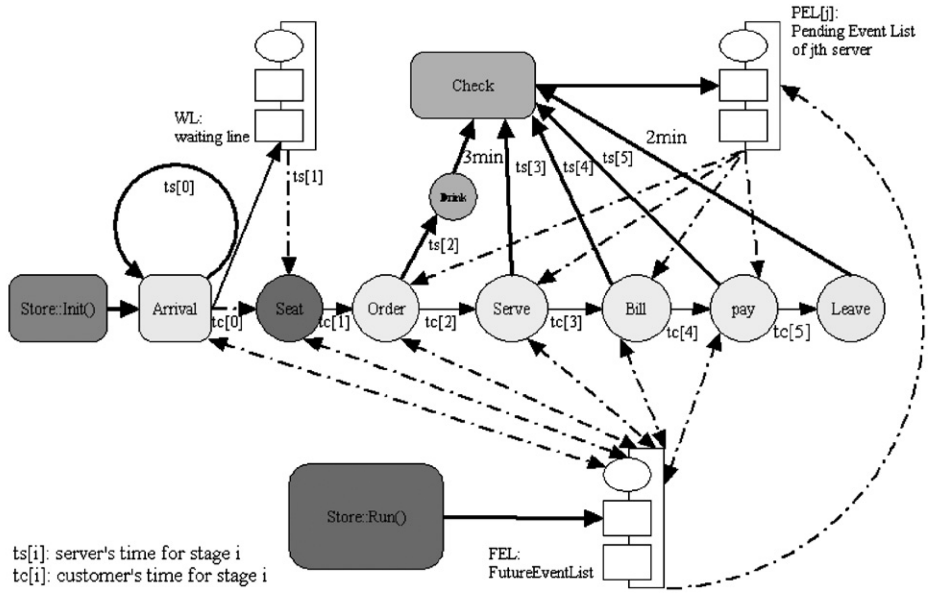

Fig. 2. Restaurant service-delivery process in simulation model.

In the experimental study, three levels of resources were based on the actual restaurant and designated as low, medium, and high. The three levels of cooks and servers correspond to the levels that the real restaurant was using. The manager's operational judgment was used to identify low and high level of cooks: 4 (low), 5 (medium), and 6 (high) and levels of servers: 15 (low), 18 (medium), and 21 (high). Six (6) cooks was the highest number of cooks that the kitchen space could allow and twenty one (21) servers was the highest number that the general manager could use for one evening. Tables were considered to be a long term capacity and the level was not able to be changed on a daily basis. The long-term decision on installment of tables has to be made as a business decision when the restaurant is opened or renovated. For this study, the three levels of tables were determined to keep the ratio of the number of tables per server at 3 throughout the three levels: 45 (low), 54 (medium), and 63 (high). Despite the need for additional space for additional tables, this study assumed that the space could hold 63 tables. The waiting time for greeting was not considered as a dependent variable because a host or hostess greeted customers in the real restaurant and customers were greeted as soon as they arrived. Thus, the greeting stage was not a problem in terms of customers waiting, and was not affected by tables, servers or cooks.

A validation was conducted by direct comparison between observed data from the real restaurant and the data produced by the simulation model. This validation method is supported by Pegden et al. (1995, p. 148). For validation, the customers' total times spent in the real system and in the simulation system were compared. Using a t-test, the simulation system was validated ($p = 0.321$, no difference in the means). The waiting time for each stage in the simulation was also consistent with the waiting time observed in the real restaurant

The simulation was run for 100 replications with a 5-hour dining window from 4:00 pm to 9:00 pm. The first 30 min was the warm-up period. Those who arrived after 4:30 pm were counted for the data analysis. Although the restaurant stopped accepting new customers at 9:00 pm, it served all of the parties who were already in the system. The simulated restaurant served on average 162 parties (428 customers) during the dinner hours (from 4:30 pm to 9:00 pm).

4. Results and discussion

This study tested the hypotheses about the impact of the change of the level of one resource and the impact of the simultaneous change of the levels of two resources on the multi-stage waiting times. The first hypothesis tested the impact of the change of the level of one resource significantly influences at least one of the waiting times in the multi-stage service process given medium levels of the other two resources.

Within the first hypothesis context, the impact of the change in the level of tables on the multi-stage service was investigated. Although a manager may not be able to change the number of tables over a short-term, it is worthwhile to explore how the table resource influences the multi-stage services in helping the manager's capacity planning. Thus, in the experiment, the level of tables was varied while holding other resources constant at the medium level. The one-way ANOVA result showed that the increase in the number of tables significantly influenced the waiting times in all the multi-stage service process, given medium levels of servers (18) and cooks (5) ($p<0.001$, $p<0.01$, $p<0.01$, $p<0.001$,and $p<0.001$ for all the five stages respectively, See Tables 1 and 2).

On one hand, as the number of tables increased, the waiting time for the seating stage significantly decreased. On the other hand, as the number of tables increased, the waiting times for the other stages after seating significantly increased although the increase in those waiting times is not as dramatic as the decrease in the waiting time for seating. Customers who wait for long periods of time before they are served are more likely to leave the system, go to competitors, and not return to the system in the future. Hence, reducing a customer's wait for seating by providing an adequate level of tables is also critical in capacity management. This finding agrees with Davis and Maggard (1990) who found that the first stage of waiting is

Table 1
Impact of change in the level of resources on multi-stage waiting times

Resource Type	Level of Resource	Waiting Time at Different Stages (minutes)				
		Seating	Ordering	Serving	Check	Paying
Number of Tables	45	35.95(14.84)	4.22(0.21)	28.78(0.43)	2.50(0.19)	3.20(0.16)
	54	14.05(10.06)	4.39(0.19)	29.06(0.48)	2.86(0.24)	3.41(0.21)
	63	4.08(4.44)	4.43(0.24)	29.15(0.46)	2.97(0.29)	3.55(0.25)
Number of Servers	15	15.43(10.00)	4.67(0.23)	29.37(0.46)	3.36(0.25)	3.80(0.24)
	18	14.05(10.06)	4.39(0.19)	29.06(0.48)	2.86(0.24)	3.41(0.21)
	21	12.62(8.9)	4.28(0.22)	28.85(0.45)	2.52(0.22)	3.24(0.22)
Number of Cooks	4	16.35(10.45)	4.33(0.18)	31.02(0.49)	2.76(0.23)	3.44(0.23)
	5	14.05(10.06)	4.39(0.19)	29.06(0.48)	2.86(0.24)	3.41(0.21)
	6	11.56(8.9)	4.40(0.20)	27.04(0.49)	2.90(0.26)	3.39(0.21)

Mean (standard deviation).

Table 2
Testing hypothesis 1: summary of one-way ANOVA results

Resource Type	Waits at Different Stages				
	Seating	Ordering	Serving	Check	Paying
Tables	***	**	**	***	***
Servers	NS	***	*	***	***
Cooks	*	NS	***	NS	NS

*** $p<0.001$.
** $p<0.01$.
* $p<0.05$.
NS: Not Significant.

the most important for customers in a 2-stage operation. However, attention should be paid to the finding that the increase in tables can overwhelm other stages. This confirms that adding one resource requires adding other resources to efficiently reduce all waiting times.

Second, the impact of the change of the level of servers on the multi-stage services was investigated by varying the level of servers given medium levels of Tables (54) and cooks (5). The one-way ANOVA result showed that an increase in the number of servers significantly decreased the waiting times for stages of ordering, serving, receiving the check, and paying except seating ($p<0.001$, $p<0.01$, $p<0.001$, and $p<0.001$, respectively) (Tables 1 and 2). The result implies that the level of servers is important in the processes that customers go through once they are seated. In the casual dining restaurant, customers wait not only for seating but also for several services in the process. Those processes are very important in terms of customer satisfaction. Specifically, results from a previous study (Hwang and Lambert, 2005) showed that customers placed highest value on the ordering stage.

Third, the impact of the change of the level of cooks on the multi-stage service was investigated. The one-way ANOVA result showed that the increase in the number of cooks significantly reduced waiting times for seating and serving given the medium levels of tables (54) and servers (18) ($p<0.05$ and $p<0.001$, respectively) (Tables 1 and 2). As the level of cooks increases, the waiting time for the stage of serving was significantly reduced. More interestingly, the waiting time for seating also decreased with the increase in the level of cooks. This shows that when the restaurant system processes the customers faster, the customers who are waiting to be seated wait less. The level of cook directly influences the waiting time for serving and indirectly influences the waiting time for seating. Thus, the first hypothesis was supported in that the change of the level of one resource significantly influences at least one of the waiting times in the multi-stage service process given medium levels of the other two resources.

The second hypothesis tested the impact of simultaneous changes in the levels of two resources on waiting times for the multi-stage services. Before running the factorial ANOVA, the conditions needed to use the factorial ANOVA were checked. The heterogeneity in the variances required data transformation using rank transformations (Conover and Iman, 1981). The rank transformation was successful to meet the conditions to continue the factorial ANOVA. As a result of the factorial ANOVA, no three way interaction existed among the three-types of resources, table, server, and cook (Table 4).

Within the second hypothesis context, first, the impact of the change in the level of tables and the level of servers on multi-stage services was investigated. The result showed that the concurrent increase in the number of tables and servers reduced at least one of the waiting times in the multi-stage service process given a medium level of cooks (5).

The factorial ANOVA result showed that the number of tables and servers interacted on waiting for the stages of ordering, receiving the check, and paying ($p<0.001$, $p<0.001$, $p<0.001$, respectively) (Figs. 3, 4, and 5) (Tables 3 and 4). For the stages of ordering, receiving the check, and paying, the waiting time decreased as the level of tables increased. The increase in waiting time is most dramatic when the level of servers is lowest. However, at the high level of servers, no dramatic changes in waiting times occurred as the level of tables increased from medium to high. This result suggests that when the manager increases the level of tables, he needs to adjust the level

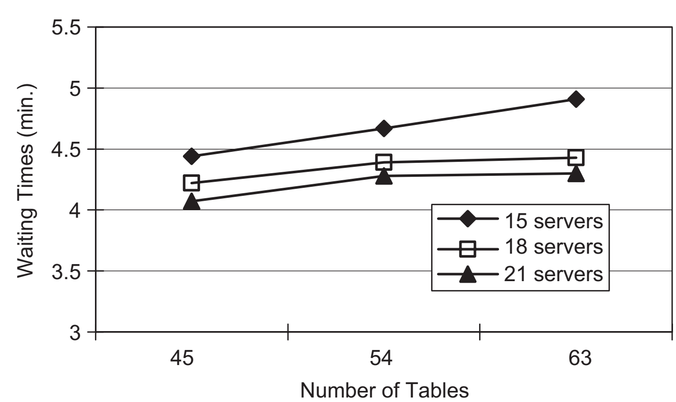

Fig. 3. Interaction of table resource and server resource on waiting times for ordering stage.

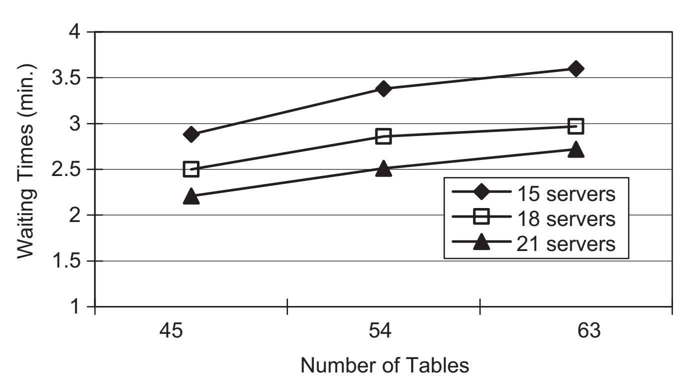

Fig. 4. Interaction of table resource and server resource on waiting times for receiving-the-check stage.

of servers to effectively lower the waiting times. The increase in the level of tables reduced the waiting time for seating as shown in the first hypothesis testing. With insufficient staffing to serve the seated customers, their waiting times for the stages such as ordering, receiving the check, and paying will increase.

Second, the impact of the change in the levels of tables and cooks on multi-stage services was investigated. The result showed that the simultaneous increase in the number of tables and cooks reduced at least one of the waiting times in the multi-stage service process given a medium level of servers (18).

The factorial ANOVA result shows that an interaction between the level of tables and cooks existed only for the stage of seating ($p<0.001$) (Fig. 6) (Tables 3 and 4). The level of cooks made a more distinctive difference in waiting

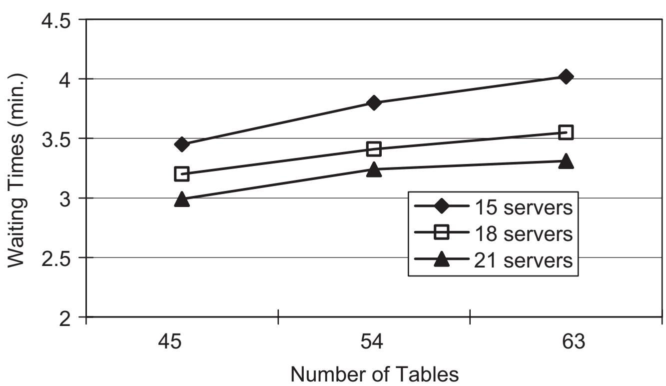

Fig. 5. Interaction of table resource and server resource on waiting times for paying stage.

Table 4
Testing Hypothesis 2: summary of factorial ANOVA results

Resource Type	Waits at different stages				
	Seating	Ordering	Serving	Check	Paying
Table	***	***	***	***	***
Server	***	***	***	***	***
Cook	***	***	***	***	NS
Table*Server	NS	***	NS	***	*
Table*Cook	*	NS	NS	NS	NS
Server*Cook	NS	NS	NS	**	NS
Table*Server*Cook	NS	NS	NS	NS	NS

***$p<0.001$.
**$p<0.01$.
*$p<0.05$.
NS: Not Significant.

Table 3
Impact of concurrent change in the level of resources on multi-stage waiting times

Level of Capacity Resource			Total duration (min)	Waiting times (min)				
Table	Server	Cook		Seating	Ordering	Serving	Check	Paying
Low (45)	Low (15)	4	116.24(16.47)	42.33(16.35)	4.36(0.19)	31.03(0.46)	2.83(0.24)	3.43(0.22)
		5	110.49(15.27)	38.39(15.08)	4.44(0.22)	29.09(0.49)	2.88(0.25)	3.45(0.21)
		6	104.47(15.02)	34.28(14.84)	4.46(0.22)	27.10(0.46)	2.93(0.26)	3.45(0.23)
	Medium (18)	4	112.67(15.53)	39.86(15.44)	4.16(0.22)	30.78(0.44)	2.45(0.18)	3.17(0.19)
		5	106.90(14.94)	35.95(14.84)	4.22(0.21)	28.78(0.43)	2.50(0.19)	3.20(0.16)
		6	100.96(14.08)	31.91(14.01)	4.26(0.23)	26.77(0.45)	2.53(0.19)	3.22(0.19)
	High (21)	4	110.05(15.31)	37.96(15.25)	4.07(0.20)	30.61(0.41)	2.20(0.16)	2.96(0.16)
		5	104.10(14.67)	34.00(14.58)	4.07(0.22)	28.58(0.42)	2.21(0.17)	2.99(0.16)
		6	98.79(14.34)	30.63(14.29)	4.09(0.21)	26.58(0.40)	2.24(0.17)	2.99(0.18)
Medium (54)	Low (15)	4	93.08(11.04)	17.85(10.81)	4.60(0.23)	31.34(0.45)	3.24(0.24)	3.79(0.23)
		5	88.88(10.31)	15.43(10.00)	4.67(0.23)	29.37(0.46)	3.36(0.25)	3.80(0.23)
		6	84.72(9.66)	13.22(9.27)	4.740.25)	27.40(0.50)	3.33(0.26)	3.77(0.25)
	Medium (18)	4	90.17(10.70)	16.35(10.45)	4.33(0.18)	31.02(0.49)	2.76(0.23)	3.44(0.23)
		5	86.03(10.32)	14.05(10.06)	4.39(0.19)	29.06(0.48)	2.86(0.24)	3.41(0.21)
		6	81.54(9.23)	11.56(8.9)	4.40(0.20)	27.04(0.50)	2.90(0.26)	3.39(0.21)
	High (21)	4	87.94(10.1)	14.86(9.93)	4.28(0.22)	30.84(0.46)	2.51(0.21)	3.20(0.2)
		5	83.75(9.2)	12.62(8.9)	4.28(0.22)	28.85(0.45)	2.51(0.22)	3.24(0.22)
		6	79.31(8.2)	10.26(7.93)	4.28(0.22)	26.81(0.45)	2.50(0.22)	3.20(0.2)
High (63)	Low (15)	4	82.66(6.77)	6.38(6.02)	4.90(0.32)	31.61(0.51)	3.54(0.35)	3.98(0.32)
		5	79.73(6.28)	5.38(5.39)	4.91(0.30)	29.57(0.51)	3.60(0.36)	4.02(0.35)
		6	76.84(5.58)	4.42(4.62)	4.89(0.32)	27.63(0.51)	3.61(0.39)	4.03(0.35)
	Medium (18)	4	79.34(5.72)	5.06(5.2)	4.40(0.24)	31.14(0.47)	2.95(0.27)	3.53(0.24)
		5	76.43(4.99)	4.08(4.44)	4.43(0.24)	29.15(0.46)	2.97(0.29)	3.55(0.25)
		6	73.67(4.39)	3.27(3.79)	4.48(0.24)	27.14(0.45)	3.02(0.31)	3.51(0.24)
	High (21)	4	78.20(5.04)	4.67(4.67)	4.27(0.18)	30.95(0.48)	2.72(0.27)	3.34(0.26)
		5	75.21(4.33)	3.68(3.88)	4.30(0.19)	28.94(0.46)	2.72(0.29)	3.31(0.22)
		6	72.28(3.69)	2.82(3.22)	4.32(0.16)	26.90(0.47)	2.70(0.27)	3.28(0.22)

Mean (standard deviation).

time for seating at a low level of tables than at a high level of tables. With a limited number of tables, the influence of the level of cooks is more significant because more cooks can speed up the production process. Then a customer's waiting time for seating decreases as the restaurant processes more customers faster. Table and cook resources did not interact on waiting times for the rest of the stages. Thus, the hypothesis was supported and it was concluded that the simultaneous increase in the number of tables and cooks reduced at least one of the waiting times, specifically, for seating, in the multi-stage service process.

Third, the impact of the change in the levels of servers and cooks on the multi-stage services was investigated. The result showed that the concurrent change in the number of servers and cooks influenced at least one of the waiting times in the multi-stage service process given a medium level of tables (54).

The factorial ANOVA result shows that an interaction between the levels of servers and cooks existed on the waiting time of only the stage of receiving the check ($p < 0.01$) (Fig. 7) (Tables 3 and 4). At the high level of servers, the number of cooks did not significantly change the waiting time for receiving the check. However, when the number of servers was low (15), a high level of cooks led to longer waiting times for receiving the check compared to a low level of cooks. This result shows that with sufficient servers to handle the service of bringing the check to the customers, the level of cooks does not influence the waiting time. However, with insufficient servers to handle the services and the higher number of cooks to produce more dishes and serve more customers faster, servers engaged in other services such as taking orders and serving. Customers may have to wait longer for the stage such as receiving the check.

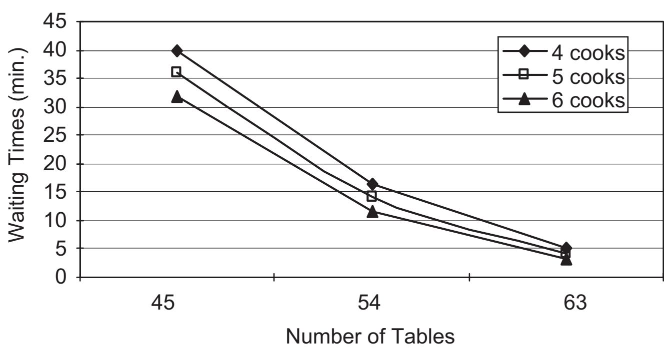

Fig. 6. Interaction of table resource and cook resource on waiting times for seating stage.

In summary, the two hypotheses were supported through the findings. The first finding was that the change in the level of one of the three resource significantly influenced at least one of the waiting times in the multi-stage service process given medium levels of the other two resources. The second finding was that the simultaneous change in the levels of two different resources interacted at least one of the waiting times in the multi-stage service process given medium level of the other resource.

5. Conclusions

The restaurant simulation was designed to answer the questions: What is the impact of each type of resource (tables, servers, and cooks) on waiting time of each stage in a multi-step service delivery process? What are the relationships among the various types of resources on reducing waiting time for each stage?

By testing the first hypothesis, this study confirmed common intuition that each capacity level influences waiting for different stages and those resources interact with each other on reducing waiting times for some of the stages in the service process. The increase in the number of tables reduced waiting time for seating, yet increased waiting time for the subsequent stages. The increase in the number of servers reduced waiting time for all stages except seating. The increase in the number of cooks reduced waiting times for both serving and seating stages. But, the most interesting finding comes from testing the second hypothesis on the interaction among the resources on reducing waiting times.

On one hand, the simultaneous increase in the levels of two resources had a synergistic effect on reducing waiting times for the stages that could not have been influenced by

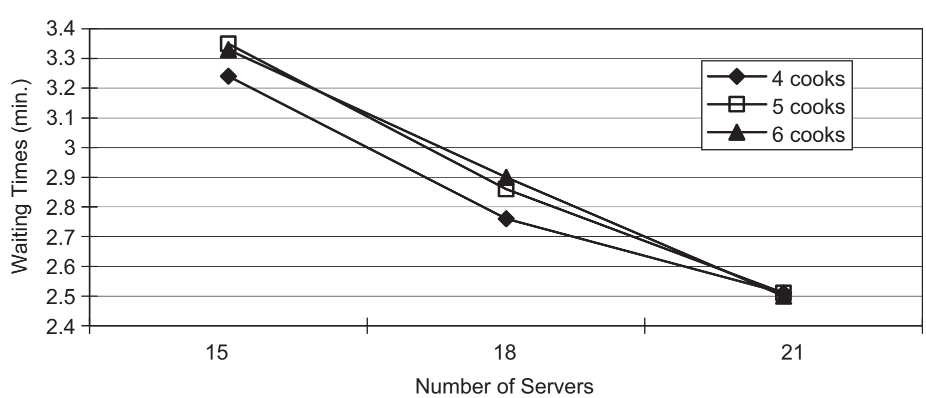

Fig. 7. Interaction of server resource and cook resource on waiting times for check stage.

only one resource type. For example, the table resource and server resource interacted to reduce the waiting times for ordering, receiving the check, and paying stages. For these stages, as the level of servers increased, the waiting times significantly decreased with the increase in the level of tables. With a fixed level of servers, the waiting time for ordering could not have been reduced by the increase in the level of table capacity. This finding indicates that a sufficient level of one resource does not reduce waiting times enough on some stages when a shortage of other resources exists. Additionally, an excessive level of one resource can increase waiting times during some stages when a shortage of other resources exists. For example, a higher number of cooks increased waiting time for receiving the check when there was a limited level of servers.

On the other hand, for some resources, the simultaneous increase in the resource levels did not help reduce waiting times when the increase in one resource type overwhelmed the other resource's function. The table and cook resources interacted on waiting time for seating. For example, the effect of the level of cooks on reducing waiting time for seating was more significant with fewer tables. This confirms that a sufficient level of one resource does not reduce waiting times for some stages when an excess of other types of resources process too many customers and it can increase the capacity flow.

6. Implications, limitations and recommendations

According to the results of the study, the impact of each resource on waiting time varied with the type of resource and the service stage. Thus, in adjusting resources to meet the waiting time standard, it is important to recognize the relationships between each resource and the service stages. This study can help managers adjust the right kind of resource in managing their capacity. In addition, when increasing the level of one type of resource, managers need to consider what the best way is to fully utilize the capacity by taking other related resources into consideration. Thus, through assigning and balancing capacities in a multi stage operation, managers can reduce customer waiting times and ultimately maximize profit by controlling costs and attracting more customers.

Simulation was beneficial for exploring the relationships between diverse resources and service performance in various service stages. Fung's study (2001) used a hypothetical restaurant with deterministic parameters to show where the waiting line forms in a multi-stage system depending on where bottleneck exists. This study expanded beyond Fung's study by incorporating more resources and stages into a stochastic and dynamic simulation system based on an actual restaurant. Using simulation prior to opening a restaurant would help managers determine appropriate staffing levels, based on the table and kitchen capacities.

These findings provide restaurant managers with insights for operational strategies that they can apply. Managers should recognize that the impact of each resource type on waiting times varies depending on the stage of the service process and that resources interact with each other on the service level of each stage. A sufficient level of one resource does not reduce waiting times efficiently on some stages when a shortage or excess of other resources exists.

Some limitations should be acknowledged in this study. The simulation model of the current restaurant should be expanded to integrate more types of resources and to explore the relationships between these resources. For example, equipment and space can be significant resources to explore. These resources affect the number of employees allowed in a kitchen so the trade-offs, based on wait times and cost, should be explored. Technology is another type of resource that is becoming more important in the restaurant industry. The effectiveness of technology in reducing customer waiting times should be explored in its interaction with other types of resources. Another limitation of this study is that service quality issues, such as employees' skills or fatigue were not considered. Those issues can be good subjects for future study. Also, future study should be done on cost and profit issues associated with managing various types of resources.

References

Adenso-Diaz, B., Gonzalez-Torre, P., Garcia, V., 2002. A capacity management model in service industries. International Journal of Service Industry Management 13 (3), 286–302.

Armistead, C., Clark, G., 1992. The balancing act. Managing Service Quality 2 (2), 115–119.

Conover, W.J., Iman, R.L., 1981. Rank tansformations as a bridge between parametric and nonparametric statistics. The American Statistician 35 (3), 124–133.

Corsten, H., Stuhlmann, S., 1998. Capacity management in service organizations. Technovation 18 (3), 163–178.

Davis, M.M., 1991. How long should a customer wait for service? Decision Sciences 22, 421–434.

Davis, M.M., Maggard, M.J., 1990. An analysis of customer satisfaction with waiting times in a two-stage service process. Journal of Operations Management 9 (3), 324–334.

Davis, M.M., Vollmann, T.E., 1990. A framework for relating waiting time and customer satisfaction in a service operation. The Journal of Services Marketing 4 (1), 61–69.

Field, A., McKnew, M., Kiessler, P., 1997. A simulation comparison of buffet restaurants—applying Monte Carlo modeling. Cornell Hotel and Restaurant Administration Quarterly 38 (6), 68–79.

Flynn, N., 1986. Performance measurement in public sector services. Policy and Politics 14, 389–404.

Fung, K.K., 2001. It is not how long it is, but how you make it long-waiting lines in a multi-step service process. System Dynamics Review 17 (4), 333–340.

Hueter, J., Swart, W., 1998. An integrated labor-management system for Taco Bell. Interfaces 28 (1), 75–91.

Hwang, J., Lambert, C.U., 2005. Identification of customers' acceptable waiting times in a multi-stage restaurant system. Journal of Foodservice Business Research 8 (1), 3–16.

Jones, P., 1988. Quality, capacity and productivity in service industries. International Journal of Hospitality Management 7 (2), 104–112.

Kimes, S.E., Barrash, D.I., Alexander, J.E., 1999. Developing a restaurant revenue- management (RRM) strategy. Cornell Hotel and Restaurant Administration Quarterly 40 (5), 18–29.

Klassen, K.J., Rohleder, T.R., 2001. Combining operations and marketing to manage capacity and demand in services. The Service Industries Journal 21 (2), 1–30.

Law, A.M., Kelton, W.D., 2000. Simulation Modeling and Analysis, third ed. McGraw-Hill, New York, NY, USA.

Lovelock, H.C., 1992. Seeking synergy in service operations: seven things marketers need to know about service operations. European Management Journal 10 (1), 22–31.

Malison, A. 2003. Benefits of handheld order taking systems in full service restaurants. Retrieved May 10, 2007 from 〈http://www.actionsystems.com/〉.

Manion, C., DeMicco, F., 2004. Handheld wireless point of sale systems in the restaurant industry. Journal of Foodservice Business Research 7, 103–111.

Parasuraman, A., Zeithaml, V.A., Berry, L.L., 1985. A conceptual model of service quality and its implications for future research. Journal of Marketing 49, 41–50.

Pegden, C.D., Sadowski, R.P., Shannon, R.E., 1995. Introduction to Simulation Using SIMAN. McGraw-Hill, New York, NY, USA.

Shemwell Jr., D.J., Cronin Jr., J.J., 1994. Service marketing strategies for coping with demand/supply imbalances. Journal of Services Marketing 8 (4), 14–24.

Siferd, S.P., 1990. Staffing and scheduling flexibility: a study of hospital nursing units. Unpublished dissertation. The Ohio State University, Columbus, OH.

Siferd, S.P., Benton, W.C., Ritzman, L.P., 1992. Strategies for service systems. European Journal of Operational Research 56, 291–303.

Sill, B.T., 1991. Capacity management: making your service delivery more productive. Cornell Hotel and Restaurant Administration Quarterly 31 (4), 77–87.

Sill, B., 1994. Operations engineering: Improving multiunit operation. Cornell Hotel and Restaurant Administration Quarterly 35 (3), 64–71.

Sill, B., Decker, R., 1999. Applying capacity-management science (CMS)—Browns restaurants. Cornell Hotel and Restaurant Administration Quarterly 40 (3), 22–30.

Taylor, S., 1994. Waiting for service: the relationship between delays and the evaluations of service. Journal of Marketing 54 (4), 56–69.

Thompson, G.M., 2002. Optimizing a restaurant's seating capacity. Cornell Hotel and Restaurant Administration Quarterly 43 (4), 48–57.

Thompson, G.M., 2004. Planning-interval duration in labor-shift scheduling. Cornell Hotel and Restaurant Administration Quarterly 45 (2), 145–157.