ISSN : 0974 - 7435 Volume 10 Issue 18

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(18), 2014 [09837-09844]

Bank service capability decision-making model based on stochastic service system

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ABSTRACT

On the basis of predecessors' researches, this paper introduces service cost as a factor that influences bank service capability, and considers customers and service quality as well, to build a bank service capability decision-making model based on stochastic service system. We subdivide customers into different types according to their different concerns about service quality, use Activity Based Costing to analyze the factors of service cost, transfer waiting time which is the most important factor of service quality that priority customers consider to cost by adopting Delay Cost Theory. At last, the paper use Matlab to verify this model through adjusting the value of service rate and the number of servers to optimize service capability in a multi-server setting, help banks find the most reasonable way of optimizing service capability. This paper finds that bank managers need to consider customers, service quality and service cost together when optimize service capability, and that a bank can reduce waiting time by choosing staffs with high service rate and by increasing the number of servers.

KEYWORDS

Service capability; Priority customer; Service quality; Service cost.

INTRODUCTION

In order to optimize service capability, different types of service enterprises will take different methods. They usually adjust factors that mostly influence service capability. Resent research shows that service capability is influenced by many factors, including customers, service quality, service cost[1-3] and diversity of service products[4], etc. Considering the practical operating situation of bank, we find that the most important factors are customers, service quality and service cost. Therefore, the best way to achieve optimal service capability with minimal input is to choose and adjust these factors based on the enterprises' traits.

In the field of bank service capability about decision-making, many scholars pay more importance on one or two factors[5] in customers and service quality, while they ignore the influence of service cost. Few scholars subdivide customers to study bank service capability[1] because it is generally considered that customers are homogeneous. As a result, these researches can contribute to helping bank branches attract more customers, but cannot benefit the banks' long-term developments.

Therefore, on the basis of predecessors' researches, this paper considers service cost as a factor of bank service capability, combined with customers and service quality to establish a bank service capability decision-making model based on Stochastic Service System[6]; In addition, this paper subdivides customers into different types according to their different concerns about service quality. Besides, based on the fact that the bank's service cost is different from other service enterprises', service delay in the bank will produce economic effect. Therefore, we use Activity Based Costing to analyze the factors of service cost and Delay Cost Theory[7] to transfer waiting time to cost.

The organization of this paper is as follows: Section I introduces the background, motivation and method to build bank service capability decision-making model; Section II uses Stochastic Service System Theory, Activity Based Costing and Delay Cost Theory to establish a model; Section Ⅲ validates the feasibility of the model, and gives decision-making advices; Section IV concludes the whole paper.

MATERIALS AND METHODOLOGY

According to the analysis in Section I, the three factors that mostly influence service capability are customers, service quality and service cost, all of which are selected to build bank service capability decision-making model.

The analysis and definition of the influence factors of bank service capability

The definition of customer classification

In terms of bank branches, when service quality is considered as a factor to adjust service capability, it should be analyzed with customers as a whole. Based on the fact that priority customers bring the greatest economic effect, the service quality of priority customers is the key to adjust service capability. Thus the following paper uses priority customers as a representative of customers.

The definition of service quality

In the eyes of priority customers, waiting time is the most important factor regard to service quality. Bank branches can attract more priority customers by adjusting waiting time to optimize service capability[8]. Thus the following paper uses waiting time as a representative of service quality.

The definition of service cost

Base on Activity Based Costing, the object of this paper is bank branches, so the service cost only includes cost that comes when branches provide service to customers, namely operating cost. However, the cost of equipment facility and staffing, which determines branches' efficiency and cost level, accounts for more than 80% of operating costs. Thus the following paper uses the cost of equipment facility and staffing as a representative of service cost.

Bank service capability decision-making model

Currently, few banks use a single server, which is easy to manage. Thus this situation will be excluded in the process of building model. Oppositely, this paper will pay more attention to a multi –server setting.

The optimization of waiting time

According to the analysis in section II*A*, many banks don't take cost into account when they try to attract customers. So in the process of analyzing waiting time, we assume that bank branches can take any measure to optimize this factor regardless of cost. Therefore, we uses M/M/s model of Stochastic Service System Theory, in which the situation of customers' leaving doesn't exist, to find the factors which influence the waiting time of customer, then optimize the waiting time.

The assumptions of the model

- All of priority customers are homogeneous.
- The source of customers is infinite and the arrival process of customers obeys Poisson flow, where parameter λ is

the arrival rate of customers.

- Service time obeys negative exponential distribution, where parameter μ is the service rate of staffs.
- The bank sets s servers and each server has the same service rate in a multi-server setting, where s is the number of servers.
- The server takes the rule of "first come first served (FCFS)". When a customer arrives, he will be serviced directly if the server is free; On the other hand, he has to queue until a free server appears if it is busy.
- No matter how long customers wait in line, they will not leave.

The optimization of waiting time in a multi-server setting

According to the M/M/s model and its hypothesis of Stochastic Service System Theory, service rate of whole service system is $s\mu$. When $\lambda/s\mu < 1$, system is stable. The state flow-chart of the system is drawn as follows.

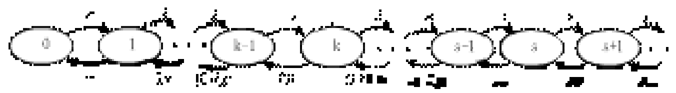


Figure 1 : State flow-chart of the system which doesn't exist customers' leaving

Set $\rho_1 = \lambda / \mu$, $\rho = \lambda / s\mu$, ρ is the service strength of system which has s servers. Because we don't consider the capacity and cost of system, the index of the system is as follows.

$$L_q = \sum_{k=s}^{\infty} (k-s) p_k = \frac{\rho \rho_1^s}{s!(1-\rho)^2} p_0 \tag{1}$$

$$L_b = \sum_{k=0}^{s} k p_k + s \sum_{k=s+1}^{\infty} p_k = n\rho = \rho_1 \tag{2}$$

$$L_s = L_q + L_b = \frac{\rho \rho_1^s}{s!(1-\rho)^2} p_0 + \rho_1 \tag{3}$$

Where p_i is the i^{th} stage of the system. L_q is the average waiting length. L_b is the number of service systems when busy. L_s is the average length of system. Little formulation tells us that for a stochastic service system, if there is the following relational expression established among L_s, L_q, W_s and W_q, which W_s is the average sojourn time of customer and W_q is the average waiting time of customer, we can say that the stochastic service system satisfies Little formulation.

$$L_s = \lambda e W_s \tag{4}$$

$$L_q = \lambda e W_q \tag{5}$$

Where λe is the average number of customers who come into the system per unit time. So according to Little formulation, W_q can be defined by:

$$W_q = \frac{L_q}{\lambda} = \frac{\rho \rho_1^s}{\lambda s!(1-\rho)^2} p_0 = \frac{\rho_1^s p_0}{\mu s \cdot s!(1-\rho)^2} \tag{6}$$

$$W_s = \frac{L_s}{\lambda} = W_q + \frac{1}{\mu} \tag{7}$$

$$C(s,\rho_1)=\sum_{k=s}^{\infty}p_k=\frac{p_s}{1-\rho}=\frac{np_s}{1-\rho_1} \tag{8}$$

Where $C(s,\rho_1)$ is the probability that customers, who come into the system, must wait in line. Therefore, the factors which influence waiting time are λ, μ and s. Because customers' arrival rate is not controlled by bank, bank branches can reduce the waiting time by increasing the number of servers or improving the service rate of staffs, to increase the satisfaction of customers.

Service capability decision-making model

It is significant for bank branches to consider their own service cost when improve service quality to satisfy priority customers. So the following paper will consider these two factors to establish service capability decision-making model of bank branches.

The influence factors of service cost

According to the analysis in Section II*A*, bank service cost can be represented by the cost of equipment facility and staffing based on Activity Based Costing. Here we assume that the cost of equipment facility of setting a server is S, that the service rate of staff is μ and that the wage level of single staff is h. For the staffing costs, according to the research of Beigi and Shirmohammadi[9], h can be defined by:

$$h=r\cdot\mu \tag{9}$$

Where r is the conversion coefficient between service rate and wages, $r>0$. C_1, the service cost of a single server, can be defined by:

$$C_1=S+h=S+r\mu \tag{10}$$

From formulation (3), we find that if the bank increases the number of servers or employs staffs with high service rate, the service cost will increase, which is not conducive to optimize service capability.

Transfer the waiting time to cost

According to the classical theory about delay that Naor put forward in 1969, the utility of customers u can be expressed as follows:

$$u(v,t)=v-C(t) \tag{11}$$

Where v is the utility value that customers gain without delay. $C(t)$ is the loss of total value due to the delay and t is waiting time. However, formulation (11) doesn't combine the impact of delay to utility with enterprises and not give the concrete form of $C(t)$. Therefore, Afèche and Mendelson[10] improved the existing Delay Cost Theory in 2004.

$$u(v,t,P)=v-C(t)-P \tag{12}$$

Where P is the price that customers are willing to pay for the service. $v-P$ is the utility value that customers gain. $C(t)$ is an increasing function of t ,and $C(0)=0$. Personal business in the bank always charges a relatively low price, thus it is acceptable for priority customers, and the effect of P can be neglected. The only way for bank branches to increase customers' utility is to reduce $C(t)$. Therefore, $C(t)$ is a key factor that bank branches should consider when they optimize waiting time.

When customers belong to risk type or risk aversion type, the function of $C(t)$ is exponential; while when customers belong to risk neutral type, the function of $C(t)$ is linear. We assume that all the customers belong to risk neutral type in this paper because few priority customers are divided based on their risk appetites. That is to say, the function of $C(t)$ is linear and $C(t)$ can be given by:

$$C(t)=c\cdot t,\ c>0 \tag{13}$$

Where c is the cost coefficient of waiting time, which is equal to the cost of unit waiting time and is decided by the customers' traits and urgency degree of business they manage. The cost of waiting time C_2 can be given by:

$$C_2(t) = c \cdot t \quad \textbf{(14)}$$

Bank branches should consider the cost of waiting time and service cost jointly when they adjust the service capability, which enables the branches to attract more customers without increasing cost. However, previous analysis shows that when bank branches take measures to reduce waiting time, the service cost increase. So the following paper will consider the proposed cost factor to build the service capability decision-making model for the purpose of minimum cost.

The assumptions of the model

The Stochastic Service System we use is established on the basis of Markov Theory, so the following analysis for service capability is conducted when the system turns stable. In order to embody the concept of cost, we adopt the stochastic service system with customers' leaving to calculate the waiting time. Among all the assumptions, the top four ones are the same with that in Section *B(I)*, and the rest assumptions are as follows:

- The server takes the rule of "first come first served". If the queue number exceeds the biggest number m when priority customers arrive, they will leave directly. m is the biggest queue number that customers can tolerate.
- If priority customers leave, they will not come back in a short time.

Service capability decision-making model in a multi-server setting

Based on formulation (10), service cost in a multi-server setting can be given by:

$$s \cdot C_1 = s \cdot (S + r \cdot \mu) \quad \textbf{(15)}$$

According to the previous hypothesis that service rate of all servers are the same, banks will pay the same wage to each staff.

Since all of priority customers are homogeneous, the cost of waiting time can still be expressed by formulation (14). As the system keeps stable, customers can only accept the service after the average waiting time. We will get the formulation (16) when rewrite t into W_q. And W_q can be calculated by the M/M/s model which exists customers' leaving.

$$C_2 = c \cdot W_q \quad \textbf{(16)}$$

For these systems, their state space is $E = \{1, 2, \cdots, m\}$. When state k meets $0 < k < s$, and the service rate of each server is μ, the total service rate of system will be $k\mu$; when state k meets $k \geq s$, all servers will be busy and the total service rate of system will be $s\mu$. The Figure below shows the state flow-chart of the system.

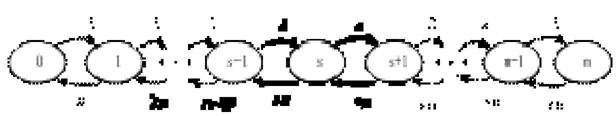
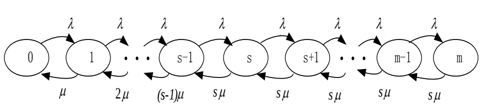


Figure 2 : State flow-chart of the system which exists the customers' leaving

Thus according to the M/M/s model of Stochastic Service System Theory, the index of the system is as follows.

$$L_b = \bar{k} = \sum_{k=0}^{s} kp_k + s\sum_{k=s}^{h} p_h = \mathrm{s}\rho\left(1 - p_h\right) = \frac{\lambda_e}{\mu} \quad \textbf{(17)}$$



(18)

$$L_s = L_q + L_b \quad \textbf{(19)}$$

According to the Little Formulation, W_q is given by:

$$W_q = \frac{L_q}{\lambda_e} = \frac{s^s \rho^{s+1} p_0}{\lambda_e \cdot s!(1-\rho)^2} \left[1-(m-s+1)\rho^{m-s} + (m-s)\rho^{m-s+1}\right] \quad \textbf{(20)}$$

It conveys that the influence factors of the average waiting time are s, μ, λ and m. For bank managers, only s and μ can be controlled. Therefore, W_q should be turned to the function of $W_q(s,\mu)$.

$$C_2 = c \cdot W_q(s,\mu) \quad \textbf{(21)}$$

Service cost emerges only when the server is busy, so the cost can be given by:

$$C_1 = L_b \cdot (S + r \cdot \mu) \quad \textbf{(22)}$$

When combine formulation (21) with formulation (22), we find service capability decision-making model in a multi-server setting can be given by:

$$C = C_1 + C_2 = L_b \cdot (S + r \cdot \mu) + c \cdot W_q(s,\mu) \quad \textbf{(23)}$$

Thus the influence factors of service capability for bank branches are μ, s, λ, m, c, S and r, among which μ and s can be controlled by banks.

VALIDATION AND CONCLUSIONS

We use MATLAB to simulate the model and give decision-making advices to help managers optimize service capability of banks. Data in the following analysis come from questionnaire of branches of bank Q, thus the following values and ranges are derived from statistical analysis of the survey.

According to field investigation and interview, $S = 100, r = 1.2$ will be substituted into the formulation (23).

$$C = L_b \cdot (100 + 1.2 \cdot \mu) + c \cdot W_q(s,\mu) \quad \textbf{(24)}$$

In a multi-server setting, banks can adjust the value of s and λ to optimize service capability. Three situations are discussed below.

Service rate is constant, only the number of servers is adjusted

In this condition, we can use marginal analysis because service rate is constant and the number of servers must be a discrete integer. The basic idea is to ensure the optimal number s^* of servers, and then to make optimal service capability $C(s^*)$ meet:

$$C\left(s^*\right) < C\left(s^*-1\right)m, and C\left(s^*\right) < C\left(s^*+1\right) \quad \textbf{(25)}$$

It is difficult to calculate such a large amount of numbers in MATLAB directly, so we set service capability $C(s,\mu)$ as a function of s, and marked as $C(s,\overline{\mu})$.

$$C = L_b \cdot (\overline{S} + r \cdot \overline{\mu}) + c \cdot W_q(s,\overline{\mu}) \quad \textbf{(26)}$$

In order to make the system stable, we assume $\lambda < c\mu$, and set $m = 5,6$, λ=4,5,6,7, $\mu = 6$. Since c will be great different when the importance of customers' business is different, we assume $c = 1,5,10$. We regard formulation (26) as one dimensional function of s , and then find out the optimal s to make C minimum. The results of calculations are shown in TABLE 1 and 2 below.

TABLE 1 : The result of calculations when $m = 5, c = 1, 5, 10, \lambda = 4, 5, 6, 7$

s^*	$\lambda = 4$	$\lambda = 4$	$\lambda = 5$	$\lambda = 6$	$\lambda = 7$
c=1	0.89	0.89	1.14	1.36	1.75
c=5	2.32	2.32	2.85	3.31	3.90
c=10	5.45	5.45	5.96	6.59	6.98

TABLE 2 : The result of calculations when $m = 6, c = 1, 5, 10, \lambda = 4, 5, 6, 7$

s^*	$\lambda = 4$	$\lambda = 5$	$\lambda = 6$	$\lambda = 7$
c=1	0.82	1.03	1.25	1.64
c=5	2.15	2.59	3.09	3.68
c=10	5.29	5.78	6.32	6.71

From the TABLE above, we find that when μ is constant, the change of m and λ has little influence on the optimal number of servers; However, c , which comes from the waiting time, has a big influence on it.

The number of servers is constant, only service rate is adjusted

Similarly, in this situation we find that when branches can only adjust service rate of staffs, the arrival rate of priority customers λ has the biggest influence on service rate in order to optimize service capability. Therefore, managers should adjust the number of staffs in time according to the change of priority customers' arrival rate.

The number of servers and service rate are adjusted simultaneously

In this simulation process, we find that the change of c has a great influence on the number of servers s and the whole cost C . Therefore, bank managers should focus on c in order to optimize service capability.

CONCLUSIONS

Based on Stochastic Service System Theory, Activity Based Costing and Delay Cost Theory, this paper establishes a bank service capability decision-making model, and tests its feasibility. We find that bank managers are supposed to take three factors—customers, service quality, and service cost—together into consideration when adjust service capability. In a multi-server setting, there are three ways to adjust service capability. If managers can only adjust service rate, they should focus on the arrival rate of customers; On the other hand, if they can only adjust the number of servers, or they can adjust service rate and the number of servers simultaneously, they should focus on the cost coefficient of waiting time.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

ACKNOWLEDGEMENT

The authors wish to thank the following funds. This paper was supported in part by a grant from Zhejiang Provincial Social Science Foundation of China (Grant NO. 13NDJC038YB) and Zhejiang Provincial Youth Talents Fund (Grant NO. 2013R407062).

REFERENCES

[1] K.S.Anand, M.F.Paç, S.Veeraraghavan; Quality–Speed Conundrum: Trade-offs in Customers-Intensive Services, Mangement Science, **57(1)**, 40-56 **(2011)**.

[2] L.Y.Cui, S.Kumara, D.Lee; Scenario Analysis of Web Service Composition based on Multi-Criteria Mathematical Goal Programming, Service Science, **3(4)**, 280-303 **(2011)**.

[3] N.Piercy, N.Rich; High quality and low cost: the lean service centre, European Journal of Marketing, **43(11/12)**, 1477-1497 **(2009)**.

[4] S.Chayet, P.Kouvelis, D.Z.Yu; Product Variety and Capacity Investments in Congested Production Systems, Manufacturing & Service Operations Management, **13(3)**, 390-403 **(2011)**.

[5] R.Ladhari, I.Ladhari, M.Morales; Bank service quality: comparing Canadian and Tunisian customes perceptions, International Journal of Bank Marketing, **29(3)**, 224-246, **(2011)**.

[6] I.Gurvich, W.Whitt; Service-Level Differentiation in Many-Server Service Systems via Queue-Ratio Routing, Operations Research, **58(2)**, 316-328 **(2010)**.

[7] M.Afanasyev, H.Mendelson; Service Provider Competition: Delay Cost structure, Segmentation, and Cost Advantage, Manufacturing & Service Operations Management, **12(2)**, 213-235 **(2010)**.

[8] M.M.Jeffery, R.J.Butler, L.C.Malone; Determining a cost-effective customer service level, Supply Chain Management: An International Journal, **13(3)**, 225-232 **(2008)**.

[9] M.Beigi, M.Shirmohammadi; Effects of an emotional intelligence training program on service quality of bank branches, Managing Service Quality, **21(5)**, 552-567 **(2011)**.

[10] P.Afèche, H.Mendelson; Pricing and Priority Auctions in Queueing Systems with a Generalized Delay Cost Structure, Management Science, **50(7)**, 869-882 **(2004)**.