



## Queue System Analysis in a Selected Branch of Mellat Bank

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Article Info	ABSTRACT
<p><b>Article type:</b> Research Article</p> <p><b>Article history:</b> Received 31 December 2025 Received in revised form 19 March 2026 Accepted 1 June 2026 Published online 1 July 2026</p> <p><b>Keywords:</b> Queue system, delivery time, Mellat Bank.</p>	<p>In today's highly competitive business environment, service organizations are increasingly driven by the dual objective of delivering superior customer service while simultaneously minimizing operational expenditures. For banks, which face intense competition from both traditional financial institutions and emerging fintech companies, achieving this balance is essential for long-term sustainability and profitability. Optimizing service delivery without compromising quality requires a deep understanding of customer flow dynamics and the cost structure underlying service operations. This study addresses this challenge by focusing on a bank branch setting, where queuing theory serves as a powerful analytical tool. The objective is to propose and evaluate a set of approaches for determining the cost parameters associated with the bank's service system. These parameters are critical inputs for optimizing the trade-off between customer waiting time and idle server costs, a core concern in operations management. To this end, a comprehensive data collection process is conducted using the bank's existing queue ticket numbering system, which records detailed logs of customer arrivals and service completions. These data are instrumental in fitting appropriate statistical distributions for both inter-arrival and service times. The extracted arrival and service rates enable a precise characterization of the system's stochastic behavior, laying a robust foundation for further quantitative analysis. Subsequently, the total queuing cost is formulated by integrating both customer waiting costs and server operating costs. A sensitivity analysis is then performed to assess how variations in the number of servers and service rates affect key performance indicators, such as average waiting time, queue length, and system utilization. The analysis reveals that while increasing the number of servers up to two provides marginal improvements, the most substantial efficiency gains are achieved when an increase in service rate is coupled with the addition of service counters.</p>

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## 1) Introduction

Queues are complex social systems that inevitably affect the performance of organizations, and managers should consider this issue and seek the ways to optimize them to enhance the productivity of the operational systems (SalehiSedghiani, 2000). Nowadays, waiting in long queues for customers as service applicants is an important issue in service systems. Customers do not accept such a delay and are dissatisfied with the quality of service. Managers of these organizations also are unhappy with their customers' excessive waiting. The concepts of queuing theory are formed to manage and optimize processes that involve queues. Queuing theory is one of the most powerful tools to analyze the performance of different systems qualitatively and quantitatively.

Nowadays, sophisticated application software have been developed that enables executives to simulate and analyze queuing systems to solve a variety of problems and issues and design new manufacturing and service systems with the maximum efficiency and effectiveness (Jaafarnejad, 1991). Managers always tend to create a balance between the costs of providing the desired service and the cost service in queues. They try to shorten the length of queues and minimize the customer waiting time as much as possible, as the long queues lead to customers' dissatisfaction, leaving the queue, and exiting the system permanently, which impose substantial costs on the organization at macro and micro levels (Karimian, 2003).

Queuing systems play a critical role in banks because customer waiting time directly affects satisfaction and loyalty. Given the highly competitive nature of the Iranian banking industry and the low switching costs for customers, improving service efficiency has become essential for bank branches. In this study, the queuing system of a busy branch of Mellat Bank is modeled and optimized. The novelty of this research lies in developing a queuing-based optimization model that simultaneously evaluates the trade-off between adding extra service capacity and improving employee productivity (service rate), enabling the identification of the most cost efficient operational configuration for the branch. The rest of the paper is organized into four sections. First, a literature review in the area of improving the queuing system in banks is presented. Then, an appropriate basic model for optimizing the queuing system in a bank branch is introduced. The instructions for using the basic model in a selected branch of Mellat Bank are presented in Section three. Finally, conclusions and managerial recommendations are presented in Section four.

## 2) Literature Review

Hao and Yifei (2011) simulated the queuing system of a branch of Nanjing Bank in order to reengineer its business processes. Their proposed optimization model determines the optimal number of servers that minimizes queuing cost from the perspective of customers and system' owners. Toshiba et al. (2013) proposed a mathematical model to improve the queuing system of the Punjab National Bank in Pakistan. Their models' objectives are to minimize the customers' waiting time and also minimize the service cost. Chowdhury et al. (2013) proposed a model to investigate the tangible and intangible costs of adding a server to queuing system and determined the optimal number of servers. They applied the model in Islamic Bank of Bangladesh. Dhar and Rahman (2013) studied the queuing system in ATMs. Data were collected from a bank ATM in a city in India. The M/M/1 model was used for the analysis of the queuing system. Yakubu and Najim (2014) applied the queuing theory to determine the optimal service level for an ATM. In this system, the maximum customers waiting time was specified to be eight minutes. Ajiboye (2014) also applied the M/M/1 queuing model to evaluate the service delivery level in an ATM in a region with high population density.

Sahu and Sahu (2014) focused on bank queuing system modeling. For this purpose, a single-channel M/M/1 queuing system with a Poisson distribution for the arrival process and exponential distribution for service times was used. Arrival rate, utilization rate, waiting time, and the average number of customers in the queue were obtained using the Little theorem and M/M/1 model. Finally, some suggestions were proposed for improving the bank queuing system. Ullah et al. (2014) studied the problem of optimizing the number of staff in the ICBC bank, China. In this bank, the system's idle time

was very high due to the extra staff. To study the system, they, first, collected the essential data through field research and then conducted the optimization process using discrete simulation along with analytical models.

Berhan (2015) modeled the queue structure with several service channels in a bank in Addis Ababa. The results show that both customers' arrival rate and service rate follow the Poisson and exponential distributions. Additionally, the optimal number of servers was found to be five channels with the efficiency rate of 0.578. Mutingi et al. (2015) focused on the modeling and analysis of the bank queue system. The analysis process was conducted in three phases: (1) identifying the key performance indicators affecting the customer perception considering the service quality, (2) simulating the behavioral performance of bank queue system, (3) evaluating and improving the quality of the system services by using the simulation results (Mutingi et al., 2015). Kuka and Badshah (2016) applied the M/M/C queue model and the Birth-Death Markov process to model the bank queue process. Their model included a multi-service queue system with Poisson arrival rate and exponential distribution. The queue discipline was FIFO. The model was operated for a Kannara Bank in Indore State of India. The results indicate that the model is applicable and practical (Koka & Badshah, 2016). Cowdrey et al. (2018) represented an overall model to optimize the waiting time in banks. In their suggested model, the waiting time from the perspective of the customer and the profit from the perspective of the systems' owner were considered as optimization criteria. Hermanto and Nugroho (2018), with the assumption that the formulas of Little's law are not able to estimate the waiting time accurately due to its statistical assumptions, have used an artificial neural network approach to estimate the waiting time of the queue (Hermanto & Nugroho, 2018).

Numerous case studies have been conducted on the application of queuing theory across various domains, particularly in logistics and service systems. Among these studies, Lakhwani et al. (2025) examined the use of drone technology in healthcare logistics, focusing on the delivery of time-sensitive medical supplies. Their research highlighted the limitations of traditional ground-based transportation systems and demonstrated how drone-based solutions can significantly reduce delivery delays and improve accessibility, especially in remote and underserved regions. The authors also emphasized the role of optimized resource allocation and system responsiveness in enhancing the efficiency of critical healthcare delivery operations (Lakhwani et al., 2025). Zou et al. (2026) conducted a case study on optimizing customer satisfaction in finite-service-time multi-server queueing systems. Their study focused on an incentive-based mechanism that dynamically adjusts service rates according to queue length to improve service efficiency while minimizing incentive costs (Zou et al., 2026). Nali et al. (2022), in a case study, investigated the optimization of truck operations in marine container terminals, particularly focusing on dual transactions where trucks deliver and pick up containers in a single trip. They developed a queuing-based and bi-objective optimization model to improve truck scheduling, equipment allocation, and terminal operational efficiency (Li et al., 2022).

The novelty of this study lies in applying the M/M/c/K queueing model to a real banking service system and explicitly demonstrating how its parameters can be estimated and interpreted under practical operational conditions. Unlike many theoretical studies, the research links queue performance measures to a cost-based decision framework and evaluates realistic improvement scenarios. This approach provides a practical tool for bank managers to determine the optimal trade-off between the number of service counters and service rate in real operational settings.

### **3) Methodology: Basic Model of Queue Optimization in the Selected Branch of Mellat Bank**

The queuing system that is considered in this study is M/M/c/K. The reason is that the customers' arrival rate has followed the Poisson distribution. Additionally, the service rate has an exponential distribution. In Table 1, the model parameters, and their calculation method, is represented.

**Table 1. Queue Model Parameters**

Parameter	Parameter Description
$\lambda$	Customers' arrival rate. To calculate this parameter for 147 days, the data for total daily entry of the customers that was registered by the queue ticket numbering system has been calculated. For each day, the number of customers' entry is calculated per minute (divided by 25 working days per month, 7 working hours per day, and 60 minutes per hour). Then, the average of this value for 147 working days has been considered as parameter $\lambda$ .
$\mu$	Service rate. This parameter has been calculated by using the data of the customer servicing time (the time of the number announcement from customer $i$ to customer $i+1$ ) which is registered by the queue ticket numbering system. For each counter and the total counters, the average per day is calculated and then, the total average for 147 working days per minute is calculated.
$c$	The number of servants. The number of servants is equal to the number of banking service providers counters.
$K$	The capacity of the system that is considered to be equal to the number of embedded seats for customers' waiting in the bank.
$C_1$	Cost per units of time in which customers are in the waiting queue. This cost parameter in the bank shows the services the bank should provide customers with the time during they are in the queue. Therefore, these costs include costs of water consumption and costs for cleaning the bank area (the customers' waiting place). In order to calculate these parameters, the related costs are extracted from the bank financial statements (profit and loss statement) and 60% of these costs are considered as the percentage that is related to the waiting customers. The estimated value of 60% was obtained through qualitative assessment based on interviews with branch staff. Their experience and observations regarding customer presence and operational costs during queue waiting times were used to approximate the share of these expenses attributable to waiting.
$C_2$	Cost per units of time in which customers are receiving service. These costs include the cost of payments and salaries, the cost of the building renting, the cost of water, electricity, gas, telephone, and internet, the press cost, the requirements cost, health costs, major repair costs, equipment depreciation cost, tea, mineral water and sugar costs, and finally overhead and management costs.
$C_3$	Cost per units of idle time of the servants. This is considered equal to the payment and salary of the counter personnel.
$C_4$	Cost per units of working time for each server, when they are giving services to customers. The work costs and the unemployment costs of servers are equal based on the opinion of bank experts and branches' managers.
$C_5$	Cost of having a unit capacity in order to providing service in the unit of time. This cost shows that if a new unit (a new seat to increase the queue capacity) is added, how much cost will be imposed to the system.
$C_6$	Cost of losing a customer who has encountered the full capacity of the system and will leave the system. In order to calculate this parameter, the profit set should be calculated per customer. In other words, losing each customer leads to the loss of profit that the branch could have from that customer. To calculate this parameter, the represented profit values in the profit and loss statement have been used.
$\rho$	The ratio of the customer arrival rate to the service rate.

According to the parameters defined in Table 1, the relations of the  $M/M/c/K$  model queue are in the form of relations from 1 to 5 (Shortle et al., 2018).

$\pi_0$ : probability of zero customer in the queue in long term, calculated through the equation 1.

$$\pi_0 = \left[ \left( \sum_{n=0}^{c-1} \frac{K!}{(K-n)!n!} (\rho)^n \right) + \sum_{n=c}^K \frac{K!}{(K-n)!c!c^{n-c}} (\rho)^n \right]^{-1} \quad (1)$$

$\pi_n$ : probability of  $n$  customers in the queue in long term, calculated through equation 2.

$$\pi_n = \begin{cases} \pi_0(\rho)^n \frac{K!}{(K-n)!n!}, & \text{if } 0 < n < c \\ \pi_0(\rho)^n \frac{K!}{(K-n)!c!c^{n-c}}, & \text{if } c \leq n < K \\ 0; & \text{if } n > K \end{cases} \quad (2)$$

$L_q$ : The average number of customers in the queue in long term, calculated through equation 3.

$$L_q = \sum_{n=c}^K (n-c) \pi_n \quad (3)$$

$L$ : The average number of customers in the system in long term, calculated through equation 4.

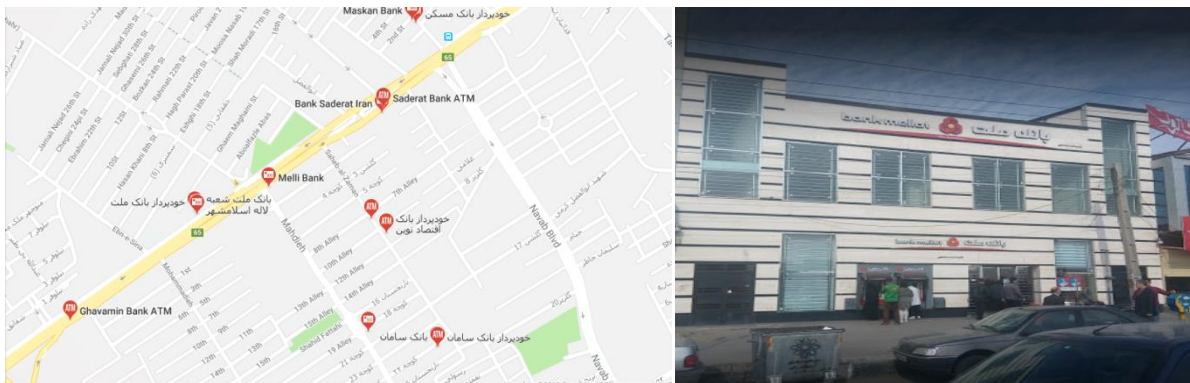
$$L = \sum_{n=0}^{c-1} n\pi_n + L_q + c \left( 1 - \sum_{n=0}^{c-1} \pi_n \right) \quad (4)$$

The total cost of a M/M/c/K queue is calculated through equation 5.

$$TC(c; K) = C_1L_q + (C_2 + C_4)(L - L_q) + C_3(c - L + L_q) + C_5K + C_6\lambda\pi_K \quad (5)$$

#### 4) Case Study

To conduct this research, we tried to select a branch as a case with a high volume of customers and with queue an issue for it. Therefore, one of the branches of Mellat Bank is selected in Islam Shahr City. The Mellat Bank in Islam Shahr and suburbs has four branches, the two of them are inside the city and two others are in the suburbs. Figure 1 shows the location of this branch and the branches in its surrounding, its exterior and interior view. As presented in Figure 1, two branches of Mellat Bank are located in the area of Laleh Town. Therefore, these two branches have the most volume of customers in Laleh Town, as well as around this region.



**Figure 1. Mellat Bank Location, Islam Shahr Laleh Branch (Left), Bank Exterior View (Right)**

Laleh Branch is located in the center of the city and is in a highly populated district. In this branch, four counters have electronic numbering devices, and two counters provide services related to less-demanded activities, such as credits, checks, and ATM cards. The number of available seats in this collection (showing the capacity of the system) is 18.

According to the definitions provided in part three, the cost parameters are calculated and provided in Table 2. It should be noted that the entering and service rates are estimated based on a statistical sample during 147 days of customers 'visiting. Information related to the time of customers' visiting is extracted from the bank numbering device.

**Table 2. The Values of Required Parameters to Evaluate the Queue**

Parameters	$\lambda$	$\mu$	$c$	$K$	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$
Values	1.5512	02232	4	18	19.57	123444.28	2527.93	2527.93	19.57	14006.87

Performance criteria of the queue system are calculated through equations from 1 to 5. As illustrated in Table 3, the average number of the customers in the queues are 12.64, while the average number of customers inside the system is 19.59 individuals, and the total cost per minute is 8,8700 Rials. As presented in Table 3, the probability that the system operates at full service capacity is 42 percent.

**Table 3. The Results of the Performance Criteria of the Current Queue Conditions**

Criterion	$\pi_0$	$\pi_K$	$L_q$	L	TC
Value	91 e -6.1	0.42	12.64 people	19.59 people	88700 Rials per Minute

### 5) Sensitivity Analysis

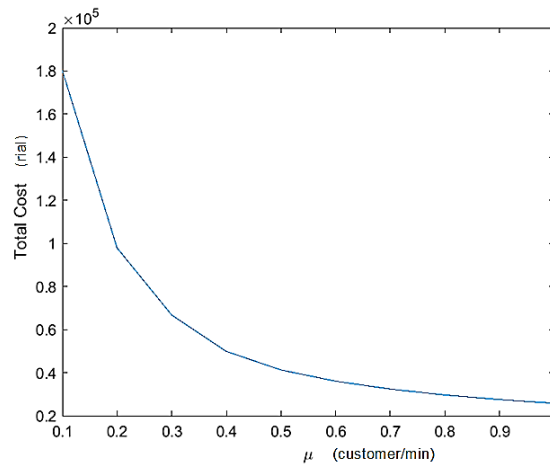
In this section, the cost behavior of the queue system has been analyzed by changing one or two parameters and maintaining the rest of the parameters constant. In this study, sensitivity analysis is conducted according to three perspectives:

- Changes in the parameter of service rate: increasing the service rate improves the efficiency of servants.
- Changes in the number of servers: increasing the number of servers means adding new servants and the increase in the system responsiveness coefficient.
- The simultaneous change in the service rate and the number of servants: in this case, the effect of increase in service efficiency as well as the addition of a new service channel will be studied simultaneously.

In Table 4, the relationship between service rates, total cost, the average number of customers in the system, and average number of customers in the queue are presented. As shown in Table 4 and Figure 2, an increase in  $\mu$ , will reduce the total cost.

**Table 4. Results of Evaluation Criteria and Total Cost Based on Changes in Service Rate**

$\mu$	(Rials)TC	(People)L	(People) $L_q$	$\pi_K$	$\pi_0$
0.100	180137.1	29.16435	13.65253	0.742132	1.77E-12
0.200	97879.72	20.6912	12.93528	0.484271	3.03E-07
0.300	66749.95	15.98127	10.81066	0.229232	0.000212
0.400	49858.74	9.264044	5.386088	0.044598	0.007303
0.500	41231.51	4.809511	1.707146	0.003582	0.032562
0.600	36029.18	3.215398	0.630094	0.000274	0.06639
0.700	32367.52	2.502806	0.286831	2.65E-05	0.102698
0.800	29627.17	2.088766	1.50E-01	3.25E-06	1.39E-01
0.900	2.75E+04	1.80922	0.085684	4.9E-07	0.175187
1.000	25793.15	1.603505	0.052323	8.8E-08	0.209627



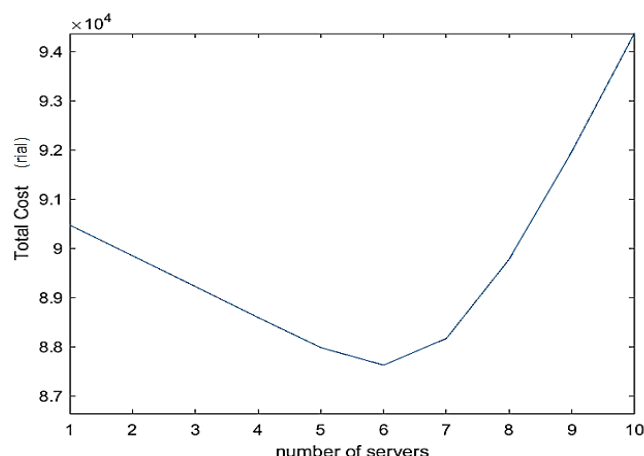
**Figure 2. Total Cost Changes Based on Service Rate**

This is obviously true, as the bank does not incur any additional costs to increase the service rate. Therefore, the more this rate increases, the more likely the costs of customer loss and the length of the queue decreases. In the executive perspectives, encouraging the personnel in the counters to increase the service rate is justifiable if, and only if, the incentives intended for these personnel are not more than the reduced costs. For example, by increasing the service rate from 0.2 to 0.3, the queue costs can be reduced by a rate of 82257.38 Rials per minute. If the rate of the incentives intended for the entire collection of counters personnel is less than 82257.38 Rials per minute, the increase in this rate can cause a reduction in the queue costs.

In Table 5, the effect of changes in the number of servers on the total cost and other parameters of the queue system has been investigated. In the current situation, four counters are working in the branch. In order to determine the number of optimized counters, the changes in the total cost based on the changes in the number of counters has been investigated from 1 to 10. Figure 3 shows changes in the total cost based on the changes in the number of counters.

**Table 5. Results of Performance Criteria and the Total Cost Based on the Changes in the Service Rate**

c	(Rials)TC	(People)L	(People) $L_q$	$\pi_K$	$\pi_0$
1	90472.17966	23.78039	16.83189	0.85608	0.00000
2	89849.02988	22.54434	15.59584	0.71217	0.00000
3	89223.54475	21.18873	14.24023	0.56825	0.00000
4	88594.13600	19.59354	12.64504	0.42437	0.00000
5	87981.21908	17.46688	10.51838	0.28173	0.00003
6	87625.86373	14.46390	7.51540	0.15173	0.00017
7	88166.06823	11.22210	4.27360	0.06316	0.00044
8	89775.10717	8.99388	2.04538	0.02288	0.00069
9	91969.18068	7.86251	0.91400	0.00853	0.00084
10	94379.36128	7.34784	0.39933	0.00358	0.00091



**Figure 3. Changes in Total Cost Based on Changes in the Number of Servers**

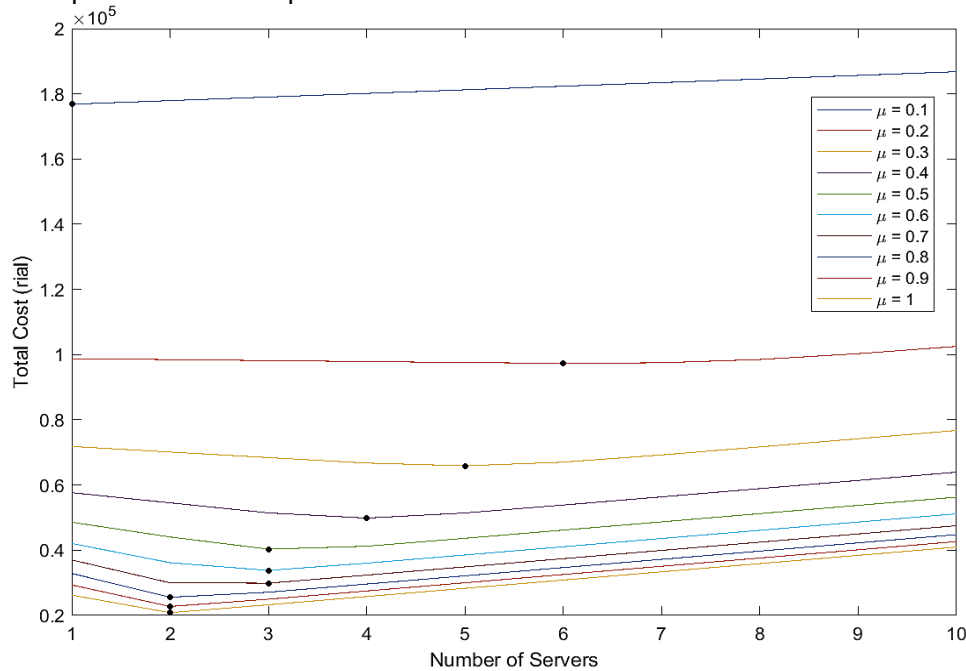
As shown in Figure 3, the minimum total cost has reached out in the server six. In other words, by increasing the number of the collection’s counters from four to six, the minimum cost of the queue structure in that branch can be obtained. If the number of counters changes from four to five, bank queue costs are reduced with a rate of 612.91692 Rails per minute. In case of an increase in the number of counters from four to six, this amount of cost reduction equals 968.27227 Rails. Considering the possibility of an increase in the counters in the bank’s interior space, it is suggested to increase the number of counters to six in order to minimize the queue costs in the bank.

In the following, the effects of the simultaneous change of  $\mu$  and  $c$  on the total cost are investigated. Table 6 and figure 3 shows the changes in the total cost based on the change in these two parameters. The highlighted cells indicate the minimum cost values according to the number of counters ( $c$ ) and the  $\mu$  value.

**Table 6. Investigating the Effects of Simultaneous Changes in the Service Rate and the Number of Service Providers on the Total Cost (Rails)**

		M										
		1	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	
c	1	26227.80	29338.44	32873.97	37016.54	42070.54	48583.64	57650.91	71827.16	98776.56	176819.54	1
	2	20836.03	22749.20	25578.74	29993.90	36166.86	44064.84	54542.54	70125.81	98479.64	177925.66	2
	3	23269.68	24976.57	27115.58	29895.74	33808.94	40329.38	51457.12	68418.01	98181.09	179031.54	3
	4	25793.15	27496.94	29627.17	32367.52	36029.18	41231.51	49858.74	66749.95	97879.72	180137.10	4
	5	28320.26	30023.54	32152.76	34890.63	38542.17	43660.87	51434.49	65894.35	97578.31	181242.27	5
	6	30848.03	32551.19	34680.17	37417.52	41067.59	46178.93	53859.57	67023.97	97345.45	182346.91	6
	7	33375.92	35079.06	37207.99	39945.20	43594.90	48704.82	56372.74	69234.28	97509.41	183450.96	7
	8	35903.85	37606.98	39735.89	42473.07	46122.67	51232.21	58897.40	71695.01	98512.03	184555.08	8
	9	38431.78	40134.91	42263.82	45000.99	48650.56	53759.98	61424.42	74205.92	100303.88	185663.94	9
	10	40959.71	42662.84	44791.75	44791.75	51178.48	56287.87	63952.07	76728.65	102524.58	186794.57	0

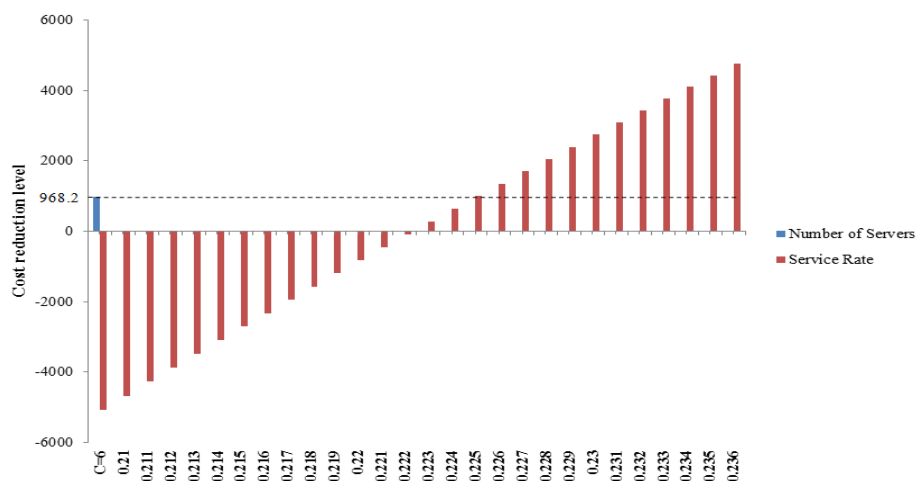
As shown in Table 6, if there is the possibility of an increase in the service rate 0.3, the minimum cost occurs in the counter number 5. According to the bank's current condition, a cost value equal to 22805.65 Rials per minute in the queue costs will be saved.



**Figure 4. Changes in the Total Cost Based on the Changes in Service Rate and the Number of Service Providers**

### 6) Comparison of the Current Condition and Proposed Solution

After evaluating the current condition and options to improve the queue costs, in this section two improving scenarios are compared to one another. The first one is changing the number of counters and the second is increasing the service rate. In order to evaluate more accurately, the changes in service rate are considered as 0.001 to calculate the changes in total cost. As shown in Table 3, the total cost of the current bank queue is 88,594 Rials per minute. According to the evaluation, the total cost of the queue by an optimal number of counters (i.e., 6 counters) equals 87625.86 Rials per minute. Therefore, the cost improvement level will be 968.2 Rials per minute. In order to compare this level of improvement with the improvement obtained by an increase in the service rate, the level of cost reduction considering the six counters plus changes service rate is drawn from 0.210 to 0.236 with 0.001 steps. As observed, the amount of cost reduction considering six counters (968.2) is more than the amount of cost reduction considering four counters and the service rate of  $\mu = 0.225$ , and less than the amount of cost reduction considering four counters and the service rate of  $\mu = 0.226$ , as shown in Table 7. In other words, if the bank does not have a decision to change the number of counters, they must change the level of service rate at least from the amount of  $\mu = 0.2232$  to  $\mu = 0.2260$ . In this way, an improvement more than a change in the number of counters from four to six is obtained. This happens when the cost of increasing the service rate is considered zero.



**Figure 5. Level of Cost Reduction According to the Optimal Number of Counters and the Changes in Service Rate**

**Table 7. Comparison of the Current Queue Condition and the Optimal Conditions According to the Changes in Service Providers and Service Rate**

Queue Condition	Number of Counters	Service Rate	Queue Total Cost	Improvement Amount
Current Condition	4	0.223	88594.136	0
Optimal Cost based on the Changes in Counters	6	0.223	87625.863	968.273
The Changes in Cost based on the Changes in Service Rate	4	0.225	87957.952	636.184
	4	0.226	87600.263	993.873

**7) Conclusion**

In this study, the queue system in one of the crowded branches of Mellat Bank was analyzed. For optimization, first, performance criteria of the queue system was calculated based on M/M/c/K model. Then, using these criteria, the cost function was defined and three different improvement scenarios were defined and compared with each other. The first scenario seeks to reduce the costs of the queue system by increasing the number of counters. Cost results as well as the current facilities of the branch indicate that adding two more counters is possible, leading to cost reduction in the queue system by 1.1%. The second scenario is increasing the efficiency of the service providers. Obviously, increasing the efficiency of each service provider will cause a reduction in costs, but it requires encouraging the servants. The amount of the encouraging budget can be calculated through determining the amount of cost reduction per the increase of one unit of change in the service rate. The third option to improve the queue system in these branches is changing the service rate and the number of servants simultaneously. The proposed model can help the branch managers to determine the best trade-off between the number of servants and the service rate according to their policies.

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