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Optimizing the Banking Service System Using Queue Theory, Fuzzy DEMATEL and TOPSIS Approach: Case Study

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Abstract
Purpose: This paper aimed to improve and optimize the overall performance of the banking service system using queue theory in various activities whilst maximizing profits.
Research Methodology: Based on previous literature and interview with related experts, the initial status of the banking system is analyzed as well as the methodologies of queue theory. The data was analyzed to modeling queuing systems for understanding queuing behavior using Wittness Software for simulation. Different queuing strategies will be implemented using the waiting time to find the most efficient solution and the optimized result is concluded.
Result: In this paper, the performance of the banking system is investigated and improved by the queuing theory. The sensitive analysis approach will provide new solutions for the optimization of the bank queuing, which could later be implemented for better banking performance. Based on the results obtained, the recommended method produces the best customer satisfaction and maximizes profits. The results of the paper enable decision-makers to obtain useful results with enough knowledge of the behavior of the system.
Limitation: This research only described the Iranian bank system. There is different limitation regarded as external factors that varies from one banking system to another and many works are needed to further combat the problems faced by the banking sectors.
Contribution: The results are a guideline for managers or decision makers and help them shorten cycle time and to save costs, and resolve problems. It also serves as a useful base for researchers to expand further research concerning the problems of the banking system in other organizations.
Keywords: *operation system, queue theory, optimization of the banking system*
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1. Introduction

Banking service systems are service organizations for transfers of funds through facilitating trade exchanges. Banks are the main element of the management and guidance of economic growth (Tan & Anchor, 2017). Therefore, a successful banking system requires the use of new technologies and new tools to overcome complex conditions, and uncertain processes (Moro, Cortez, & Rita, 2015).

Despite the importance of this fact, most studies, have focused on the banking system processes in definite environments and have neglected the environment's dynamics as well as the uncertainties of customer behavior (Martin, Lakshmi, & Venkatesan, 2014). Because these studies have not considered the uncertainties of the banking systems, the results of such studies are not applicable to the strategic planning of organizations (Csikósová, Čulková, & Janošková, 2016; Yang, 2012). Most Iranian banks are facing a serious problem- customer queuing and challenges, which led to low service rates of the bank counters, poor business environment and a number of high-quality customers and potential customer loss and so on (Koetter & Noth, 2013; Zhao, 2007).

Queue theory is one of the tools that have been used widely in several manufacturing areas and organizations. Using a valid model may give several advantages in creating a better organizational design in order to improve system performance. This tool is rapidly gaining popularity in systems design and analysis. Modeling and queue techniques are often powerful tools devoted to analyze the best layout for industrial plants or organizations. In fact, these methodologies allow the investigation of the most suitable features or parameters regarding for instance buffer capacities or the number and type of machines and facilities. In addition, Queue theory is an effective analysis tool that helps engineers and planners make intelligent and timely decisions in the design and operation of a system (Elsinger, Lehar, & Summer, 2006). Queue theory itself does not solve problems, but it does clearly identify problems and quantitatively evaluate alternative solutions (Kosmidou & Zopounidis, 2004). In this paper, the aim is to model the services given by the Iranian bank branch accounting department and simulate it with WITNESS. The following sections discussed the detailed modeling methods and analysis of Queue theory outputs to improve the efficiency of the studied system (Sarkar, Mukhopadhyay, & Ghosh, 2011).

According to the analysis of the previous research, there are different reasons leading to the existence of the problem of bank queuing (Moradi & Beigi, 2020). The level of management of banks, Lacking outside competition, does not use new tools and technologies for improvement of operation. Therefore, we must focus on improving the queuing system of the bank (Wang & Jiao, 2008; Zhang, 2002).

Therefore, given the increasing importance of the banking system in Iran, the present study used a simulation method with selected processes of the service in the banking system of Iran. The present research was conducted in many-selected Bank of Iran.

The aim of this study was to provide a model for the optimization of the service of the Bank, by examining the selected processes of the banking system. Improving the service processes of banks requires optimizing banking processes as well as understanding the interaction between the elements of each process. This paper applies queuing modeling to configure selected processes of the Iranian Bank. The interactions between the processes are examined and the research model is presented. The model of the paper is executed in a simulated environment. The simulation results are analyzed using a sensitivity analysis method.

2. Literature Review

Every profit or non-profit organization needs to arrange its financial activities and must set up an accounts department that looks after the accounting details of the organization (Birge & Júdice, 2013). An accounting department is the backbone of every business because it controls the cash flow of organization. Due to this significance, every accounting department must be efficient and responsive to its clients (Drehmann & Gambacorta, 2012).

Scientists found that the service quality of bank branches, the waiting time of customer queuing, the convenience, and the service of the bank's staff are the best way to affect the consumer experience (M Forozandeh, Teimoury, & Makui, 2019; Li, 2008). The waiting time is the most impotent element influencing the consumer experience. In fact, the most direct complaint from customers not satisfied with the bank is that the customers wait for a long time to line up (Mohammad Forozandeh, 2021). All aspects of the bank are considered, subjecting to a variety of factors to solve the problem of the long queues. It is not only a problem of the efficiency of business and management but also a problem of the commercial banks' innovation (Hao & Yifei, 2011; Li, 2008). In this paper, the problem of customers waiting for the shortest time is studied by means of the queuing theory. The measure to reduce the time of customer queues is obtained to achieve the greatest effectiveness for the banks.

The main research question to answer is if the time spent at banks could be improved if a queuing system is implemented. The important element that needs to be defined in queuing theory is arrival rate, service rate and utilization (Allen, 1980; Gross, 2008). When implementing the queuing system in an intelligent manner waiting times and customer satisfaction will be improved (Nosek Jr & Wilson, 2001). In order to improve queuing systems, it must be understood in-depth and queuing theory is used to do this, which leads to a Queuing Management System. It can be implemented to manage the efficiency of a queuing system, which is the objective researched within this paper.

Previously implemented methods have been researched to improve specific aspects of the banking environment. Using a remote and local service could provide the Queuing Management System with better performance (Bagchi, 2015). Using an M/M/1 queue simplifies the modeling process (Mahmood, Chilwan, Østerbø, & Jarschel, 2015). The round-robin method will not be implemented, as customers need to be serviced in order until successfully helped (Rasmussen, Yu, Ruepp, Berger, & Dittmann, 2014). It is known that queuing delay could have a negative impact on the performance of a system thus different servicing models will be introduced into the system to measure performance improvements (Al-Mogren, Iftikhar, Imran, Xiong, & Guizani, 2015). There are implementations to improve service quality, the efficiency of the tellers, the service time, and more recently the queue length and waiting time of the banking scenario (Hammond & Mahesh, 1995). Moreover, Mappadang, Wijaya, and Mappadang (2021); Toloie-Eshlaghy and Behbahaninezhad (2020) pointed out that software simulations are performed, but this paper will improve by adding hardware in the form of an FPGA as a local element as in.

Queuing system of a bank was chosen to investigate how using different servicing and scheduling methods will affect the efficiency of the overall waiting time and throughput of the customers arriving and leaving the bank (Olusola, Okolie, & Adesina, 2013). One important factor to form the basis of the implemented Queuing Management System is the fact that every customer will arrive at the bank requesting a specific banking service. Each service will have a different service time thus knowing the chosen banking service an informed decision can be made regarding the queue for the customer to follow. The main objective of this investigation is to see how a Queueing Management System can improve the efficiency of a bank when using queueing and scheduling techniques (Sauer, MacNair, & Kurose, 1984).

The average service time will depend on the type of service that the customer wants to be completed. The customers will walk into the bank and select their reason for visiting the bank on a machine. The customer will then receive a tag that will indicate if it is the customer's turn to be serviced. The jobs that would have the smallest service time are completing an account statement and the largest services will be completing a loan or creating a new account (Sauer et al., 1984; Xiao & Zhang, 2010).
Iranian bank located in university for students and other customers. It has been established to do different activities (table 1).

Table 1. Banking activities

Class	banking activities	Considerations	Time(min)	Payments kind
1	Banking statements	To explain the payment regulations to the customer (which have been approved by the University authorities)	0-2	
2	Deposits and withdrawals General banking activities	To receive the money paid by customer	2-5	Tuition fee; service fee; Activity fee; customer service fee

		To manage the collection of tuition fees from customer		customer orientation fee Co-curriculum fee Registration fee Alumni subscription Examination fee Computer service fee Hostel fee
		To manage the payment of the loan to the customer		
3	New accounts	To manage the record of customer's finances in a proper manner, which can be used as a source of referent	15-30	
4	Loan or complicated banking duties	To manage the claim letter to the customer, which is related to the debated payment	>30	

Source: compile by author

There are two different queues in the Iranian bank. One of them has been designed to help customer to find appropriate answers to their questions which is named inquiry service. The other queue has been assigned to financial and accounting activities within which customer pay their depth to the bank. Customers who come to the bank separate from each other by choosing their required service. A scheduling machine does this distinguishing process. Each of these two queues has been explained in detail in the following and shown in figure 1. In view of this matter, the time of payment is flexible; customers can go to the bank to pay all over the year. Thus, if someone goes to the bank, he will see that there are always some customers waiting to pay money or ask financial questions.

1. One mode is that customer gets the intended information and leaves the bank.
2. The other happens when the counter operator is not able to provide the customer with enough information. In this case, the counter operator has a customer referred to the head of the department. Meeting with the head of the department results in either leaving the office or going to the payment queue.
3. The last one happens when a customer after getting information from the counter goes to the payment queue.

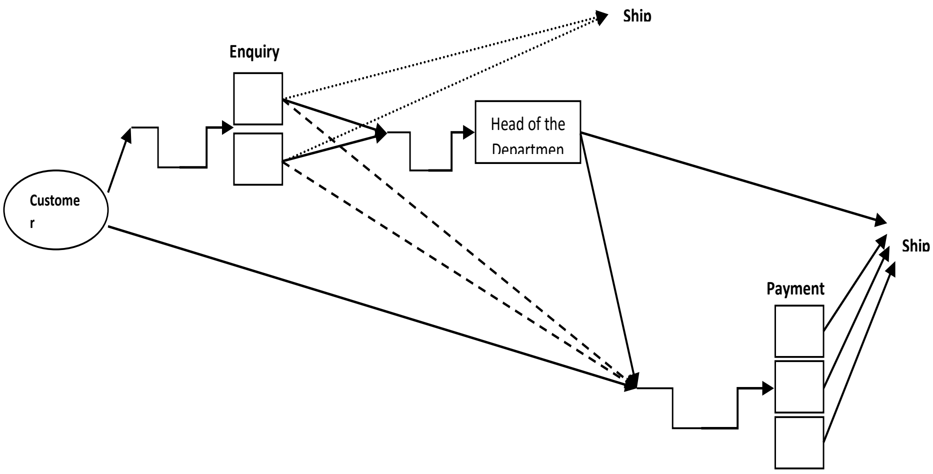


Figure 1. Inquiry service

The payment queue has been designed to provide the customer with financial services. The payment queue includes three counters each counter does the same work. Customers who arrive at the counters pay their money and after that, they leave the office. Figure 2 shows the flowchart of two different queues in an Iranian bank.

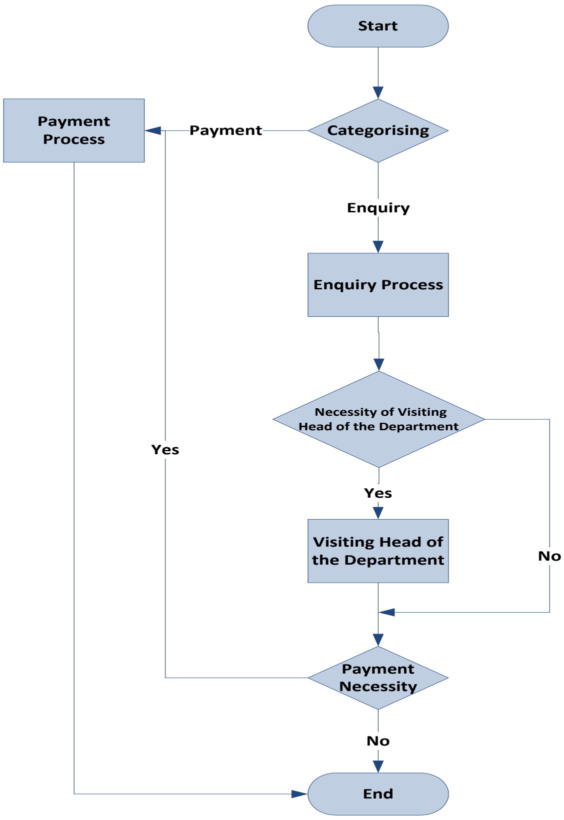


Figure 2. Flow Chart

3. Research Methodology

In order to create a queuing model for banking service, different assumption needs to be created. The results of this assumption can be seen in Table 1.

Table 2. Assumption of banking service

Population	Probability distribution	Discipline	Queue model
unlimited	negative exponential	FIFO	infinite

The outputs of the model are:

1. Expected waiting time per customer in the system
2. Expected waiting time of customer in the queue
3. Expected number of customers in the system
4. Expected number of customers in the queue

The exact calculation of these measures requires knowledge of the probability distribution of the arrival rate and service time. Thus, some simplifying assumptions are required.

1. The most basic of these assumptions is that the arrival rate obeys Poisson distribution, which the inter-arrival times are exponential?
2. The second assumption is regarding the nature of the probability distribution of the service times. Moreover, successive inter-arrival times and service times are assumed statistically independent

of each other. Collectively, the Poisson assumptions of the M/M/s model make for a reasonably tractable solution.

Next, it must prepare the timetable of counters providing services to simulate the activities of Iranian banks with more reality. In this paper, the time data collected within two work shifts in the mornings and afternoons, have been allocated to each counter. There is no reception at the last thirty minutes of each working shift and just the people who are present in the office will be serviced. Furthermore, for each counter, a fifteen-minute allowance time has been considered. During this time, operators can leave their jobs and the services will be off. Data was collected in about 7 days in two shifts a day. Therefore, the client entrance to the system was calculated separately and one arrival time and finished time were calculated for every counter. The waiting time for clients in the queue until being served is calculated as a waiting time and concerned in the conceptual model. In addition, it needs to set the initial level of various factors in the model and validate the model once built.

Data fall into one of three categories: Available, Not available, and not collectible. In order to deal with the third category, the data was estimated by using the experience of people who are familiar with the operation and by referring to the manufacturer's specifications. Data can also be estimated by making the model for unknown parameters. The process that human takes part in it does not have constant time, so the system modeling needs to fit data and eliminate inappropriate data.

In the Iranian bank department, three gates respond to client requests or questions: an inquiry gate, a payment gate and the office of the department's head. The first gate included two cabins for response to the question. The payment gate included three cabins for doing the client's work. Some of the clients do not satisfied with the answer to the inquiry gate and refer to the department's head. In this paper, going to the gate means the arrival time of the customer and when the work is finished and the customer left the gate, describe the exit time. The difference between arrival time and exit time gives us the cycle time of that gate. The cycle time of every gate should fit, calculate the P value and determine data distribution to find out whether that data is acceptable or not. At each gate collected about 50 samples and calculated the cycle time.

The arrival rate to the system shows with λ before being separated. Regard to the sample approximately 20% of clientships go out after the inquiry gate and 15% of them do not satisfy with the inquiry and are referred to the head of the department and 65% enter to payment queue. In addition, 87% of client gate ship out after the head of the department and the rest of them enter to payment queue. Some of the collected data is part of and should be eliminated. For solving this problem, the collected data should be put between ±3σ and define the maximum and minimum of the data and inappropriate data must be omitted.

Average of data - 3σ ≤ X ≤ average of data + 3σ

MIN MAX

In this model, the breakdown time is defined as making a simulation of the model near the fact and making it more correct. The allowances for staff have the follow distribution of breakdown time. The conceptual model is shown in Figure 2.

Distribution for it: **Uniform (7, 12)**

The time between failure distribution: **Uniform (80,180)**

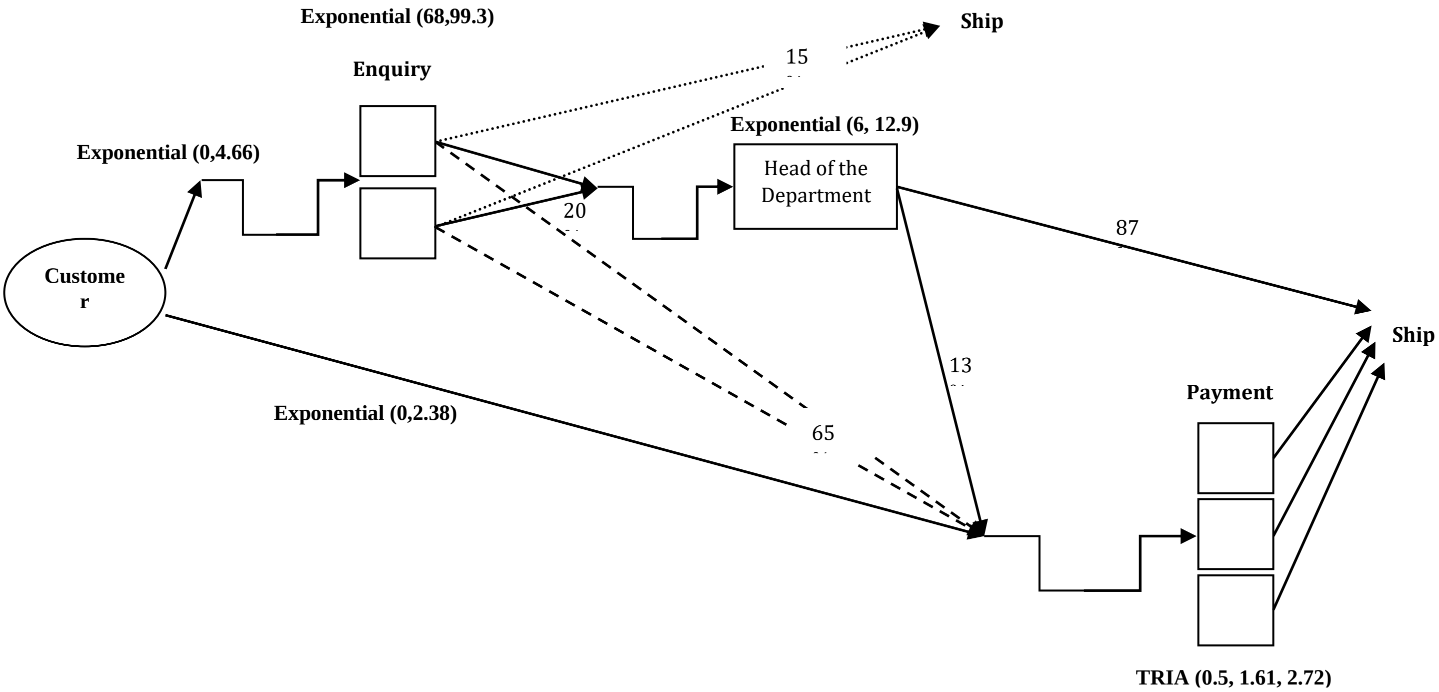


Figure 2. Conceptual model

Finally, the brief information on test kind, p-value, and other information about arrival time distribution or cycle time distribution is shown in table 3. There are two different kinds of tests for fitting the data including Kolmogorov test and Anderson-darling. In this paper, The Kolmogorov test is selected. In addition, in this study, a two-phased integrated multi-criteria decision-making (MCDM) method is suggested to examine the results of the sensitivity analysis. In the first phase, the fuzzy DEMATEL method is applied to evaluate the importance level of banking service benefits indicators. In the second phase, the fuzzy TOPSIS method is applied to rank the results of sensitive analyses based on their performance levels.

Table 3. The Kolmogorov test

	CT				Arrival Time			
	distribution	**mean**	**Standard deviation**	**P value-(KOLMOGOROV)**	**distribution**	**mean**	**Standard deviation**	**P value-(KOLMOGOROV)**
Arrival time payment	*	*	*	*	Exponential(0,2.38)	2.38	1.7	0.28
Arrival time inquiry	*	*	*	*	Exponential(0,4.66)	4.66	4.52	0.12
PAYMENT	TRIA(0.5, 1.61, 2.72)	1.67	0.47	0.15	*	*	*	*

INQUIRY	Exponential (68/60,99.3/60)	167.26	84.53	0.7	*	*	*	*
Head of department	Exponential (6,12.9)	18.86	12.3	0.8	*	*	*	*

4. Results and Discussions

The extracted model implement in the computer by using witness simulation software. According to this, the simulation model was developed based on the final conceptual modeling diagram. It considered various operating conditions in simulated model, to keep up with a real situation such as servers' timetables and work shifts. At the start of this stage, the model developed by using various elements such as machines, attributes, variables, shifts and different types of connecting rules.

Verification of the model be done based on incremental method via the replication calculation and replicate the run to reach at least 90% of confidence. After that, extracted some indexes such as the number of output and WIP to compare with the real situation. The development of the model is done in simulation software step by step and separate phases. At figure 3, the complete model layout picture is shown in witness consisting of servers, buffers, and shift elements.

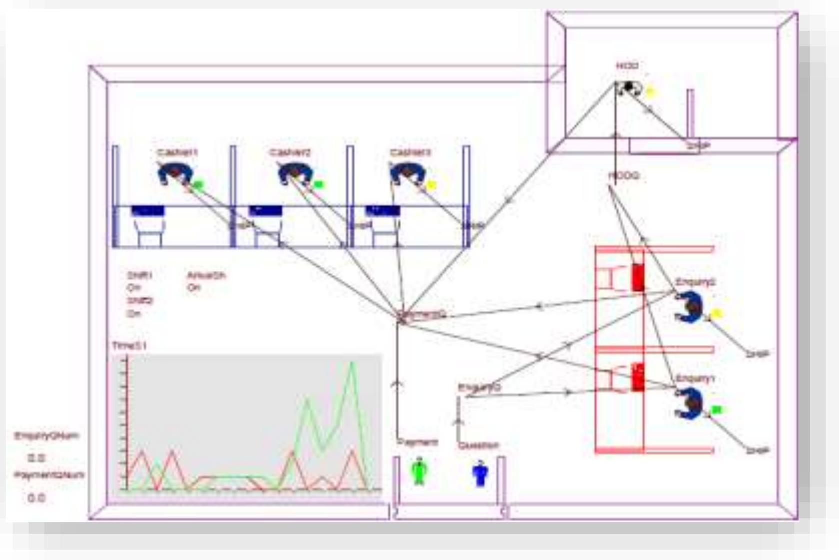


Figure 3. the witness model

The simulated model has two main sections and a queue, which are inquiry and payment. The payment queue is consisting of one part, one infinite buffer, and three single servers. This paper used simple push and pull rules to connect these elements. The entities are just created and pass through the queue. After being processed by cashier servers, the entity ship and depart the model. The inter-arrival time for the payment element is following the inter-arrival shift elements' rules. Servers also are following the Shift1 and shift2 elements rules. The author uses shift elements to stipulate the working timetable and shifts into the model and make it more realistic.

The inquiry line is consisting of 1 part, 2 servers for answering the question and 1 server as head of the department and use multiple rules for connecting the servers. After the creation of entities in the question part element, entities pass through the InquiryQ buffer element to reach the Inquiry servers. After this, three possible conditions may happen. In this regard, entities may add to the PaymentQ buffer element or HODQ buffer element, or ship and depart the total system. An entity that enters the

HOD server is also separated into two various paths. Some of them add to the PaymentQ buffer element and others just ship out of the system. The inter-arrival time for the Question element is following the inter-arrival shift elements' rules. Inquiry servers also are following the Shift1 and shift2 elements rules.

After all, the model is enhanced by adding some report elements to the model. According to this, the author defines two variable elements to monitor the number of payments and inquiry queue. Also, add a time series chart to show the fluctuation of these variables, over time. To consider the complexity of the model, it is added the breakdown time for each server according to consider the personal allowances of each server.

There are many matters in the simulation model such as the model classification, warm-up, and running length. In this regard, there are many approaches to the classification of each simulation model. A model can be either Deterministic or Stochastic. While a deterministic simulation model ignores randomness, a stochastic model includes one or more random events. The other way to classify a simulation model is related to time. A Dynamic model describes the behavior of the system through time while a Static model shows the behavior of a system at a single point in time (Sokolowski, 2011). Simulation models can also be Terminating and Non-Terminating. A terminating simulation model runs for a predetermined length of time or until the specific event, takes place such as the end of the day, the week, or the shift. On the other hand, non-terminating models do not contain such end-points and the model could be theoretically run for an unlimited amount of time (Ippolito, Ozdagli, & Perez-Orive, 2018). According to what was mentioned above our model could be classified as a Stochastic, Dynamic, and Terminating model. According to our model specification which is classified as a terminating model, there is no need for the warm-up process to be considered in this model.

The author specifies the length of the model, equal to the total working time in a day. The model runs for 480 minutes per day or per replication. It is important to draw a conclusion from a model based on a result generated by a single model. In the next stage, the model initially runs five times to calculate the replication time. The replication time will be calculated by using the below formula.

$$= \left(\frac{ZS}{\propto X}\right)$$

The author considers inquiry in the model for calculating the number of replication. This paper set the confidence level at 90% in this experiment. Thus, the result is shown in table 4.

Table 4. statistical data

Input data for	1	2	3	Average	STDV	n
Payment	126	137	148	137	11	2
Question	75	91	71	79	11	5.4

Based on the stats that have been shown in table 4, decide to replicate the model six times. After all, extract data from reports of witness simulation software and took the average of various replications. Table 5, table 6, table 7 and table 8, it is shown the paper report and the Number of Entered and Shipped.

Table 5. number of data

Name \ Rep Num	1	2	3	4	5	6	Average
Payment	142	137	148	155	128	126	139
Question	74	91	71	86	74	75	79

Table 6. Buffer Statistics

REP NUM	PaymentQ Num of IN	PaymentQ Num of Out	PaymentQ Max Size	PaymentQ Ave Size	PaymentQ Ave Time	InquiryQ Num of IN	InquiryQ Num of Out	InquiryQ Max Size	InquiryQ Ave Size	InquiryQ Ave Time
1	196	196	8	1.26	3.07	74	74	5	0.54	3.53
2	210	207	23	3.41	7.79	91	91	7	0.69	3.65
3	201	201	10	1.24	2.97	71	71	7	0.45	3.02
4	224	224	23	4.5	9.63	86	86	5	0.53	2.97
5	186	186	6	0.59	1.53	74	74	5	0.42	2.74
6	187	187	11	1.38	3.54	75	75	5	0.57	3.62
Average	201	200	14	2.1	4.8	79	79	6	0.5	3.3

Table 7. Machine Statistics

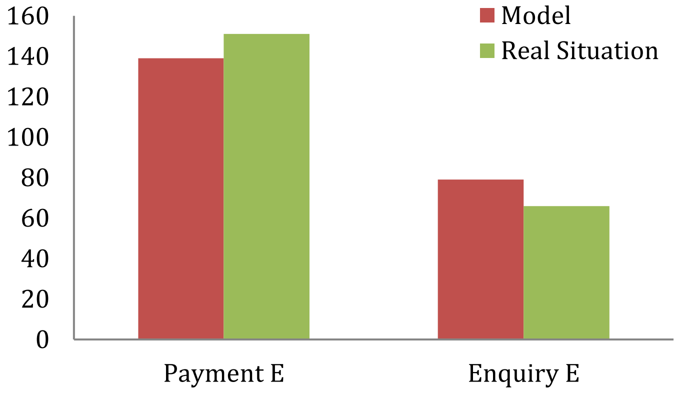
REP NUM	HOD Num Ops	HOD % Idle	HOD % Cycle	Inquiry1 Num Ops	Inquiry1 % Idle	Inquiry1 % Cycle	Inquiry2 Num Ops	Inquiry2 % Idle	Inquiry2 % Cycle
1	13	50.22	49.78	36	45.17	54.83	38	43.82	56.18
2	15	54.44	45.56	48	38.54	61.46	43	30.59	69.41
	16	36.84	63.16	40	40.7	59.3	31	49.61	50.39
4	15	13.04	86.96	50	28.46	71.54	36	38.47	61.53
5	7	78.08	21.92	37	49.22	50.78	37	34.78	65.22
6	11	38.34	61.66	40	47.48	52.52	35	43.75	56.25
Average	13	46	55	44	40	58	37	40	60

Table 8. Number of cashier

REP NUM	Cashier 1 Num Ops	Cashier 1 % Idle	Cashier 1 % Cycle	Cashier 2 Num Ops	Cashier 2 % Idle	Cashier 2 % Cycle	Cashier 3 Num Ops	Cashier 3 % Idle	Cashier 3 % Cycle
1	50	56.16	44	50	56.26	44	96	15	85
2	55	54	46	53	54	46	96	13	87
3	61	47	54	59	48	52	80	20	80
4	62	48.56	51	60	48.10	52	102	4.41	96
5	53	54.24	46	56	49.62	50	77	25.48	75
6	52	56.49	44	48	58.65	41	87	17.21	83
Average	55	50	47	56	51	48	91	16	84

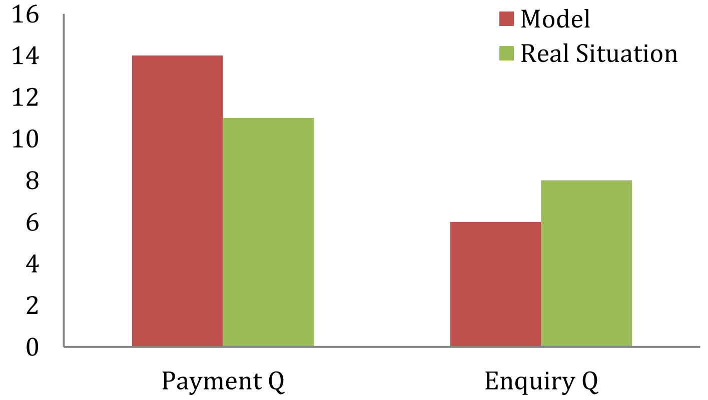
Validation of the model is performed on completion of the model. This validation should test the overall accuracy of the model and the ability to meet the paper's objectives. The validation of the suggested model is done in various ways. First, compared the simulated model with mathematical theories or queues theories. The second compared the simulated model with the actual system. In this regard, model indexes are compared by even historical data. The result of the real system and model system be put in front of an expert who has enough proficiency in these kinds of systems to evaluate the findings. Next, the author chose some indexes from the model to compare them with indexes of the real situation, which are the number of entries, maximum queue number and Number of operations for each station. The entries and operations' numbers are extracted from the teller scheduling machine and the maximum number is observed during time collection. The differences between these indexes have been shown in table 9, table 10 and table 11.

Table 9. Model Entries



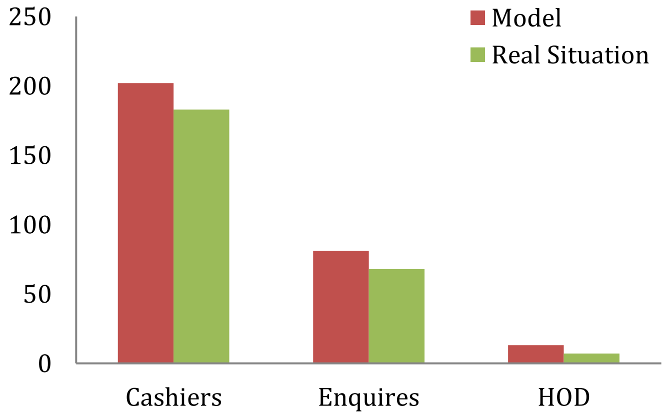
Index	Model		Real Situation	
	Payment E	Inquiry E	Payment E	Inquiry E
Average	139	79	151	66

Table 10. Maximum Queue Numbers



Index	Model		Real Situation	
	Payment Q	Inquiry Q	Payment Q	Inquiry Q
Max	14	6	11	8

Table 11. Operation Numbers



	Model			Real Situation		
Index	Cashiers	Enquires	HOD	Cashiers	Enquires	HOD
Average	202	81	13	183	68	7

As we can see from the charts, there is little difference between the actual and simulated situations. Thus, we can see that constructed model is a valid model.

The main problem encountered within this model was the long queue number that occurs in afternoons in the payments queue. This happens due to payment staff decrease in afternoons. Another thing was the low productivity of our staff. The payment staff’s busy time was mostly below 50% which shows less productivity and efficiency in the operation system. After simulating the current situation, the author has created comments on the model and discussed the ways of enhancing the operation of the Iranian bank. Thus, the consequences of that meeting cause some changes to the model. The results are coming in figure 4.

Figure 4. the ways to enhance the operation

To make the model work better, the following changes have done in the simulated model.

1. CH1: Reduce the number of staff in the payment station by 1
2. CH2: Reduce the number of staff in the inquiry station and force them to work full-time.
3. CH3: Change the working shift for paid staff. One of them has to work full-time and the other part-time. You can find the part time designed shift in table 12.

Table 12. part-time designed shift

	9:00	10:00	11:00	12:00	13:00	14:00	15:00	16:00	17:00
Full time					1:30 hr				
Part time					1:30 hr				

It can see the new layout of the model in witness simulation software is in figure 5. The results of changes are shown in table 13, table 14 and table 15.

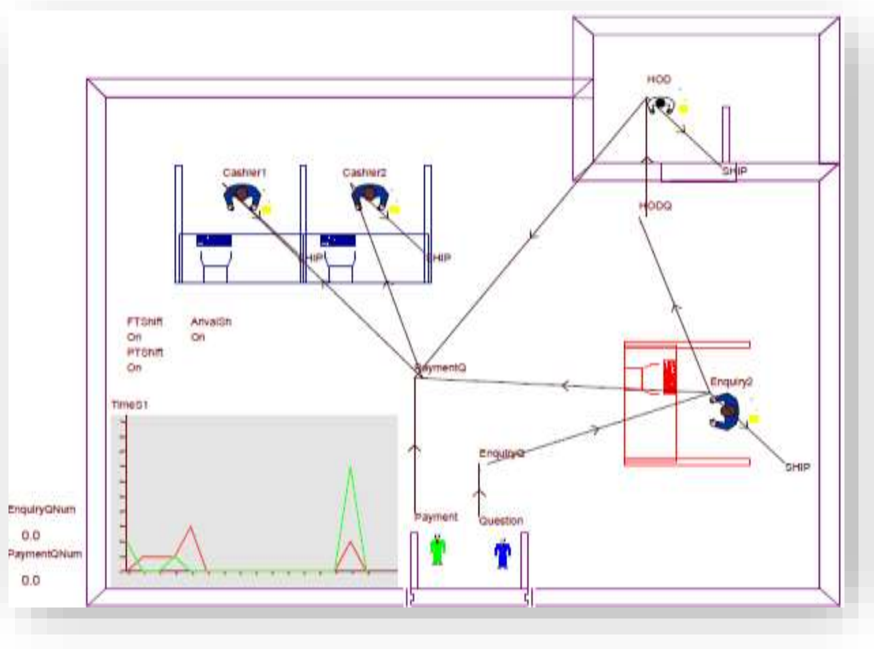


Figure 5. witness output

Table 13. After Change Results for Buffer Statistics

	PaymentQ					InquiryQ				
Buffer	Num of IN	Num of Out	Max Size	Ave Size	Ave Time	Num of IN	Num of Out	Max Size	Ave Size	Ave Time
Current	201	200	14	2.1	4.8	79	79	6	0.5	3.3
After Change	201	201	9	0.69	1.64	71	71	5	0.35	2.35

Table 14. After Change Results for Buffer Statistics

	Cashier1			Cashier2			Cashier3		
	Num Ops	% Idle	% Cycle	Num Ops	% Idle	% Cycle	Num Ops	% Idle	% Cycle
Current	55	50	47	56	51	48	91	16	84
After Change	123	42.45	45	78	45.75	54.25	-	-	-

Table 15. results of change

	HOD			Inquiry1			Inquiry2		
	Num Ops	% Idle	% Cycle	Num Ops	% Idle	% Cycle	Num Ops	% Idle	% Cycle
Current	13	46	55	44	40	58	37	40	60
After Change	14	41	45	-	-	-	71	45	55

In the next step, a questionnaire was designed to identify and evaluate the intensity of the relationship between the benefits index of the banking system. It was provided to a number of experts active in the field of scope. First, with the consultation of experts, the following indicators were determined by the banking benefits index: Impact on Alignment with goals and new technology (C1), Cost (C2), Responsiveness/speed (C3), competitive advantage (C4), flexibility (C5). (Fig 6)

Figure 6. factors that banking service benefits

Additional information for weighting the parameters was obtained through questionnaires and interviews with experts. A questionnaire is designed for the fuzzy DEMATEL, in which each criterion is defined briefly for easy understanding and response. Then, respondents are asked to analyze the casual relationships among the criteria by using a fuzzy linguistic scale. Casual relationships are interpreted through paired comparison analysis to generate the initial fuzzy direct relation matrix within and among the criteria. The average initial fuzzy direct relation matrix is obtained as shown in Table 16 below.

Table 16. Fuzzy decision-making matrix

C5	C4	C3	C2	C1	Z
(0.33,0.58,1)	(0.33,0.58,0.83)	(0.67,0.92,1)	(0.25,0.5,0.75)	(0,0,0)	C1
(0.5,0.75,1)	(0.33,0.58,1)	(0.75,1,1)	(0,0,0)	(0.8,1,1)	C2
(0.25,0.5,0.75)	(0.5,0.75,1)	(0,0,0)	(0.17,0.33,0.58)	(0.8,1,1)	C3
(0.33,0.58,0.83)	(0,0,0)	(0.25,0.25,0.5)	(0.25,0.5,0.75)	(0,0,0.25)	C4
(0,0,0)	(0.5,0.75,1)	(0.75,0.75,1)	(0.5,0.75,0.75)	(0,0,0.75)	C5

The total relations matrix was obtained as follows (Table 17):

Table 17. The relations matrix

Definitive D-R	Definitive D+R	Indicator
-0.4	-2.42	C1
-0.8	-2.87	C2
-0.08	-2.22	C3
1.41	-11.71	C4

-0.12	-2.23	C5

The results from the causal diagram are interpreted that Alignment with goals and new technology (C1), cost (C2), responsiveness (C3), and flexibility (C5) are divided into the cause criteria group, while competitive advantage (C4) are considered as effect criteria group. Since cause criteria have an impact on the banking service benefits, they should be considered strategically important. The most important criterion that influences banking service benefits is determined as responsiveness/speed and flexibility (C3, C5) with the highest D+R value.

In the last stage, the effect of the index on sensitive analysis alternatives was investigated and ranked with TOPSIS technique. Using this technique and the weights obtained in the previous step, the indexes are ranked. The linguistic terms are converted into intuitionistic fuzzy numbers. The aggregated intuitionistic fuzzy decision matrix is calculated as shown in Table 18.

Table 18. The fuzzy weightless scaling matrix

Criteria	CH1	CH2	CH3
C1	(0.57,0.31,0.12)	(0.75,0.1,0.15)	(0.53,0.4,0.07)
C2	(0.6,0.25,0.15)	(0.6,0.3,0.2)	(0.6,0.25,0.15)
C3	(0.75,0.1,0.15)	(0.57,0.32,0.15)	(0.71.0.13,0.16)
C4	(0.53,0.37,0.1)	(0.54,0.34,0.12)	(0.57.0.3,0.14)
C5	(0.66,0.19,0.16)	(0.57,0.32,0.14)	(0.71.0.13,0.16)

In the last step, calculate the distance of each point from the positive and anti-ideal ideal points. Indexes that are closest to the positive ideal and farthest away from the counter-ideal are preferred. However, due to the availability of opportunities to modify constraints, the sensitive analysis alternatives may change. This determined that decision-makers remove or add specific alternatives. The relative closeness coefficient values of each sensitive's analysis alternatives are shown in Table 19. Therefore, CH3 can be selected as the most suitable alternative with the highest benefits for this banking system.

Table 19. The results of sensitive's analysis alternatives evaluation and ranking using fuzzy TOPSIS

Rank	Similarity rate	Sensitives analysis alternatives
3	0.4	CH1
2	0.49	CH2
1	0.56	CH3

The results within this paper are obtained by averaging over 10000 iterations of random numbers. The results could be improved if more iteration is presented; also, the current implementation takes into account a single day. In the reality, banking traffic should be monitored for each day of the week in order to produce a better simulation. The implications of this study caused improved banking models in real-time implementation. Limitations presented with the current simulation model include that only a queuing strategy is implemented. This gives an opportunity for future research on how other queuing methods would affect the waiting time. Given the practical limitation to only simulate the banking model, future work allows for a practical implementation that could be designed that takes into account users as they arrive at the bank, sorting them into the correct queue, regarding the appropriate queuing strategy relating to their reason for visiting the bank. When implementing this in a bank, different scheduling methods may be used according to the requirements of the bank. Previously implemented methods focused on service quality, service time and efficiency of the bank.

The focus for a bank is to achieve customer satisfaction and obtain a profit. To be able to implement the scheduling methods for a banking scenario, the bank has to be remodeled by the management to include a machine to allocate tickets to customers and remove the normal queuing system for the bank. When the bank has been remodeled, different scheduling methods can be implemented to optimize the bank.

5. Conclusion

The main purpose of this paper was to optimize the banking service system with queue theory. There are many different alternatives to sensitive analysis that impact the banking benefits index. An integrated simulation, fuzzy DEMATEL and TOPSIS method are proposed to select the best alternatives, which have the greatest benefits for banking service. In the first step, the simulation method is used for analyzing the status of the bank and sensitive analysis alternatives. Then, the fuzzy DEMATEL method is applied to determine causal relationships among banking service benefits criteria. The indicators were extracted based on the literature review and experts. It was found that indexes C3 and C5 have the highest priority for placement. In the last step, the fuzzy TOPSIS method is implemented to identify the simulation's alternative, which has the greatest benefit of performance. It showed that CH3 has a high impact on the banking benefits index.

Using different scenarios is concluded that a queuing system for a bank can be improved. The different sensitive analyses implemented in this paper, each have their own functionality. The overall queuing scenario listed in this paper will reduce waiting time and improve customer satisfaction, whilst improving profits for a banking firm. Nevertheless, this study contains some limitations that might lead to future studies. First, due to the structure of MCDM methods, the evaluations are made based on human judgments and results may contain subjectivity. Additionally, the proposed method can be applied to other companies.

In future studies, different strategies can be suggested to solve the problem and the results of the proposed method can be compared. In real applications, problems could arise after the new policy, which presents an opportunity for further research. These problems may include a lack of information about service shortages in certain parts of the capital, increased times, and long queues for routes. Other types of problems could arise when companies force employees to change payment methods. Finally, the complexity of the allocation problem leads to the design of approximate algorithms, primarily based on meta-heuristics.

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