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Proposed Simulated Strategy To Increase Customer Satisfaction In A Chain Store Using Data Envelopment Analysis

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***Abstract*—Basically, customer service is not the only factor that influences their decide where to buy, but it is an important one. Quality of service can be a competitive privilege for companies and leads to affecting other factors. To satisfy this requirement, different types of techniques are used in companies by trial and error which imposes high costs on them. Using simulation as a tool for assessing the effect of alterations on the performance of the overall system might be significant. Thereby, in this study enterprise dynamics8 as a simulation event-oriented software is being applied to a case study of Refah chain stores in Sanandaj. The objective is to develop a simulation model based on real system to improve customer service and reduce waiting time in the queues of checkouts. For this purpose, in 2013 data are collected from existing system and applying full factorial design of experiments technique, different scenarios have been considered. To find the best one we used data envelopment analysis technique as a method for measuring the relative efficiency of similar units. The results show that, the optimum scenarios are 3, 5, 8, 2 and 6 respectively. Proposing a special checkout for customers with less shopping, the average waiting time in this queue according to scenarios '6', '8', '2' and '5' is almost 'zero' which enhances the customer satisfaction.**

Keywords— Simulation; Enterprise dynamics; Customer satisfaction; Design of experiments; Data envelopment analysis

I. INTRODUCTION

Nowadays, in many companies 'customer satisfaction index' is considered as one of the key performance indicators, few of them are aware of the importance of this indicator in the company's profitability, though. According to Singh (2006), one of the fundamentally important drivers of organizational success is that enterprisers must take the needs and wants of their customers into account.

Customer service is not the only factor that involves their decide where to buy, but it is an important one. Quality of service can be a competitive privilege for companies and in this way, other factors might be affected.

Most of the customers are not satisfied with chain stores in terms of the products and services they receive so improving the quality of servicing has a great effect on their satisfactory. Since waiting in line for clients is very uncomfortable, most of their complaints from service providers related to these categories.

Using simulation as a tool for enriching existing systems might be significant because it allows assessing the effect of alterations on the performance of the overall system.

The Oxford English dictionary describes simulation as: "the technique of imitating the behavior of some situation or system (economic, mechanical, etc.) by means of an analogous model, situation, or apparatus, either to gain information more conveniently or to train personnel". In simulation, a computer is used because of its speed in mimicking a system over a period of time. Again, most of these simulations could (in theory at least) be performed without a computer. But in most organizations, important problems have to be solved quickly. Computer simulation methods have developed since the early 1960s and may well be the most commonly used of all the analytical tools of management science (Pidd, 1986).

In a study, Maria (1997) answered some critical questions regarding an overview of simulation modeling. The paper includes anyone who is involved in system design and modification such as; system analysts, management personnel, engineers, military planners, economists, banking analysts, and computer scientists. The study may useful for those unfamiliar with the area of discrete event simulation.

As simulation is a great tool for assessing systems, so simulation introduction is very useful. Introducing simulation and modeling and the main concepts in simulation is developed in Carson (2003)'s study. In addition, a number of key notes related to simulation team and managing a simulation project is presented through some guidelines in this study.

A discrete event simulation study of an emergency department in Moncton (Canada) was modeled, analyzed and improved by Duguay and Chetouane (2007). An analysis of waiting times by patient codes demonstrated high waiting times in comparison with Canadian standards. Thus, the objective of the study

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was to reduce patient waiting times and to improve overall service delivery and system throughput. Model development was made using Arena software.

Brickner et al. (2010) simulate a queuing model useful in a service system with the help of ARENA simulation software. The service calls (henceforth referred to as customers) arrive to a processing center according to a Markovian arrival process (MAP). They observed that servicing calls that arrive in a positively correlated manner incur the largest expected total cost per hour to the system.

A review is done on commercial discrete event simulation software and its models by Cimino et al. (2010). In this survey some critical aspects such as domains of application, 3D and virtual reality potentialities, simulation languages and prices is considered. Moreover, a supply chain order performance simulator (SCOPS, developed in C++) is presented for investigating the inventory management problem along the supply chain under dissimilar supply chain scenarios.

Using simulation optimization a decision support tool for Supply chain coordination (SCC) with contracts was developed by Eskandari et al. (2010). They propose a new linear demand model in order to represent a real competitive price and effort dependent sensitivity. Due to the stochastic nature of the market demand and the interaction between decision variables, simulation employed to model/analyze the SCC with contracts problem as a tool. Solving such problems with traditional mathematical techniques are usually time consuming and subject to rather restricting assumptions. The use of simulation modeling and optimization in the supply chain contracts problem has allowed them to effectively analyze and solve the problem in order to realize the channel coordination and find the optimum or near optimum set of decision variables in the cases of Centralized SC or coordinated supply chain using contracts.

Ibrahim et al. (2012) review some models proposed for call arrivals to a telephone call center (Gans, Koole, and Mandelbaum 2003; L'Ecuyer 2006; Aksin, Armony, and Mehrotra 2007). These centers have a huge economic importance. A key aspect of their management is to try to optimize their staffing and the work schedules of agents, to minimize the operating cost while providing a sufficiently good quality of service. These models are used both for simulation and to forecast incoming call volumes to make staffing decisions. They evaluate the forecasting accuracy of selected models in an empirical study with real-life call center data.

A literature review of simulation modeling for the provision of social care services presents by Onggo (2012). The review discusses the gap between findings from the literature and challenges in social care policies. The paper shows that the number of research articles on the application of simulation modeling to the provision of care services is limited, especially in the areas of care supply and care delivery methods. Hence, there are good opportunities for simulation researchers who are interested in contributing to improving the provision of social care services. Potential areas in which simulation modeling work can make a real impact (based on the public engagement discussion organized by the UK Department of Health) have been identified. These include the provision of good quality personalized care services (especially the supply side and the use of assistive technologies), the interface between care services and relevant services, intervention and early prevention, and the sustainable financing of care services.

This paper is presented as follows: in section 2 we present the structure of our conceptual model and the performance measures. Section 3 shows computer simulation model of existing system applying enterprise dynamics8 software. In section 4 results and discussion are shown. Conclusions and further research recommendations are presented in section 5.

II. CONCEPTUAL MODEL

In this study, it is considered a case study of Refah chain stores in Kurdistan which is located in Sanandaj and shoppers of the foodstuffs are taken in to account. Refah Supermarkets is an Iranian supermarket chain. The establishment has currently 160 branches across the nation. Refah is carrying a wide assortment of goods in the lines of food, beverages, fresh produce, hygienic, cosmetics, home appliances, electronics, clothing, textiles and stationeries.

Using 'oval' symbol as an entity symbol which has the roll of input in a system and 'rectangular' symbol as an activity symbol, Data flow diagram (DFD) is drawn for customers and is indicated in Figure 1.

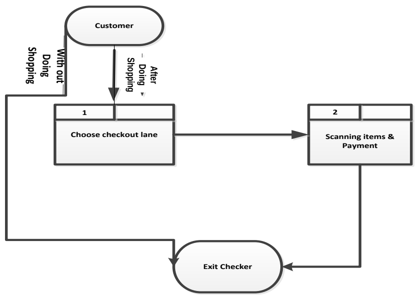

Fig. 1. *Level one of Logical Data Flow Diagram in Sanandaj Refah chain store*

For evaluating performance of the system (our case study), we define some performance measures (PFMs). These output variables are defined as the output we want to collect. Table 1 shows PFMs of the chain store.

TABLE I. PERFORMANCE MEASURES OF SANANDAJ REFAH CHAIN STORE

PFMs	Description
Y1	Average queue at queue3
Y2	Average waiting time at queue3

In the next section, simulation software used to model the checkout part of the chain store. Using Enterprise Dynamics8 (ED) the conceptual model is converted. Regarding ED simulation software, we use its special elements to describe the servicing process such as Server as an activity represents the scanning items and payment in checkout lanes of the system.

III. COMPUTER SIMULATION MODEL

In this section, applying ED the converted model is depicted as follows.

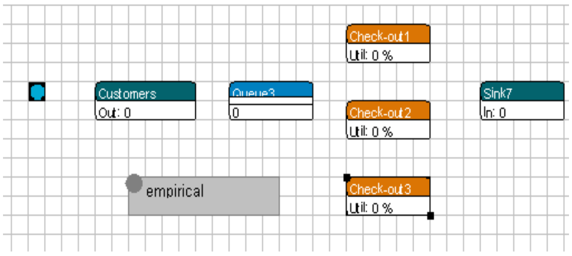

Fig. 2. *The snap shot of created simulating model using ED software*

In Sanandaj Refah chain store, there are three checkout lanes available, where after doing shopping the customers go to the checkouts and choose a queue. In each queue, the scanning time per product is 5 seconds and that payment takes 60 seconds.

Some special 4DScript coding is used to run the simulated current state model accurately. Then, using 4dscript coding in the required atoms, we have these commands in the following Servers, namely Check-out1, Check-out2 and Check-out3. (see figure 2):

Server: Cycle Time= products*5+60.

Initial sampling information is based upon last two months. On Thursdays and Fridays, the days when the study is conducted, the checkouts are open from 9:00 to 20:00 hours. Data of 12:00 to 14:00 were ignored in this study. Each checkout has 1 hour break after working for about 8 hours. An average about 500 shoppers arrive during 8 hours on a random basis. Measurements have shown that the following empirical probability (P) distribution can be used for the number of purchased products (N). The details are indicated in Table 2.

TABLE II. EMPIRICAL PROBABILITY DISTRIBUTION FOR CYCLE TIMES IN ED MODEL OF SANANDAJ REFAH CHAIN STORE

N	P	N	P	N	P
1	1	11	5	21	2
2	1	12	4	22	2
3	2	13	4	23	2
4	2	14	4	24	4
5	2	15	4	25	4
6	5	16	4	26	4
7	5	17	4	27	4
8	5	18	4	28	4
9	5	19	3	29	1
10	5	20	3	30	1

In addition, based on collected data, statistical characteristics of required atoms are determined and the parameters are recorded in the related atoms. The details are indicated in Table 3.

Then, the required simulation adjustments for running the model in ED are made.

IV. RESULTS AND DISCUSSION

A. *Applying Simulation of Existing System and the Validity of Simulation Model*

To express the performance of the proposed simulated model, applying ED software, these settings were done in Experimentation menu. In Experiment wizard the amounts of Observation, Number of observations and Warm up period are defined in the same sequence as 80 hours, 30 and 8 hours. Afterwards, the results based on the real world situation are taken in to account as follows;

Waiting time in the checkouts is the main problem in this system, which is considered to be decreased.

TABLE III. STATISTICAL CHARACTERISTICS OF REQUIRED ATOMS IN SANANDAJ REFAH CHAIN STORE (TIMES IN SECONDS)

Input variables	Variable code	Statistical distribution	Parameters
Cycle time of checkout1 (in seconds)	CT1		$products * 5 + 60$
Cycle time of checkout 2 (in seconds)	CT2		$products * 5 + 60$
Cycle time of checkout 3 (in seconds)	CT3		$products * 5 + 60$
Inter-arrival time of customers (in seconds)		Neg Exp	λ =1/57.6
Time till first product of customers (in seconds)		Neg Exp	λ =1/57.6
Time to failure for each checkout	MTTF		Hr(8)
Time to repair for each checkout	MTTR		Hr(1)

After the implementation of the current state ED model, it is crucial that the model represents the actual system performance. Accordingly, it is important to validate the simulation model. Regarding this, the graphical difficulties of model has been resolved by experts and operators in Sanandaj Refah chain store and the final model was confirmed by the same key personnel and experts. In addition, to test the validity of the model we used the non-parametric Mann-Whitney test. Based upon 23 samples, the Mann-Whitney-Wilcoxon test gave a P value of 0.0059 with adjusted ties tell us not to reject the null hypothesis at the 10% significance level and W of 964.0. However, there is some weak evidence of a difference in medians between the two data series. The results according to Minitab software, comes here:

N Median

Waiting time simulated 30 1104.2

Real waiting time 23 780.0

Point estimate for ETA1-ETA2 is 285.1

90.3 Percent CI for ETA1-ETA2 is (96.0; 465.2)

W = 964.0

Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0059

The test is significant at 0.0059 (adjusted for ties)

B. Design of Experiments and Comparative Table

A new strategy is created to improve the situation of Sanandaj Refah chain store based on the expert's approach. Accordingly, we consider one of the checkouts as a special checkout which is exclusively allocated to those customers who have some specific number of shopping (a defined range of shopping) and other checkouts are assigned to other customers. To implement this strategy, the following 4DScripts and some other adjustments are made:

Customers: Trigger on creation = setlabel([items],products,i)

Server: Cycle time= label([items],first(c))*5+60.

In this case, our PFMs are modified and adapted PFMs are shown in Table 4.

TABLE IV. UPDATED PERFORMANCE MEASURES OF SANANDAJ REFAH CHAIN STORE

PFMs	Description
Y1	Average queue at queue3
Y2	Average waiting time at queue3
Y3	Average queue at queue9(special queue)
Y4	Average waiting time at queue9(special queue)

An ED model of this strategy is also depicted in Figure 3.

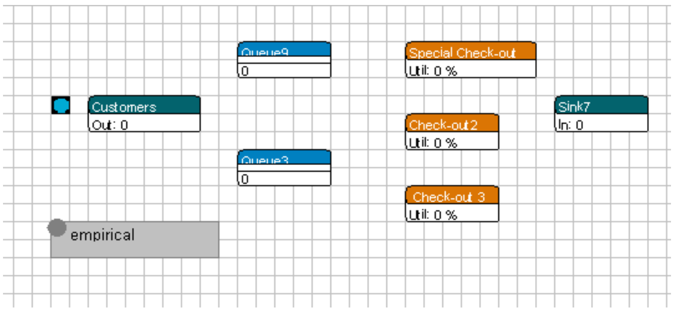

Fig. 3. *The snap shot of proposed strategy created simulating model using ED software*

To design the scenarios based on this new strategy, we use design of experiment (DOE) method and the methodology of full factorial DOE is applied. DOE is a method to identify the important factors in a process then identify and fix the problem in a process. In real engineering settings, there are usually multiple factors involved and it is typically important to consider them together in case they interact.

Factorial design is a method to determine the effects of multiple variables on a response. This method reduces the number of experiments one has to perform by studying multiple factors simultaneously. Because factorial design can lead to a large number of trials, which can become expensive and time-consuming, factorial design is best used for a small number of variables with few states (1 to 3). Factorial design works well when interactions between variables are strong and important and where every variable contributes significantly.

Therefore, we define input variables as X_1, X_2 and X_3 respectively as maximum allowable number of shopping in special checkout, time to failure (MTTF) and then time to repair (MTTR) of each checkout.

The following scenarios are defined based on DOE to increase productivity, efficiency and reduce waiting time in the system. Table 5 presents the coding of ranges in scenarios.

TABLE V. THE CODING OF RANGES IN SCENARIOS

Inputs	The range	
Input variables (X)	***Low(-1)***	***High(+1)***
X_1	5	11
X_2	Hr(3)	Hr(5)
X_3	Hr(0.5)	Hr(1)

Then, based on Table 5 and full factorial DOE method, the scenarios are created. Table 6 indicates the scenario design based on coded ranges.

Using data envelopment analysis technique the proposed scenarios are compared.

For years, data envelopment analysis (DEA) has been considered as one of the most well-known methods for measuring the relative efficiency of similar units. DEA is a mathematical method of performance assessment of homogeneous decision making units (DMUs). It has been successfully implemented to evaluate different kinds of DMUs such as producer or service provider units, in recent years.

TABLE VI. THE SCENARIO DESIGN BASED ON CODED RANGES

Scenario#	X_1	X_2	X_3	Y_1	Y_2	Y_3	Y_4
1	+1	+1	+1	76.64	7213.08	5.91	910.96
2	-1	+1	+1	146.14	12229.57	0.07	64.4
3	+1	-1	+1	126.57	13142.15	6.16	1034.72
4	+1	+1	-1	13.11	1208.63	2.24	337.41
5	-1	-1	+1	147.98	13812.1	0.09	111.78
6	-1	+1	-1	144.46	11086.7	0.04	37.96
7	+1	-1	-1	47.14	4344.66	3.18	482.72
8	-1	-1	-1	146.5	11943.94	0.06	57.48

We considered each scenario as a DMU, since their inputs and outputs are the same type. Then applying the model first developed by Charnes, Cooper and Rhodes called as CCR model the efficiency of each scenario is calculated.

They formulated their efficiency model for ‘n’ unit decision maker with ‘m’ input and ‘s’ output as a ratio of a weighted sum of outputs to a weighted sum of inputs. The efficiency of unit ‘zero’ is a fractional linear program as shown in (1).

$$\max E_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

$$s.t. \quad \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \qquad j = 1,2,\ldots\ldots,n$$

$$u_r \ge 0 \qquad r = 1,\ldots\ldots,s$$

$$v_i \ge 0 \qquad i = 1,2,\ldots\ldots,m \qquad (1)$$

Where ‘u_r’, and ‘v_i’ are the weight to be applied to the outputs and inputs. Based on computations by Lingo the results are shown in Table 7.

It is clear that, higher efficiency indicates better scenarios, i.e. 1. Therefore, scenarios with numbers ‘3’, ‘5’and also ‘8’ will be helpful in order to improve the situation of this system.

TABLE VII. THE PERFORMANCE MEASUREMENT OF SCENARIOS BASED ON DEA

Scenario #	Efficiency
1	0.8803925
2	0.9875668
3	1.000000
4	0.3260883
5	1.000000
6	0.9860769
7	0.4665224
8	1.000000

V. CONCLUSION

In this study, in order to decrease waiting time in checkouts and improve the service level of Sanandaj Refah chain store, a simulation model was created, taking into account numerous system constraints and process time logic based on statistical methods. This model was validated against waiting time within a 90% confidence interval. Applying ED, the simulated model can allow various modeling scenarios to be examined in future simulations with less expense, time and resources than experimentation with the real world system.

As it is taken from the results;

In efficient scenarios:

- Applying scenario ‘8’, the average waiting time at queue number 3 is ‘199’ minutes, which is the minimum waiting time in Q3 out of others.

- Minimum waiting time at queue number 9 is approximately ‘1’ minute, which belongs to the scenarios ‘8’.

- Average number of people in the queue at Q3 based on efficient scenarios are ‘127’, ‘146’ and ‘148’ which is belong to scenarios ‘3’, ‘8’ and ‘5’ respectively.

In all the scenarios:

- Approximately there is not any people who are waiting in the queue of special checkout (Q9), based on scenarios ‘8’, ‘5’, ‘6’ and ‘2’.

- Although minimum stay time in Q9 is about ‘38’ seconds applying scenario ‘6’, minimum stay time in Q3 is ‘20’ minutes applying scenario ‘4’.

- Scenario ‘5’ is one of the efficient scenarios, however average waiting time in the Q3 is ‘230’ minutes which has the maximum amount out of other scenarios.

-Minimum Q3 is ‘13’ people in queue by using scenario ‘4’, while minimum Q9 is about ‘zero’ and this is taken by utilizing scenarios ‘6’, ‘8’, ‘2’ and ‘5’.

This study can be extended for future works in different ways,

- The scenarios will be more complete by extending the defined ranges in DOE.

-The proposed scenarios were focused basically on decreasing the waiting time in the checkouts, while there are other important factors such as sufficiently good quality of service that affect shopping to be more satisfactory and should be considered.

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