The cost analysis of a leading optics business in Saudi Arabia

Ahmed A. Bakhsh

Industrial Engineering Department,
Faculty of Engineering,
King Abdulaziz University,
Jeddah, 21589, Saudi Arabia
Email: aabakhsh@kau.edu.sa

Abstract: This study aims to use discrete event simulation (DES) to minimise the processing cost of a leading optics business in Saudi Arabia. Data is collected from three branches to calculate the operating cost and delivery time of the products. A proposed solution is developed to replace three technical workshops inside every branch with one central workshop in the city. Numbers of replications are carried out to reach the optimal solution. Cost analysis is done to compare the process cost, delivery time and idle working hours of the two options. A significant reduction is observed in the process cost and delivery time of the products besides increasing the idle working hours of the technicians. These improvements can be utilised to enhance the productivity and profitability of the organisations.

Keywords: cost effectiveness; discrete event simulation; DES; resource allocation; delivery time; optimal solution; productivity; profitability; business process re-engineering; production scheduling; Saudi Arabia.

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Biographical notes: Ahmed A. Bakhsh is an Associate Professor of Industrial Engineering at King Abdul-Aziz University in Jeddah, Saudi Arabia. He received his BS and MS degrees in Industrial Engineering from King Abdul-Aziz University in Jeddah, Saudi Arabia. He also received an MS and PhD degrees in Industrial Engineering from the University of Central Florida (UCF) in Orlando, FL. His research and teaching interests include organisational development, stochastic objectives, cluster analysis, decision making analysis, object-oriented simulation, discrete event simulation, heuristic optimisation, strategic management, and forecasting. He is a member of SIAM, IIE, ASQ, and SCS.

1 Introduction

Organisations are always keen to adopt business strategies that enhance their market share and competitive advantage rather than only surviving. Nowadays, computer simulations are widely used to analyse and optimise process workflows (Muthyala et al., 2018). Different types of simulation models, such as system dynamics, business games, spread sheet simulation and discrete-event simulation (DES) are used to enhance the effectiveness and efficiency of the systems (Kleijnen, 2005). This study focuses on a leading optics organisation in Saudi Arabia, which deals in the field of eyewear, lenses, and related services. The orders received from the clients in different branches are further processed in technical workshops available within the same branch. It not only enhances the operational cost of business but also creates difficulty in ensuring the quality of services. Scope of the study is limited to three main branches that deal in lens cutting and glasses preparation for customers. The study aims to use DES model to analyse the current system of these branches. Each of these three branches has its own built-in workshop to receive customers' orders and do all necessary process. DES model is being designed on the proposition to have one central workshop instead of three independent workshops and see its impact on the business operations. The goal is to increase the productivity and profitability by reducing the overall operational cost.

The next section presents the literature review for this study. In Section 3, problem description is presented. The methodology is described in Section 4. The proposed solution, results and comparison are presented in Section 5. Conclusions and future suggestions are presented in Section 6.

2 Literature review

Simulation modelling has numerous commercial software that help analysts to pick up the best suited package (e.g., user-friendly interface, add-on modules, reporting and statistical analysis, etc.) (Mahboubian, 2010). The simulation users range from academic institutions to industrial clients like manufacturing, health, communications and military (Hlupic, 2000). A typical simulation model is used to reduce the complexity and dynamics of those processes that involve many components (Nallapati et al., 2018). The main goal is to satisfy customer demand with minimal cost. Thus, simulation modelling improves work processes by recommending the optimal solution to decision makers and problem solvers (Klodawski et al., 2018).

The systematic procedure is mandatory to conduct any valid or reliable simulation study (Abdelkhak et al., 2018). However, the data used to construct the simulation model determines the efficiency of the results. This data can be gathered using different methods, e.g., technical documents; interviewees; site visits; and questionnaire surveys or it can be extracted from qualitative data and converted into quantitative data (McCusker and Gunaydin, 2015).

Figure 1 The systematic procedure for simulation study (see online version for colours)

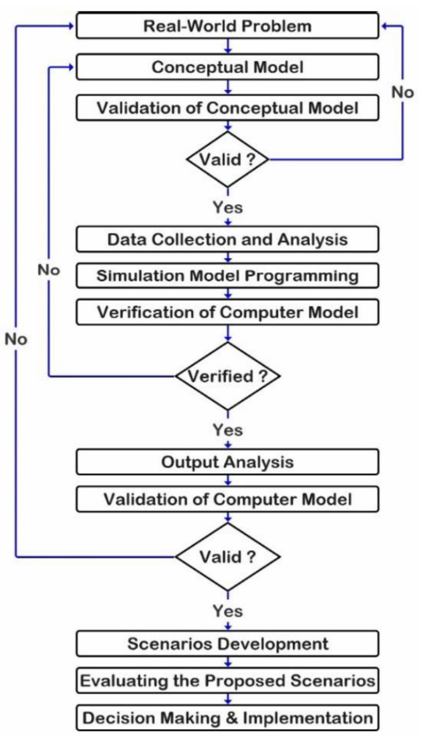
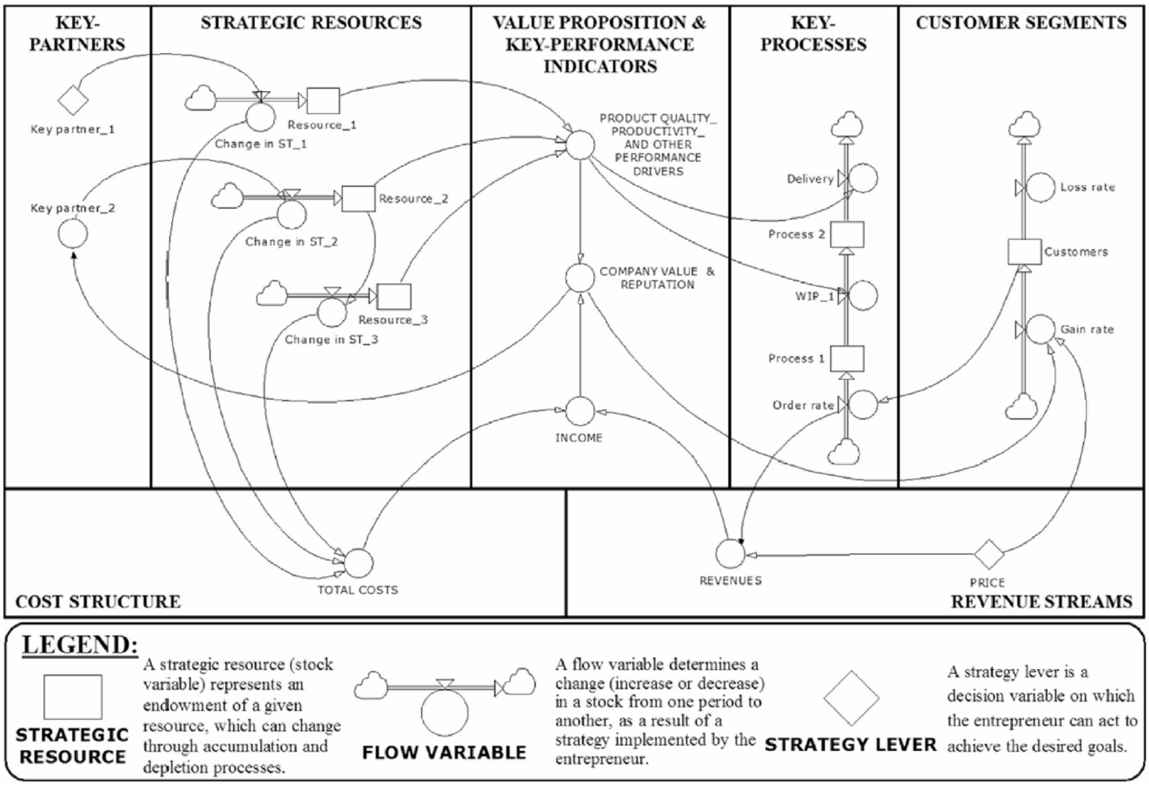


Figure 1 shows the schematic procedure of the simulation study, in which the real-world problem is initially conceptualised. Once the concept passes the validation, only then can data collection and its analysis be done, otherwise, necessary changes must be made in the initial concept. The simulation is developed on the basis of data analysis results. Different combinations can be tried at this stage to reach the final optimum solution. The discrete event simulation modelling is an efficient tool, which is used for objectivity optimisation (e.g., cost, time, distance, etc.). It models the operation of a system as a discrete sequence of events that are spread over time (Dagkakis and Heavey, 2016). In a study conducted by Burinskiene et al., efficiency of the warehouse was improved by reducing travel time and cost in order picking and replenishment activities. DES modelling was used to schedule forklift driving and picking vehicle routes. Resultantly, 67% of the wastage was reduced in warehouse (Burinskiene et al., 2018). Another research revealed the combination of DES and ARENA to identify bottlenecks, evaluation of possible alternatives and final redesigning of facility layout to improve the system performance (Rahman and Sabuj, 2015). Palvic et al. used DES modelling to investigate smart systems implementation in the boarding process at Split Airport. Human and machines resources were modelled by integrating as-is process simulation and to-be process simulation. The model helped the decision makers to find an optimal decision regarding the effects of cost savings and turnaround time in the processes (Pavlic et al., 2018).

On the other hand, many scholars and practitioners argued the affectivity of static business models in the changing environments of 21st century and instead, proposed the dynamic business models to improve system performance, innovation, and value creation as shown in Figure 2 (Cosenz and Noto, 2018).

Figure 2 depicts the key processes and strategic resources that play an important role in optimising the objectives. Moreover, key partners and customers are shown in the extreme left and right columns, respectively. Centre column highlights the key performance indicators to assess the productivity, cost, and reputation of the system. During the normal course of process flow, strategic resources can be added or depleted, which are measured with the help of different variables. A strategic lever is used to achieve a crucial balance between revenue and costs with the help of dynamic decision making. However, the addition of social, economic and environmental impacts further enhances the affectivity of multi-criteria decision-making models (Baudry et al., 2018). Simultaneously, any compromise in the process of decision-making models not only harms the credibility of business decisions but also hampers the financial growth of the organisations (Alvandi et al., 2017). Keeping in view the use of mobile phones in all spheres of life, an important research was conducted by Brožek and Jakeš (2017) to analyse the application of smartphones in simulation-based decision making. Another research integrated the use of fuzzy techniques and analytical hierarchy process (AHP) to analyse human behaviour in the prevention of industrial incidents (Petrillo et al., 2017). Activity-on-arrow (AOA) approach is used to simulate the use of construction resources to improve construction productivity and reduce operational cost (Zaneldin, 2017). Similarly, waste separation and recycling simulations are used by organisations to reduce costs and increase profits (Straka et al., 2018). Discrete event simulation can be used to enhance the efficiency of production line with the help of any logic software by identifying and analysing the bottlenecks (Heshmat et al., 2017).

Figure 2 The dynamic business model structure



Moreover, simulation modelling is used to manage the costs of product life cycle with the objective to increase the attractiveness of product in market (Todic et al., 2017). Another study used discrete event simulation to analyse the cost of surgical procedures in the operation room of hospital with an aim to optimise resource consumption (Monnickendam and De Asmundis, 2018). Various studies indicated that simulation and modelling is an effective tool, which is used by decision makers to see how real-world systems behave over time (Scheidegger et al., 2018).

Numerous contemporary studies are carried out to optimise business processes using DES and other simulation models. However, most of these researches are context specific and related with the business categories. The business dynamics of GCC countries in general and Saudi Arabia is significantly different from other countries due to the dependency on expatriate workers. Under these situations, it is quite imperative to use simulation modelling on small and medium level business enterprises in the context of Saudi Arabia with an objective to find any cost-effective solution.

3 Problem description

The optical business has different classifications depending upon the number of services being offered in their branches. In this regard, some of the branches only offer frames and lenses in their showrooms, while others have small technical workshops inside along with specialist labour. Branches without built-in technical workshop have to send their jobs to one central workshop owned by the same optics organisation. However, sending a job to the central workshop requires a logistic contract with some local transport company for picking up the glasses from the concerned branch, take it to the central workshop and then deliver it back when the job is done. This process, which is repeatedly done increases the logistic costs and reduces the profitability. This study aims to find an optimum solution for the optics organisation. The objective is to reduce the process cost without compromising on customer satisfaction. Scope of the study is limited to three branches that are in the city of Jeddah.

4 Methodology

Simulation is considered as a powerful tool for decision making and problem solving. Thus, the study aims to use discrete event simulation for analysing the current and proposed situations. The performance measures include the order time (received from the client until delivered back), the cost of operations (i.e., the salaries of workers in the workshop), fixed cost (i.e., machines in the workshop), and the utilisation of the workers.

Data collection is done for selected branches that are included in the scope of study. Data is collected from three branches using the same method to ensure that no discrepancy is done during its collection. The collected data is related with the cost, number of workers, number of machines in each workshop, and the approximate demand in each shop.

Table 1 The input fixed data

No.	*Input data*	*Explanation*	*Value*
1	Shifts time	Shifts time for worker in central workshop	8 hours per worker (2 shifts)
2	Run time	running time for the simulation model	360 days
3	No. of workers	Number of workers in the workshops	3 at the central workshop and 1 in each branch
4	No. of machines	Number of machines in each shop beside the central workshop.	4 at the central workshop and 2 in each branch
5	Cost of machines	Total cost for machines	SR 250,000
6	Salaries	Salaries for each worker on central workshop monthly.	SR 2,500 for each worker
7	Cost of maintenance	The maintenance cost for machines monthly.	SR 160 per machine
8	Cost of electricity	The electricity bill monthly.	SR 400 workshop
9	Cost of transportation	Transportation cost paid to transportation company monthly.	SR 2,400 for each branch

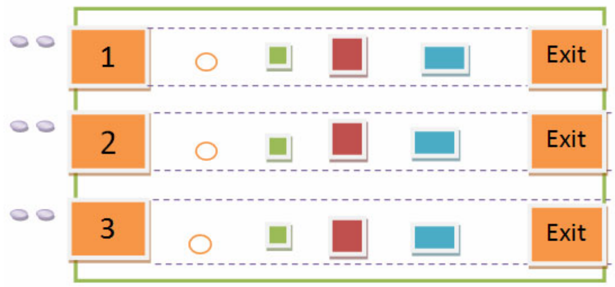
Table 2 The input variable data

No.	*Input data*	*Explanation*	*Distribution*
1	The time of scanning	The time required in the scanning of lenses.	EXPO(3)
2	The time of cutting	The time required in the cutting of lenses.	EXPO(8)
3	Transportation time	Moving time for cars between central workshop and branches	EXPO(20)
4	Preparation time	Preparation time to get a product ready	EXPO(3)
5	The current demand in central workshop yearly	Number of lenses orders that arrive daily to the central workshop	NORM(52.7, 15)
6	The current demand in first branch yearly	Number of lenses orders that arrive to the first branch.	UNIF(9.5, 16.5)
7	The current demand in second branch yearly	Number of lenses orders that arrive to the second branch.	NORM(15.8, 3.55)
8	The current demand in third branch yearly	Number of lenses orders that arrive to the third branch.	UNIF(8.5, 15.5)

The collected data is used as inputs for the simulation model, which is further divided into fixed and variable data as shown in Tables 1 and 2. Simulation environment consisted of both fixed and variable inputs that are shown in Tables 1 and 2, respectively. ARENA software was used to conduct the simulation analysis. Constant inputs include shift times, runtime, number of workers, number of machines and costs (machines, salaries, electricity and transportation), while stochastic variables include the times of (scanning, cutting, transportation and preparation) and demands in (central workshop, first branch, second branch and third branch). All these inputs are used in simulation software ARENA. In the first phase, dummy data is used for the modelling. The results of the dummy data were shared with concerned business experts to get the necessary verification. Once the model was verified, then, the actual data was used to get the validated results.

In this study, three branches are considered for the optics organisation. Each of these branches has its own workshop with one worker who operates it. These branches (with workshop inside) complete the job without any outside help. Figure 3 demonstrates the schematic diagram of the three branches.

Figure 3 The schematic diagram for the three branches (see online version for colours)



On the other hand, four machines are available in the central workshop. The first two are scanning machines and the rest are cutting machines. A separate preparation surface is available to prepare lenses after scanning and cutting. There are three workers in the central workshop. Two of them work on the machines, while the third one is responsible for preparing the lenses. The central workshop does not receive any orders of lenses from the three branches. Figure 4 shows the schematic diagram for the central workshop while Table 3 illustrates the symbols description for schematic diagram.

Figure 4 The schematic diagram for the centre workshop (see online version for colours)

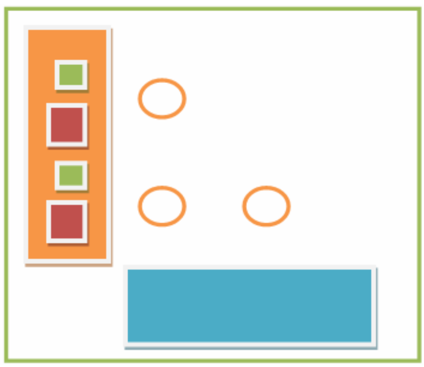


Table 3 The symbol description for the schematic diagram (see online version for colours)

Symbol	*Meaning*
	Scanning machine
	Cutting machine
	Worker
	Preparation surface

5 Computational study and performance comparison

This section illustrates the proposed solution and a comparison to the current situation.

5.1 The proposed solution

The customer arrives in any of the three branches and gives an order. Subsequently, the car comes to the branch and collects the order. It then transports the order to the central workshop. The central workshop receives the order and starts the process by cutting the lenses. Once the finished lenses are ready, the car transports them back from the central workshop and drops them at the respective branch. Customer comes and receives their order. Figure 5 shows the schematic diagram for the proposed system and Table 4 illustrates the symbols describing the schematic diagram.

Figure 5 The schematic diagram for the proposed system (see online version for colours)

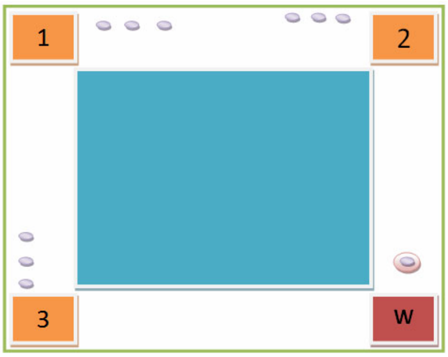


Table 4 The symbols description of schematic diagram (see online version for colours)

Symbol	*Meaning*
	Shops
	Central workshop
	Entities
	Car that carries the entities from shops to the central workshop and vice versa

There are three shops with their own classifications as flagship. The car, which is used for the transportation of orders, is not owned by the optics company. The process of picking and dropping the orders is outsourced to a third party and the car visits each branch twice a day. Simultaneously, the central workshop consists of four machines. The first two are scanning machines and the rest are cutting machines. There is also preparation surface that prepares lenses after scanning and cutting. There are three workers in the central workshop and two of them working on the machines and the third one is responsible for preparing the lenses.

After running the simulation model and tracing the entities that starts from the use of vehicles to the central workshop and back to the branches, each entity is given an acceptable time. The run time for the system 1 year is equal to 360 days. The number of replications is 91 as determined by the formula in equation (1):

$$No. of\ replications = n_0 \frac{h_0}{h}, \tag{1}$$

where n_0 the number of initial replications, h_0 the half width 95% confidence interval and h is assumed as a number, which is about one third of h_0.

5.2 The analysis of proposed solution

Table 5 shows the average time consumed between the requesting of order, till the time it is completed and delivered back to the customer. Figure 6 shows the confidence interval with 95% for the total time of each demand. The average time for the orders of the first branch is 14 hours and 34 minutes per order. In the second branch, the average time is 14 hours and 12 minutes per order. In the third branch, the average time is 14 hours and 11 minutes per order. The average time to process the order in central workshop is 11 hours and 43 minutes.

Table 5 The average time of making order

Place	*S1*	*S2*	*S3*	*CWD*
Total time (H)	14.58	14.02	14.19	11.72

Table 6 shows the utilisation for the three workers in the central workshop. Figure 7 shows the confidence interval with 95% for the utilisation of all workers in the central workshop. The percentage of utilisation for the first worker is 78%. The percentage of utilisation for the second worker is 75%. The percentage of utilisation for the third worker is 78%.

Table 6 Total time in the system

Worker	*1*	*2*	*3*
Utilisation	78%	75%	78%

Figure 6 C.I 95% for the total time of each demand (see online version for colours)

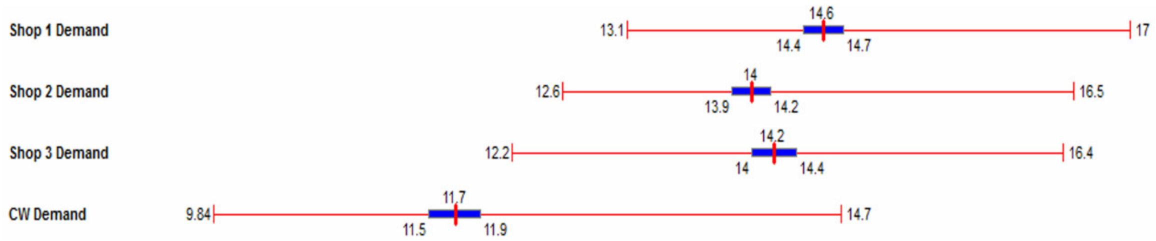
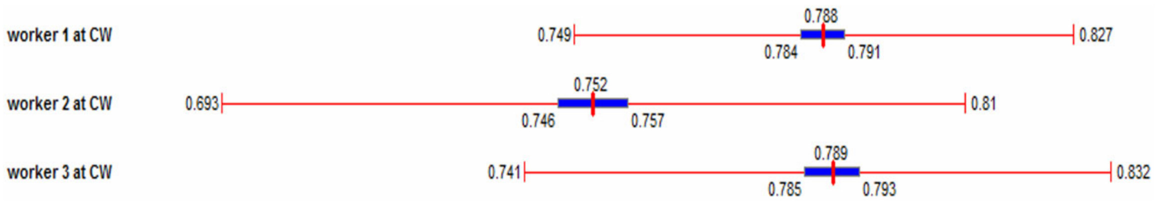


Figure 7 C.I 95% for the utilisation of all workers (see online version for colours)



5.3 Performance comparison

This section compares the results of current system with the results of proposed system. The comparisons are done for the following indicators:

- The capability of the central workshop to receive additional orders from the three branches (i.e. is the workshop capable? the idle time for resources?)
- The extra resources (i.e. machines/ workers) available in the central workshop to accept more orders from branches (if needed).
- The time needed to complete orders for customers (when central workshop is the only option).

After simulation model is developed and run for each situation independently, it becomes clear that plenty of idle time is available for the resources (workers/ machines) in the central workshop. It is observed that new orders can be accepted without giving any additional resources to central workshop. In addition, the order completion time is also reduced in the new proposed system. Table 7 show the comparison between the results for the current system (A) and the proposed system (B).

Table 7 Comparison between results

No.	*Comparison factor*	*Result A*	*Result B*
1	The Idle time percentage for the first worker at central workshop.	82%	22%
2	The Idle time percentage for the second worker at central workshop.	87%	25%
3	The Idle time percentage for the third worker at central workshop.	84%	22%
4	The time needed to deliver the orders for the first branch.	14 h and 34 min	4 h and 29 min
5	The time needed to deliver the orders for the second branch.	14 h and 12 min	5 h and 36 min
6	The time needed to deliver the orders for the third branch.	14 h and 11 min	4 h and 11 min

DES model improved the working of central workshop by reducing the process time of orders without using any additional resources. Table 8 shows information related to costs for the different situation, thus, leading to the minimisation of the system overall cost, which is the prime objective of this study.

Table 8 Data related to the cost

No.	*Input data*	*Value*
1	No. of workers	3 in the central workshop and 1 in each branch
2	No. of machines	4 at the central workshop and 2 in each branch
3	Cost of machines	SR 250,000 per workshop
4	Salaries	SR 2,500 for each worker per month
5	Cost of maintenance	SR 160 per machine per month
6	Cost of electricity	SR 400 per workshop per month
	Cost of renewal fee of workers	SR 650 per year
7	Cost of transportation	SR 2,400 for each branch per month

Table 9 shows the cost of the current system and the proposed system, before any economic changes take place. The table shows a comparative cost analysis of central workshop and three branches along with savings. The annual saving is SR 43,710, if the proposed system is implemented. Moreover, after adding the cost of the machines for three branches workshops that are cancelled, the saving cost can be SR 750,000 in addition to the annual saving cost.

Table 10 shows the cost comparison between current system and the proposed system. One of the changes that can affect the system cost is any possible increase in the current price of electricity (e.g. if cost of electricity is SR 400, it is changed to SR 855). Also, the change in the renewal fee of workers, which is determined by the government can affect the cost analysis, but the above mentioned two factors do not cause any significant change in the current cost analysis of the organisation. However, the effect of these minor economic changes is also shown in Table 10. The annual saving is calculated at SR 60,540, if the proposed system is implemented. Moreover, if the cost of the machines that are cancelled for three workshops is counted, one time saving of SR 750,000 can further add to the recurring annual saving. Present study used DES to analyse complex data with the help of different iterations. Multi-variant comparisons are done against different options in the presence of both qualitative and quantitative data. This study is unique in the context of a country like Saudi Arabia, where the small and medium enterprises are shifting towards cost affectivity due to changing economic situations. These results can also be used by business owners of other GCC countries (Gulf cooperation council) due to the commonality of socio-cultural values.

Table 9 Comparison between the current and proposed system cost before the economic changes

Input data	*Current system*		*Proposed system*	
	3 branches	*Central W.*	*3 branches*	*Central W.*
Workers' salaries	9,000	9,000	0	9,000
Electricity cost	1,200	400	0	400
Maintenance cost	480	320	0	320
Renewal fee cost	275	275	0	275
Transportation cost	0	0	0	7,200
Total monthly cost	20,950		17,195	
Total yearly cost	251,400		206,340	
Saving per year	43,710			
Saving per 10 years	437,100			

Figure 8 Cost comparison of current and proposed system (see online version for colours)

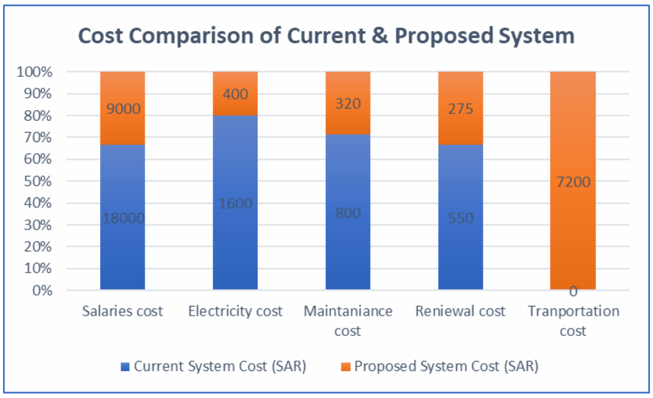


Figure 8 illustrates the cost comparison of current and proposed systems. Significant reduction is observed in the expenses of salaries, electricity, renewal, and maintenance costs. Major cost saving is done due to the replacement of three independent workshops with one central workshop. Transportation cost is added in the proposed system due to outsourcing of orders from three branches to the central workshop. Nevertheless, the proposed system offers a handsome saving considering the turnover and size of business.

Table 10 Comparison between the current and proposed system cost after the economic changes

Input data	*Current system*		*Proposed system*	
	3 branches	*Central W.*	*3 branches*	*Central W.*
Workers' salaries	9,000	9,000	0	9,000
Electricity cost	2,265	855	0	855
Maintenance cost	480	320	0	320
Transportation cost	0	0	0	7,200
Renewal fee cost	900	900	0	900
Total cost monthly	23,720		18,275	
Total cost yearly	284,640		219,300	
Saving per year	65,340			
Saving per 10 years	653,400			

6 Conclusions

The proposed solution of replacing the three independent workshops with one centralised workshop is both cost effective and efficient, especially in the long term. Average delivery time of the order is reduced from 14 hours to 4 hours, creating an opportunity that orders can be delivered back to respective customers on the same day of its receiving. It not only enhances the satisfaction level of customers but also gives competitive advantage to the organisation. Similarly, organisation can save the cost of machines and other resources, which it used to spend in three independent workshops instead of one central workshop. Moreover, the idle time of three technicians at central workshop is significantly reduced with the help of simulation. This extra time can be utilised by giving them workload from other branches of the same organisation in Jeddah City. It increases the productivity of organisation without adding any new resources, which can lead to cost saving and more profitability. Also, the concerned organisation can also avail the option of reducing the number of workers from three to two in the central workshop, since their idle time is high, or they can be engaged into other useful activities for better utilisation. Once the phenomenon of replacing independent workshops with one central workshop is established, future research can be done to further optimise the operational cost and process flow within the central workshop. Similarly, a new study can be conducted to improve the management of business supply chain to increase the productivity and profitability of the organisation.

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