# Managing Warehouse Inventory: a Simulation Based Case Study

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# MANAGING WAREHOUSE INVENTORY: A SIMULATION BASED CASE STUDY

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**ABSTRACT:**
*Simulation is the imitation of a real-world operation or process over time. Warehouse inventory management played an important role in improving customer service and reducing stock outs. Managing warehouse inventory is a challenging task and to address this challenge, we use simulation application in warehouse inventory management. The purpose of this paper is to use simulation in managing inventory of A Building Materials Trading Company in United Arab Emirates (UAE). Firstly, we will develop a model to improve average inventory level, average lost sales, and percentage of customer's dissatisfaction for the main component in the company which is cement. Secondly, we verify and validate our developed model using Arena simulation software. Finally, some recommendations regarding reorder point, batch size and target stock will be given to improve overall warehouse inventory management system.*

**KEYWORDS:** *Warehouse, Inventory Management System, Simulation, Arena, Inventory Level, Reorder Point.*

## 1 INTRODUCTION

Warehouses play a vital role in mitigating variations in supply and demand, and in providing value-added services in a supply chain. Simulation is the process of imitating a real phenomenon with a set of mathematical formulas. Advanced computer programs can simulate weather conditions, chemical reactions, atomic reactions and even biological processes. In theory any phenomenon that can be reduced to mathematical data and equations can be simulated on a computer. In developing useful simulations models, it is important to determine what the most important factors are. In addition to imitating processes to see how they behave under different conditions, simulators are also used to test new theories .After creating a theory of causal relationships, the theorist can codify the relationship in the form of a computer program. If the program the behaves in the same way as the real process, there is a good chance that proposed relationships are correct.(Neetu, 2011).
Over the last decade, many researcher and practitioners applied simulation in several field such as healthcare, supply chain management, and military. (Mielczarek and Uzialko-Mydlikowska, 2012, Negahban and Yilmaz, 2013 and Terzi and Cavalieri, 2004). More specifically, simulation played a significant role in warehouse inventory management system. Successful implementation of simulation in many real-world problems solution proved its effectiveness. Many books such as Kelton, et.al 2010, Law, 2006, Banks *et. al*. 2009 and Ross, 2006, discussed in details about the general topic of simulation and application different software of simulation. This shows the importance of simulation in analyzing and improving process or system. According to Sainathuni *et. al*. 2014, modern supply chains rely heavily on warehouses for rapidly fulfilling customer demand through retail, web-based, and catalogue channels.

### 1.1 Inventory Strategies

The strategy of inventory management is one of the techno - economic characteristics of the stocks. In practice, there are different strategies of inventory management, and only few, basic ones, will be shown. A very important part of the strategy of inventory management is a choice of parameters that defines it. ( Dosković , *et.al.* 2015)
The first strategy is the (Q, R) strategy. In this strategy, inventory is managed by two parameters: quantity Q and the level Rn. Q is a replenishment quantity which will be supplied and Rn is the level on which a user makes an order. This strategy implies that lead time is known in advance and it is very suitable for inventory management in terms of stochastic consumption because the quantity of an item is ordered when it reaches a protective level of stock (Rn). In this strategy two extreme cases might happen and they are shown in the figure 1 (Vukićević, 1995).

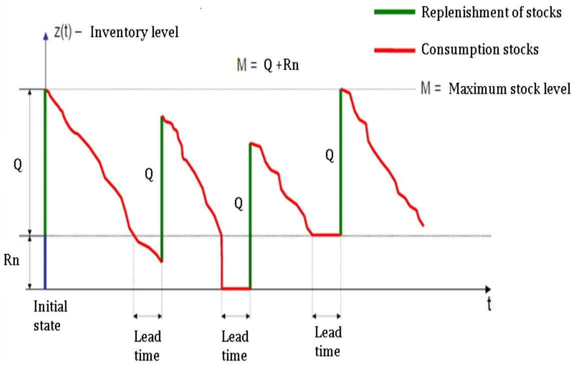


Figure 1: Strategy (Q,Rn)

## 2. COMPANY OVERVIEW AND PROBLEM DEFINITION

The Building Materials Trading Company(name will be withheld due to confidentiality), located in northern part of UAE is into trading different types of building materials such as cements, irons, woods, etc. The company is located in one of the busiest locations in the city (industrial zone) and the trading in the shop takes great pride in the excellence reputation they have developed with the suppliers and the customers in and around U.A.E. Company supplies the materials from relevant suppliers and locates them in the company's warehouse, then resell them to different customers. Figure 2 shows the supply chain considered in over problem.

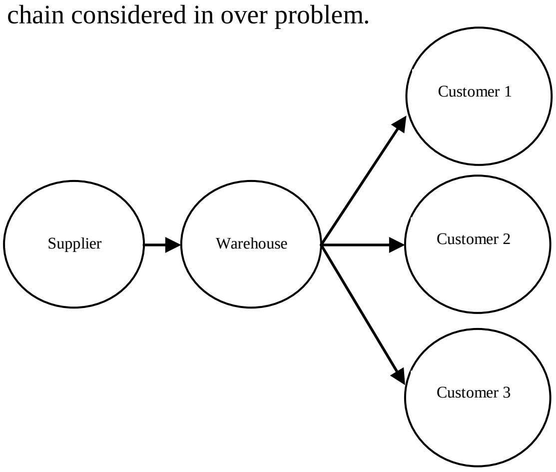


Figure 2: Considered Supply Chain

Currently company is facing following problem.

i) Stock out situations because of improper inventory level which causes lost customer and sales.

ii) Current batch size is high.

iii) Target stock is not defined well.

A current inventory policy of The Building Materials Trading Company is as follows.

i) The warehouse has a target level for cement of R=10,000 units. The company stops ordering cement when the inventory in the warehouse reaches the target level.
ii) The reorder point of cement is r=2,000 units, therefore we order cement only if its inventory level reached this point or below.
iii) At the reorder point we order fix quantity which is 9,000 units.

## 3. LITERATURE REVIEW

There are many ways in which simulation can be used in supply chain process. It mostly depends on what kind of problem that is required to evaluate and solved. Thierry et.al, (2010), discussed two main problem features that have an impact on final solution of simulation model nature which are as follows.

– The degree of systemic decomposition of the SCM system (decision system, information system, physical system)
– The distribution level of the system (centralized or distributed)

The difference between centralized and decentralized supply chain system is that in centralized supply chain system consists of single information system for all entities of considered supply chain system. While in decentralized system, information is distributed over the different entities of the supply chain.

### 3.1 SIMULATION OF SCM USING A CONTINUOUS SIMULATION APPROACH

In continuous simulation approach, different types of flows (manpower, technology, money, and market) ** stocks or levels which are integrated over time according to flow variations System dynamics is centred on the dynamic behaviour. It is a flow model where it is not possible to differentiate individual entities (like transport resources). Management control is performed by making variations on rates (production rates, sale rates). Control of rates can be viewed as a strong abstraction of common production management rules. (Thierry, *et.al.* 2010)

### 3.2 SIMULATION OF SUPPLY CHAIN MANAGEMENT USING THE DISCRETE EVENT APPROACH

In the discrete event approach, we distinguish between a “time bucket driven approach” and an “even driven approach”. This differentiation is based on the time advance procedure which characterized these two approaches. With the time bucket driven approach (sometimes called “spreadsheet simulation” (Jack, 2008.):

–time is divided in periods of a given length (time buckets)
–time is incremented step by step within a given time bucket.

At the end of each step a new state is calculated using the model equations. The implication is that events (corresponding to a change of state) occur at the beginning of each period –the lead time for an item in a production resource is considered small compared to the size of the time bucket –the main states are the states of the set of resources. They describe the activities in which resources are implicated in a given time period. (Thierry *et.al*.2010).

### 3.3. DECISION SYSTEMS AND SIMULATION MODELS

The inherently distributed nature of a supply chain is a feature that must be properly captured in any simulation model. There is furthermore general agreement that the modularity of the control (i.e., management) system and the shop floor model must be retained. This separation principle enables to introduce the concept of emulation.

Table 1 shows some decision systems and simulation models summary(Thierry *et.al*.2010).

| **S.No.** | **Decision System Simulation Models** | **Description** |
|---|---|---|
| 1 | Centralized Simulation Model | In a centralized simulation model approach one single simulation model reproduces all the supply chain structures (entities and links) which is quite distinct from a distributed approach. |
| 2 | Multi Agents Systems decision simulation | An organizational form where partners must closely collaborate is intrinsic to the SCM concept. In fact the producing enterprises operate as nodes in a partnership network and share activities in order to produce and deliver their goods. In such a context, integration of the planning at all the nodes is essential; i.e., the partners have to be able to distribute and synchronize their activities. |
| 3 | Simulation for Product Driven Systems | In this system, SCM system can be viewed as being composed of planning and scheduling agents together with agents representing the physical elements that correspond to products. |
| 4 | Model Synchronization | One particular application for distributed simulation within the SCM context is the case where a unique control system manages several physical system simulation models. Another arises when there is a substantial level of information exchange required among the various components of the simulation model. We note also that two specific issues relating to distributed simulation are message coordination between the partners of the supply chain and synchronization of these partners. |

Table1 shows some decision systems and simulation models summary(Thierry *et.al*.2010).

## 4. METHODOLOGY

In order to resolve issues that company is currently facing, we will develop a simulation model and run the system for 30 days. Following proposed methodology will be developed and followed.

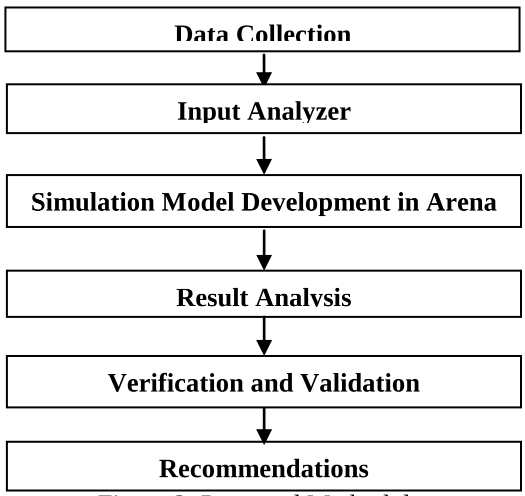


Figure 3: Proposed Methodology

**Step 1:** In this step, the researchers will collect data of the inter-arrival time (50 samples) and demand size (60 samples) from the company.

**Step 2:** The researchers will use input analyzer to find the best fit distributions for inter arrival time and demand size.

Figure 4 shows the results of inter-arrival time:

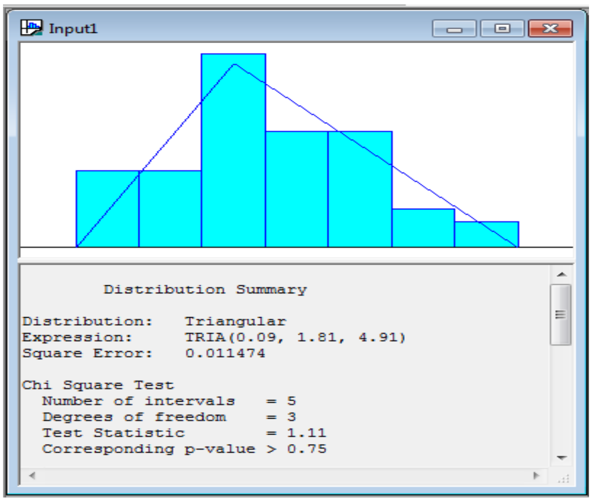


Figure 4: Distribution fit of Inter Arrival Time

As shown in figure 4 above, the best fit distribution of the inter-arrival time is Triangular distribution of TRIA (0.09, 1.81, 4.91), with Square Error= 0.011474 and corresponding p-value > 0.75 which is acceptable as it's greater than 0.1. Therefore, we concluded that inter arrival time is following triangular distribution with parameters TRIA (0.09, 1.81, 4.91).

Similarly, figure 5 shows the result of demand.

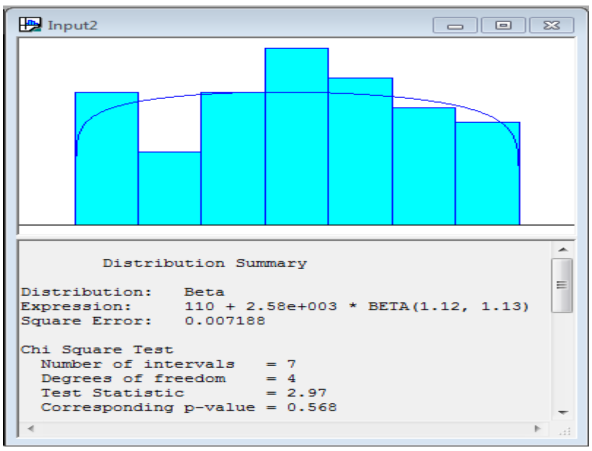


Figure 5: Distribution fit of Demand

As shown in figure 5, the best fit distribution of the demand size is Beta distribution of 110 + 2.58e + 003 * BETA (1.12, 1.13), with Square Error= 0.007188 and corresponding p-value=0.568 which is acceptable as it's greater than 0.1.

**Step 3:** In this step, the researchers will build a model in Arena software by adding all the conditions. Model will be divided into two parts which are inventory part and selling part. Figure 6 will show the inventory part of the model and figure 7 will show selling part of the model.

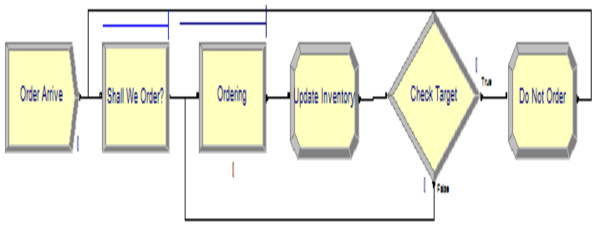


Figure 6: Model for Inventory Part

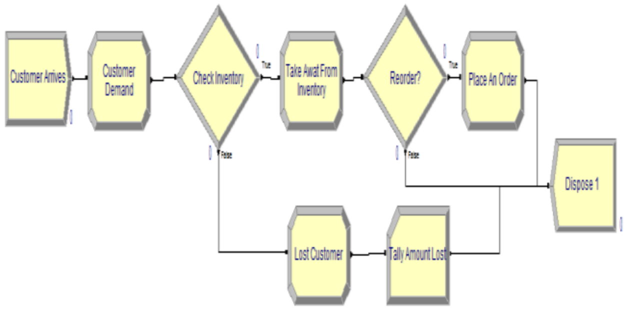


Figure 7: Model for Selling Part

**Step 4:** In this step, the researchers will run the model for 30 days and figure 8 will show the results.

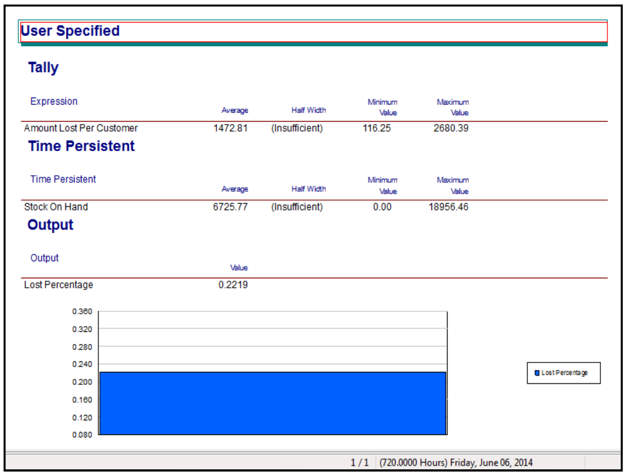


Figure 8: Results after 30 Simulation Runs

After simulating the model for 30 days, as shown in figure 8, warehouse average inventory level= 6725.77 cement units, average lost sales per customer= 1472.81 cement units and percentage of customer's dissatisfaction= 22.19%.

**Step 5:** Verification and validation of the results will be done in this step to check applicability in the considered case of a building material company.

**Verification** is a static practice to ensure that the model is of high quality by verifying documents, codes and program. Also it's a very important step to ensure that the model represents the actual system. In our model we followed specific steps to ensure that it's verified like:

a) Reviewed the model to check input data (see whether there is spelling mistakes, wrong entering of data, etc.).

b) Checked the parameters in Arena and the distributions in the input analyzer.

c) Checked the logic of the model and the logical sequence of the modules and the connections between them.

d) Changed the parameters to check if the output changed logically:

- Parameter 1: We changed the Inter-Arrival time from TRIA (0.09, 1.81, 4.91) to TRIA(1, 2.1, 3.91, and we got:

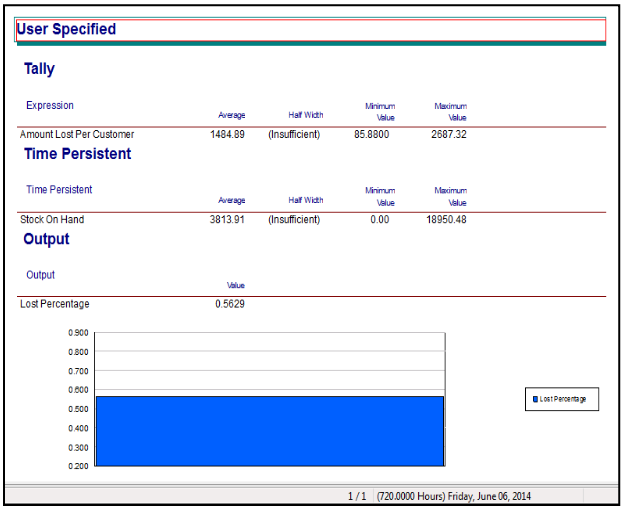


Figure 9: Verification Output With Parameters 1

As shown in figure 9, we got the warehouse average inventory level= 3,813.91 cement units, average lost sales per customer= 1,484.89 cement units and the percentage of customer's dissatisfaction= 56.29%. The original model is better as it has less percentage of lost customer and lost sales and higher stock on hand.

- Parameter 2: We changed the Demand size from 110 + 2.58e + 003 * BETA (1.12, 1.13) to 110 + 2.58e + 003 * BETA (2.12,2.13), and we got:

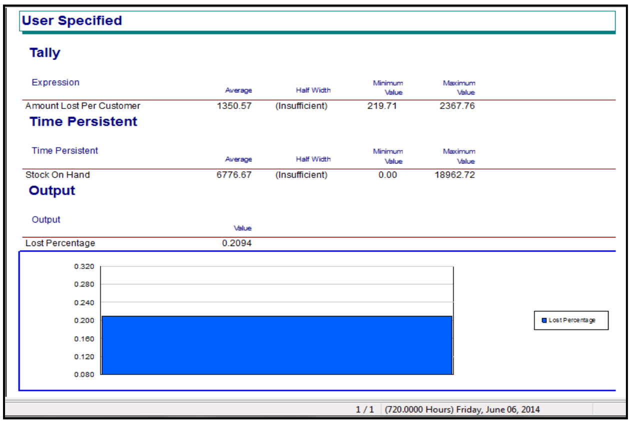


Figure 10: Verification Output With Parameters 2

As shown in figure 10, we got the warehouse average inventory level= 6,776.67 cement units, average lost sales per customer= 1,350.57 cement units and percentage of customer's dissatisfaction= 20.94%. This is better than the original model because it has less loss customer and lost sales and more stock on hand, and it makes sense because as the probability of cement units available in the inventory is less, the probability of lost customer increases.

Validation shows how realistic the model assumptions are, by comparing the performance obtained from multiple runs. In our model we will choose the loss customer to be our performance measure and will conduct hypothesis testing and test the normality of our data distribution. To validate our model we increased the number of replications to 10 runs and in order to conduct the hypothesis testing, our data for 10 replications must follow the normal distribution; therefore we took the lost percentage of the 10 replications and put in input analyzer to test the normality, the result is shown in figure 11:

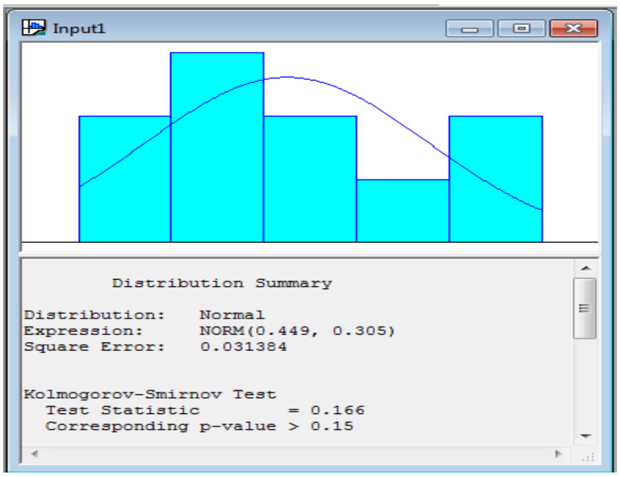


Figure 11: Normalilty test

The data follows normal distribution as its p-value > 0.15 is greater than the acceptable level (0.1), and the Square Error= 0.031384.

**Step 6:** Recommendations regarding how to improve current situation will be given to the company and simulation results will be shown with updated input parameter.

Based on above mentioned analysis of simulation model, following recommendations has been given to the company:

a) Increase the Reorder Point from 2,000 units to 2,500 units, in order to update the inventory level faster and decrease the probability of lost customers and sales.
b) Decrease the batch size from 9,000 units to 8,000 units
c) Increase the target stock from 10,000 units to 11,000 units, which showed us the best improvement as it cuts the lost percentage to approximately 1%.

## 5. CONCLUSION

In this paper, the researchers collected data and performed initial analysis such as find the best fit distribution, model building in Arena software and results of initial run of simulation model for 30 days. In next step the researchers will run the simulation after adjusting input parameters, verify and validate the model and give some recommendations to the company in order to minimize lost customers and stock out situations. Impact of cost of the proposed solution can also be added after adjusting input parameters and getting real data from case company.

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