Simulation Study of Inventory Performance Improvement in Consumer Products Trade Business Unit Using System Dynamic Approach

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Abstract. This paper focused optimal inventory study on multi-product, multi-period, perishable products replenishment quantity in consumer product trade business unit (CPTBU) warehouse in Bahir Dar city. We proposed system dynamics method to improve optimal replenishment quantity of expired and stock-out products and saved the total operation cost such as loss of sale, expired cost, holding cost and ordering cost using vensim software. This study proposed 34.7% improved replenishment quantity of expired products, 32.2% replenishment quantity of stock-out products and totally this proposal saved 43,000US$ (1.2 million birr) of operational cost per year.

Keywords: Stock and flow diagram · Inventory replenishment · Simulation · System dynamics

1 Introduction

Inventory replenishment of multi-product, multi-period, perishable consumer goods is highly complex nature. Vermore and Joannes (2012) proposed mathematical model for inventory operation problem. They optimized replenishment quantity and total cost of inventory operation cost of stock-out and expired products.

Inventory management comprises various actions taken by the management to reduce cost, maintain production, continuous supply with optimal quantity and reduce loss according to Saleemi (2009); Nyabwanga and Ojera (2012). Many fast moving distribution companies such as whole sale and retailer have been giving due to attention to compute in global market by delivering quality product and service according to Ballou (2000). Distribution company have the responsibility to deliver quality products and service by good inventory management because of the cost of inventory and discontinuous supply with non-optimal quantity have the impact of profitability and customer satisfaction. Numerous tools and techniques have been developed for

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designing optimal inventory parameter for transfer, order and storage to reduce the cost of operation and optimal quantity replenishment due to this increase company profitability and customer satisfaction of distribution system chain. But replenishment quantity and the operation cost of inventory have variations in the planned replenishment quantity by 25%, inventory operation cost by more than 890000 birr from the actual replenishment quantity and cost of inventory operation in consumer product business unit. This is because most of tools taken to solve this problem in distribution companies are not effective enough to reducing the inventory operation cost and replenishment quantity. In consumer product business trade unit, the common non-conforming or damage product and shortage quantity which are occurring in replenishment products that result loss products as expired and stock-out; operation inventory cost occurred due to expired cost, lost sale cost, ordering cost and holding cost. The high inventory replenishment quantity fluctuation and inventory cost in CPTBU occurred due to poor of replenishment quantity products and poor inventory operation.

Application of mathematics, statistics and a system dynamics process has contributed to the development of many models, which has real life applications. Also separate set of models has been developed for the determination of optimal re-order size for perishable products such as vegetables, fruits, eatables, and drugs. Proceeding below is few of the literature related to the models under study. Fast changing competitive world, companies are losing their significant number of customer not because of the price they offered to those products but the quality of the product or not delivering quality service. Inventory management comprises various actions taken by the management to reduce cost, maintain production, continuous supply according to Nyabwanga and Ojera (2012). System Dynamics is an integrated methodology that combined system scientific theory with Computer simulation, believing that the internal structure is the determination of the behavior model and features of a system according to Zhong et al. (2013). The structure of a system in inventory system dynamics methodology is exhibited by causal-loop diagram (CLD) and stock and flow diagram.

System dynamics (SD) is an approach to understanding the nonlinear inventory of complex systems over time using stocks, flows, internal feedback loops, and time delays. System dynamics is a methodology and mathematical modeling technique to frame, understand, and discuss complex issues and problems. Managing a company's perishable inventory stock based on demand and supply is important in different firms and Business such as food, chemical, parametrical warehouse and stores. Without a proper perishable inventory stock management sys-tem in warehouse, stores and retailer long-term profits can be affected, as more inefficiency is likely to occur Bai and Zong (2008).

Simulation of system dynamics approach has been used to improve the performance of fast moving consuming goods and optimize the replenishment quantity, ordering quantity using casual loop and stock and flow diagram.

2 Methodology

Different literatures from various journal and related to inventory simulation and performance and improper replenishment quantity and inventory operation costs are reviewed in writing this article. Both primary and secondary data were collected using questionnaire, face to face interview, observation and NAV report in case company, Consumer Product Trade Business Unit (CPTBU) AlleBejmila, (Government of Ethiopia, warehouse) Bahir Dar Branch. Collected data such as quantity of transferring product, quantity of expire product, quantity of shortage and demand the customers and other data were collected from different and concerned department. At the time working in this case company and have been seen such problem in working process and operation at the time of replenishment products, operation of storage and dispatching products and sale of products to customer. The collected data through the means of interviews, observation and NAV report analyzed by using table, figures and theoretically interpreted from system dynamics vensim software.

Many of the systems and problems can be built as models on a computer. System dynamics is an approach to present and analyze the inventory of a complex system in order to have a well understanding of what is exactly going on within the process according to Zhong et al. (2013).

System dynamics takes advantage of the fact that a computer model can be of much greater complexity and carry out more simultaneous calculations than the mental model in the human mind. Manetsch and Park (1982) lists six steps to solve a problem with system dynamics:

- Identifies a problem
- Develops a dynamic hypothesis explaining the cause of the problem
- Builds a computer simulation model of the system at the root of the problem
- Tests the model to be certain that it reproduces the behavior seen in the real world
- Devises and tests in the model alternative policies that alleviate the problem

A. Mathematical model for perishable products

Total expired cost = (Expired quantity of a product M at period T (EVMT)) (Expiry cost of a unit product type M at period T(WEM)) plus (Inventory level of product M with j periods of lifetime remaining at the end of period T (LJMIT))(Cost of discount remaining life product Mat period T(CSMT)) plus Cost of replenishment near expiry product M at period (RGMT) plus Disposal cost product M (DOM) (1)

Total loss of sales cost due to shortage = (Shortage of quantity of products M at period T (OMTD)) (Price per unit(UMT) Stock out day(yMT)) + Cost of consequence(AMT) (2)

Total holding cost (AT)= (holding cost rate) unit cost of inventory) or (IO)(CI) that by ordering Q units every time we order, we will have to place D/Q orders per year (3)

Total ordering cost = (number of order/year)(cost/order) or ((KM/T)/QMT)(CO) (4)

$$\text{Minimization total cost} = \sum \text{CMT. QMT} + \sum \text{AT. QMT} + \sum \text{HMT.IJMT} + \sum \text{LMt.Omt} + (\sum \text{WEM.EVMt} + \sum + \text{WEM.IJMT} + \sum \text{DOM} + \sum \text{RGMT} \quad (5)$$

From mathematical Eq. 1 calculate total expired cost, Eq. 2 calculate total loss of sales due to shortage items, Eq. 3 calculate total holding cost, Eq. 4 calculate total ordering cost and Eq. 5 minimize total cosy. After model of expired, stock-out and total cost products as shown in Fig. 1, output of replenishment quantity and others factor related to operation cost such as cost of disposal, cost of reaming life, day stock-out quantity, average inventory level and cost of order are calculated. Figures 2 and 3 shown the simulation model of annual percentage improvement in both expired and shortage items. Finally Fig. 4 calculate model of expired and total cost simultaneously using casual loop and stock and flow diagram engineering tools with vensim software.

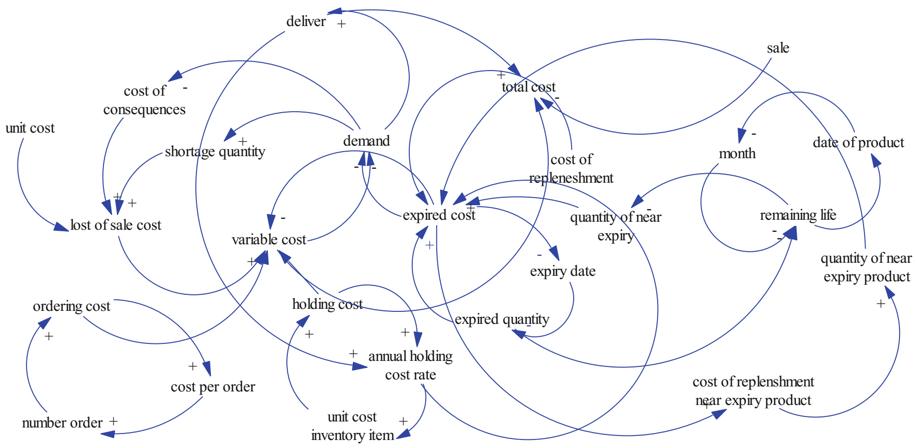

Fig. 1. Simulation model of shortage, expiry and total cost in casual loop diagram

B. Minimization of total inventory cost by stock and flow diagram.

Total expired cost = quantity of unsold * cost of expire product quantity of remaining life product * cost of discount remaining life product total cost of near expiry replenishment disposal cost.

Total loss of sale cost = Shortage quantity * price per unit * out of stock day cost of consequences.

Total holding cost = average inventory level * unit cost holding.

Total ordering cost = unit of cost per order * number order.

Variable cost = INTEG (total expired cost total holding cost total loss of sale cost + total ordering cost, 0).

Total cost = INTEG (variable cost, 0).

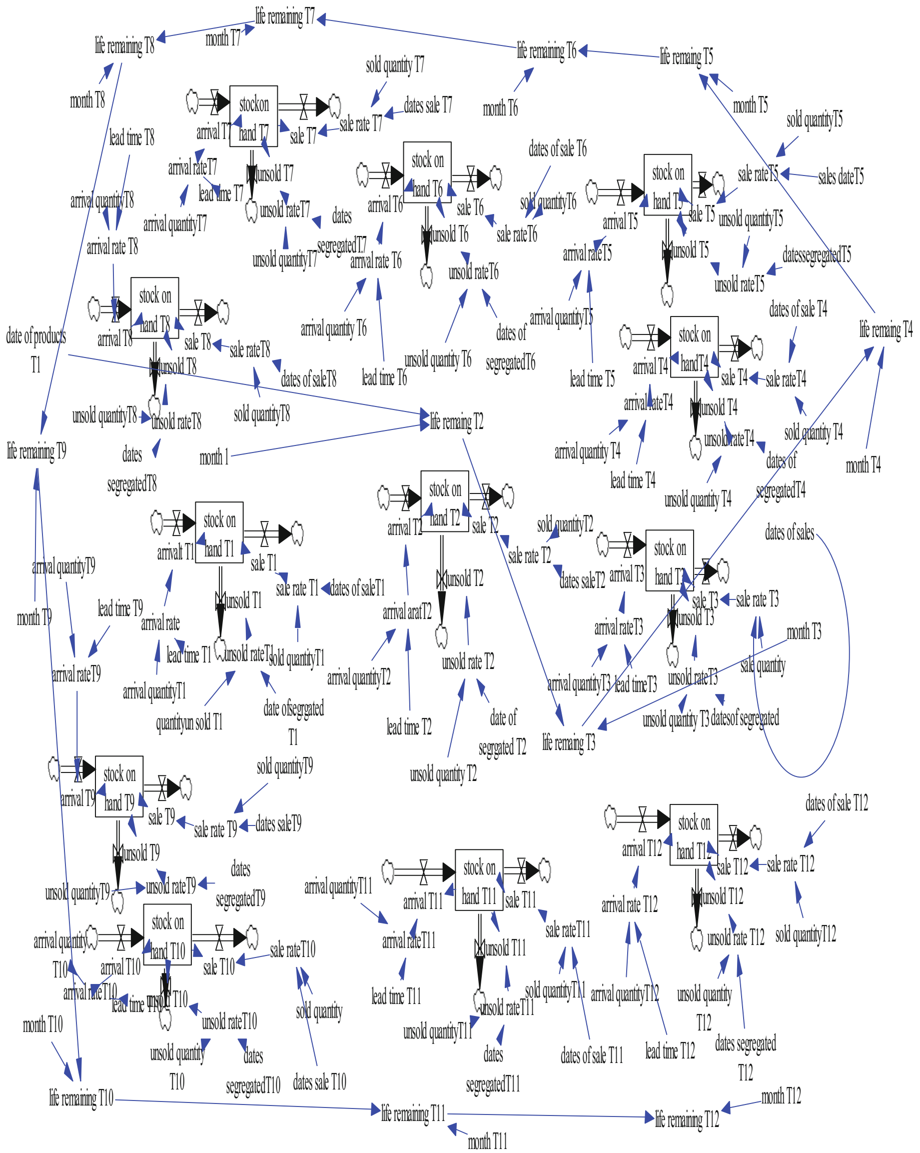

Fig. 2. Annual percentage improvement of expired replenishment quantity in stock and flow diagram

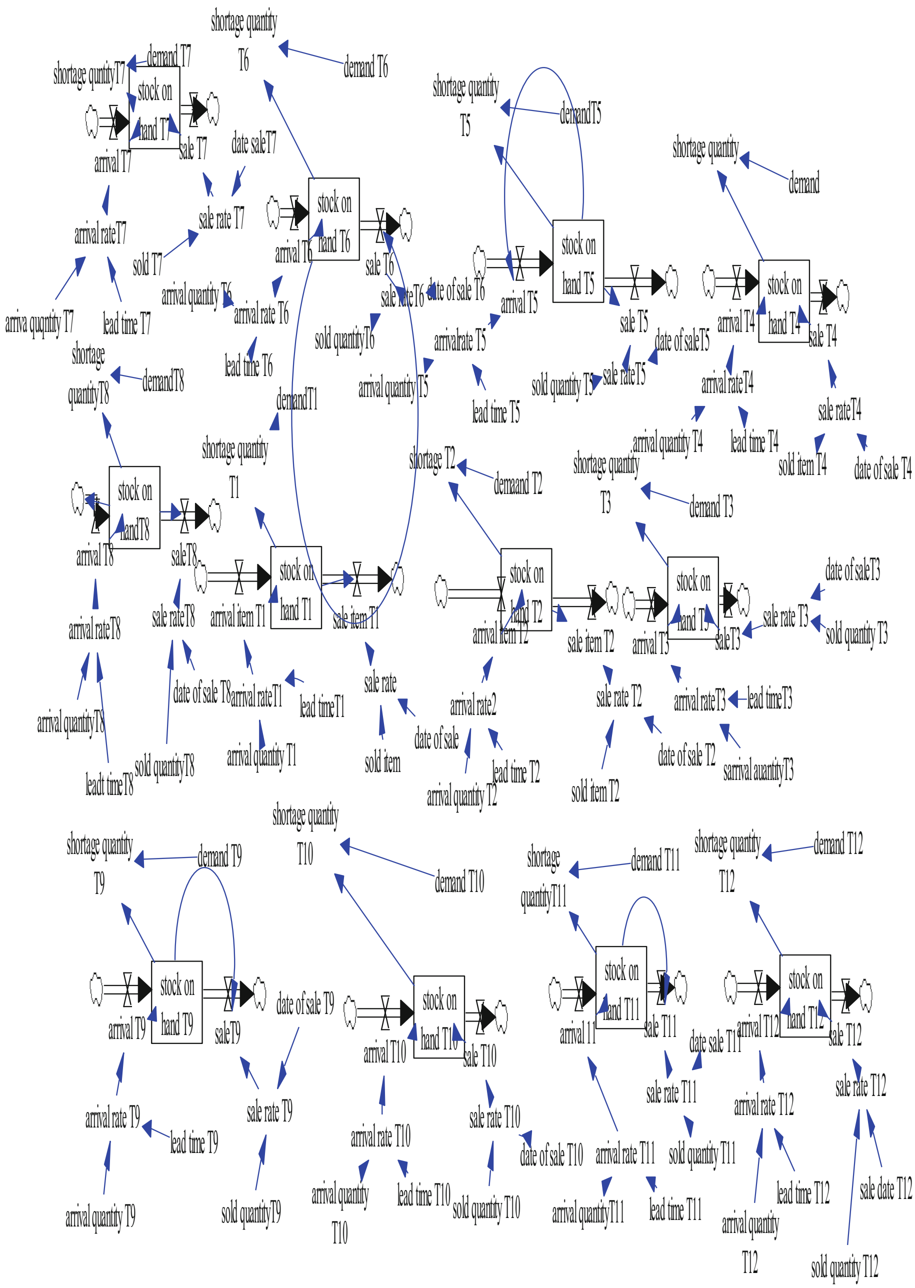

Fig. 3. Annual percentage improvement of shortage replenishment quantity in stock and flow diagram

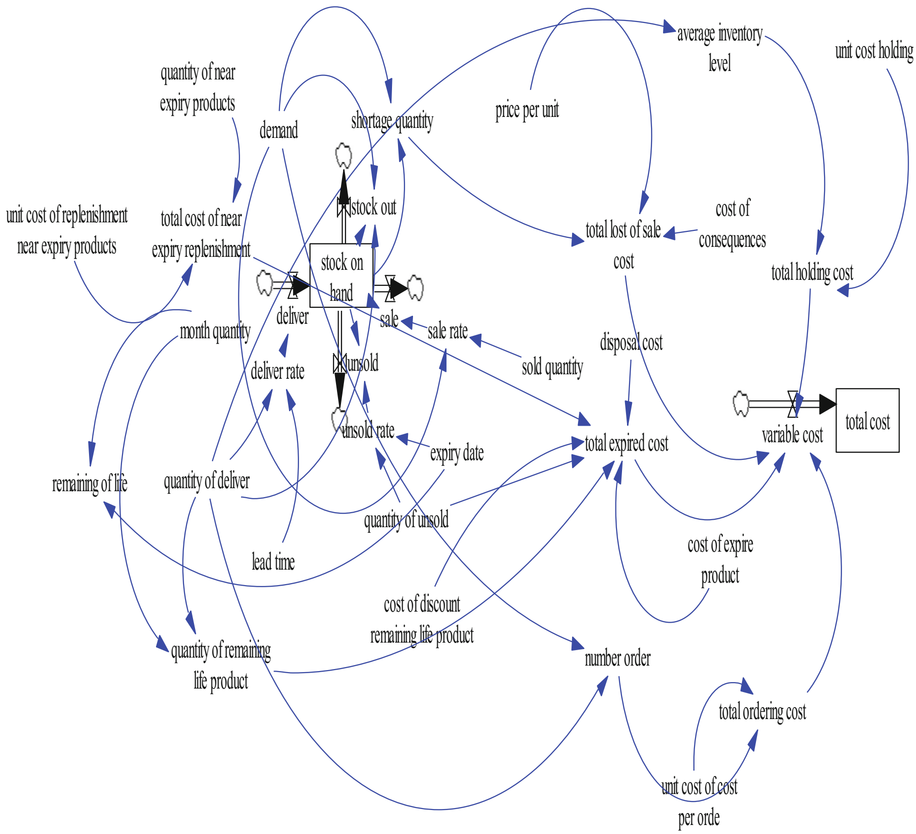

Fig. 4. Simulation model of expired cost and total cost by stock and flow diagram

3 Result and Discussion

Expired and shortage products in our case company warehouse was affected total inventory cost. In this article casual loop and stock & flow diagrams with different parameters were considered in each expired and shortage products separately. The dynamic nature of the business, affects inventory performances such as replenishment quantity, remaining of life, customer demand and other factors. Incorporated expired, loss of sale and cost operation in 12 months for 10 expired and 10 stocks out products.

Expired quantity of each product in each month has been changed by their replenishment quantity in the proposed system dynamic model. Expired products with RI number for model of stock and flow diagram reduced the percentage of expired products by considering factors of replenishment quantity, remaining life of products and date of sales as shown in Table 1. Improved percentage of shortage products in Table 2 and total inventory operational cost in Table 3.

Table 1. Annual percentage improvement of expire cost

No	1	2	3	4	5	6	7	8	9	10
RI	241	245	186	500	252	320	325	326	338	732
% of improvement	3.92	4.6	2.1	3.37	2.7	3.69	3.8	4.1	4	2.4

Table 2. Annual percentage improvement of shortage products

No	1	2	3	4	5	6	7	8	9	10
RI	521	320	964	1011	385	343	750	185	342	351
% of improvement	24.5	14.6	11	9.9	10.1	10.3	12.5	11	10.9	18.3

Table 3. Total cost saving of proposed model

No	Types of cost	Amount saved in birr/year (1US$ = 27.8 Birr)
1	Expired cost	751410.6
2	Loss of sale cost	457886.1
3	Ordering cost	457886.1

Stock-out quantity of each product in each month has been reduced by changing their replenishment quantity in the proposed system dynamic model. Stock-out products with RI number in the Table 1 model of stock and flow diagram improved the percentage of stock-out products considering factors of replenishment quantity, customer demand and date of sales.

4 Conclusion

In this work, system simulation study was carried out in consumer product trade business unit warehouse inventory management in Bahir Dar-Ethiopia. Every year, huge amount of items was expired due to fluctuation of market demand and some items were stock-out within short period due to high demand. This work was pro-posed optimal inventory replenishment quantity of both expired and stock-out items using system dynamic simulation method. After detail investigation of all existing items transfer process, we have selected 10 most expired items and 10 high demand items in this case study. Framed mathematical model of both expired items & their costs and shortage items & their cost with all the variables related to replenishment. Simulated expired, shortage and total operational cost items separate system dynamics model. We optimized transfer replenishment quantity of expired products and stock-out products for saved in total inventory operation cost using casual loop and stock and flow diagram.

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References

AlleBejimilla: Overview and history of AlleBejimilla, Technical report (2016)

Bai, L., Zhong, Y.: Improving inventory management in small business. Master thesis in International Logistics and Supply Chain Management (2008)

Ballou, H.: Evaluation inventory management performance using turnover curve. Int. J. Phys. Distrib. Logistics Manag. (2000)

Manetsch, T.J., Park, G.L.: Systems analysis and simulation with applications to eco-nomic and social systems. Department of Electrical Engineering and System Science, Michigan State University, USA (1982)

Nyabwanga, R.N., Ojera, P.: Inventory management practices and business performance for small-scale enterprises in Kenya. J. Bus. Manag. **1**(4), 11–28 (2012)

Vermorel, J.: Economic Order Quantity (EOQ), Definition and Formula (2012). Accessed 14 April 2015

Zhong, Y., Jia, X., Qian, Y.: System Dynamics. Science, Beijing (2013)