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An Application of an (R, S) Inventory Management Model for a Construction Materials Manufacturing Company by Using Simulation

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Abstract
Globalization has motivated companies to develop competitive strategies in today's business environment. In this context, they lead them to review their costs. When the cost items are analyzed, the most critical point that will give an advantage to companies in terms of cost is that companies healthily manage their inventory. Inventory management is of vital importance as the companies have a significant percentage in terms of cost and ensure that the customer demands are met in a timely and sufficient manner. This study focuses on the problems of the company's inventory control decisions that ensure balanced and minimum costs through effective inventory management. In this study, one-year data on demand, consumption, and inventory of a company that uses traditional methods including semi-finished products are considered. Since the demand is not known precisely and it is probabilistic, we apply the (R, S) inventory control model. We use simulation as a stochastic methodology to determine the inventory level of the construction materials manufacturing company under consideration. As a result of the study, after comparing the actual data in the current system with the developed model we apply, it is observed that the cost reduction and its use provided additional benefits to the company.

1. Introduction

Inventory is the quantities of items that the enterprises hold to meet customers' expectations. Determining and managing the right inventory model plays a critical role in the prevention of problems that may arise in the future. Any mistake that may accrue in this regard may cause financial damages to the companies together with the loss of reputation. The companies may hold more inventory on hand than they need. This situation causes waste and loss of money due to the becoming obsolete of the product over time. Also, it will increase the risk of investing in high quantities of the items, the cost of workers, insurance, security, and storage.
On the other hand, having a high inventory level is a problem as well as having a too-low level of inventory that may increase the costs and the effectiveness of the companies. A small quantity of shortage of inventory for the company may lead to high-level costs, a decrease in customer satisfaction, and a loss of commercial reputation. Effective inventory management ensures the elimination of disruptions caused by production and keeps the product ready at the time of purchase by the customer. If the companies have appropriate systems to manage their inventory effectively, they may control their operating costs and increase profitability. Hence, the most appropriate inventory management policy should be selected and implemented.
Multi-stage inventory systems are modeled as either deterministic or stochastic. In real life, because some variables, like demand and lead time, are not likely to be known in advance, it is necessary to consider inventory management in a stochastic way. Thus, in this study, we use simulation as a stochastic

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methodology to determine the inventory level of the construction company under consideration.

Inventory is the physical goods that enterprises store to meet the requirements that may occur in future periods or to prevent problems that may accrue in the production process. The determination of the suitable inventory management method counts on the capacity, organizational structure, production type, and financial situation of the company. In order to use the resources effectively in inventory management, companies should use appropriate methodologies.

There are different studies carried out by different sectors for inventory management with different methods. In this part, the research studies using ABC analysis and the Analytical Hierarchy Process (AHP) method, the Just in Time (JIT) philosophy and system, and the stochastic stock control method in the literature are investigated. In the literature, the most common inventory control systems are (R, s), (s, Q), (s, S), (R, S, S), and (r, s, nQ) systems. In the (R, s) system, the inventory status is checked in each R period and if S is at or below the reorder point, the inventory position is raised the to S level. It includes a periodic review feature, which gives companies an advantage in reducing shipping costs. It is generally preferred by companies that purchase the material from the same supplier. Rabta and AÏssani [1] investigate the steadiness in an (R, S, s) inventory modeling and apply a strong stability method to consider quantitative estimates. Poisson distributed demand pattern is used in the numerical experiments for the (R, s, S) modeling. The effect of the strong v-stability of the Markov chain is observed in the study. Babiloni et al. [2] study estimating the fill rate in an (R, S) system. An approach to estimate the exact fill rate is proposed when the demand behavior fits a discrete probability distribution. A simulation methodology is proposed to test and show the effectiveness of the study. Janssen et al. [3] propose a method to find the reorder point and mean inventory level including service level constraints for the (R, s, Q) inventory model. The proposed approach covers the discrete demand process. Gökçen et al. [4] develop a heuristic to find optimal inventory control parameters of Optimization via Simulation (OvS) for the (R,s, S) policy and supplier selection in a two-stage supply chain taking into account the lost sales. They aim to show how the OvS model can be applied effectively with the lost sales taking into account the supply chain cost. Rodrigues and Yoneyama [5] present a new inventory control model for non-repaired products that are periodically checked. They propose an (R, s, S) model that minimizes the total cost of inventory with a fill rate constraint.

Tarim and Smith [6] develop a constraint programming (CP) model for an (R, s, S) system including service level constraints. To improve the performance of the algorithms, domain reduction methods are made use of. It is found that the proposed CP model performs better in mixed-integer programming modeling. Moors and Strijbosch [7] introduce a formula for the average shortage of an (R, s, S) inventory control system in which demand data fit the gamma distribution. The Delphi software is used to simulate the proposed (R, s, S) system for gamma distributions. Ekren and Arslan [8] aim to compare different lateral transfer policies in an (S, s) inventory control problem for a supply chain network system. Simulation models are developed in ARENA 14.5. Using the OptQuest tool, the total cost is minimized by taking the fill rate into account and the performances of the models are compared. They show that the proposed supply chain design produces efficient results compared to the supply chain without a lateral transfer policy. Moors and Strijbosch [9] develop a fast and effective algorithm to simulate an (R, s, S) model in which both the demand and lead time are stochastic. They emphasize that the proposed algorithm can be used to calculate fill rate performance measurements and find parameter values leading to a projected service level. Aytekin [10] aims to eliminate the management difficulties that may arise due to the usual increase in product diversity and applies the Just in Time (JIT) method by using the data obtained from a hospital material and service management unit. Inventory control model alternatives are evaluated by using the priority matrices method.

Another application is carried out on the raw material inventory control at the cement factory by Karahan and Aslan [11]. Since the orders made by the factory are given at certain intervals during the year, it is found appropriate to use the inventory model from the stochastic inventory control models (R, S) in this application. A simulation model is designed by using the ARENA simulation software to see the changes that may be obtained in the operations and costs of the company's current model and the developed (R, S) inventory model. Fisher and Raman [12] study determining the minimum order quantity on the stochastic inventory control model. In the proposed stochastic programming model, they try to estimate the probability distributions of the demand. The model increases the profit by 60% compared to the current system. Madduri [13] develops inventory policies for foods based on continuous and periodic inspections. Review policies are evaluated using simulation models. Considering the perishability of the product from the results of the simulations, EOQ

order policies are examined. The periodic review policy is stated to be ideal.
Yalçınkaya and Karataş [14] use ABC analysis to identify critical items in the inventory. To analyze the company's current inventory management policy for the specified items in the inventory, ARENA is used as software. The criticality of the materials needed in hospitals and their continuity has created the necessity of taking advantage of stock management policies. Wang et al. [15] aim not to be in stock out occurrence for hospital materials and to keep the costs of the inventory to a minimum as much as possible. Additionally, the study enables overcoming the disadvantages of existing reorder point approaches. Aslantaş [16] performs an ABC analysis for the products used in the production of distribution transformers in a transformer factory. A simulation-optimization approach is implemented for the periodic review inventory policy (R, s, nQ). A significant cost reduction is observed with the policy implemented. Kasımoğlu et al. [17] develop a mixed-integer programming model to solve the excess buffer inventory problems for a white goods production company with sequence-dependent setup times. Utku [18] proposes an optimization model and a simulation model to evaluate the bottlenecks and improve production procedures by investigating different alternatives at an automobile industry company. Pınar et al. [20] perform an ABC analysis for a textile company and propose a management strategy for the company.
Table 1 summarizes the literature about the (R, s, Q) stochastic inventory models and enables us to compare and see the differences between the proposed model. The proposed model contributes to the literature by using the simulation as a solution and diagnostic tool for stochastic inventory modeling.

Table 1. Some of the related studies in which (R, S) inventory management is considered in the literature.

Authors	Subject	Method
Rabta & AÏssani (2004) [1]	Investigating the steadiness in an (R, S, s) modeling and applying a strong stability method to consider quantitative estimates	Markov Chain
Babiloni et al. (2012) [2]	Estimating the fill rate in the (R, S) system	Simulation
Janssen et al. (1996) [3]	Determining the reorder point and average inventory level for the (R, s, Q) inventory modeling.	Compound Bernoulli Process (CBM)
Gökçen et al. (2015) [4]	Showing how the Optimization via Simulation (OvS) model can be applied effectively with the lost sales system considering the supply chain cost	Optimization via Simulation (OvS)
Rodrigues & Yoneyama (2020) [5]	Minimizing the total cost of inventory with a fill rate constraint	Prognostics and Health Monitoring (PHM)
Tarim & Smith (2007) [6]	A Constraint Programming (CP) model for a nonstationary (R, s, S) system including service-level constraints	Constraint Programming (CP)
Moors & Strijbosch (2017) [7]	A model for the average shortage of an (R, s, S) model in which demand fits the gamma distribution	Delphi Program
Ekren & Arslan (2019) [8]	The comparison of different lateral transfer policies in an (S, s) inventory control problem for a supply chain network system	Simulation modeling
Moors & Strijbosch (2002) [9]	A simulation model for an (R, s, S) inventory system in which both demand and lead time are stochastic	Delphi Program
Aytekin (2009) [10]	An application of just-in-time inventory management (Hospital)	Just in Time (JIT) inventory management
Karahan & Aslan (2016) [11]	An application on inventory control (Cement Factory)	Stochastic stock control modeling (R, S).
Fisher & Raman (1996) [12]	Cost reduction in case of the demand uncertainty	Stochastic modeling
Madduri (2009) [13]	Inventory policies for perishable products with fixed shelf -lives	Simulation modeling
Yalçınkaya & Karataş (2020) [14]	Simulation modeling of ABC inventory control process for spare parts in an automotive company	Simulation modeling

Wang et al. (2015) [15]	An inventory management problem	
Aslantaş (2019) [16]	Simulation optimization for the inventory control in a transformer production company	An (R, s, nQ) model and a simulation-based optimization approach are used.
Kasimoğlu et al. (2021)	Optimization for the prevention of excess buffer inventory	Mixed-integer programming

In this study, we consider the inventory management of two types of final products of exterior materials manufacturing with the stochastic behavior of the real demand data. Different from the literature, as a contribution, the (R, S) inventory management of the manufacturing system is modeled by using discrete event simulation regarding the cost and inventory level of the products.

In the remainder of the study, the material and methodology are stated in the second section including simulation modeling and input data analysis; results are discussed, and an output analysis is carried out in the third section finally, the conclusion and the suggestions are mentioned in the fourth section.

2. Material and Method

An inventory management model for the “Betopan” and “Yalipan” items in a construction material manufacturing company is developed and real data are used for the application. The demand, consumption, and inventory data for the factory's products in the past years are shown in Table 2, Table 3, and Table 4, respectively.

Table 2. One-Year Purchasing, Consumption, and Inventory for Betopan product.

Months	J.	F.	M.	A.	Ma.	J.	Ju.	Au.	S.	O.	N.	D.
Betopan Purch.	5.23	760	503	418	29	4.74	148	43	127	3.17	5.43	3.99
Betopan Cons.	2.32	2.16	2.34	5.87	7.21	5.56	4.13	2.80	5.98	4.64	3.47	2.80
Betopan Inv.	28.32	26.47	23.24	21.19	15.21	15.14	10.12	7.23	1.10	1.115	3.12	4.90

Table 3. One-Year Purchasing, Consumption, and Inventory for Yalipan product.

Months	J.	F.	M.	A.	Ma.	J.	Ju.	Au.	S.	O.	N.	D.
Yalipan Purch.	0	0	0	0	29	4.74	0	0	0	0	0	0
Yalipan Cons.	570	1.148	2.96	2.31	1.90	289	80	1.81	464	501	1.27	2.13
Yalipan Inv.	15.28	14.56	11.01	9.62	9.19	10.50	10.21	7.74	7.32	7.48	6.38	4.62

Table 4. Inventory Statistics for the Past Year.

One year total Betopan consumption	49,313	One year total Yalipan consumption	15,444
Average monthly Betopan consumption	4,109,417	Average monthly Yalipan consumption	1,287
One-year total Betopan inventory	157,174	One-year total Yalipan inventory	113,944
One year Betopan inventory cost (TL)	3,245,780	One year Yalipan inventory cost (TL)	2,783,120

The quantity of Betopan consumed by the factory is 49,313, while the actual amount of Betopan kept in inventory in the factory is 157,174 (Table 4). That is, the inventory held is about 3 times the amount consumed. The quantity of Yalipan consumed in the company is 15,444 and the actual quantity of Yalipan inventory held is 113,944. Accordingly, the quantity of inventory held is approximately 7 times the quantity consumed. As shown in Table 4, the quantity held in inventory is much greater than the quantity consumed.

2.1. Simulation Modeling

Simulation is a suitable methodology that we can be used for analyzing the behavior of real systems by mirroring the components and relevant processes to evaluate and foster measurements to improve the systems. Designing the model and necessary experiments are the major two phases in the implementation of the simulation. Simulation is used for various types of supply chains and their management because of the opportunities that it assures a wide spectrum of benefits. Accomplishing the appropriate level of inventory for every component of the supply chain, determining the desired service levels that stand for an efficient struggle for the uncertainties, and helping an efficient production planning, scheduling, and implementation of them in the supply chains are some of these opportunities [19]. Simulation enables us to foresee the system's efficiency, compare different alternatives, and decide on the best alternative. The discrete-event system simulation modeling is used for the simplified imitation of real-world systems which are generated to understand their performance over time and to identify different behaviors of systems.

In this model, since the demand is unknown and probabilistic, we use simulation as a suitable method to apply the (R, S) inventory control model for a construction materials manufacturing company. The inventory control policy of Betopan and Yalipan products is modeled with the simulation method and the safety inventory and order quantities are determined as a result of the simulation study. Using the outputs obtained, the current situation and results of the proposed model are compared considering the costs. For the application, the necessary monthly consumption data are analyzed, and the probabilistic behavior of the data is mirrored in the simulation model by determining the distribution of the past data via input data analysis.

In this study, the assumptions considered for the developed model are as follows:

(1) (R, S) inventory policy is applied.

(2) Production is a continuous activity.

(3) The order cost is independent of the number of orders.

(4) The simulation model is accepted to be initiated from the initial condition.

The distribution functions of the consumption amount of the semi-finished products of the company are analyzed by using ARENA software and its Input Analyzer module.

2.2. Input Data Analysis

In order to establish the simulation model, the probability distributions of the product groups are to be examined, and the quantity of demand is required. Input data analysis is essential for the simulation model to reflect the real system. The data that is used in the model include the data of “Betopan” and “Yalipan” inventory records obtained in the previous year of the company. The minimum, maximum, and standard deviation values of the product groups are determined in accordance with the data obtained. Also, information on demand distributions and lead time of products are stated in this section.

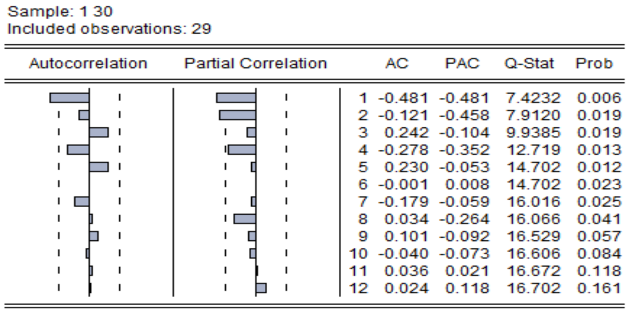
ARENA Input Analyzer is used to analyze the distribution of the data observed, and it provides the histogram graphics of the data to use for the diagnosis of the family of the distribution that fits the data. In this way, the probabilistic behavior of the system is simulated in the simulation model generated. For the Betopan consumption, the most appropriate distribution is found as $2 + 5.73 * BETA\,(0.58, 0.996)$ by the ARENA Input Analyzer. Accordingly, the P-value is found as 0.15 for the distribution which proves that the data fit the Beta distribution. In addition, the minimum value of the product group is 2.16, the maximum value is 7.22, the standard deviation is 1.72 and the average is 4.11. For the Yalipan consumption, according to the input analysis, the data fit $1 + WEIB(43.5, 0.351)$. The P-value is found as 0.15 for the distribution that supports that the data fit the Weibull distribution. The company waits for a certain time to supply products from the same supplier. In this case, they try to prevent this situation by keeping extra inventory. In order to determine the behavior of the system, we use past data as stated in Table 5. Accordingly, the distribution of the data is determined by using real lead time data.

Table 5. The sample data for finding the distribution of the lead time.

Order Number	Lead Time (days)	Order Number	Lead Time (days)
1	4	**16**	5
2	3,7	**17**	4,8

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

In Figure 1 the autocorrelation (AC) and partial correlation (PAC) in the first lag are not within the limits but have about 5% off the limits which is acceptable since there is a very small difference considering the limit. Since the sample of data is independent of each other, they are random and can be used to generate a distribution of delivery times. Using the ARENA Input Analyzer, we fit the lead time values and get the fitted distribution result as $2 + 3 * BETA(0.722, 0.788)$. The beta distribution is a distribution used for continuous unbiased variables limited to values between 0 and 1 but is defined by shape and scale as two parameters. The P-value is 0.16 which supports the good fit to the Beta distribution.


Sample: 1 30
Included observations: 29

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	-0.481	-0.481	7.4232	0.006
		2	-0.121	-0.458	7.9120	0.019
		3	0.242	-0.104	9.9385	0.019
		4	-0.278	-0.352	12.719	0.013
		5	0.230	-0.053	14.702	0.012
		6	-0.001	0.008	14.702	0.023
		7	-0.179	-0.059	16.016	0.025
		8	0.034	-0.264	16.066	0.041
		9	0.101	-0.092	16.529	0.057
		10	-0.040	-0.073	16.606	0.084
		11	0.036	0.021	16.672	0.118
		12	0.024	0.118	16.702	0.161

Figure 1. Autocorrelation and Partial Correlation.

2.3. Simulation Model

In this section, a simulation model is developed for the production and inventory system of the company by using ARENA software. As shown in Figure 2, the model includes two components. In the first part, the model simulates customer demand generation. This component starts with the creation of the customers and the demand associated with them. The entity is the customer. There are two decision modules available to indicate whether the customer demands can be met from the inventory or the production will start to maintain the inventory level. Thus, it checks the inventory level and initiates the production when the level of the inventory reaches reorder point. Additionally, it also monitors the demand that is lost when the customers are not satisfied.

The entities in the production component of the simulation are the production units. In this section, incoming raw materials accumulate in the in-process queues and they are processed and eventually added to the variable that we define with the name “inventory”. In addition to the inventory, there are two decision modules to check whether adequate production has been done.

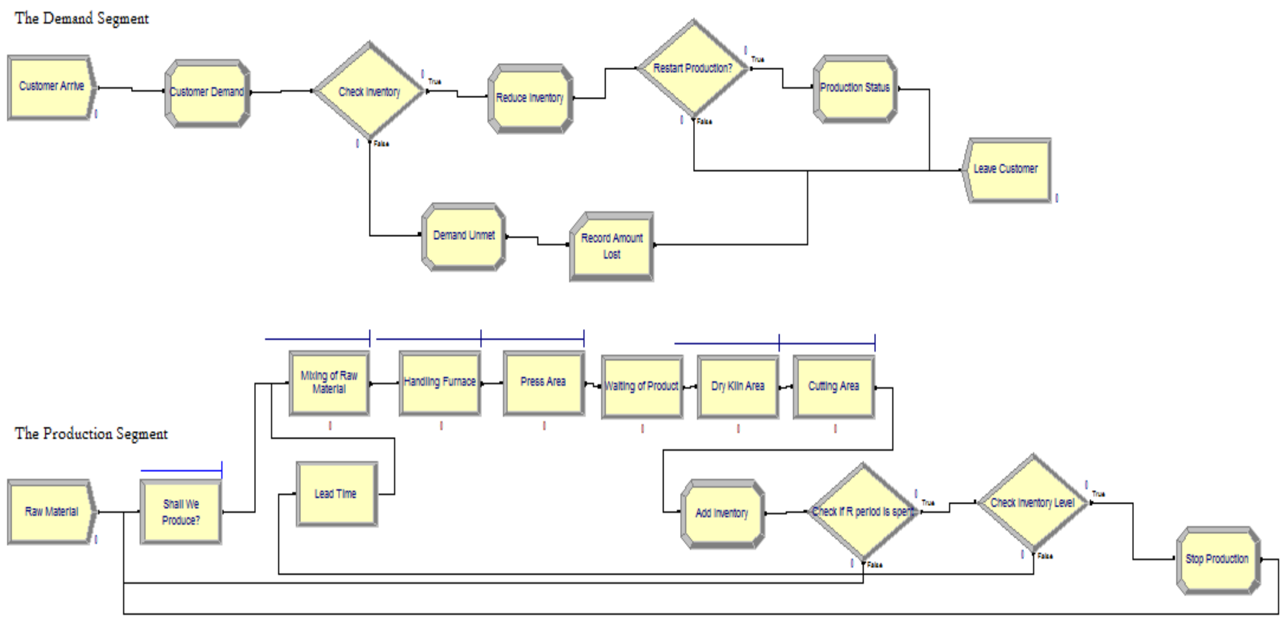


Figure 1. Arena Interface for the Simulation Model.

Accordingly, the major subcomponents including the input data and output data transformation procedures are also included in both of the model components in Figure 2. These procedures include all of the necessary elements like variables, resources, and statistics that set the relevant input variables, calculate the necessary statistics and produce the related report.

The source of the customer demand is generated by using the "create" module that is defined as "Customer Arrive" in the demand component of the model. The customer arrivals are determined as random behavior with a random variable that is found that fits the uniform distribution with parameters (2, 7). Besides, the customer demand is found that fits a beta distribution with parameters (0.58, 0.996) by using the Input Analyzer tool in ARENA by applying the real data obtained from the company. Thus, the customer entity enters this module and is assigned a random value within this distribution range. Then the customer entity comes to "Check Inventory" as a decision module to decide if the customer demand can be satisfied from the inventory. The control module may follow two ways: (1) If the variable "Inventory" has a value that is equal to or greater than the value of the "Demand", this means that the demand is to be satisfied. Accordingly, the entity named "customer" gets the "True" statement from the module named "Assign". Then, "Reduce Inventory" decreases the onhand inventory considering the demand. Then switches to the decision module that is named "Restart Production?", to control if the variable named "Reorder Point" is "Inventory < = Reorder Point". In case that is true, the constraint defined in our "Assign" module named production status (Production = 1) enables the connection to the second segment in case of production needs. This will enable the product that is held in the "Hold" module named (Shall we Produce?). In general, the work completed in this segment is to create customers and demands and to adjust the changing inventory level with customer arrivals. (2) In case the value of the "Inventory" variable has a smaller value than the demand value, it means that the current demand is not satisfied or partially satisfied. In both ways, the customer entity moves to the "Update Shortage module, which is an "Assign" module, where the Inventory variable is set to 0. At the same time, the "Lost" variable is followed by the customers whose demand could not be satisfied. In additiıon to this, the variable "Amount Lost" states the demand lost. The entity related to the customer then goes through the module named "Record", that records the amount lost, to keep track of the quantity that is lost for each of the customer (unsatisfied customer) by using "Tally". Then, by using the module named "Leave Customer", the entity moves in order to be disposed of.

The production segment starts with the "Raw Material" module which is a "Create" module. Entities defined in this part represent the production units. The product entity moves in the model repeatedly, with each cycle representing a production cycle. The "Shall We Produce?" which is a "Hold" module controls the process modules that come after themselves and carry out the production. The "Hold" module helps the user to monitor an entity by searching for the true or false logic condition. If the "Production = 1" condition is correct, it moves to the other modules, otherwise, it continues to wait in the queue "Shall We Produce?". When the condition is satisfied, the entities go through a six-stage production process including mixing raw material, handling furnace, pres area, waiting of product, dry kiln area, and cutting area. All of these operations are provided by the module named “Process” by using the ARENA software interface. All these processes have their unique processing time values, for example, mixing raw materials takes 10 to 20 minutes.

The level of inventory in the warehouse is kept by the “Inventory” variable that is at the beginning determined and stated to be 502. At the end of operations, the product entity in circulation comes to the “Assign” module named “Add Inventory”. The “Add Inventory” module adds a group of 20 of the final products to the inventory. Then the product entity has to go through two decide modules. The first one is "Check if the R period is spent", which allows us to check whether the elapsed time is up to the “r” period. Using the information obtained from the company, R represents 3-month periods and since the “TNOW” expression refers to the current time in the arena program, this indicates the time corresponding to 3 months (TNOW = 2160). The second is the “Check Inventory Level” module, which checks whether the updated inventory level is greater than or equal to the s level (Inventory > = S Level). If the entities do not meet the requirements, they must return to the beginning of production and repeat the processes. The entities that meet these two conditions come to the “Stop Production”, which is an “Assign” module, where the production is updated as “0” and the production stops.

By using the “Variable” module, the defined variables in the model can be examined and evaluated. Figure 3 shows the defined “Variables”.

Variable - Basic Process

	Name	Comment	Rows	Columns	Data Type	Clear Option	File Name	Initial Values	Report Statistics
1	Inventory				Real	System		1 rows	✓
2	S Level				Real	System		1 rows	✓
3	Batch Size				Real	System		1 rows	✓
4	Reorder Point				Real	System		1 rows	✓
5	Demand				Real	System		0 rows	✓
6	Total Customers				Real	System		0 rows	✓
7	Lost				Real	System		0 rows	✓
8	Demand Met				Real	System		0 rows	✓
9	Production				Real	System		0 rows	✓
10	Specific Production Cost				Real	System		1 rows	✓
11	Specific Shortage Cost				Real	System		1 rows	✓
12	Specific Holding Cost				Real	System		1 rows	✓
13	Amount Production				Real	System		0 rows	✓
14	Number of Setup				Real	System		0 rows	
15	Set Up Cost per Unit				Real	System		1 rows	

Figure 3. The “Variables” in the model.

By using the module named “Statistic”, it is possible to obtain the added statistics by the modeler that are collected throughout the simulation run and it makes it available to specify the output data files by the user. Figure 4 shows the “Statistic” module (spreadsheet) that helps us to see the information kept in the Inventory Model.

Statistic - Advanced Process

	Name	Type	Expression
1	Average Inventory Level	Time-Persistent	Inventory
2	Production On	Time-Persistent	Production == 1
3	Lost Rate	Output	Lost Customer / Total Customers
4	Holding Cost	Output	Specific Holding Cost * Inventory
5	Shortage Cost	Output	Amount Lost per Customer* Specific Shortage Cost
6	Production Cost	Output	Amount Production
7	Total Inventory Cost	Output	OVALUE(Holding Cost) + OVALUE(Production Cost) + OVALUE(Shortage Cost) + OVALUE(Set Up Cost per Unit)
8	Set Up Cost	Output	Set Up Cost per Unit * Number of Setup

Figure 4. Spreadsheet of the Statistic Module.

In Figure 4, there are two (DSTAT) Time-Persistent statistics, which are stated as “Average Inventory Level”, for the “Inventory” variable and “Production On”, for the expression “Production=1”. The outputs which are kept in the “Time-Persistent” statistics include the mean value, minimum and maximum values of the variables, and the 95% confidence interval that is observed during any run.

Additionally, the list includes six outputs: holding cost, shortage cost, production cost, set-up cost, total inventory cost, and loss rate. This help cost calculation while finding (near to) optimal results.

3. Results and Discussion

In this section, we implement validation and verification to check whether the simulation model established will work as a real system and investigate whether the results of the simulation are realistic together with the output analysis.

We determine the inventory level that will result in the lowest expected cost from the designed model. The "Process Analyzer" in ARENA is used and the trials are conducted to find the Betopan product inventory level. New values for the desired parameters are found over the revised values (reorder point, batch size, and s level).

Table 5. Results for the Betopan Product.

	Total Inventory Cost	Inventory (Level)	Production On
Base Model	3,712,768.073	30,961.059	0.978
Alternative 1	3,186,992.582	26,578.997	0.977
Alternative 2	2,839,193.154	23,680.026	0.976
Alternative 3	2,665,893.154	22,235.026	0.976
Alternative 4	2,695,084.744	22,473.056	0.979

In Table 5 it is seen that the inventory cost for the "Alternative 3" trial is less than the others. The inventory level corresponding to this cost for the Betopan product is 22,235. This alternative also provides a 97 percent utilization. We consider "Alternative 3" since the primary goal is repeated in the same way for the "Yalipan" product and the results are reported in Table 6.

Table 6. Summary Results for the Yalipan Product

	Total Inv. Cost (TL)	Inventory (Level)	Production On
Base Model	2,750,312.010	26,059.365	0.977
Alternative 1	2,126,540.063	19,468.001	0.975
Alternative 2	1,737,863.190	14,680.746	0.976
Alternative 3	2,003,769.157	16,996.219	0.977
Alternative 4	1,557,862.139	11,330.086	0.978

As shown in Table 6, after 4 trials for the Yalipan product, the optimal "s" level is found. The fourth alternative result is the lowest in terms of cost and the highest utilization when compared to other values. Thus, Alternative 4 is selected.

Table 7. Summary Results for Both of the Products.

	Total Inventory Cost (TL) After Simulation Application	Total Inventory Cost (TL) of The Current System
Betopan	2,665,893.154	3,245,780
Yalipan	1,577,862.139	2,783,120
Total	4,243,755.293	6,028,900

Table 8. Results for the Betopan and Yalipan Products.

	Total Inv. Cost (TL)	Inventory (Level)	Production On
Betopan	2,665,893.154	22,235.026	0.976
Yalipan	1,557,862.139	11,330.086	0.978

As seen from Tables 5-8 Betopan values are higher than Yalipan because it is more preferred by the customers.

For the validation purpose, after the simulation results are obtained as in Table 5 – 8, the comparison of the results from the (R, S) stochastic inventory control model developed and proposed in the study with the current inventory control performed by traditional methods are implemented. For both products, the factory has calculated the total annual inventory cost as 6,028,900 TL with their classical method. The total cost of holding inventory is calculated by the developed stochastic (R, S) model as 4,243,755.293 TL for the following year. In other words, even if the proposed inventory control model is used for only two products, it is seen that it reduces the inventory cost by 1,785,144.707 TL annually.

4. Conclusion and Suggestions

In this study, the inventory status of two types of final products belonging to the factory which is a manufacturer of exterior materials is considered. An application is implemented according to the data obtained from the production facility of the siding factory. In order to reflect the stochastic nature of the demand data, the (R, S) inventory management system is modeled by using discrete event simulation regarding the cost and inventory level of the products. In the model, two types of product groups are considered: “Betopan” and Yalipan” products. The simulation model developed aims at the inventory control of the “Betopan” and “Yalipan” products of the company. With the developed model, (R, S) parameters that make the total cost minimum is found. In line with the results obtained, it is observed that total inventory cost decreases by about 30 percent. Additionally, the cost reduction and its use provide additional benefits to the company. The study can be extended and applied to all end products and inventory levels that make the total cost minimum can be determined. As a future study, the simulation model can be used for the implementation and comparison of different inventory policies for the companies.

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Conflict of Interest Statement

There is no conflict of interest.

Statement of Research and Publication Ethics

The study complies with research and publication ethics.

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