A case study of supply chain simulation for determining the best stock allocation

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Abstract. You *Dare* is a Small and Medium Enterprise (SME) engaged in fashion, namely the sale of shoes. The problems that occurred in *Dare* are their limit on the amount of the shoes supply from suppliers and the inventory allocation policies are unplanned, so the profit is not maximized. This study simulates inventory allocation policy that *Dare* applies to see the impact on profits of *Dare* then proceed with the design of new system scenarios. The new scenario aims to implement policies more appropriately to increase the profits of *Dare*. Simulations are performed with ProModel software.The results of this study indicate that the policy of only using intuition cannot maximize the profits. An appropriate policy to increase profits of *Dare* is to consider the demand and cost allocation. Based on simulation results, *Dare* will only have an average profit of IDR 52.187.000, whereas if *Dare* uses the proposed policy, the average profit will increase to IDR 55.948.000 within two years.

1 Introduction

Inventory inaccuracy is a main issue in businesses dealing with goods supply chain. The allocation policy of inventory is a significant concern for the smooth flow of goods. Less inventory will have an impact on loss of sales, while excess inventory will be detrimental due to costs incurred. An appropriate allocation policy analysis is required for each retail supply in the supply chain. Inventory problems not only occur in large companies, but also in small and medium industries. One of them is *Dare*. The aim of this paper is to examine the best stock allocation from supplier to their retail with different cooperation system in *Dare*.

Dare is one of the fashion industries that sell products such as snikers shoes. *Dare* is currently unable to meet the demand for shoes in real time. This is shown by the inventory shortages that occurred in retail of *Dare* during 2015. Based on the historical data, *Dare* in 2015 discovered that the average of total inventory shortage reaches 133 requests per month. The inability of *Dare* to meet the market demand is caused by two factors, firstly the limit on the amount of supply from suppliers, i.e. a maximum of 500 shoes per month, and secondly the inventory allocation policy from *Dare* factory to the retail shop is not well planned. The allocation policy is not well planned because it does not consider the system of cooperation established with retail. In the supply chain system, one of *Dare's* suppliers is located in Bandung. The supplier will send the shoes by an amount that *Dare* determines, but it should not be more than 500 shoes per month. After that, *Dare* will sell the shoes through the online store and through cooperation with nine distributions that are willing to become a retail of *Dare*. These distributions are located in Java and Bali.

There are two systems of cooperation between retail and *Dare*. The buying system is bifurcated. Firstly, the direct buying system. *Dare* would provide special pricing on retail and the retail of *Dare* is willing to buy shoes for resale. Shipping costs will be paid by the retailer. Secondly, the consignment system. In this system, the retailer does not buy shoes from *Dare*, but *Dare* leaves shoes at the retail. *Dare* had to pay the shipping costs and the cost of the consignment. Consignment fee is the remuneration given to the retail which *Dare* deposited on each shoe. There are six retails using consignment cooperation system and there are only three retails using direct buying system. Each retailer has a stochastic demand. The data in the data request in 2015 showed that retail consignment had a higher level of demand.

The allocation policy to the retail inventory implemented by *Dare* currently only relies on the intuition of the owners without considering both systems. Under the policy, *Dare* will lose whenever there is a remaining inventory at retail consignment arrangement and when there is a shortage of inventory in retail using direct buying system. This is because *Dare* already spent more allocation to retail by the consignment system. If the loss is not prevented, it will have an impact on *Dare's* inability to survive in the competitive business of fashion. Thus the main objective of conducting this research is to get the inventory allocation policy to increase the revenue of *Dare* orders and not to experience losses.

The approach will be used to find a product allocation policy of *Dare* which is a simulation method. Simulation is a clone of the system using a computer model to evaluate and improve system performance [1]. The

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simulation method is chosen because it can see the behavior of the real system as a whole, have a high flexibility, and provide representative results.

In supply chain context, simulation can undoubtedly play an important role, above all for its main property to provide what-if analysis and to evaluate quantitatively bene fi ts and issues deriving from operating in a co-operative environment rather than playing a pure transaction role with the upstream / downstream tiers [2]. Siprelle et al. [3] performs a simulation to find the best strategy in terms of supply allocation at the distribution center to avoid cross-shipment of product. Another research is conduct by Arreola et al. [4]. This research consider a two-stage decision problem, in which an online retailer first makes optimal decisions on his profit margin and free-shipping threshold, and then determines his inventory level. Arreola et al. [4] use Arena to simulate the operation of the online retailer, and then use OptQuest to find the optimal solutions.

The software that is employed in this paper is ProModel. ProModel is a simulation and animation tool designed to quickly yet accurately model manufacturing systems of all types, particularly supply chain systems [5]. In this study, the model will be designed by adjusting the existing policy system at *Dare*. The results of the development of the model will be used to create inventory allocation policy scenarios that can increase revenue of *Dare*.

2 *Dare* System

Dare sells its shoes through its online store and by collaborating with nine distros (distribution outlets) who are willing to be retail. For sales through online stores, all activities are carried out at the office of *Dare. Dare* provides wages to 10% of the shoes selling price for its employees who concurrently administer the online store. Shipping costs will be borne by the buyer. The retail demand of any nature is uncertain or stochastic. The system of cooperation is the direct buying system and the consignment system.

1. Direct buying system. The Purchasing system is bifurcated into a cooperation established between *Dare* and retailing in which the retailer is willing to pay the shipping costs and buy shoes from *Dare* for resale. In addition, *Dare* is also willing to give 20% discount of the shoes selling price. This co-operation system is more advantageous for *Dare* compared with consignment system because *Dare* will not lose any money if these shoes are not sold. However, there are only three retails willing to use this cooperation system. Retail usually comes from a small town and has not had loyal customers.
2. Consignment system. The Consignment system is a system of mutually beneficial cooperation between *Dare* and retailing in which the retailer acts as a place to leave shoes to *Dare*. To entrust the shoes to retail, *Dare* charges a consignment of 15% -20% of the selling price of these shoes. The gain derived by *Dare* is able to sell its products on a distro that has loyal consumers. Consumers at the retail consignment are usually consumers of the community, such as the skateboard community, band, BMX bikes, etc. Thus *Dare* shoes can be more quickly recognized and can draw a definite interest. The drawback of this system is *Dare* consignment must pay a fee for every shoe that is deposited and has to pay shipping costs. Thus, if the deposited shoes are unsold, then *Dare* will lose the shipping costs and the cost of the consignment.

At the end of every month *Dare* will order the shoes to the supplier. The number of orders is determined by *Dare*, but the supplier limits the number of shoes that are ordered. It should not exceed 500 pairs per month. The shoes are ordered on the 30th every month and will come one month later on the 1st of the following month. So, if *Dare* orders on January 30th, then shoes will come on March 1st. Every beginning of the month, *Dare* receives the supply of shoes. The shoes are then repackaged using a cardboard shoe from *Dare* and carried out allotment allocation. The time required for packing and rationing the allocation of shoes is one day. Once packaged, the shoes are then allocated to every *Dare* retail. *Dare* has nine retails and one online store. *Dare* Retail is located in various regions of Java Island and one retail in Bali Island, while the online shop is operated in *Dare* office. The list of retail and its location can be seen in Table 1. The amount of allocation for each retail is determined based on the policies and intuition of the *Dare* owner. After receiving the allocation of shoes from *Dare*, every retail will make sales until the end of the month. Every 30th, the retail will send a sales report containing the number of shoes that have been sold, the remaining shoes, and the number of unmet requests. This report of each retail will be used by *Dare* to place orders to suppliers and determine the amount of inventory allocation for each retail in the next month.

Table 1. The list of retail and the location

No	Retail Name	Locations	*Lead Time (day)*	System
1.	Electrohell	Jogja	1	Consig-ment
2.	Koffin	Jogja	1	
3.	Rumbble	Jogja	1	
4.	Koffin Jgj	Semarang	3	
5.	Dominion	Surabaya	3	
6.	Rumbble Bl	Bali	3	
7.	Blind	Tuban	3	Direct Buying
8.	Maxx	Jember	3	
9.	Pride	Banyuwangi	3	

Dare has nine retails and one online store where each retail has a varying demand level. There are some data used in this study, both primary data and secondary data. Primary data in this study are drawn to complete the secondary data through interviews with the owners of *Dare*. Secondary data are taken from historical data of the company during the period from January 2015 to April 2016. The secondary data are as follows; consumer demand of each retail, product allocation of *Dare*, the shortage that occurred in each retail, supply of shoes from suppliers, the retail characteristic, and the data of shipping and consignment.

3 Research Method

Simulation is an imitation of a dynamic system using computer models to evaluate and improve system performance [1]. Simulation is one of the most widely used operations research and management methods. Simulation is used as a mean of numerical analysis of the models to see which inputs that affect the measurement of output on the system performance. Simulation is not an optimization tool that gives a decision but it is the result of a decision support tool, thus the interpretation of the results depends on the purpose of the decision maker. ProModel is one of the windows-based simulation softwares that can be used to model and analyze a system of various types and sizes. ProModel provides a good combination of usage, flexibility, and ability to model a real system. ProModel is equipped with animation feature, so that the model looks more realistic. ProModel is closely related to resource utilization, optimization of production capacity, productivity, production scheduling, and inventory levels. Development of the real system model simulation is constructed with the following steps :

3.1 Fitting Distribution

Fitting distribution is applied to determine the pattern of the data. Determination of distribution pattern for consumer demand data to each retail is done by Stat :: Fit in ProModel. By using Stat :: Fit, there will be some theoretical distribution corresponding to the data in the real system. The used theoretical distribution is a discrete distribution.

3.2 Calculate the percentage of shoe supply arrival from supplier

To determine the product supply data from supplier to *Dare*, this research will employ user distribution menu that is also found in ProModel. User Distribution was chosen because the number of shoe supplies are known, i.e. among 400, 450, or 500 shoes. For this purpose, the user distribution is used to determine the percentage of supply values emerging during the simulation process. The percentage is determined based on the company historical data.

3.3 Calculating the proportion of allocation of products of the real system

In the real system, the number of products allocation from *Dare* to each retail is determined based on the owner intuition. On the construction of a real system model simulation, the allocation amount is entered in the form of proportions. To determine the proportion, the test is carried out by summing the number of allocations of each retail for 16 months.

3.4 Development of real system simulation

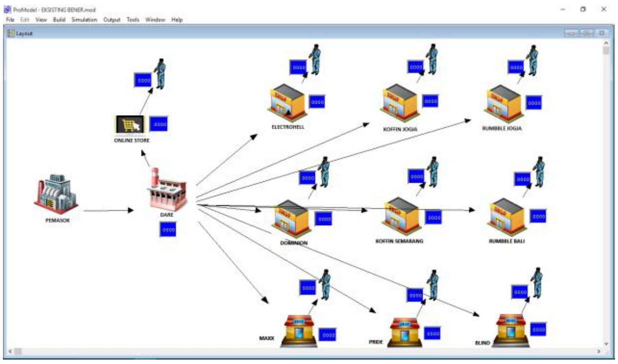


Fig. 1. The illustration of real simulation system

Development of real models is constructed using ProModel. Data inputs that used in the construction of the model are distribution data that are requested, the data distribution of the arrival of the supply of shoes, and the proportion of allocation. The construction of the real system simulation, at least needs some components in ProModel, those are Location, Entities, Variable, Arrivals and Processing. Location is where the entity of the system will be processed. Entities are components that are processed in the system. Variables are used to record the movement of entities. Arrivals is a coding process that defines the entity arrival time in the system. Processing is a coding process used to describe commands. The real system simulation using ProModel is illustrated in Figure 1.

Figure 1 is depiction of shoes that come from supplier to *Dare*. After that, shoes will wait for one day to be allocated to the retails. The proportion of allocations is adjusted to the current *Dare* policy. Retail will receive shoes at the beginning of the month, then at the end of the month retail will receive the orders from consumers. Retail will send shoes supplies to consumers. All delivery processes are recorded by variables in the simulation. Variables are indicated with blue boxes. From these variables can be seen whether the retail experiences a shortage of inventory or excesses inventory.

3.5 Verify the simulation model

Verification is a process to ensure whether the model is correct. The verification process identifies the errors in the simulation logic and the input data. The first step of the verification process is checking the code of the model. The model codes check is used to check whether coding entered into the system simulation is in conformity with the logic in the conceptual model. Secondly, checking output. An output check is performed to see if the simulation results are reasonable. Examination is done by comparing the result of simulation running with original data. This check only ensures that the simulation results make sense. The last is checking the animation. Animation checks are performed to determine whether the entity flow is in conformity with the conceptual model.

3.6 Validation of the model

Validation is implemented to determine whether the simulation model that has been made already represents the real system. Validation is comparing simulation result with the real system output. Law and Kelton [6] describe validation as illustrated in Figure 2.

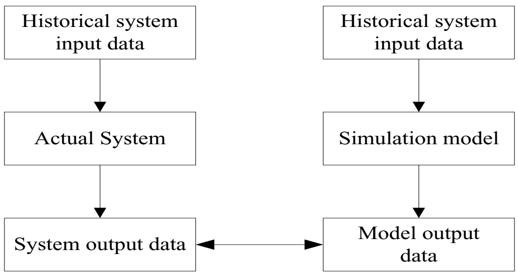


Fig. 2. Validation of Simulation [6]

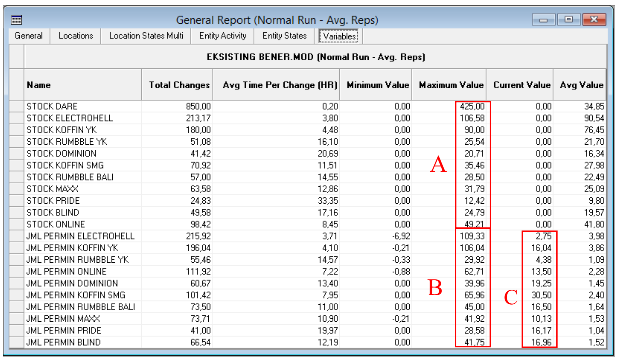
The entity to be tested is the number of demand and the amount of inventory shortage. The number of demand represents the data used as input, while the amount of inventory shortage represents the simulation output. Prior to the validation, there are data normality test and homogeneity test. Normaly distributed data validation is done by using an independent t-test, while another distributed data validation is performed by the Mann-Whitney test. The confident level that is used is 95%. Validation test results can be seen in Table 2.

Table 2. Validity test of demand and shortage data

No	Retail	Statistic Test Method				Result
		Demand	P-value	Shortage	P-value	
1	Online	*Ind. T test*	0,928	*Ind. T-test*	0,279	Valid
2	Electrohell	*Ind. T test*	0,546	*MW Test*	0,056	Valid
3	Kofiin Jgj	*Ind. T test*	0,989	*Ind. T-test*	0,254	Valid
4	Rumbble	*Ind. T test*	0,255	*MW Test*	0,090	Valid
5	Koffin Smg	*Ind. T test*	0,391	*MW Test*	0,509	Valid
6	Dominion	*Ind. T test*	0,980	*Ind. T-test*	0,253	Valid
7	Rumbble Bl	*Ind. T test*	0,071	*Ind. T-test*	0,820	Valid
8	Maxx	*Ind. T test*	0,236	*Ind. T-test*	0,911	Valid
9	Pride	*Ind. T test*	0,385	*MW Test*	0,776	Valid
10	Blind	*Ind. T test*	0,913	*Ind. T-test*	0,826	Valid

3.7 Simulation result

The simulation runs with 24 times replication. The simulation result shows the average of the shoes allocated to each retail, the number of demand, and the number of shortages that occur in each retail. The result of the real system simulation can be seen in Figure 3. Figure 3 shows there are three boxes, i.e A, B, and C. These three boxes are the result of temporary records (variables) that have been made during the simulation. Box A shows the number of shoe allocations to each retail. Box B shows the number of consumer demand to each retail. Box C denotes the end condition of the demand. If the value in box C is positive, there is a shortage of inventory. If the value in box C is negative, then the remaining inventory is at retail accounts (absolute value).



EKSISTING BENER.MOD (Normal Run - Avg. Reps)

Name	Total Changes	Avg Time Per Change (HR)	Minimum Value	Maximum Value	Current Value	Avg Value
STOCK DARE	850,00	0,20	0,00	425,00	0,00	34,85
STOCK ELECTROHELL	213,17	3,80	0,00	106,58	0,00	90,54
STOCK KOFFIN YK	180,00	4,48	0,00	90,00	0,00	76,45
STOCK RUMBBLE YK	51,08	16,10	0,00	25,54	0,00	21,70
STOCK DOMINION	41,42	20,69	0,00	20,71	0,00	16,34
STOCK KOFFIN SMG	70,92	11,51	0,00	35,46	0,00	27,98
STOCK RUMBBLE BALI	57,00	14,55	0,00	28,50	0,00	22,49
STOCK MAXX	63,58	12,86	0,00	31,79	0,00	25,09
STOCK PRIDE	24,83	33,35	0,00	12,42	0,00	9,80
STOCK BLIND	49,58	17,16	0,00	24,79	0,00	19,57
STOCK ONLINE	98,42	8,45	0,00	49,21	0,00	41,80
JML PERMIN ELECTROHELL	215,92	3,71	-6,92	109,33	2,75	3,98
JML PERMIN KOFFIN YK	196,04	4,10	-0,21	106,04	16,04	3,86
JML PERMIN RUMBBLE YK	55,46	14,57	-0,33	29,92	4,38	1,09
JML PERMIN ONLINE	111,92	7,22	-0,88	62,71	13,50	2,28
JML PERMIN DOMINION	60,67	13,40	0,00	39,96	19,25	1,45
JML PERMIN KOFFIN SMG	101,42	7,95	0,00	65,96	30,50	2,40
JML PERMIN RUMBBLE BALI	73,50	11,00	0,00	45,00	16,50	1,64
JML PERMIN MAXX	73,71	10,90	-0,21	41,92	10,13	1,53
JML PERMIN PRIDE	41,00	19,97	0,00	28,58	16,17	1,04
JML PERMIN BLIND	66,54	12,19	0,00	41,75	16,96	1,52

Fig. 3. Real system simulation output

In Figure 3, it can be seen that the average supply of shoes to *Dare* is 425 shoes per month. *Dare* policy calculation results can be seen in Table 3.

Table 3. Real system simulation result (Average)

No	Retail	Allocation	Demand	*shortage*	Sold
1	Online	49	63	14	49
2	Electrohell	107	109	2	107
3	Koffin jgj	90	106	16	90
4	Rumbble	26	30	4	26
5	Koffin	35	66	31	35
6	Dominion	21	40	19	21
7	Rumbble Bl	29	45	16	29
8	Maxx	32	42	10	32
9	Blind	25	42	17	25
10	Pride	12	29	17	12

From the ProModel simulation output results, the calculation is carried out as follows:

a. Numbers of sold shoes : if the allocation average < demand average, the average sold is equal to the allocation average. If not, then the sold average is equal to the demand average.
b. Average of cost allocation : (allocation average x shipping costs) + (allocation average + cost cooperation).
c. Revenue average: (selling average x IDR 280.000) - cost allocation average.
d. The average profit : The average amount of revenue - Cost of Procurement
e. Procurement costs : average number of supply shoes x IDR 120,000, -

4 Development of Scenarios

Meeting the optimal policy of the stock allocation simulation can help *Dare* improve the profit. There are 4 (four) scenarios generated in the simulation model.

Scenario 1 (Applying the old policy, i.e the number of supply is 500 shoes per month). On the real system, *Dare* experiences a lot of lack in each retail inventory. This happens because during 2015 the supply of shoes from suppliers ranged only around 400 to 450 shoes per month. Thus, incoming demand can not be fulfilled. In 2016, *Dare* got more quotas from suppliers of 500 pairs of shoes per month. This first scenario will simulate conditions from *Dare* in 2016.

Scenario 2 (Prioritizing retail in high demand). In this second scenario, the policy will be amended to prioritize the allocation of retail that has a high demand. The demand average used in the preparation of this scenario refers to the results of running the real system simulation. The demand average is then sorted from largest to smallest. Once it is sorted, it is also proceeded with the determination of the allocation proportion to each retail.

Scenario 3 (Prioritizing low retail cost allocation). This scenario will prioritize retail that has low cost allocation. This scenario is created with the aim to raise the income of *Dare*. Compiling this scenario requires the calculation of the cost allocation for each shoe retail. After obtaining the retailers are prioritized to receive an allocation, the next is to determine what proportion of the allocation is given to each retail. Calculations are based on the proportion of the consumer demand average to each retail.

Scenario 4 (Weighting). This scenario will weight to see the level of demand and cost allocation. Given these two aspects are equally important, the proportion of demand interest rate compared to the cost allocation is the same, namely 50:50. With these proportions, weights can be calculated for each retail. Retail discount level of high demand and low cost allocation will have greater weight. Inventory allocation will be based on weight of the gain. Retail has the highest weight, then the demand will be prioritized to be met first. The simulation of four scenarios above can be seen in Table 4.

Table 4. The Results of the scenarios simulation

Scenario	Description	Cost Allocation (IDR)	Profits (IDR)
Existing	Simulating real condition	20.137.500,-	48.022.500,-
1	Policy of Dare for 2016	23.613.000,-	52.187.000,-
2	High demand retail	23.175.000,-	54.865.000,-
3	Low cost retail	22.509.000,-	54.131.000,-
4	Average demand and costs of cooperation	22.652.000,-	55.948.000,-

5 Conclusions

Based on data processing and analysis that have been done in this study, it can be seen that policies introduced by *Dare* are currently not effective to increase profits of Dare. From the simulation scenarios, all of the policies applied in scenario 1 to 4 can increase profits for *Dare*. The best scenario is scenario 4 because it mostly increases the profits for *Dare*. There are eight retails that get shoe inventory allocation, they are Online, Koffin Jogja, Electrohell, Koffin Semarang, Bali Rummble, Pride, Maxx, and Blind.

6 Further Research

Further research should be simulated by considering the addition of supplier to see if it can increase profits for *Dare*. Simulations should be performed to calculate how many shoes exactly to book *Dare* for suppliers, It can be done by changing the proportion of development scenarios corresponding to weighting another viewpoint. The consumer behavior needs to be considered in each retail when there is the closure of retail. For example, if a retail Rumbble Jogja closed, whether it will affect the distribution of demand in the Electrohell, Koffin Jogja, and Online Retails.

References

1. C. Harrel, B. K Ghosh, R. Bowden, *Simulation Using ProModel.* (2004).
2. S. Terzi, S. Cavalieri, Sim. in The SC Context: a Survey. *Computers In Industry, Vol. 53*, 3-16. (2004).
3. J. A. Siprelle, J. D. Parsons, J. R. Clark, Benefits of Using a SC Sim. Tool to Study Inv. All. *Winter Simulation Conference*. 238-245 (2003).
4. B. R Arreola, M. Leng, M. Parlar. OL ret. prom. pric, free-ship. thres., and inv. dec. *European Journal of Operational Research, Volume 230*, 272-283 (2013).
5. D. Benson. Sim. Mod. & Opt. Using Prom. *Winter Simulation Conference*, pp. 587-593 (1997)
6. 6. M. A. Law, W.D Kelton. *Sim. Mod. An.* Singapore: McGraw-Hill Book Co (2000)