Master of Science in **Management and Information Systems**

Modeling methods of System Dynamics – Supply Chain Simulation using the Anylogic software

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1. Introduction

This paper concerns the modeling methods of System Dynamics and Simulation using the Anylogic software. The purpose is to show how to use software to provide answers to supply chain issues, in particular inventory policy.

We developed a supply chain simulation model that operates **24 hours** a day and consists of four departments: **customers**, **retailer**, **wholesaler**, and **factory**.

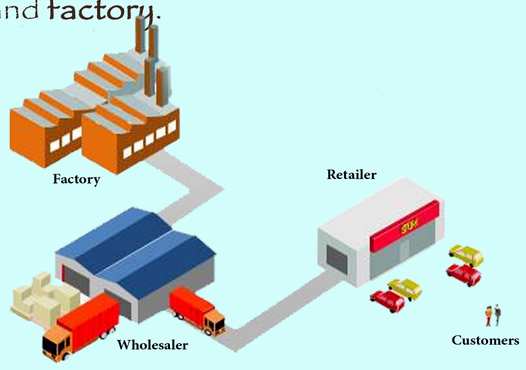

Fig.1 Supply Chain Model

Using an optimization experiment we tried to find the **optimal inventory policy for specific operating costs.** Due to the interaction of the members of a supply chain, it is impossible to find a solution to the above problem without the use of modeling / simulation software. Based on this, we attempted to answer the problem using the **Anylogic** software.

2. Methodology

The design of the simulation model has been done in such a way that there is no communication between the units other than using **messaging**, so the units do not need to know anything else about the **internal structure of their "neighbors."** This allows independent unit development (retailer, wholesaler, factory) and also allows the wholesaler to connect with another wholesaler, or a retailer directly at the factory.

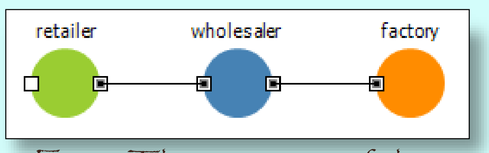

Fig. 2 The structure of the model (top-level)

Our goal is to minimize operating costs by keeping our customers satisfied.

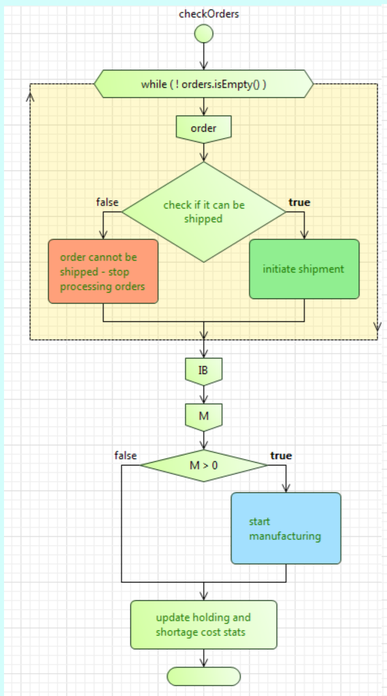

Fig. 3 Factory Structure Diagram

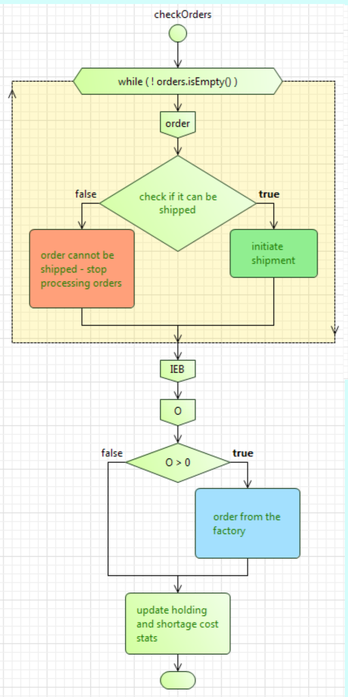

Fig. 4 Wholesale Structure Diagram

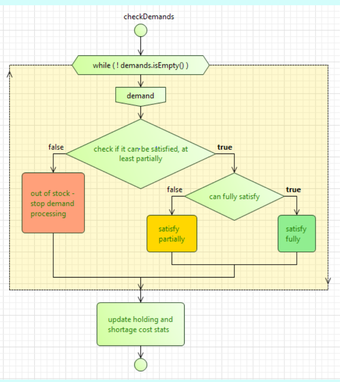

Fig. 5 checkDemands Structure Diagram

	Factory	Wholesale	Retailer
Inventory Policy	$M_F = \begin{cases} S_F - I_F^N & \text{if } I_F^N < s_F \\ 0 & \text{if } I_F^N \geq s_F \end{cases}$	$O_W = \begin{cases} S_W - I_W^N & \text{if } I_W^N < s_W \\ 0 & \text{if } I_W^N \geq s_W \end{cases}$	$O_R = \begin{cases} S_R - I_R & \text{if } I_R < s_R \\ 0 & \text{if } I_R \geq s_R \end{cases}$
Hording Cost / day	h_F = \$0.75	h_W = \$1.25	h_R = \$30
Setup Cost	K_F = \$50	K_W = \$40	K_R = \$30
Incremental Cost	i_F = \$5	i_W = \$4	i_R = \$3

3. Results

The optimization experiment runs **5,000 simulations** and chooses the combination of the best stock policy for the retailer, wholesaler and factory. After the experiment completes next to each icon of our items (retailer, wholesaler, factory), the **s, S** value for stock policy is listed.

Fig.6 Optimization Simulation

We create **six** (6) policy stocks values for our three items (retailer, wholesaler and factory). These parameters are type **integer** and get values from **0** to **200** in step **1**.

Parameters:

Parameter	Type	Value Min	Max	Step	Suggested
s [Retailer]	int	0	200	1	
S [Retailer]	int	0	200	1	
s [Wholesaler]	int	0	200	1	
S [Wholesaler]	int	0	200	1	
s [Factory]	int	0	200	1	
S [Factory]	int	0	200	1	

Fig.7 Parameters Definition

The Optimization Simulation uses a **MySQL Database** for saving the results. The Manager or CEO can use the **Dashboard of Simulation (GUI in PHP)** for viewing those results.

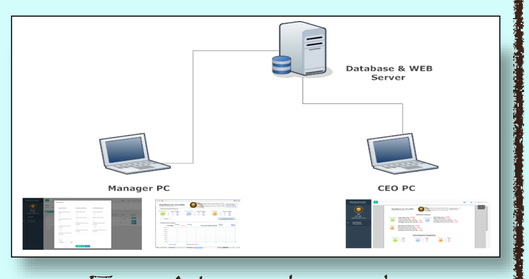

Fig.8 Network topology

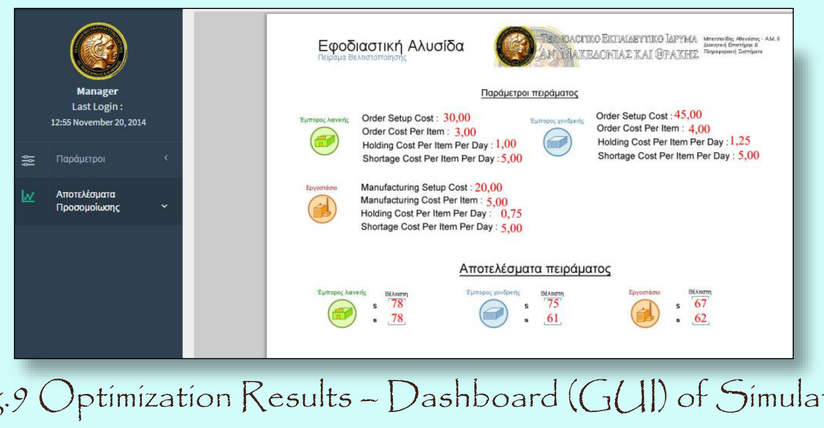

Fig.9 Optimization Results – Dashboard (GUI) of Simulation

4. Conclusions

The use of modeling and simulation of stock policy in a supply chain, makes understandable the fact that stock-related decisions are **affected by all those involved in the chain**.

Our model is based on customer-based variables and their orders. The above method was chosen because there were no actual product's demand data where we could base our simulation model. Using actual data will add **more precision** to the model and simulation. This feature can be achieved by linking the model to an **ERP database with real-life data**.

In this way, the result of the optimization experiment will be even closer to the actual optimal stock policy value than now, where odds are being used.

5. References

[1] Borshchev, A. (2013). The big book of simulation modeling. [Lisle, IL]: AnyLogic North America.

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[3] Nissen, M. (2001). Agent-Based Supply Chain Integration. *Information Technology & Management*, 2(3), pp.289-312.