SYSTEM DINAMYCS APPROACH FOR LOGISTIC MODEL BASED ON MARKET SATISFACTION

ALVINSYAH
Transport Research group
Civil Engineering Department
University of Indonesia
Depok, 16424, Indonesia
Fax.:62-21-727-0028
E-mail : alvin@eng.ui.ac.id

Sutanto SOEHODHO
Transport Research group
Civil Engineering Department
University of Indonesia
Depok, 16424, Indonesia
Fax.:62-21-727-0028
E-mail : tanto@eng.ui.ac.id

Abstract: This research deals with the development of logistic model based on system dynamic approach by considering producer and customer needs. The discussion is focused on the development of algorithm concept for commodity distribution based on the existing system dynamic architecture, the justification related variables in the state of dynamics context, the formulation of variables correlation and their contribution in term of positive/negative feedback to the system. The developed model consists of several sub-models and several delivery policy strategies that consider budget constraint, production and delivery capacity, fleet-size and service regions are determined. The nature of dynamic interaction between variables in the system, the role of control systems and the behavior of the system due to feedback in a continue evaluation process are analyzed through simulation based on the predetermined policy scenarios. Simulation to the model shows that different behavior response of the market occurs due to delivery policy implemented. This result leads to the selection of the best delivery policy in order to gain the most optimum benefit for the producer while still maintains customer satisfaction.

1. INTRODUCTION

Logistic systems have three interrelated major components namely, production, market and distribution. These three components should work altogether as efficient as possible to obtain two main objectives at the same time, that is customer satisfaction in one side and producer profit in the other side. Figure 1 shows the interrelation between these components and the dashed area reflects the customer and the producer needs (i.e. satisfaction and profit). If one of these components does not work properly, it will disturb the equilibrium of whole systems and will not achieve the aforementioned objectives. Implicitly, interrelation of the components in the system is dynamic in nature. This research deals with the development of logistic model based on system dynamic approach by considering producer and customer needs.

The proposed model covers several sub-models, namely, production model, customer model, distribution model, cost model, and market response model. The model is developed in dynamic simulation to represent the characteristics and interrelation of sub-models via predetermined delivery policy strategy that consider budget constraint, production and delivery capacity, fleet size and service regions.

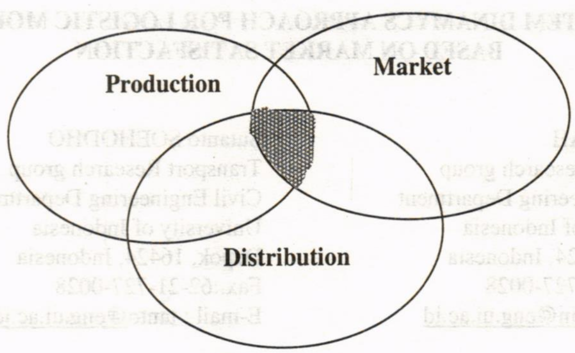

Figure 1. Major Components in Logistic Systems

In this research the objective function is determined as to maximize revenue to fulfil customer satisfaction. Through some simulation, the most appropriate delivery strategy in order to optimize the objective can be introduced by the producer.

The following sections are going to discuss the theoretical background in section 2, model formulation in section 3, simulation and discussion in section 4 and conclusion in section 5.

2. THEORETICAL BACKGROUND

Prior to the model formulation, a brief discussion is made for the logistic systems and dynamic simulation for logistic model in the following sub-sections as a theoretical background.

2.1 Logistic Systems

Logistic system is a system that covers planning, implementation and evaluation process of several repeated activities range from raw materials procurement to product distribution. There are some important factors, which should be considered in logistic system, namely;

- Raw materials procurement (i.e. quantity, delivery time, transportation and stock)
- Raw materials handling
- Production process
- Packaging process
- Product storage (i.e. quantity, warehouse location and storage system)
- Product distribution (i.e. fleet-size availability and distribution capacity)
- Product marketing (i.e. market respond, budgeting and product launching),
- Product order (i.e. quantity, scheduling, delivery rate, time agreement and order received).

There are some limitations in logistic system should be born in mind. These limitations should be handled carefully in order to keep the production and the delivery of product is going well, hence it will keep the customer satisfaction (Ballou, 1990).

2.2. Dynamic Simulation for Logistic Model

Figure 2 depicts the best illustration of the interrelation of logistic components and problems as shown in Figure 1. Figure 2 clearly shows the interrelation among the logistic components, wherein the causal loop may further indicate the balance, and hence arrow adjusts its feedback with opposing or supporting manners. A more comprehensive discussion on the system dynamics is described in Forrester (1969, 1971).

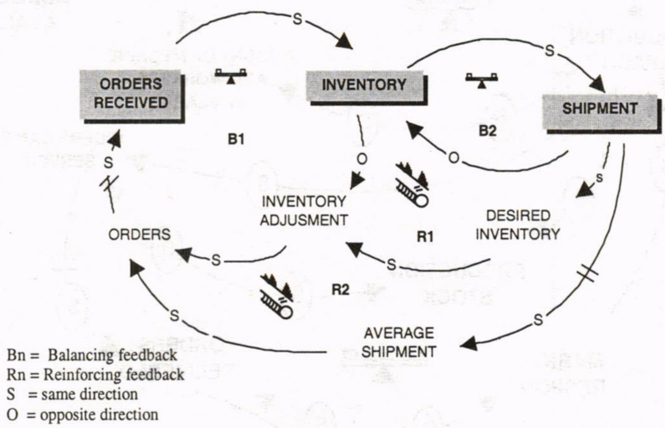

Figure 2. Example of Causal Loops in Logistic Systems

Having the causal loop as represented in Figure 2, any simulation can be made for certain resources or strategies of expected situation. In the analysis the indicating trends of impact are more emphasized rather than the accuracy of results. This in line with the assumptions made and the objective of the developed model to propose a good decision tool to formulate best delivery policy.

3. MODEL FORMULATION

As mentioned in the previous section, the model objective is to maximize revenue by considering some constraints in satisfying customer order such as delivery time fulfillment, fleet-size availability, stock availability, order scheduling and order delivery. To comply with the model some assumptions are made as followings;

- Producer serves only three regions
- Product is delivered to major customers only
- Budget and additional budget are made constant and random
- Maximum and minimum orders are predetermined for each region
- First in and first out (*FIFO*) concept is applied in order delivery

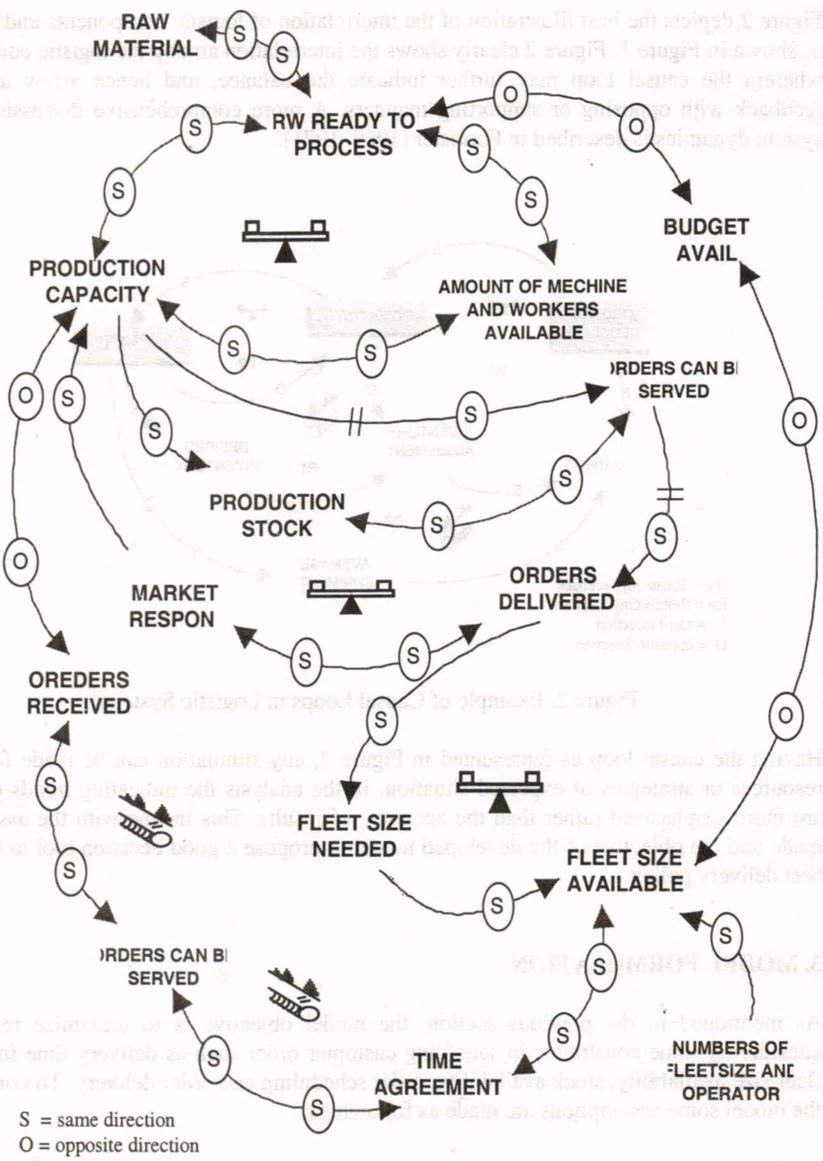

Figure 3. The Proposed Dynamic Logistic Model

Based on the proposed dynamic logistic model represented in Figure 3, several sub-models are developed for each level of logistic process as discussed in the following sub-sections.

3.1 Production Process Sub-model

This sub-model represents the process of production that covers source of raw materials, the amount of raw materials, available number of production machine, number of required machine for production, process of production, and production capacity. These interrelated components are then composed in the model as shown in Figure 4.

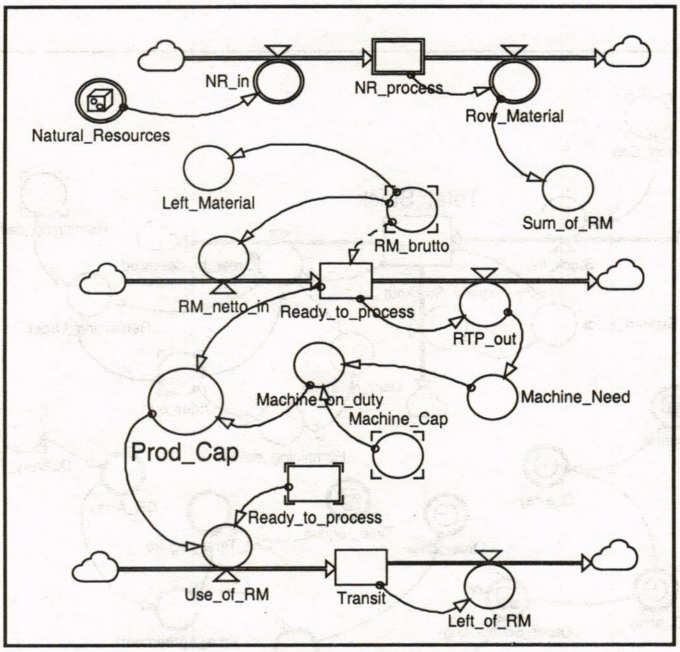

Figure 4. Production Model

3.2 Customer Sub-model

In this model, customer order is managed by considering the amount of received order, delivery time agreement, the amount of order could be served, and the amount of delivered order in the form of order scheduling. The following assumptions are made in the model; *FIFO* concept is applied, received order will be processed to satisfy the required delivery schedule, the following received order will be stored first and then will be processed after the previous order is finished, and the order that could not be served become un-processed order and will be the first priority for the next order. Figure 5 represents customer sub-model.

3.3 Distribution Sub-model

This model handle the strategy of product delivery which is constrained by the available number of fleet, the required fleet-size for delivery, the number of fleet that can be operated, delivery capacity and delivery time. The model is shown in Figure 6.

3.4 Cost Sub-model

As consequence of the objective function aim, cost is an important component in the model in order to obtain net profit of the product sales. Therefore, this sub-model is developed to figure out the cost of procurement, production and distribution process in the system. Figure 7 represents the cost model for procurement of raw materials, production and distribution cost.

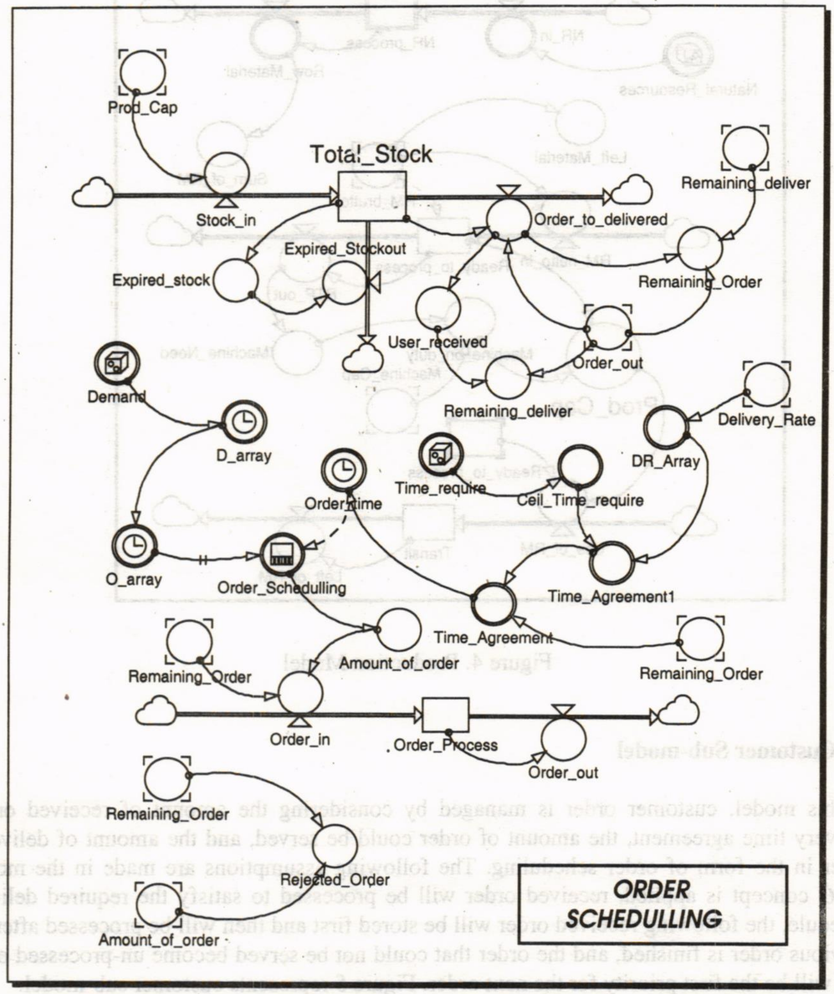

Figure 5. Customer Model

3.5 Market Response Sub-model

As mentioned in the previous section, the merit of dynamic approach is its capability in representing feedback capability of the system. In the model characteristics of interrelated components reflected by customer reaction are illustrated in the market response sub-model. Basically characteristics that affects the market response is recognized as punctuality of delivery time and product quality. The response can be positive or negative and this affects to the amount of the following order. Figure 8 illustrates the model.

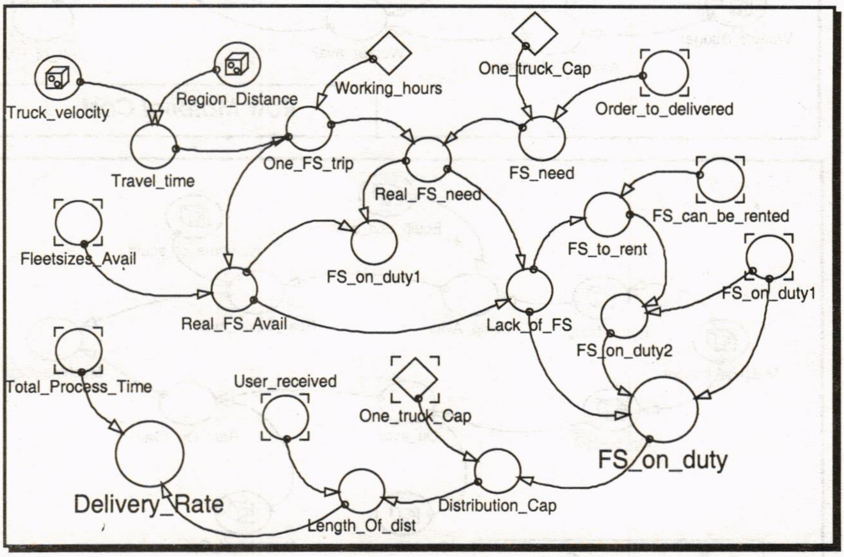

Figure 6. Distribution Model

4. SIMULATIONS AND DISCUSSION

4.1 Delivery Policy and Simulation Results

Based on the developed model, some simulations are carried out to comprehend the model. Since the policies to be taken are based on trend of the results, which do not require any accuracy, and the validity process is not compulsory to the model, hence real data or case is also not necessary. Therefore, in this research, real data is used only in the production sub-model. Three different delivery policies are applied wherein reality more policies are possible to be applied, but these three policies are considered to be sufficient for the purpose of the research. Furthermore, in order to obtain a figure of how the market response will affect the system, the simulations are carried out without and with feedback characteristic. The policies are as follows:

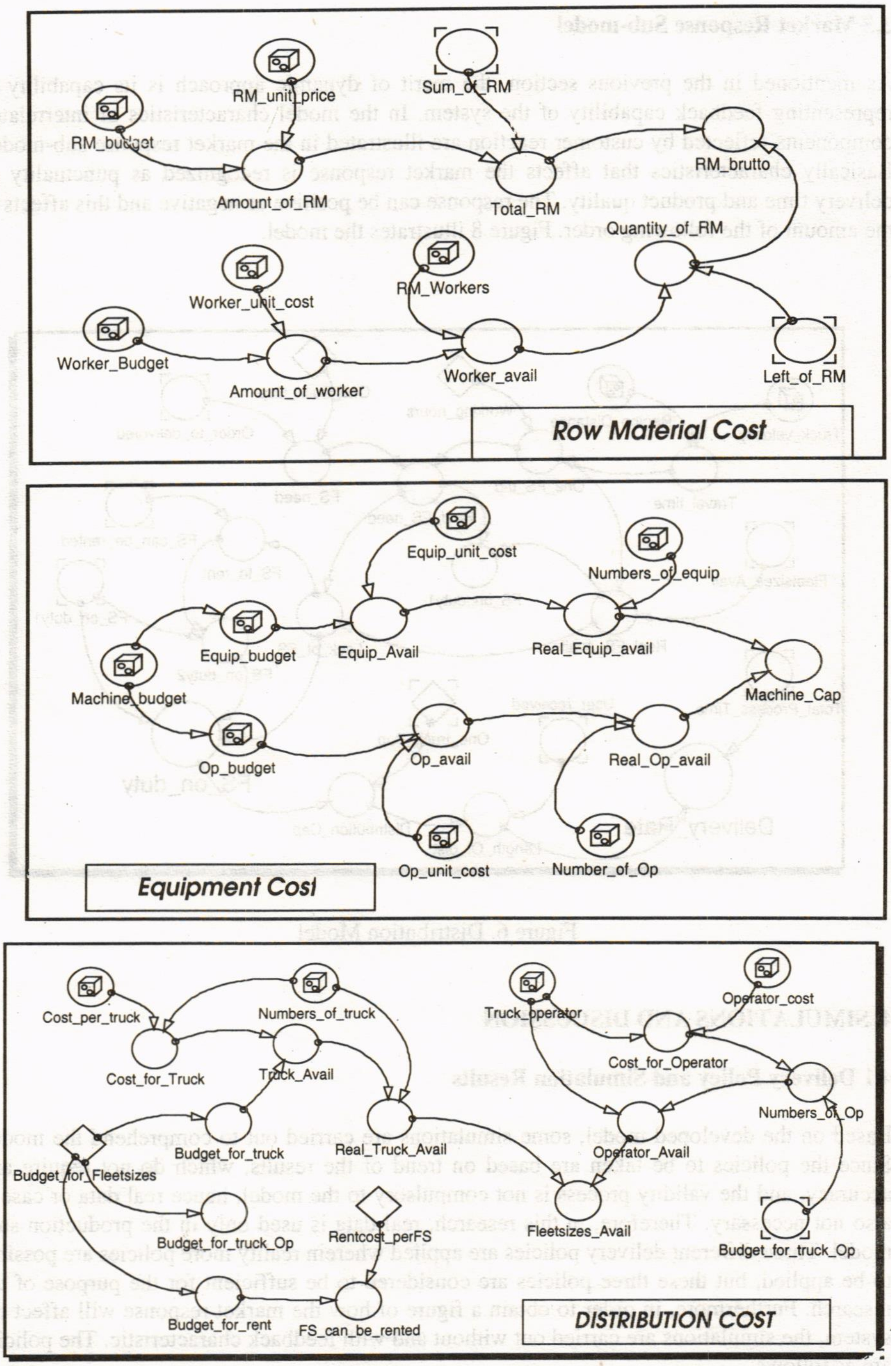

Figure 7. Cost Model

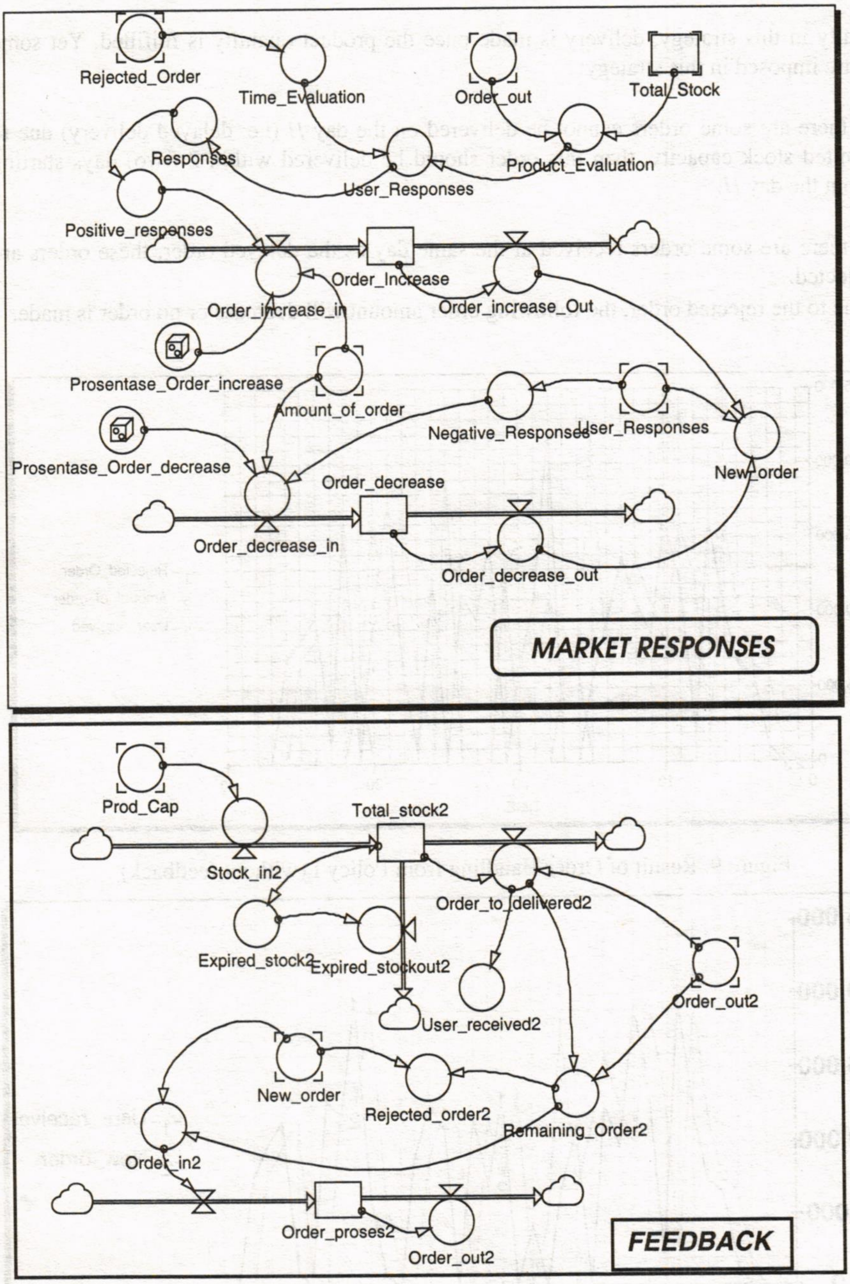

Figure 8. Market Response Model

4.1.1 Policy I:

Basically in this strategy, delivery is made once the product quantity is fulfilled. Yet some rules are imposed in this strategy:

- If there are some orders cannot be delivered on the day *H* (i.e. delayed delivery) due to limited stock capacity, then this order should be delivered within 2 (two) days starting from the day *H*.
- If there are some orders received at the same day as the delayed order, these orders are rejected.
- Due to the rejected order, the following order amount will decrease or no order is made.

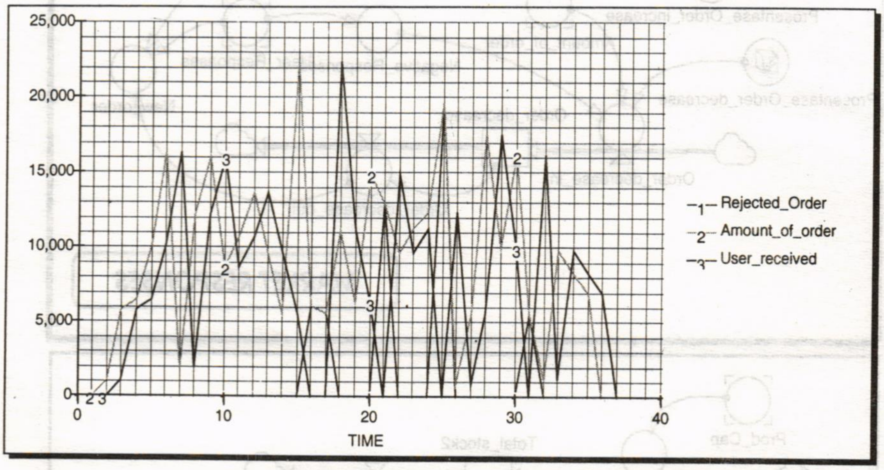

Figure 9. Result of Order Handling from Policy I (without feedback)

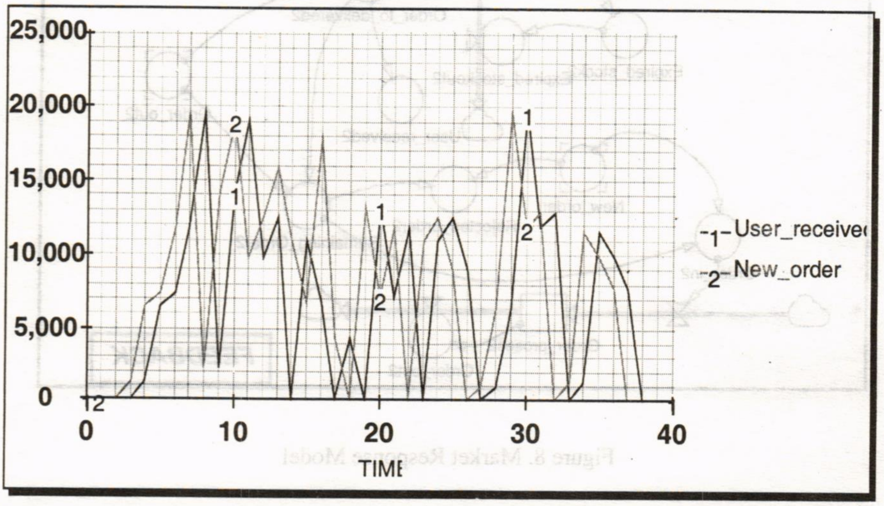

Figure 10. Result of Order Handling from Policy I (with feedback)

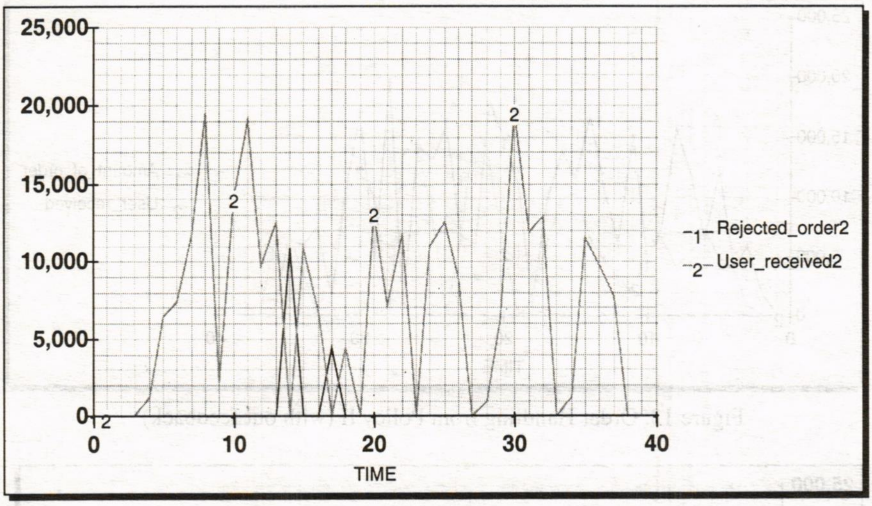

Figure 11. Rejected Order from Policy I (with feedback)

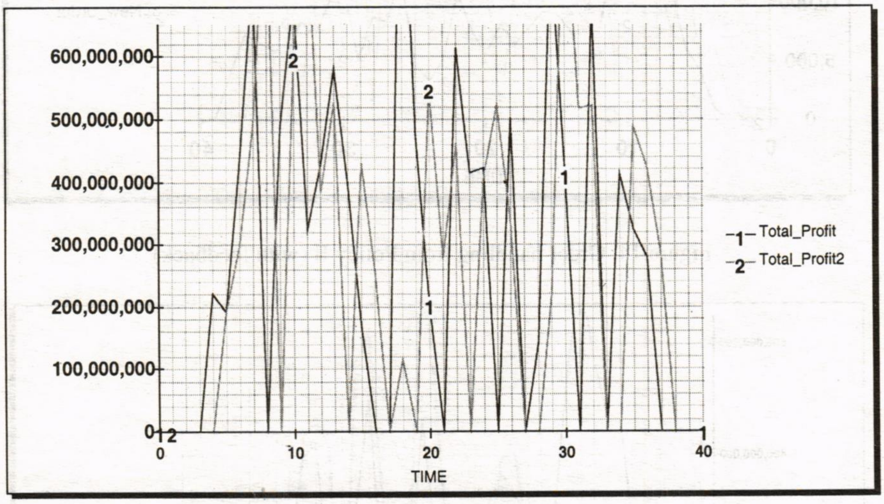

Figure 12. Profit Comparison from Policy I (with and without feedback)

4.1.2 Policy II:

In this strategy, half of all the order is delivered on the required day and the other half is delivered on the following day.

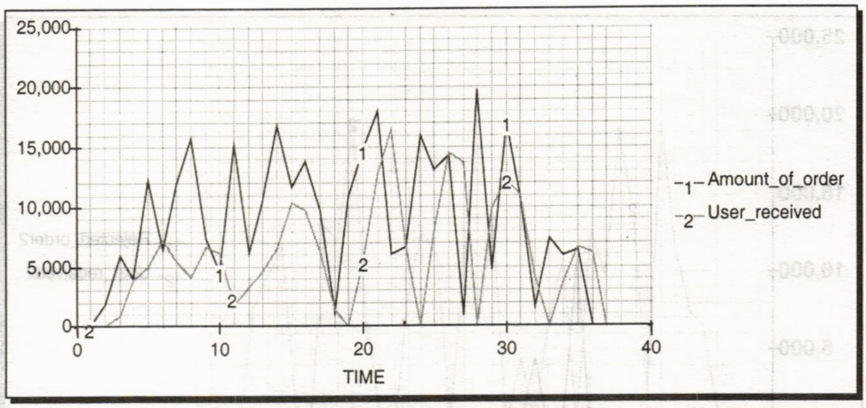

Figure 13. Order Handling from Policy II (with out feedback)

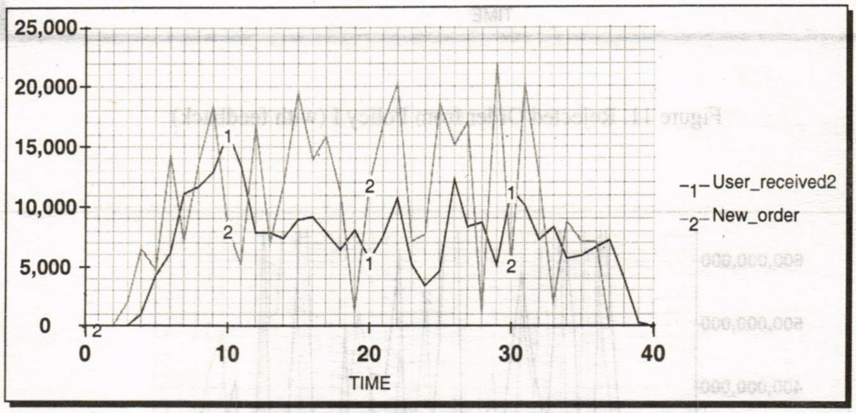

Figure 14. Order handling from Policy II (with feedback)

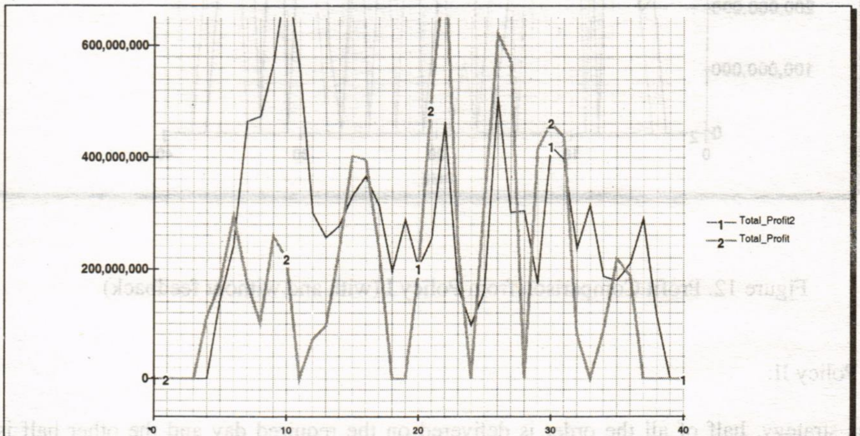

Figure 15. Profit Comparison from Policy II (without and with feedback)

4.1.3 Policy III:

This strategy is sort of a combination between the above two policies. Basically, if the stock is more than the total order then all the order can be delivered. But if the stock is less than the total order, then the installment strategy is imposed. The rules imposed in this strategy are:

- If the stock is less or equal to the total order of the day *H* the order is delivered with the following quantity of the available stock. And the rest of the order will be delivered on the next day (*H+1*).
- If there are some orders received on the day *H+1* these orders would be rejected due to the priority given to the previous unsatisfied orders.
- Due to the rejected order, the following order amount will decrease or no order is made.

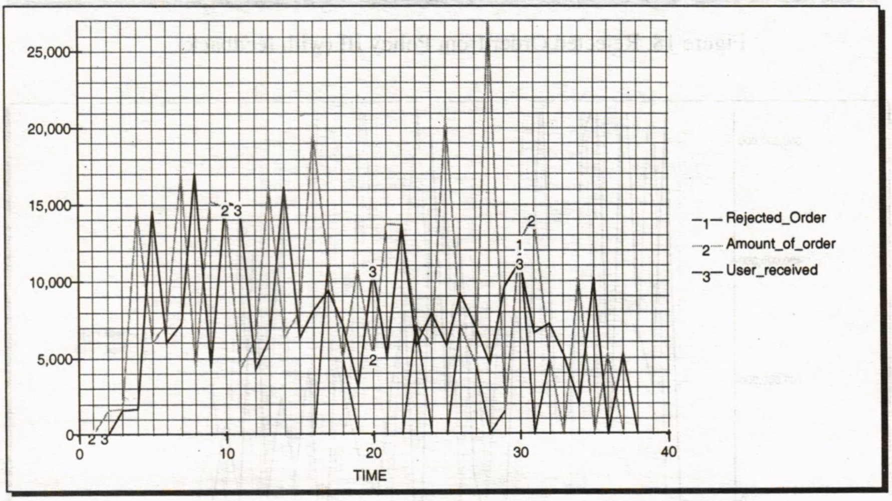

Figure 16. Order Handling from Policy III (without feedback)

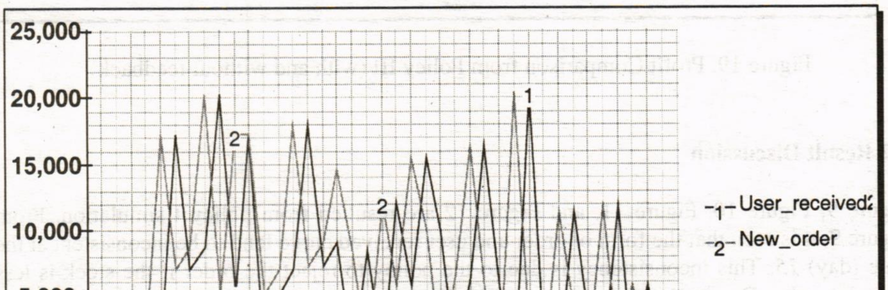

Figure 17. Order Handling from Policy III (with feedback)

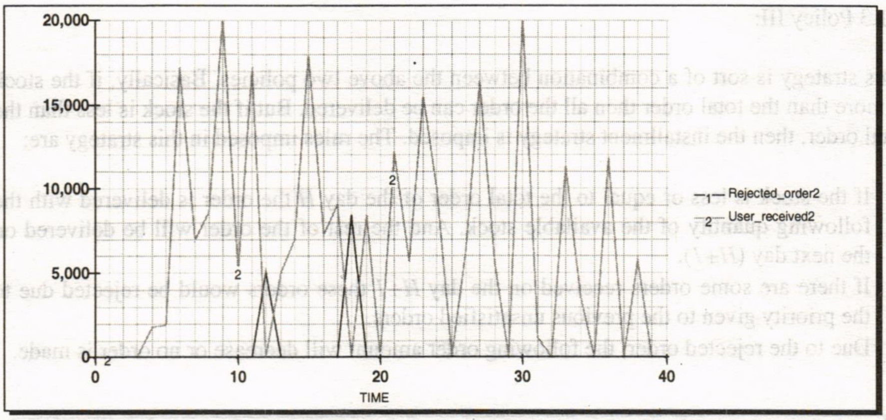

Figure 18. Rejected Order from Policy III (with feedback)

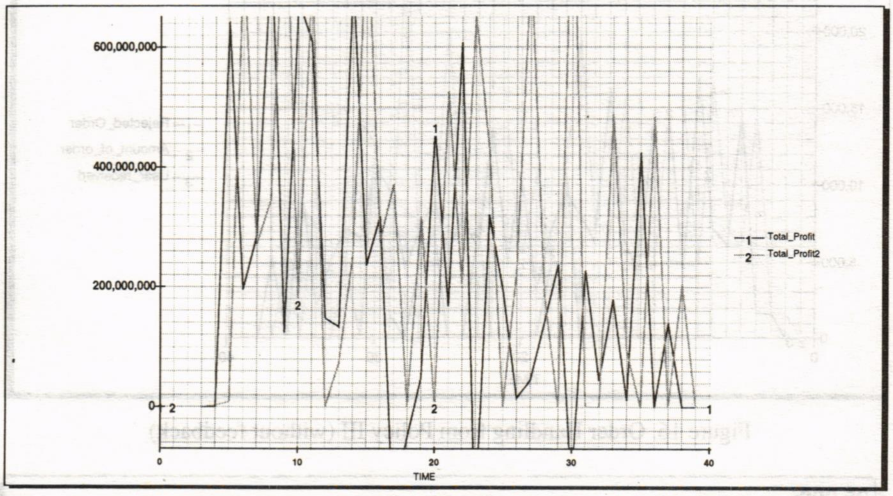

Figure 19. Profit Comparison from Policy III (with and without feedback)

4.2 Result Discussion

Figure 9, Figure 10, Figure 11, and Figure 12 are resulted from policy I simulation. From Figure 9, it is seen that the form of order and user received curve tend to be inconsistent at the time (day) *15*. This inconsistency is due to the policy to reject the order if the stock is less then the order. Due to the policy imposed in the delivery the producer performance tends to decrease and this is clearly shown when feedback is introduced into the model. (Figure 10 And Figure 11).

Figure13, Figure 14, and Figure 15 are resulted from policy II simulation. From Figure 13, it is seen that the inconsistency of the form of order and user received curve starts from the time (day) 0. This is due to the installment policy imposed in the delivery strategy. In this strategy

the amount rejected order is less than that of in the policy I, but as a consequence delivery time takes longer (Figure13). Still, the producer performance tends to decrease and this is clearly shown when feedback is imposed (Figure 14).
Figure16, Figure 17, Figure 18, and Figure 19 are resulted from policy III simulation. From Figure 16, it is seen that the form of order and user received curves start to be inconsistent at the time (day) 21, when the stock is less then the order. Starting this time, due to shortage of stock, the delivery is changed from policy I to policy II. And at time 31 when the stock is equal or more than the order, the delivery policy is changed again to policy I.

5. CONCLUSION

In this research a dynamic logistic model as a making policy tool is developed. Based on the simulation, it is seen that negative impacts occur when the order cannot be delivered either totally or on time. This impact is reflected in the form of less revenue received by the producer. From three different delivery policies simulated in the model, it is shown that the policy number III yields better result that is in the profit. It is important to note for further development in the future that this kind of model is not suitable for such analysis that requires some accuracy of the results. Many other policies could be introduced into the model to observe the outcome of such policy. The results from the model can further be used as guidance in making an appropriate policy.

REFERENCES

Ballou H. Ronald (1990) **Business Logistics Management**, Prentice Hall. Inc.
Forrester, J. (1971) **Industrial Dynamics**, MIT Press.
Forrester, J. (1969) **Urban Dynamics**, MIT Press.
Law, A.M. and Kelton, W.D. (1991) **Simulation Modeling and Analysis**, 2nd ed., Mc. Graw Hill, New York.
Robert, N. et.al. (1983) **Introduction to Computer Simulation a System Dynamic Approach**, Addison-Wesley Publishing Company.