Proceeding of Industrial Engineering and Service Science, **2011**

Dynamic Simulation Model to Enhance Market Share of Liquid Fertilizer Industry

Erma Suryani; Hanim Maria Astuti

Information System Department, Sepuluh Nopember Institute of Technology, Surabaya, Indonesia
erma@its-sby.edu; hanim@its-sby.edu

ABSTRACT

As with any other companies, liquid fertilizer companies need to keep its market share increases in order to remain competitive in this global economy. Although the demand of liquid fertilizer is quite high, some liquid fertilizer companies are failed to increase their market share. One of the causes is their inability to predict market demand.
This paper aims to propose a model using system dynamics that is used to model and to generate scenarios because of their capability of representing physical and information flows as well as scenarios for liquid fertilizer companies to predict market demand and therefore enhance their market share. Since the formulation of scenarios refers to the model, the model is verified and validated to ensure its correctness before the scenario is defined. The result of this paper is expected to help liquid fertilizer companies maintain their competitiveness through the increase of their market share.

Keywords**:** *simulation, system dynamics, liquid fertilizer industry*

1. Introduction

With the increasing business competition in the global era, companies including liquid fertilizer industries need to improve their performance. Companies' performance can be defined by some indicators such as market share, revenues, profit margin, etc. However, one of the crucial issues faced by liquid fertilizer companies is inability to fulfill their projected market share. One of ways to increase the market share of a company is by increasing its sales volume. Nevertheless, this is a non trivial task and can be difficult because there are various internal and external factors that affect the level of sales such as changes happened in industrial structure, fluctuating demands and supply, governmental policy and regulation, etc. A tool such is thus required to support management of a company formulating strategy to achieve the increased sales.

Sales forecasting is a tool that has been widely used to support business by providing prediction of future demand and performance that are essential for business decisions. System dynamics model is considered as a good sales forecasting tool reacting to the aforementioned problems. This model can be used to predict corporate sales based on some scenarios analysis so that a company can increase market sales. This model can be useful to understand the demand and sales behavior that evolve over time. Comparing to other forecasting methods, system dynamics has several strengths as follows [4]:

(a) Forecasts derived from calibrated system dynamics models are likely to be better and more informative than those from other approaches. The models are calibrated to historical data and used to produce a forecast of the future sales. With the detailed and calibrated models, once is possible to accurately predict the demand and sales volume based on demand scenario analysis.
(b) System dynamics models can provide more reliable forecasts of short- to mid-term trends than statistical models, and therefore lead to better decisions.
(c) System dynamics models provide a means to determine key sensitivities, and therefore more robust sensitivities and scenarios.

This paper provides a model using system dynamics for a liquid fertilizer company to increase corporate sales and therefore enhance its market share. In this study, we utilized a liquid fertilizer company in Indonesia as our case study. Recently, this company has market share around 1.24% whereas the target market share is 1.6%. Using system dynamics, we propose a model as well as scenarios for the liquid fertilizer company to achieve its targeted market share.

This paper is organized as follows. Section 2 provides the literature review. Section 3 describes the base model development. Section 4 shows the model validation, Section 5 demonstrates scenario development and Section 6 shows the conclusion and further research. Finally in Section 7, references are presented.

2. Literature Review

The projected market share can be obtained by forecasting the expected demand, expected sales by having promotion programs; providing seasonal discounts and easy access to fertilizer through its distribution structure.

System dynamics models allow managers to test alternative assumptions, decisions and policies [2]. According to [8], system dynamics can be utilized to develop models to improve resources management policies. They identified some insights of policies during model building and testing, including group model testing, strategy, and scenario building. A research proposed by [6] has already developed a system dynamics model to forecast and analyze demand based on some scenarios analyses related to planned capacity expansion. Based on their research, system dynamics framework can be used to model and to generate several scenarios because of their capability of representing physical and information flows, which will enable us to understand the nonlinear dynamics behavior in uncertain conditions.

3. Base Model Development

According to [7], there are five essential steps to develop system dynamics model: 1) problem articulation i.e. defining the problem to be solved and the model's objective, 2) dynamic hypothesis i.e. the development of an influence diagram, 3) formulation simulation model that is, a level-rate diagram, 4) testing i.e. making sure the validity of the model, and 5) policy formulation and evaluation i.e. evaluating of simulated results and formulating new potential strategies. The first up to the third step are explained in this section whereas the remaining steps are respectively explained in section 4 and 5.

Applying to our case study, in the first step, we identify the inability of the fertilizer company to achieve the targeted market share as the problem to be solved whereas the objective of the model is to increase market share. The increasing of market share is influenced by many factors called variables. Thus, in the second step, we identify variables in order to develop an influence diagram. We did a survey to our case study in order to obtain the variables including their relationship. All variables are then modeled and represented in a causal loop diagram as seen in Figure 1.

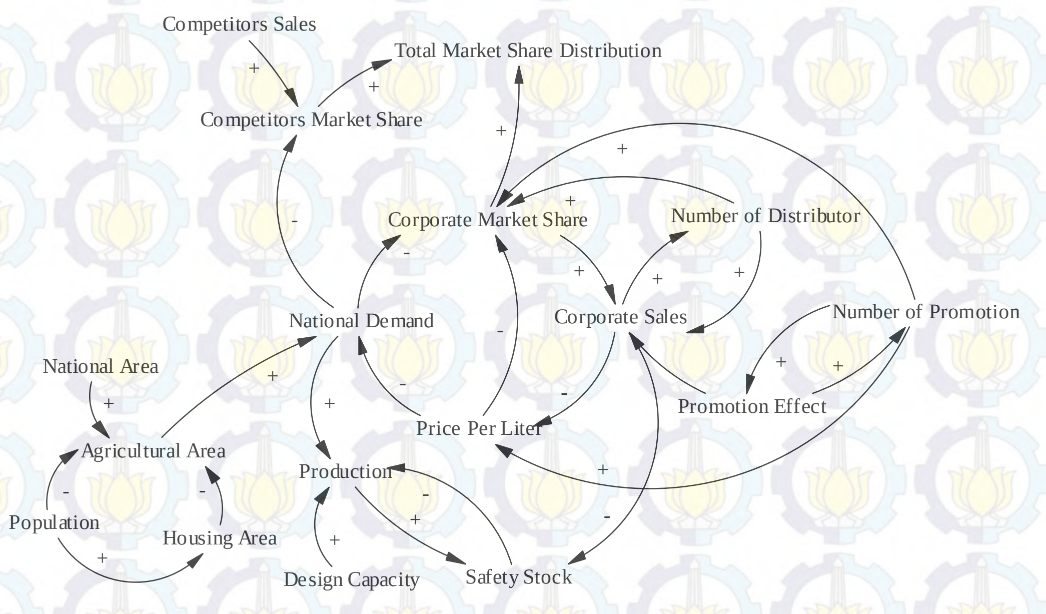

Figure 1 The causal loop diagram represents an influence diagram

Figure 1 shows the causal diagram of variables influencing the increase of market share such as number of corporate sales, promotion effect, price per liter, number of distributors, national demand, agricultural area, housing area, etc. The causal loop diagram is then expanded into a stock and flow diagram to represent the causal relationship among the level, rates and constant of the system. Based on this diagram, it is possible to see relationship between variables in the system which could not be seen using conventional tools like spreadsheet and other statistical models. This diagram is the basis to run the system dynamics simulation. The stock and flow diagram is presented in Figure 2.

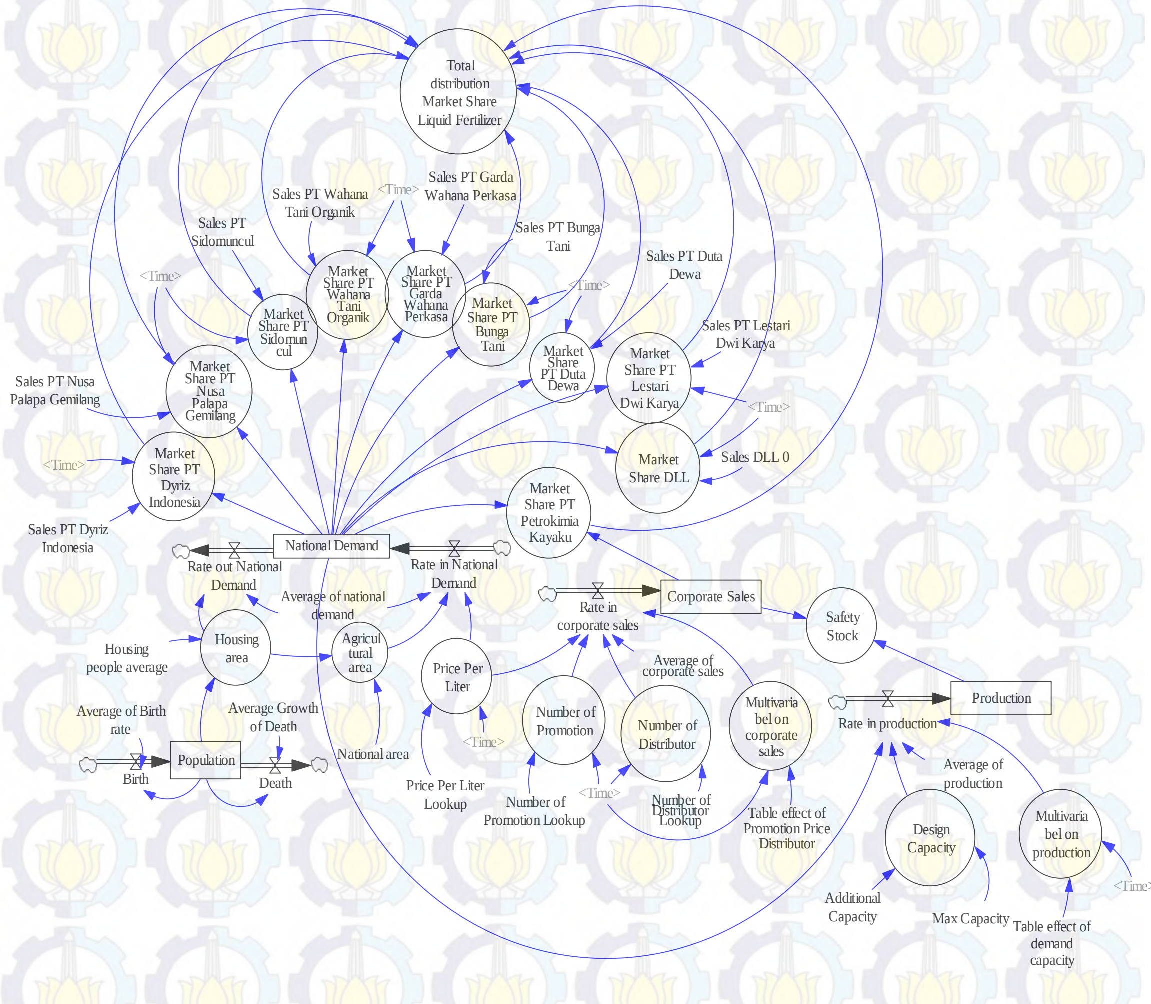

Figure 2 The flow diagram of national demand, number of distributors, corporate sales, and market share

On the basis of the diagram, we formulate simulation models as the third step to develop system dynamics simulation. In this sense, we develop six models of which the formulation is as follows.

Agricultural area model. The *Agricultural Area* is strongly influenced by two factors: *National Area* that has a constant value of 1,922,570 km² and *Housing Area*. The *Housing area* is determined by two factors i.e. the number of *Population* and the average room area for population which has a constant value of 6 m²/person. The *dt* parameter represents the time interval of simulation. In this study we set *dt* = 1 year based on the change of variable status and the availability of data. The formulations of agricultural, national, and housing areas within *t* period of simulation are depicted in Eq. (1)-(5).

$$Agricultural\ Area = National\ area - Housing\ area \quad (1)$$

$$Housing\ population\ area = Housing\ people\ average * Population \quad (2)$$

$$Population\ (t) = population\ (t\text{-}dt) + (Birth - Death) * dt \quad (3)$$

$$Birth = Average\ of\ Birth\ rate * Population \quad (4)$$

$$Death = Average\ Growth\ of\ Death * Population \quad (5)$$

During simulation time, i.e. from 2000 – 2010, the average birth rate has a constant value of 0.01 whereas the average growth of death rate from 2000 to 2010 has a constant value of 4.863.694,94.

National demand model. Rate of *National Demand* depends on *Agricultural Area* and *Effect of Multivariable on National Demand* (e.g. seasonal effect). We classified national demand as a level variable to accumulate the *Rate of National Demand* (please see Eq. (6)-(10)).

National Demand (t) = National Demand (t-dt) + Rate of National Demand (t) (6)

*Rate of Demand = Average of rated national demand * (Agricultural area/100) * Multivariable effect on national demand* (7)

Multivariable effect on national demand = (National Demand (t+1) – National Demand (t)) / Rate of Demand (t) (8)

Price Per Liter= Price Per Liter Lookup(Time) (9)

Price Per Liter Lookup ((2000,12000), (2001,12500), (2002,12500), (2003,13000), (2004,13000), (2005,13000), (2006,13000), (2007,15000), (2008,15000), (2009,15000), (2010,15500)) (10)

Corporate sales model. *Rate of corporate sales* depends on *Average rate of corporate sales*, *Number of promotion growth*, *Price per liter* and *Number of Distributor*. We classified *corporate sales* as a level variable to accumulate the *rate of corporate sales.* All these relationships are depicted in Eqs. (11)-(15)).

Corporate Sales (t) = Corporate Sales (t-dt) + Rate of Corporate Sales (11)

*Rate of Corporate Sales = Average rate of corporate sales * (Number of Promotion Growth/100) * Price per liter * Number of distributors * Effect of Multivariable on corporate sales* (12)

Effect of Multivariable on corporate sales = (Corporate Sales (t +1) - Corporate Sales (t)) / Rate of Corporate Sales (t) (13)

Number of Distributor= Number of Distributor Lookup(Time) (14)

Number of Distributor Lookup ((2000,100), (2001,110), (2002,110), (2003,112), (2004,115), (2005,120), (2006,120), (2007,128), (2008,128), (2009,115), (2010,146)) (15)

Market share model. *Market Share* depends on the percentage of *corporate sales* and *national demand.* It is defined as an auxiliary to carry out the functional relationship between *corporate sales* and *national demand* as depicted in Eq. (16):

*Market Share = (Corporate Sales /National Demand) * 100%* (16)

In this study, we set the time horizon to 10 years for the base model based on consideration that during the period, the system behavior can be learned. Figure 2 represents corporate market share starting from 2000 to 2010 as a result of our base model.

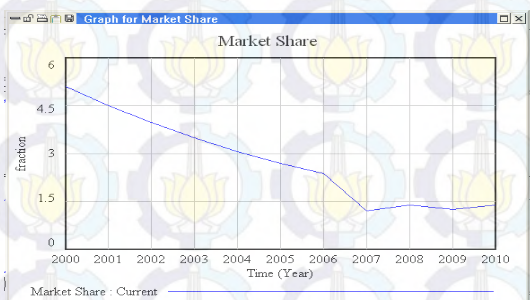

Figure 3 Corporate market share

As seen in Figure 3, corporate market share is around 1.4% starting from 2007 to 2010. It is therefore, we developed some scenarios to enhance corporate market share based on optimistic, most likely, pessimistic projections as depicted in Section 5.

4. Model Validation

In this section, we apply the forth step of developing system dynamics model, that is, testing the validity of the model. According to [1], the validity of the internal ***structure*** of a model is crucial. It is therefore, a white-box testing is required to check the validity of the model structure. In this study, we utilized causal descriptive models as a white-box testing that can be described as follows:

An increase in the *Number of Distributor* and *Number of Promotion* will affect *the Corporate Sales* as well.

A rising in *Corporate Market share* will influence the *Corporate Sales*, which in turn the increased of *Corporate Sales* will decrease *Price Per Liter*.

An Increasing *Price Per Liter* leads to a decreasing *National Demand.* The amount *of National demand* is influenced by *Agricultural Area* and *Price Per Liter*.

An increase in the *National Demand* induces a decrease in *Corporate Market Share* and *Competitors Market Share.*

A rising in *Corporate Market Share* and *Competitors Market Share* leads to an increasing in *Total Market Share Distribution.*

5. Scenario Development

In this section, we show how the system structure of a valid model can be changed by adding some feedback loops, adding new parameters, and changing the structure of the feedback loops (structure scenario), and how the parameter model can be changed to see the impact to other variables (parameter scenario). In this study, we have developed some scenarios, those are most likely, optimistic, and pessimistic scenarios.

5.1. Optimistic Scenario

In this scenario, we modified the model parameters such as the average growth rate of *national demand* to be around *7.25% (based on the Indonesian Agricultural Department Projection)*, *price per liter* to be around 15.38%, the *number of distributor* to be around 37.11%, and *the number of promotion* to be around 35% (based on the data from the year 2000 to 2010).

Based on this scenario, we can obtain *corporate sales* would be around 3,920,000 kg/liter in 2020, and *corporate market share* would achieve 19.16%.

5.2. Most Likely Scenario

In this scenario, the model structure has been modified to predict corporate sales and market share based on historical data obtained from the department of agriculture. We modified the structure of *Number of Promotion* as a level variable and added some variables such *as bonus of distributor*, meeting selling (*temu selling*), *promotion activity* as the inputs to the *Rate of Number of Promotion*. In this scenario, we set the average growth rates of *bonus* to be around 7%, *meeting (temu) selling* to be around 5.25%, *price* to be around 4%, and *the number of promotion* to be around 6% . All these growth rates are defined based on the data in 2000 to 2010.

Based on this scenario, we found that *corporate sales* would be around 2,980,000 kg/liter in 2020, and *corporate market share* would achieve 14.9%.

5.2. Pessimistic Scenario

In this scenario, we modified the model parameters such as the average growth rates of *national demand* to be around *3.25% (based on the Indonesian Agricultural Department Projection)*, *price per liter,* the *number of distributor* and *the number of promotion* would be fix from time to time (zero growths).
Based on this projection, we can obtain *corporate sales* would be only 2,700,000 kg/liter in 2020, and *corporate market share* would be only 13.5%.

6. Conclusion

In this research we assume that fertilizer demand will grow as general economic trends are positive for fertilizer industry. This study provides a method in developing models to enhance market share of liquid fertilizer in the future based on the optimistic, most likely, and pessimistic projections. The model can provide important inputs such as growth in the number of promotions, the number of distributors, and the price of liquid fertilizer to specific business decisions in enhancing corporate sales and market share.

6. References

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