A Relationship Model between Manufacturer and Buyer for Order Fulfillment in Export Oriented Furniture Industry with Sustainability Considerations

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***Abstract*—Teak wood furniture industry is one kind of industry that plays important role in Indonesia. By the time passed, demand for teak furniture increased, but some problems appear. Buyer wants product that has a high variety but low price and produced with social and environmental consideration. Manufacturer should consider all those aspects to have good relationship to its buyers. This paper concerns about the relationship between manufacturer and buyer to get maximum benefit that considering all those aspects. Maximum profit for the manufacturer and buyer will be the purpose of economic aspect. Considering the worker safety and consumer satisfaction become social purposes. The environmental purposes are maximizing the value of waste and building a green product. A goal programming is addressed to solve the problem of multiple purpose goals. The result shows that all aspects considered are satisfied.**

***Index Terms*—Export oriented furniture industry, goal programming, relationship model between manufacturer and buyer, sustainability**

I. Introduction

INDONESIAN furniture export decreases recently[1]. Actually the opportunity of furniture industry in Indonesia to grow is still so wide. The share of furniture export in Indonesia is 1.62% in the world [2]. Manufacturing company as an object of research expects to make diversification and development of product with low cost for each order placed by its buyer or customer. So the problems to be discussed in this case involve market and product uncertainty, supply uncertainty, and supply chain ability. Those problems need to be managed by applying a suitable supply chain strategy for the company [3]. They should also concern about the environment, because the new issue of a green product becomes a hot topic [4].

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Overseas buyer wants product with a high variability with low price [5]. Common problems faced by the wood furniture industry in Central Java are strong bargaining position of buyers, so they try push the price as minimum as they can, unfair competition among companies related to price and design, bad coordination among the wood furniture industry, and poor government's support especially in marketing wood furniture to some countries [6]. The other problems are some of the wood furniture industry satisfied with the current conditions achieved and less attention to develop the product to anticipate the future [6]. Most market segments of the wood furniture industry are in lower and middle classes, so the growth of the product relatively small [6]. This condition shows that there is a sustainability problem in furniture industry. To become more sustainable, furniture industry should concern about strategic achievement and integration of social, environmental, and economic goals [7].

Based on those reasons, it is necessary to develop a model to determine the new paradigm of business contract between manufacturer and buyer in three aspects i.e. economical, environmental, and social aspects for order fulfillment in export oriented furniture industry with sustainability considerations [8], [9]. It is possible that all aspects are conflicted; consequently we propose a relationship model between manufacturer and buyer using goal programming technique [10].

This paper is organized as follows. In Section 1, we propose the background of our research. In Section 2, we describe the problems in real system. In Section 3, we provide mathematical modeling for solving the problem. In Section 4, we design the solution method, numerical example, and analysis. In Section 5, we deliver the summary and conclusion.

II. Problem Description

The number of furniture export today getting lower than some years ago. Based on data in 2008, we found that the export of Indonesian furniture is US$ 2.23 billion. That value decreased 5.5 % from the year of 2007. In the year of 2009 that number decreased 35% from 2008 [1]. This is a big warning for the manufacturer and also the government how to increase furniture export. In this case, we study a manufacturer, CV Valasindo Sentra Usaha (VSU) that located in Surakarta, Indonesia. The problems in VSU today are the consumers want product that have a high variability

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but with low price and the consumer cares about the issue of environment. Due to the problems related to economic, social and environmental issues, so it is necessary for VSU to consider the sustainability aspects to fulfill the demand from the consumer. The relationship between manufacturer and buyer shows in Fig. 1.

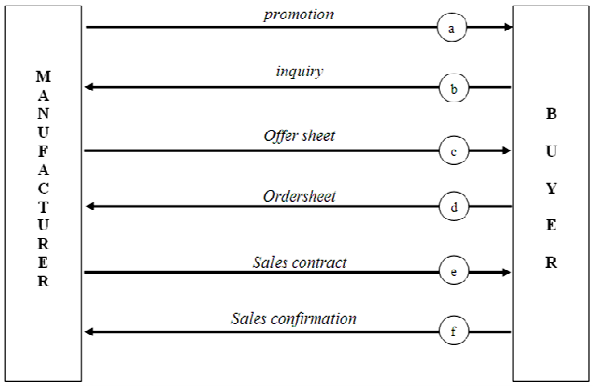

Fig. 1. Relationship between manufacturer and buyer.

The first step is the manufacturer will promote their product to buyer by using catalog or join in an expo (a). Then if there is a buyer that interested in the product, they will send letter of inquiry to the manufacturer about the product specification, price, quantity, etc. (b). After getting letter of inquiry from the buyer, the manufacturer will check the price, quantity that they can fulfill, and all aspect of the product, and then they will give confirmation with offer sheet (c). If the buyer approves all of the offering given by the manufacturer, buyer will send manufacturer the final order sheet to clarify that they agree to order (d). The next step is manufacturer will make a sales contract that will be signed by manufacturer. The points mentioned in sales contract are the same with the ones in offer sheet and in order sheet (e). The last step is the buyer will sign the sales contract and send back as a sales confirmation (f).

In this model, we consider sustainability aspects in the relationship between manufacturer and buyer. Buyer in this model will sell again after buying the furniture. Therefore we consider economic, environmental variable, and social variable. So we develop six goals that can be categorized in three main objectives that shown in Fig. 2.

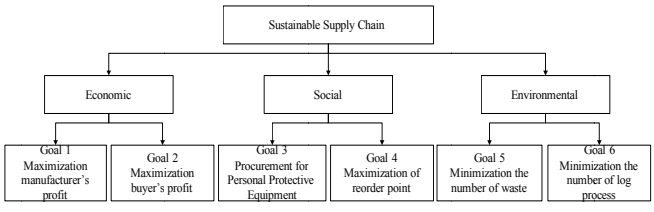

Fig. 2. Frame of Sustainable Supply Chain.

From the manufacturer side, the first goal related to economic variable that is maximizing profit. The second goal is related to environmental goal that is to minimize waste. The last goal is related to social goal that is to maximize safety equipment for the VSU's employees.

In the buyer side, we also determine goals for the buyer. The fourth goal is related to the economic goal that is to maximize buyer's profit. The fifth goal is related to environmental goal that is to maximize the green design product quality. The last goal is related to social goal that is to maximize the satisfaction level, because the satisfaction level will influence reorder from the buyer.

III. Mathematical Modeling

Due to multiple objectives, we use Goal Programming (GP) for solving this model. GP is a suitable tool for decision maker to analyze the achievement of the desired goals considering multiple objectives, that sometimes conflicting.

A. Index and Notation

The definition of sets, variables, and parameters of the model are shown in table I and table II.

TABLE I
DEFINITION OF DECISION VARIABLE NOTATION

Notation	Definition of Decision Variable Notation
$Q_{i,t}$	quantity of product demand each type i (m^3)
JP	quantity of reorder product (m^3)

TABLE II
DEFINITION OF PARAMETER VARIABLE NOTATION

Notation	Definition of Parameter And Variable Notation
l	Amount of log that is needed in one year
p_j	Price for log class j (IDR/ m^3)
cr	Employee's regular cost (IDR/ m^3)
cl	Employee's overtime cost (IDR/ m^3)
co	Overhead cost (IDR/ m^3)
lb	Percentage of profit
hr	Waste price (IDR/ m^3)
$vr_{j,t}$	Volume of log j processed in regular time at t Month (m^3)
$vl_{j,t}$	Volume of log j processed in overtime at t month (m^3)
pr	The number of waste (m^3)
ca	Personal Protective Equipment price (IDR/ set)
jt	The number of employee
ck	Total cost for Personal Protective Equipment (IDR)
hj_i	The price for product i
cb	Price of another material (rattan) (IDR/ m^3)
tk	Presentation of reorder
pp	Manufacturer's profit (IDR)
pb	Buyer's profit (IDR)
i	Product type (1= type 1, 2 = type 2, 3 = type 3, 4 = type 4, 5 = type 5, 6 = type 6)
j	Log type (1= AII, 2= AIII)
t	Time period (t = 1, 2, 3, …, 12)
r_i	Ratio of rattan depend on type of product i
α_i	Conversion value from product to log for product type i
β_i	Conversion value from log to waste for product type i
n_i	Negative deviation of fungtion i
p_i	positive deviation of fungtion i
ω_i	desired *value* function i

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B. Mathematical Formulation

There are three aspects considered and two entities in this paper, manufacturer and buyer. The six objective functions will cover all aspects from two entities.

$$pp = ((\sum_{i=1}^{6}\sum_{t=1}^{12} \mathrm{Q_{i,t}} \,.\, hj_i) + pr.\, hr) - ((\sum_{j=1}^{2}\sum_{t=1}^{12} vr_{j,t} + vl_{j,t}).(p_j + co) + \sum_{i=1}^{6}\sum_{t=1}^{12} \mathrm{r}_i \,.\, Q_{i,t}.cb + \sum_{j=1}^{2}\sum_{t=1}^{12} vr_{j,t} \,.\, cr + \sum_{j=1}^{2}\sum_{t=1}^{12} vl_{j,t} \,.\, cl) + ck) \quad (1)$$

$$pb = lb.\sum_{i=1}^{6}\sum_{t=1}^{12} hj_i \times Q_{i,t} \quad (2)$$

$$ck = jt.ca \quad (3)$$

$$JP = tk.\sum_{i=1}^{6}\sum_{t=1}^{12} Q_{i,t} \quad (4)$$

$$pr = \sum_{i=1}^{6}\sum_{t=1}^{12} \alpha_i \; \beta_i \; Q_{i,t} \quad (5)$$

$$l = \sum_{i=1}^{6}\sum_{t=1}^{12} \alpha_i \; Q_{i,t} \quad (6)$$

The first goal (1) is maximization of manufacturer's profit. The second goal (2) is maximization of buyer's profit. The third goal, maximization Personal Protective Equipment (PPE) cost for employee safety is expressed in (3). The fourth goal (4) is maximization reorder point by increase the satisfaction level of the customer. waste selling from furniture production. Equation (5) and (6) are state social goals. Equation (5) states the fifth goal, minimization the waste. The last goal (6), minimization the number of log consumed.

Goal Programming (GP) is a suitable tool for decision maker to analyze the achievement of the desired goals considering different and sometimes conflicting multiple objectives [11]. The model then can be formulated as Goal Programming (GP) below:

$$Z_{\min} = n_1 + n_2 + n_3 + p_3 + n_4 + p_5 + n_6 \quad (7)$$

Subject to

$$((\sum_{i=1}^{6}\sum_{t=1}^{12} \mathrm{Q_{i,t}} \,.\, hj_i) + pr.\, hr) - ((\sum_{j=1}^{2}\sum_{t=1}^{12} vr_{j,t} + vl_{j,t}).(p_j + co) + \sum_{i=1}^{6}\sum_{t=1}^{12} \mathrm{r}_i \,.\, Q_{i,t}.cb + \sum_{j=1}^{2}\sum_{t=1}^{12} vr_{j,t} \,.\, cr + \sum_{j=1}^{2}\sum_{t=1}^{12} vl_{j,t} \,.\, cl) + ck) + n_1 + p_1 = \omega_1 \quad (8)$$

$$lb.\sum_{i=1}^{6}\sum_{t=1}^{12} .hjx\, Q_{i,t} + n_2 + p_2 = \omega_2 \quad (9)$$

$$jt.ca + n_3 + p_3 = \omega_3 \quad (10)$$

$$tk.\sum_{i=1}^{6}\sum_{t=1}^{12} Q_{i,t} + n_4 + p_4 = \omega_4 \quad (11)$$

$$hr.\sum_{i=1}^{6}\sum_{t=1}^{12} \alpha_i \; \beta_i \; Q_{i,t} + n_5 + p_5 = \omega_5 \quad (12)$$

$$\sum_{i=1}^{6}\sum_{t=1}^{12} \beta_i \; Q_{i,t} + n_6 + p_6 = \omega_6 \quad (13)$$

$$\sum_{j=1}^{2}\sum_{t=1}^{12} vr_{j,t} \le 300 \quad (14)$$

$$\sum_{j=1}^{2}\sum_{t=1}^{12} vl_{j,t} \le 60 \quad (15)$$

$$\sum_{i=1}^{6}\sum_{t=1}^{12} Q_{i,t} \le \sum_{j=1}^{2}\sum_{t=1}^{12} vr_{j,t} + \sum_{j=1}^{2}\sum_{t=1}^{12} vl_{j,t} \quad (16)$$

Where ω_q, n_q, and p_q are defined as preferential weight, negative deviational variable, and positive deviational of the goal, ω_1, ω_2, ω_3, ω_4, ω_5, and ω_6 denote the target level for each goal respectively. Target 1 is desired profit for manufacturer, target 2 is desired profit for buyer, target 3 is cost for worker, target 4 is the reorder quantity from the buyer that indicate their satisfaction, target 5 is the income from the waste, and the target 6 is the quantity of the wood that should be processed.

In this paper we develop six goals. The first goal is maximization profit of manufacturer (8) which must maximize to ensure that the solution is closely as possible as the desired goals. The second goal is buyer's profit (9). The third goal is cost procurement for safety equipment that represent social care of manufacturer to the employee (10) and reorder quantity that represent the level of consumer's satisfaction (11). The environment goal consists of waste utilization (12) and amount of log needed (13).

The maximum capacity for regular time production in a year is 300 m^3 (14) and the maximum capacity for overtime production is 60 m^3 in a year (15). The maximal of products demand is lower or equal to the total of the regular production and overtime production (16).

IV. Solution Method, Numerical Example And Results

In this computational study, we analyze the impact of the changes in parameters in the manufacturer - buyer relationship model on fulfill the demand on several goals that must be achieved.

A. Solution Method

The algorithm used to solve the GP formulation is simplex method. The algorithm to solve this model is given by Fig.3.

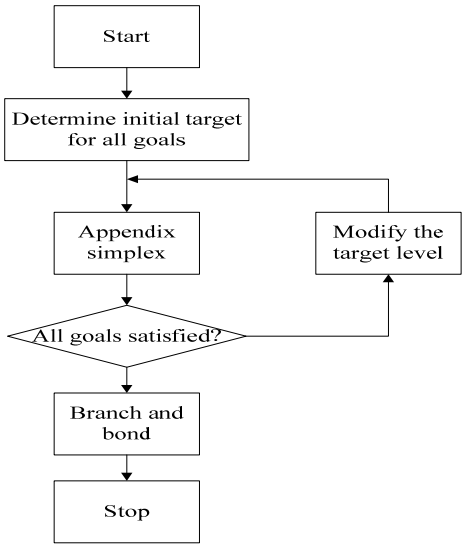

Fig. 3. Solution procedure for solving a mathematical model.

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The first step to solve the GP formulation is determining initial target level for all goals. Initial target level is determined by decision maker. Then we apply appendix simplex to minimize the deviational variable. After that, the output of the model will be compare with the initial target level and check them satisfied or not. If there are goals not satisfied yet, we must modify the target level until all goals satisfied.

B. Numerical example

To illustrate the model, we need to input data in order to the model can be run and make a decision for the problem. This is the data that needed to run the model. Table III presents two types of log type to make furniture. In Table IV, supply of log is presented. The number of product demand is presented in Table V.

In Table VI we differentiate each type of the product by the varying presentation of material need. The prices of the corresponding furniture are ranging from IDR 27,750,000 to IDR 37,750,000.

TABLE III
LOG TYPE

LOG TYPE	PRICE/M^3
AII	Rp 2.750.000
AIII	Rp 4.500.000

TABLE IV
LOG TYPE SUPPLY (M^3)

LOG TYPE	SUPPLY											
	1	2	3	4	5	6	7	8	9	10	11	12
AI	500	500	500	500	500	500	500	500	500	500	500	500
AII	500	500	500	500	500	500	500	500	500	500	500	500

TABLE V
FURNITURE DEMAND (m^3)

PERIODE	DEMAND					
	GF1	GF2	GF3	IND1	IND2	IND3
1	3	4	0	4	0	0
2	0	0	5	0	5.5	0
3	0	4	4	0	0	6
4	4	0	4	2	0	0
5	0	5	0	0	8	0
6	3	0	5	0	0	4.5
7	5	0	0	0	5	0
8	0	5	4	0	3	5
9	5	0	0	5	4	0
10	0	5	0	0	7	0
11	6	0	3	0	3	0
12	7	4	0	5	0	0

TABLE VI
DESIGN PATTERN OF PRODUCT

TYPE	AII	AIII	RATTAN
GF1	0%	70%	30%
GF2	0%	60%	40%
GF3	0%	50%	50%
IN1	80%	0%	20%
IN2	70%	0%	30%
IN3	60%	0%	40%

C. Results

From the solution procedure in Fig. 2, the first step of the proposed GP is to set the target level for all goals. These values are estimated based on historical data or even decision maker's desire and goal. The initial target values for the goals are depicted in Table VII. For G1 is the minimal profit for the manufacturer in a year, the G2 is the minimal profit for the buyer in the year, G3 is the desire value for PPE in a year, G4 is the minimal number of reorder point, G5 is the maximal number of waste in a year and G6 is the minimal number of log process in a year.

TABLE VII
SCENARIO

Goal	Target Level
G1	At least IDR. 350,000,000
G2	At least IDR. 400,000,000
G3	Equal to IDR. 24,786,000
G4	At least 200 m^3
G5	At most 300 m^3
G6	At least 400 m^3

The next step of the solution procedure, the GP seeks to minimize the unwanted deviational variables according to goals that must be achieved. The initial solution of the corresponding initial target level is given in Table VIII. Both economic goals are not satisfied compare to the target level set by decision maker. Both of the social goals are achieved by the initial target level. Environmental goal for manufacturer is not satisfied but environmental goal for buyer is satisfied.

TABLE VIII
INITIAL EFFICIENT SOLUTION

Solution	Goal	Target Level	Achieved Value	Satisfied
Initial	G1	350,000,000	315,940,000	No
	G2	400,000,000	377,000,000	No
	G3	24,786,000	24,786,000	Yes
	G4	200	660	Yes
	G5	300	324	No
	G6	400	400	Yes

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Based on the result in Table VIII, we need to modify the target level. From Table IX, it can be inferred that for economic aspect, unsatisfied goals are underachieved. Hence, decision makers modify the target levels by lowering the initial target values. And for environmental goal for manufacturer, the result is more than the maximum number allowable. So we must increase the target level. The Pareto efficient solution is presented in Table VIII. It can be seen that all economic goals are somewhat satisfied equal to their initial target values. It means that the target profit of manufacturer and buyer are satisfied. For the social aspect, all the goals are satisfied too. Manufacturer can allocate the cost with the amount IDR 24,786,000 for one year to PPE. This facility can make an added value to the manufacturer because considering the social aspect. The minimal of reorder point is much higher than the target level. This is very good for the manufacturer because this representation that the consumer satisfaction level is very good. It is hoped that they will be come back to reorder. The environmental goal for manufacturer is satisfied with values 324 m^3 that means lower than the maximum value permitted. And for the minimal log that being processed is satisfied equal to the target level.

TABLE IX
PARETO EFFICIENT SOLUTION

Solution	Goal	Target Level	Achieved Value	Satisfied
Pareto efficient	G1	315,940,000	315,940,000	Yes
	G2	284,346,064	377,000,000	Yes
	G3	24,786,000	24,786,000	Yes
	G4	150	660	Yes
	G5	340	324	Yes
	G6	400	400	Yes

V. CONCLUSION

The proposed model can be used to determine the sixth goals for order fulfillment in export oriented furniture industry with sustainability considerations. The GP approach was used to determine the value of decision variables. There are some extensions from this work that could be derived to elaborate the model formulation such as considering the buyer and manufacturer budget, providing raw material of green design alternatives, and offering the option of distribution channel system.

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