ISSN : 1978-774X

THE ALGORITHM FOR NEGOTIATING PRICES IN A PALM OIL SUPPLY CHAIN

Syarif Hidayat

Industrial Engineering Department, Al Azhar Indonesia University, Jakarta, Indonesia
syarif_hidayat@uai.ac.id

ABSTRACT

In supply chain (POSC) the operational risk and investment levels between the actors may not be proportionately rewarded by the same levels of added value. Each actor will attempt to obtain the highest reward. However, each actor must consider the level of added value obtained by other actors so as to maintain the fair balance in the overall supply chain profitability. Otherwise any of the least profitable actor will withdraw itself from the supply chain and the supply chain will collapse. In this study the authors proposed a formula to calculate the utility function based added value for each of the actors in the POSC. The utility function is a formula based on the risk and investment levels of each of the POSC members. To optimize the added value distribution between the agents the concept of stakeholder dialogue was used. This research is important because the developed iterative algorithm may be used by other supply chain and other products in general. Agent-based modeling approach was used for this purpose to facilitate the negotiation between all actors to reach the balanced added values along the POSC to ensure supply chain sustainability. Netlogo software is used in developing the POSC negotiation model while considering the stakeholder dialogue. The proposed utility function formula proves to be practical to calculate the expected negotiated prices between all the actors. Application of the formula to other types of commodity and different supply chain model will need some adjustments in the calculation.
Keywords: *Added-value, Agent Based Modeling, Netlogo software, iteration*

1. INTRODUCTION

Companies in a supply chain operate in sequence and cooperate in handling, improving and controlling the flows of goods, money and information (Preckel *et al*, 2004, van der Vorst, 2004). The principal roles of the supply chain is to add value to the products by moving them from one to another location, or to perform the modification processes (Janvier-James, 2012). The value adding processes may be applied to the quality, costs, delivery activities, flexibilities in sending the products, and innovations (Trienekens, 2011).

1.1. Palm Oil Supply Chain

Figure 1 shows the 10 actors in the palm oil supply chain (POSC). The smallholder farmers sell their fresh fruit bunch (FFB) to Crude Palm Oil (CPO) Factory through traders. CPO factory also get the FFB from its own Core and Plasma estates. CPO Factory converts the FFB into CPO. CPO is sold to the Frying Oil Factory (refinery), who converts CPO into frying oil and sends the product to the distributors who sell it to local users. CPO factory can also sell the CPO through the exporter to the foreign users. The farmers want to get the highest price for their crops, but the traders and factories demand the lowest cost for quality product (Awal, 2012). Between the farmers and the trader selling-buying prices are negotiated such that they reach a level acceptable by both parties. In a negotiation, prices are adjusted in such a way by both parties so as to gain a positive value from deducting the sales by all costs incurred, plus the minimum profit margin. The negotiations between neighboring actors occurred along the POSC.

ISSN : 1978-774X

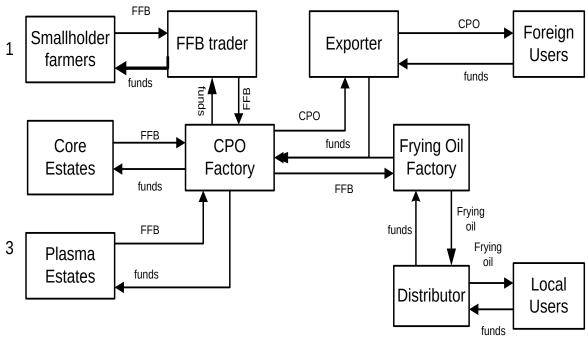

Figure 1. Palm oil supply chain actors

1.2. The question in this study

The question in this study is how to find the right levels of prices between the actors which will give the sufficient added values for each actor while maintaining the acceptable overall supply chain added value. This study will formulate an algorithm and procedures to answer the question.

The business scale of each of the POSC actor is different from each other. The risks faced by each actor are different in type and level. The investment level employed by each actor is also different. These two factors influence the capacity and the opportunity to create added values in each of the actors.

2. THEORETICAL BACKGROUND

This study will be conducted using some basic theories in business as well systems.

The first theory that will be utilized in this study is about risk and risk management. Holton (2004) defined risks as the exposure to the probability of uncertain event. Risks may also be defined as the uncertainty of the achievements by a company (Kaplan and Garrick, 1981). Risks must be controlled otherwise problems may happen in the supply of raw materials which may cause financial loss to the company (Zsidisin, *et al*., 2008).

The second theory is about investment. Investment is time, energy, or matter spent in the hope of future benefits actualized within a specified date or time frame. In this paper investment is defined as the amount money put into an activity in POSC. The money is invested with the expectation of gain in added value as the result of doing business activity either manufacturing, selling, or moving products to other actor in the POSC.

The third theory is about added value. Hines (2004) defined added value as the “difference between output value and the input costs”. Added value is the main motivation for the establishment and the growth of an enterprise. Without this no investor or a businessman is willing to invest in or nurture a business. The motives for the investor or the businessman to engage in any enterprise including the agroindustry is the fair and just arrangement of risk and benefit (Preckel *et al*., 2004).

The last theory discussed in this study is the Utility formulation to describe added value calculation. The concept about the utility function is that all of the tangible and intangible outputs of various business processes, represent inputs into the intrinsic satisfactions (process benefits) associated with one or another activity (Juster, T., 1990). With satisfaction the author is referring to the optimization of the added value obtained from the business negotiation in the POSC. In this study the utility function is written as an exponential function.

3. RESEARCH METHODS

This study is organized into several parts as follows: (1) identification of the negotiation behaviour in the POSC, (2) identification of risk and investment scores of the POSC actors, (3) the formulation of added value utility in exponential format, (4) the formulation of the iterative algorithm, and (5) using agent based approach with the development of the Netlogo simulation model to facilitate the negotiation behavior.

The selling prices are negotiated between the actors until each actor reached a satisfactory value, which was ruled by the levels of optimum added value utility. This added value utility is based on investment and risk level was introduced. To calculate the added value as a function of different scores and weight levels of risk and investment, the author developed an algorithm using the iteration of the two weight levels.

3.1. Identification of negotiation behavior

The negotiation process is based on the Stakeholder Dialogue method. Basically the method is a structured discussions between the representatives of business partners or companies (Palazzo, 2010). In agroindustry supply chain the method aims at maintaining supply continuity and improve the raw materials quality while balancing the financial interests for each actor.

The farmers want to get the highest price for their crops, but the traders and factories demand the lowest cost for quality product (Awal, 2012).

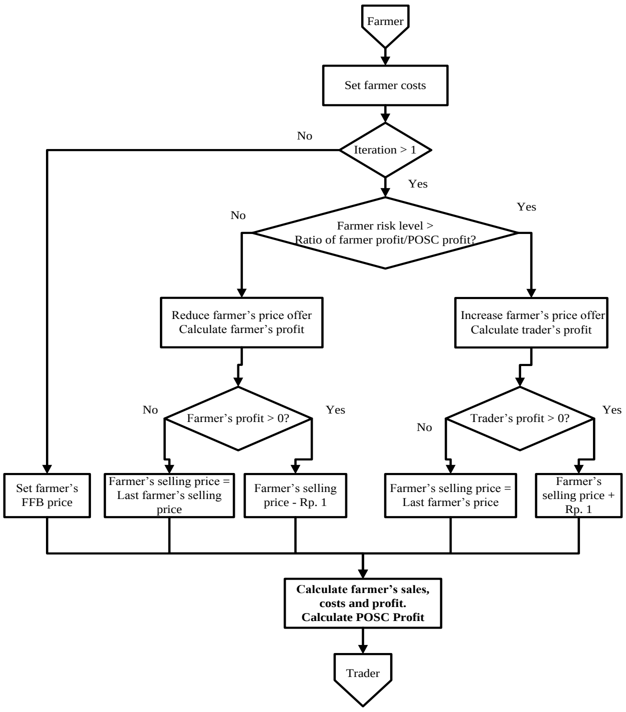

Figure 2. Negotiation flowchart between the farmer and the trader

Figure 2 shows a flowchart on how the negotiation process is conducted between farmers and traders. This diagram represent the application of stakeholder dialogue approach. Initially the farmer offer a FFB selling price. The trader will calculate if this price will give him acceptable profit. This is done by checking if the profit obtained by each POSC actor is higher than the expected gain, and if the gain is higher than the overall POSC gain. The process is iterated between two consecutive actors in the POSC. Figure 3 shows how the overall negotiation process work to ensure that all POSC actors are happy with the outcome of the negotiation. The overall processes are then translated into Netlogo software program.

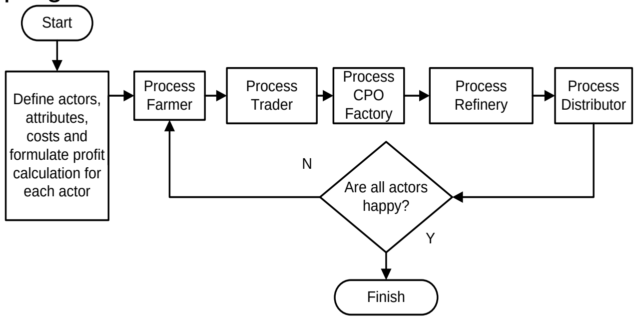

Figure 3. Overall negotiation process in the POSC

3.2. Identification of risk and investment scores of the POSC actors

The risk and investment scores for each POSC actor are collected from replies to questionnaires sent to relevant industry managers, as well as from secondary resources. These inputs were processed using fuzzy Analytical Hierarchical Process (FAHP). Most quantitative results are taken from the author's previous study in the POSC (Hidayat, *et al,* 2012).

Table 1. Modified Hayami method to calculate added value

	Variables	Unit	Value
Palm Oil Supply Chain Interaction			
1	Raw Material Price	Rp/kg	(1)
2	Product Selling Price	Rp/kg	(2)
3	Total Added Value per kg output	Rp/kg	(3)
I. Output, Input, and Prices			
4	a. Output (sales volume)	kg	(4a)
	b. Output (sales value)	Rp	(4b)
5	Raw Material Purchases	Rp	(5)
6	Direct Labour	Manday	(6)
7	Conversion Factor (Output/RM)		(7)=(4b)/(5)
8	Coefficient - Direct Labour	Rp/Manday	(8)=(4b)/(6)
9	Direct Labour Wage	Rp	(9)
II. Revenue and Added Value			
10	a. Other Input costs - Production	Rp	(10a)
	b. Other Input costs - Non Production	Rp	(10b)
11	a. Added Value (Profit)	Rp	(11a)=(4b)-(5+10a+10b)
	b. Added Value Ratio	%	(11b)=(11a)/(4b)
III. Rewards to the owner of Production Factors			
12	Margin (Rp/Kg)	Rp	(12)=(4b)-(5)
	a. Contribution of other input	%	(12a)=(10a+10b)/(12)*100%
	b. Company Profit	%	(12b)=(11a)/(12)*100%
IV. Portion of added value per kg of product			
13	a. Real Added Value for Actor	Rp	(13a)
	b. Supply Chain Added Value	Rp	(13b)
	in %	%	(13c)

Calculation of input material quantities, investment and maintenance costs follow modified Hayami Method. The calculation for added-value for each actor were performed using the modified Hayami method. Table 1 describes the generic model of modified

Hayami method. The added values are shown at row 11 for each actor. The modified Hayami method was used to calculate the investment levels for each actor in the POSC. This table shows for all five POSC actors the respective data types as shown in the column "variables". Using this Hayami table we calculated the respective added-values (=profits) for each actor.

3.3. Formulation of added value utility in exponential format

Following (Suharjito, 2011) by common sense it was assumed that if the risk is higher then the added value should be higher. Likewise, the higher the investment level the higher the expected added value. The level of risk and investment will never be zero. Nowadays for any real business there are always risk faced by the industry and need for investment although with differences in their level. An exponential function is the best representation of this logic as shown in (4).

$$AV = f(\text{investment, risk})$$
$$AV = \alpha\, e^{(w1i*x1i+w2i*x2i)\,\alpha} \quad (4)$$

where:
AV = Total supply chain added value
α = variable coefficient
w1i = risk level for i-th POSC actor
x1i = risk score for i-th POSC actor
w2i = investment level for i-th POSC actor
x2i = investment score for i-th POSC actor
i = 1, 2, 3, 4, 5, 6 the actors of the POSC
Subject to the constraints:

$$0 < w1i, w2i < 1 \quad (5)$$
$$w1i + w2i = 1 \quad (6)$$

The total sum of weights should be equal to 1. The value of α from previous research was selected at 2.0 as this value provides sufficient visibility of the graph movement. Risk and investment scores for each actor were obtained from replies to questionnaires sent to the relevant industry managers.

3.4. Formulation of iterative algorithm approach

While we have 2 factors to consider i.e. the weight levels of risks and investments for all five of the supply chain actors, we use mathematical iteration algorithm to seek the right combination of the factors which will provide the highest added value of the POSC business.

1. Start with assigning the lowest possible risk weight level 0.001 and assign the highest possible investment weight level of 0.999;
2. Calculate the exponential AV function, and plot a point in the graph (Netlogo output);
3. Increase the risk weight by 0.001 to get 0.002 and decrease the investment value by 0.001 to get 0.998;
4. Calculate the exponential AV function, and plot another point in the graph (Netlogo output);
5. This iteration when repeated until risk weight level reaches 0.999 and investment weight level reaches 0.001. When completed, the continuous plot will be an exponential curves.
6. Simultaneously we allocate the risk weight level to start at 0.999 and the investment weight level at 0.001. Calculate the exponential AV function.
7. Perform activities 3 to 5 for the new allocation. We get two graphs side by side.
8. The two graphs will have a crosspoint because they start from different points and move in approaching direction. We consider the crosspoint to be the iteration wherein the POSC reaches a balance in added values for all actors.

Tabel 2 shows the iteration of changing the risk and investment weight level.

.

Table 2. Iteration

	1st	2nd	3rd	4th	5th	6th	7th	end value
Risk	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.999
Investm	0.999	0.998	0.997	0.996	0.995	0.994	0.993	0.001

The process described above is implemented in the first model i.e. Uitility Netlogo Model. Using both weight levels into the Netlogo Optimization model, we obtain optimum selling prices and the profit values of each POSC actor.

These weight levels then are entered into the Netlogo Optimization model to find the selling prices and the individual added values for each of the POSC actors. In this Optimization model, the selling prices undergo the iterative negotiation process

ISSN : 1978-774X

again to achieve the most acceptable added value level, following the logic shown in Figure 2. The Optimization model is written to facilitate the calculation following the process described in paragraph 2.4.

3.5. Development of Agent-based Netlogo model

Agent-based modeling was used for this purpose as it provided the best means to identify and study the supply chain actors (or agents) behaviors. To facilitate fair distribution of rewards for the supply chain actors a concept of added value utility based on investment and risk level was introduced. To optimize the added value distribution between the agents the concept of stakeholder dialogue was used. The selling prices were negotiated between the actors until each actor reached a satisfactory value, which was ruled by the levels of optimum added value utility.

Many situations and subsystems can be viewed as being characterized by the presence of a number of autonomous entities whose behaviors determine (in a non-trivial way) the evolution of the overall system. Agent-based models are particularly suited to tackle these situations and they support the study and analysis of topics like decentralized decision making, local-global interactions, self-organization, emergence and effects of heterogeneity in the simulated system (Bandini, *et al.,* 2009).

Agent-based modeling approach is used for this purpose as it provided the best means to identify and study the supply chain actors (or agents) business and decision making behaviors. The agent-based approach facilitates the interaction between all the POSC actors with the characteristics of autonomy, social interaction, reactive and pro-active behaviours (Wooldridge and Jennings, 1995).

Netlogo open-source programming software is used to develop the agent-based program due to its vast modeling facilities, easy availability, and continuous development by the diverse user communities communities (Wooldridge and Jennings, 1995). The programming language is flexible and facilitate appropriate algorithm coding. It also has the facility to write the numerical calculation output in an Excel-like format (Tisue and Wilensky, 2006).

Two Netlogo models were developed, i.e. Utility model and the Optimization model. The Utility model is used to obtain the weight levels of risk, investment and technology that give the optimum utility or added value. This Utility model works on an iteration logic changing the levels of risk and investment levels as shown on Table 2.

The Optimization model is used to find the level of products prices and profits after entering the weight levels given by the Utility model. This Optimization Model works on a logic to change iteratively the product prices by Rp 1 to obtain the optimum profit level. This model applies the stakeholder dialogue approach. The profits are calculated for each iteration of the product prices and plotted in the “world output” and the quantitative results are recorded in a comma separated value (CSV) file.

4. RESULTS AND DISCUSSION

4.1 The Actors in The POSC

The CPO factory in the study has a processing capacity of 30 tons of FFB per hour. To operate for a year (working 300 days per year and 20 hours per day) the factory needed 180.000.000 kg of FFB). This amount of FFB is produced by a palm oil estate of 3.032 hectares. Assuming that one farmer owns 2 hectares, then 1.516 farmers are involved in producing the required FFB. The respective operating maintenance costs, yields, and added-values were calculated using these capacity and respective amount of FFB needs, to obtain corresponding value-added or utility values.

4.2 Risk and Investment scores

The values of risk and investment levels for each actor in the POSC were obtained from the interviews with the selected respondents. These are taken from the authors previous study in the POSC (Hidayat, *et al*, 2012). Identified individual risks are shown on Table 3. This risk levels for each actor were processed using fuzzy Analytical Hierarchical Process (FAHP). The investment levels were identified from each of the financial reports, and normalized to result together with the risk levels in the scores shown on Tabel 5.

Table 3. Identified risks and their final scores

Risk Type	Farmer	Trader	CPO Fct	Refinery	Distributor	Consum	Score
Price	0.236	0.228	0.066	0.159	0.155	0.195	0.160
Supply	0.095	0.163	0.214	0.186	0.187	0.266	0.177
Transportation	0.046	0.129	0.051	0.075	0.172	0.120	0.088
Information	0.029	0.029	0.028	0.028	0.029	0.031	0.029
Policy	0.037	0.030	0.029	0.028	0.028	0.028	0.030
Market	0.037	0.128	0.084	0.070	0.153	0.090	0.085
Warehousing	0.097	0.062	0.034	0.030	0.026	0.029	0.041
Production	0.134	0.064	0.147	0.102	0.058	0.080	0.092
Environment	0.077	0.036	0.101	0.097	0.031	0.037	0.056
Quality	0.129	0.083	0.143	0.154	0.082	0.074	0.106
Partnership	0.055	0.026	0.027	0.027	0.053	0.025	0.033
Technology	0.035	0.022	0.076	0.046	0.026	0.025	0.035

Table 4. Selling-buying prices among POSC

	unit	Farmer	Trader	CPO Factory	Refinery	Distributor	Consumer
Palm Oil Supply Chain							
1 Raw Material Need	Rp/kg	1,209	1,423	1,162	6,500	12,000	12,215
2 Product Selling Prices	Rp/kg	1,423	1,162			12,215	

Table 3 shows the levels of risks and investment of the five POSC actors. Table 4 shows the initial selling-buying prices along the POSC. This is the condition prior to running the utility model. Table 5 shows that the farmers obtained the highest level while the distributors face the lowest level of 0,103.

The investment levels obtained from the respondents were processed using Hayami modified method, and after normalization give a row of result shown on Table 5.

Table 5. POSC actors risk and investment levels

Variable	Farmer	Trader	CPO Factory	Refinery	Distributor
Risk Level	**0.355**	**0.124**	**0.224**	**0.193**	**0.103**
Investment Level	**30**	**85**	**3,938**	**5,858**	**89**

4.3 Results of Netlogo simulation models

All quantitative data obtained from the respondents after being processed through FAHP or Modified Hayami methods are entered into the Netlogo models.

The Netlogo Utility model shows output graphs as depicted in Figure 5. They show the movement of the utility added-value figures following the changes of each iteration as described in paragraph 3.4. The vertical axis represent the movement of the utility level (in percentage of maximum value) for each actor, while the horizontal axis represent the iteration. At the intersection the optimum utility level is obtained for a certain value of weight risk and investment levels.

The weight levels are entered into the Optimization Netlogo Model and the model is run to seek the optimum values of product prices and profits for each actor in the POSC. In this model the product prices are changed in iteration of Rp 1. The CSV results for the profits for selected iterations are shown on Table 6, while the results for the prices for selected iterations are shown on Table 7.

Figure 6 shows the output "world model" in Netlogo showing the actors profits for each incremental iteration. The profit graphs moves up and down at iteration but stabilize after more than 1500 iterations. Figure 7 shows the dynamics for the product selling prices. The stabilizations of both figures are concurrent as the profit follows the calculation on the prices.

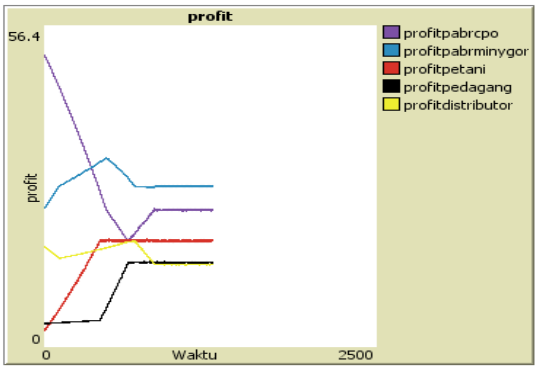

Figure 6. The Netlogo Optimization Model output showing the profit dynamics

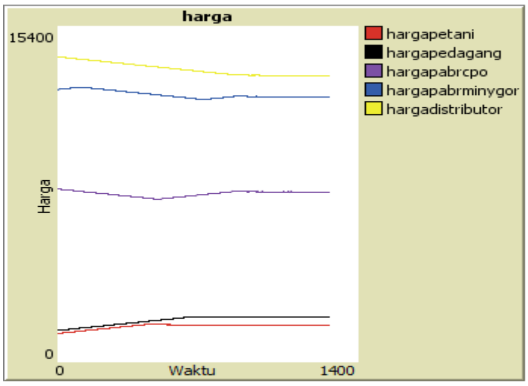

Figure 7. The Netlogo Optimization Model output showing the product prices dynamics

Table 6. Price changes for selected iteration

Iteration	Farmer	Trader	CPO Factory	Refinery	Distributor
	per kg	per kg	per kg	per kg	per kg
1	1,454	1,513	6,465	11,857	12,026
200	1,653	1,712	6,418	11,658	12,225
400	1,749	1,912	6,618	11,458	12,329
600	1,723	2,028	6,818	11,258	12,129
800	1,709	2,006	7,018	11,058	11,929
1,000	1,699	1,984	7,218	10,878	11,729
1,200	1,693	1,976	7,266	10,936	11,675
1,400	1,693	1,978	7,272	10,940	11,679
1,600	1,697	1,982	7,278	10,948	11,687
1,700	1,697	1,980	7,274	10,948	11,689
1,800	1,695	1,980	7,274	10,944	11,685
1,900	1,693	1,978	7,278	10,950	11,687
2,000	1,695	1,982	7,282	10,956	11,693
2,010	1,697	1,982	7,280	10,958	11,699
2,020	1,699	1,982	7,282	10,958	11,697
2,030	1,697	1,982	7,280	10,958	11,699
2,040	1,695	1,982	7,282	10,958	11,697
2,050	1,695	1,980	7,278	10,960	11,705

Table 7. Add-value changes for selected iteration

Iteration	Farmer	Trader	CPO Factory	Refinery	Distributor
	per 100 kg	per 100 kg	per 24 kg	per 18,2 kg	per 18,2 kg
1	5,350	2,450	38,077	60,893	2,864
200	15,300	2,400	21,560	58,391	10,141
400	20,400	7,550	10,966	49,980	15,705
600	19,400	14,650	6,786	41,513	15,705
800	18,750	14,350	13,261	33,047	15,686
1,000	17,850	13,700	19,759	24,982	15,303
1,200	17,350	13,650	21,577	24,870	13,279
1,400	17,200	13,700	21,567	24,799	13,297
1,600	17,300	13,700	21,354	24,819	13,279
1,700	17,800	13,600	21,412	24,897	13,315
1,800	18,100	13,750	21,412	24,824	13,333
1,900	17,700	13,700	21,687	24,837	13,224
2,000	18,150	13,850	21,450	24,887	13,260
2,010	18,350	13,750	21,450	24,935	13,315
2,020	18,300	13,600	21,450	24,887	13,260
2,030	17,250	13,650	21,402	24,935	13,315
2,040	17,750	13,750	21,450	24,905	13,260
2,050	17,800	13,750	21,532	25,056	13,370

Table 8 shows the comparison of prices before and after the Netlogo model simulation is completed. It is obvious that the selling prices for the refinery and the distributor are decreasing, while the selling prices of CPO factory, farmers and the traders are increasing following the relevant added values. The sequence of profit levels are for the refinery, CPO factory, the farmers, the traders and the distributors respectively. The existing sequence therefore must change if the POSC is to be sustainable.

Table 8. The result of running the Netlogo Optimization model

		Unit	Farmer	Trader	CPO Factory	Refinery	Distributor
1	Input Price	Rp/kg	1,209	1,423	1,162	6,500	12,215
2	Product Selling Price (now)	Rp/kg	1,423	1,500	6,500	12,000	12,420
3	Risk Level		0.355	0.124	0.224	0.193	0.103
4	Investment Level		30	85	3,938	5,858	89
5	Optimum Utility Value		2.984	2.301	3.608	4.192	2.233
7	Selling Price (should be)	Rp/kg	1,620	1,942	7,274	11,136	11,973
8	Profit (rupiah)	Rp/kg	178	138	897	1,377	735
9	Profit (%)	%	3	4	2	1	5

5. CONCLUSION

This study has managed to provide a utility added value calculation and optimization computer model to obtain the optimum added value and the product selling prices for each of the POSC actors. The utility model was a function of the risk and investment scores and weight levels of each actor. The algorithm used to obtain optimum value of the utility added value was based on the iteration of the weight levels. But the iteration in the Optimization model is based on price iteration. The POSC prices are stabilized after the simulation at the levels that ensure balanced and acceptable profit and added-value for all actors as a group.

The business levels among the POSC actors must be maintained to have fair flow of materials and money. The balancing process was initiated by optimizing the added value utility of each actor, while considering the overall POSC business continuity.

The model may be extended to be used for other commodity and different supply chain model with some adjustments in the profitability calculation formula. The model may also be extended to cover the most upstream of the POSC namely the palm oil seed industry. The secondary downstream industry may include other products such as margarine, soap, vitamin E and many other palm oil based products.

6. ACKNOWLEDGEMENTS

The author would like to express his gratitude to the Higher Education General Directorate (Direktorat Jendral Pendidikan Tinggi) of the Education and Culture Ministry of the Republic of Indonesia (Kementerian

ISSN : 1978-774X

Pendidikan dan Kebudayaan Republik Indonesia) for providing the financial support for the study.

7. REFERENCES

(a) Awal S. 2012. "Strategi Penyediaan Karbohidrat Bersumber Dari Ubi Kayu". *PhD Thesis*. Bogor Agricultural University (IPB).

(b) Bandini, S., Manzoni, S., and Vizzari, G. 2009. "Agent Based Modeling and Simulation: An Informatics Perspective". *Journal of Artificial Societies and Social Simulation* 12 (4) 4.

(c) Hidayat, S., Marimin, Suryani, A., Sukardi, and Yani, M. 2012. "Model Penyeimbangan Nilai Tambah Berdasarkan Tingkat Risiko Pada Rantai Pasok Minyak Sawit". *PhD Thesis*, Bogor Agricultural University (IPB).

(d) Hines T. 2004. *Supply Chain Strategies: Customer-driven and Customer-Focused*. Great Britain. Elsevier Butterworth. Heinemann.

(e) Janvier-James, A.M. 2012. "A New Introduction to Supply Chains and Supply Chain Management: Definitions and Theories Perspective". *International Business Research Journal* 5(1), pp. 194-207.

(f) Holton, G.A. 2004. "Perspective – Defining risks". *Financial Analysts J*, CFA Institute; 60(6): 19-25.

(g) Juster, T. 1990. "Rethinking Utility Theory". *The Journal of Behavioral Economics*, Volume 19, Number 2, pages 155-179. JAI Press Inc.

(h) Palazzo B. 2010. *An Introduction to Stakeholder Dialogue, Responsible Business.* How to manage a CSR strategy successfully. John Wiley and Son; 17-42. Oxford.

(i) Preckel, P.V., Gray, A., Boehlje, M., and Kim, S. 2004. "Risk and value chains: Participant sharing of risk and rewards". *Journal on Chain and Network Services*. 4(1), pp. 25-32.

(j) Suharjito. 2011. "Pemodelan Sistem Pendukung Pengambilan Keputusan Cerdas Manajemen Risiko Rantai Pasok Produksi/Komoditi Jagung". *PhD Thesis*, Bogor Agricultural University (IPB).

(k) Tisue, S., and Wilenski, U. 2006. *NetLogo: Design and Implementation of a Multi-Agent Modeling Environment*. Center for Connected Learning and Computer-Based Modeling Northwestern University, Evanston, Illinois.

(l) Trienekens, J.H. 2011. "Agricultural Value Chains in Developing Countries ; A Framework for Analysis". *Journal of International Food and Agribusiness Management Review.* 14(2), pp. 51-82.

(m) Van der Vorst J.G.A.J. 2004. *Supply Chain Management: Theory and Practices. The Emerging World of Chains & Networks*, Elsevier, Hoofdstuk 2.1. Wageningen.

(n) Wooldridge, M., and Jennings, N.R. 1995. "Intelligent agents : theory and practice". *Knowledge Engineering Review* 10. London.

(o) Zsidisin, G.A., Wagner, S.M., Melnyk, S.A. Ragatz, G.L., and Burns L.A. 2008. "Supply risk perceptions and practices: an exploratory comparison of German and US supply management professionals". *Int. J. Technology, Policy and Management*, 8 (4), pp 401-419.

AUTHOR BIOGRAPHIES

Syarif Hidayat is a lecturer in Department of Industrial Engineering, Faculty of Sains and Technology, Al Azhar Indonesia University, Jakarta. He graduated from Electrical Engineering Department in Bandung Institute of Technology, received his Master of Engineering Science degree from the University of New South Wales and Doctor's degree from Bogor University of Agriculture. His research interests are in the area of Supply Chain Modeling and Enterprise Resource Planning. His email address is <syarif_hidayat@uai.ac.id>

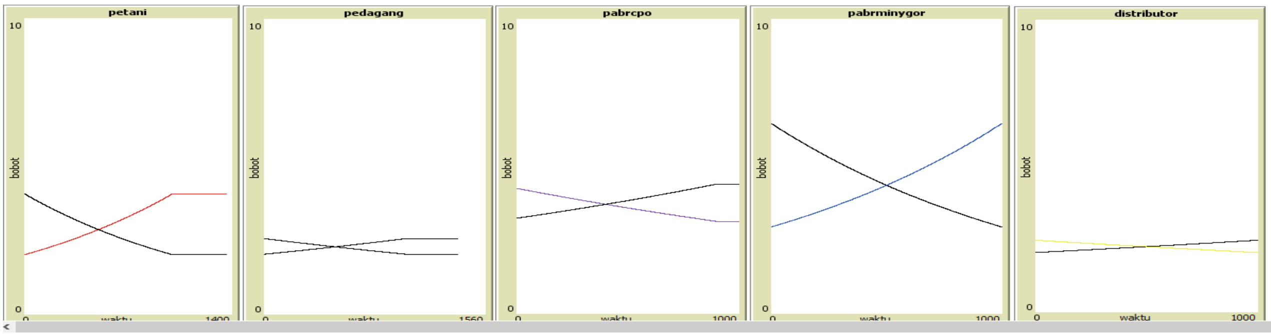

Figure 5. The side-by-side exponential graphs from Netlogo Utility Model