

APPLYING NETLOGO SIMULATION MODEL TO BALANCE THE UPSTREAM PALM OIL SUPPLY CHAIN

Syarif Hidayat, Mas'ud Ridwan

Industrial Engineering, Faculty of Science and Technology, Universitas Al Azhar Indonesia,
Jl. Sisingamangaraja Kebayoran Baru, Jakarta Selatan, 12210, Indonesia
E-mail : syarif_hidayat@uai.ac.id

ABSTRACT

Palm oil and its derivative products are the most important non-oil & gas commodities in the Indonesian economy. This is due to its increasing dominant non-oil and gas exports, and the large number of job opportunities available. The upstream palm oil industry supply chain consists of the farmers, the traders and the CPO factories. The aim of this study is to measure the business risk levels. The methods used are the Fuzzy Analytical Hierarchy Process (FAHP) and Agent Base Modeling using Netlogo. Highest risk is obtained by farmers with a value of 0.516, followed by CPO-factory at 0.306 and the traders at 0.179.

Key words: profit, value-added model, simulation

1. INTRODUCTION

Today, palm oil products especially Crude Palm Oil (CPO) is one of the most important agricultural commodities in Indonesia for at least three reasons. Firstly, palm oil is the main raw material for cooking oil, therefore a continuous supply of CPO to the processors is imperative to maintain cooking oil availability and price stability. Secondly, CPO has proven to be a promising major source of foreign exchange earnings and taxes in Indonesian economy. Thirdly, the palm fruit farming, supply chain and CPO processing has been creating employment opportunities and at the same time improve the welfare of the community (Soetrisno and Winahyu, 1991).

Palm oil supply chain is a very complex system, starting from palm oil cultivation by the farmers. Fresh fruit bunches (FFB), the harvest of the farms, are collected by traders who then sell them to CPO factories where these FFB are processed into CPO. CPO is sold to the downstream processors to be converted into various products, such as cooking oil, margarine, cosmetics raw materials, and more edible and no-edible products. Indonesian palm oil farmers are generally trapped in a weak bargaining position. This is due to the monopsonistic general market structure of FFB (Lubis, 2006) in most palm fruit farm areas in

Indonesia. In this market structure, only few traders and CPO factories in most areas control the market. Most farmers have limited capital and market information.

The low bargaining power, resulting in a lower rate of return than the risk faced by farmers. This prompted the need for a model that describes the interaction of palm oil agro-industry value chain that delivers a balanced level of benefits to weight the risks to the perpetrators or stakeholders. One method that can be used to find the weight of the risks faced by individual actors upstream palm oil supply chain is to use the method of fuzzy analytical hierarchy process (FAHP) and its agro-industry value chain interactions can be described by the manufacture of simulation-based object oriented programming using one software agent base modeling.

2. THEORETICAL BACKGROUND

Supply Chain Management

Supply chain Management is the systematic, strategic coordination of the traditional business functions within a particular company and across business within the supply chain for the purpose of improving the long-term performance of the traditional company and the supply chain as a whole (Chopra & Meindl, 2007)

Supply chain is not only oriented to the internal affairs of a company, but also the external affairs concerning relationships with partner companies. Because the companies that are at the core of a supply chain want to satisfy the final consumer, they must work together to make a cheap product, send it on time, and with good quality. Only by cooperation between the elements of the supply chain of these objectives will be achieved. Today's competition is no longer between one company with other companies, but between one supply chain with another (Pujawan, 2010).

2.1 Value added

Value added is the value that occurs as a commodity is processing, transport and storage in a production process (the use/provision of functional inputs). The added value is influenced by technical factors and non-technical factors. Or output information obtained from analysis of the added value is the value added, the ratio of added value, margin and fringe benefits received by the owners of factors of production (Hayami, 1987).

2.2. Fuzzy AHP

Fuzzy AHP is one of the ranking methods. Fuzzy AHP AHP combines the fuzzy concept approach (Raharjo et al, 2002). FAHP cover the weaknesses contained in the AHP, the problem of the subjective nature of the criteria that have more. Uncertainty is represented by the sequence numbers of the scale. To determine the degree of membership of the FAHP, use the rules function in the form of triangular fuzzy numbers or Triangular Fuzzy Number (TFN).

2.3. Agent Based Modeling

ABM concept derived from the combined interdisciplinary concept known as "Science of Complexity", which is a term that is expressed by Ramalingam and Jones (2008). In the scientific concept of biological and social sciences are combined to produce a complex joint that can anticipate that non-linear systems, self-regulated, heterogeneous, adaptable, no feedback, and can bring out the behavior. All combined science was implemented into a computer and software engineering that makes agent-

based modeling framework, which is the result of the development of theories ranging from artificial intelligence computer, neural network, and computer programming to evolve.

3. RESEARCH METHOD

The research method in this study can be seen graphically in Figure 1.

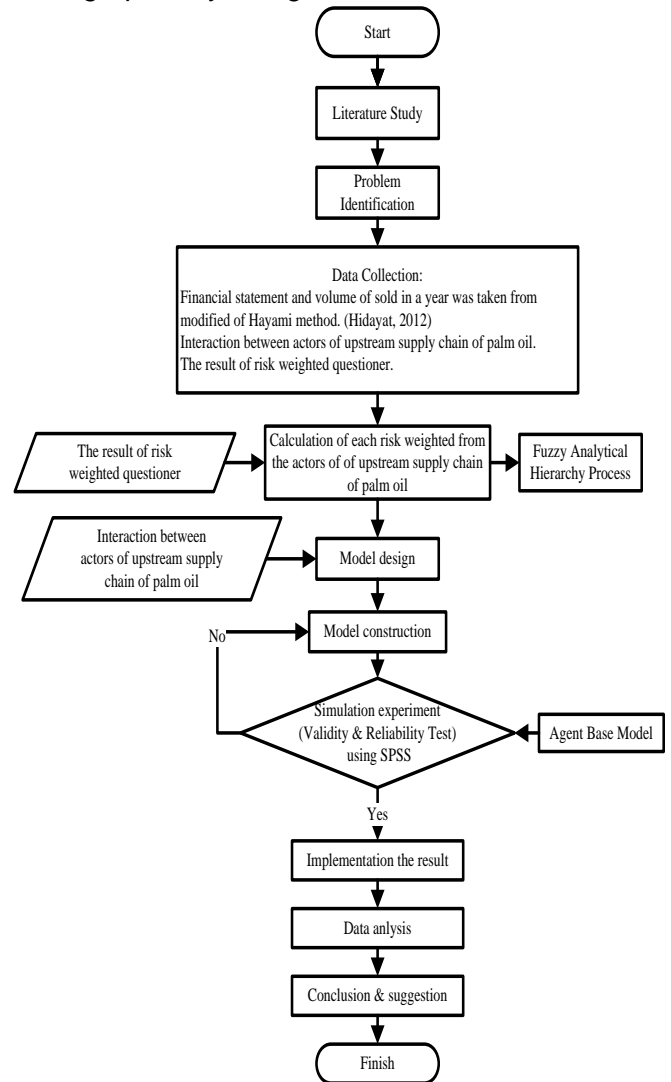


Figure 1. Flowchart of research methodology

Flowchart presented in Figure 1 shows the flow chart of this study are as follows:

3.1 Literature Studies

Literature study is an initial step of reading research literature related to the theme to be taken. The literature referred to here can be books, articles from newspapers and magazines both print media and others, and

journals related to the theme you want and it will be taken, such as balancing the value-added models based on the level of risk in the supply chain of palm oil (Hidayat, 2012).

3.2. Data Collection

The method of data collection in this research are as follows:

- a. Interviews and questionnaires charging risk weight to the upstream supply chain actors including palm oil growers, dealers or collectors and CPO mills.
- b. Library Studies conducted in order to determine what methods will be used to resolve the issues to be examined as well as acquire the basics of a strong reference in applying the method to be used in this thesis.
- c. Observation (Observation) is one of the methods of data collection/ facts by direct observation, in this case, to see business process supply chain actors directly upstream palm especially farmers and traders / collectors.

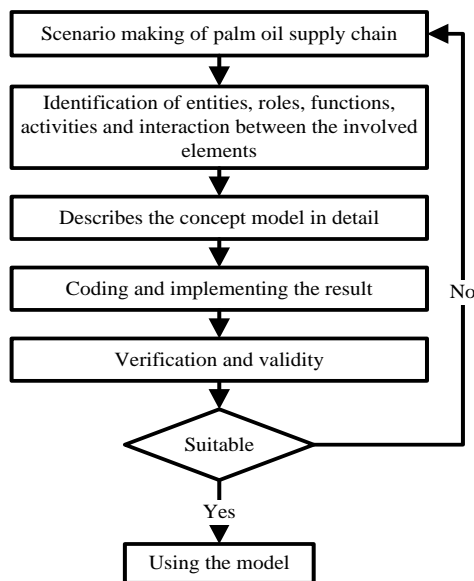


Figure 2. Stages of the manufacturing process using agent-based modeling software Netlogo

3.3. Data processing

The steps required in the processing of the data is as follows:

- a. Calculating risk weightings of each palm oil supply chain actors using fuzzy AHP.
- b. Making simulation model of balancing the value-added supply chain upstream palm oil using agent-based modeling

using software Netlogo. Details of the modeling process can be seen in picture 2.

4. RESULTS AND DISCUSSION

At this stage, it describes the marketing research of the upstream supply chain of palm oil that has been done is the 3 main components that play an important role in the marketing supply chain upstream palm oil starts producing fresh fruit bunches, CPO is to become farmers, wholesalers, CPO mill. The three actors who played these are interdependent with each other, so everything needs to maintain good relations so that the distribution of value added in balance and all the parties do not feel disadvantaged. Public exposure of each actor involved in the marketing of palm oil supply chain is discussed in this study in the form of a chart as shown in Figure 3 and Figure 4 are attached.

4.1. Financial data

In this study, the overall financial data that is used is the data from previous studies are taken from the dissertation Hidayat, 2012. Financial data used can be seen in table 1. Detailed financial data used, contained in Attached Financial Data.

Table 1 Financial Data Research

Information	Actor		
	Farmer (IDR)	Collector (IDR)	CPO mills (IDR)
Sales output	180.000.000	180.000.000	43.200.000
Raw materials	6.411.988.173,84		
Other input costs of production	124.777.601.078,17	1.462.433.333,33	23.769.000.000,00
Other input costs of non production	5.406.064.690,00	2.331.091.666,67	8.395.965.000,00

Source: Hidayat, 2012

4.2. Risk Identification

Figure 5 shows the AHP structure to prepare the questionnaires by experts to determine the assessment of risk factors. The experts comprised of the upstream supply chain players are the palm oil growers, traders and CPO mills.

4.3. Fuzzy Analytical Hierarchy Process (FAHP)

Work using FAHP get the highest risk weight that is borne by the farmer, then CPO mills, followed by collectors. Weighting the results that have been done using FAHP obtained results in Table 2.

4.4. Agent-based Modeling Results

Based on the calculation of value added in general and the formulation of the decision-making for each actor upstream palm oil supply chain can be described simulation program flow diagram using agent-based modeling software Netlogo which can be seen in Figure 6 are attached.

In Figure 6, the first to do is perform the calculation of value added services to farmers, and then proceed to the merchant value-added calculations. In the calculation of value added services to merchants, the cost of raw materials used are the result of the actor's previous sales, the farmers. This also applies to the actor after traders (CPO mill), the cost of raw materials used are the result of the selling dealer, and so on. Quantitative output of the results of agent-based modeling is a form of data contained in the file with comma separated values (CSV) file in the folder you created Netlogo program. The results of agent-based modeling view can be seen in Figure 7.

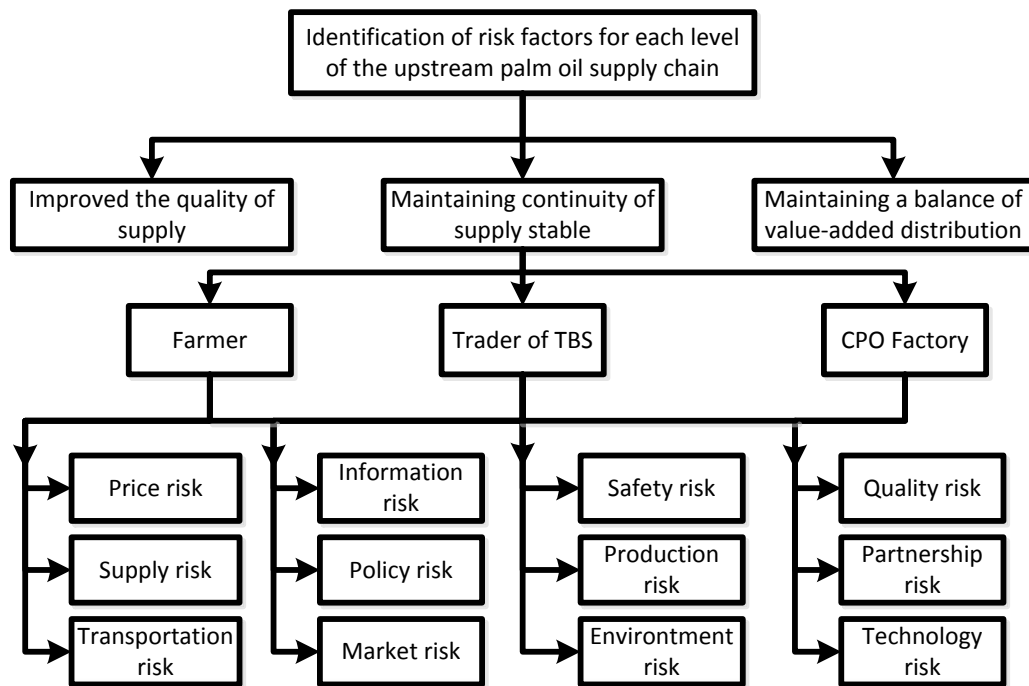


Figure 5. Hierarchy of Risk Identification

Table 2. The weighting results of actors of the upstream palm oil supply chain

Actor	Quality of supply	Continuity of supply	Distribution of value added	End Weighted
Farmer	0.565	0.393	0.628	0.516
Collector	0.097	0.284	0.097	0.179
CPO Factory	0.338	0.323	0.275	0.306
Weighted	0.151	0.437	0.412	1.000

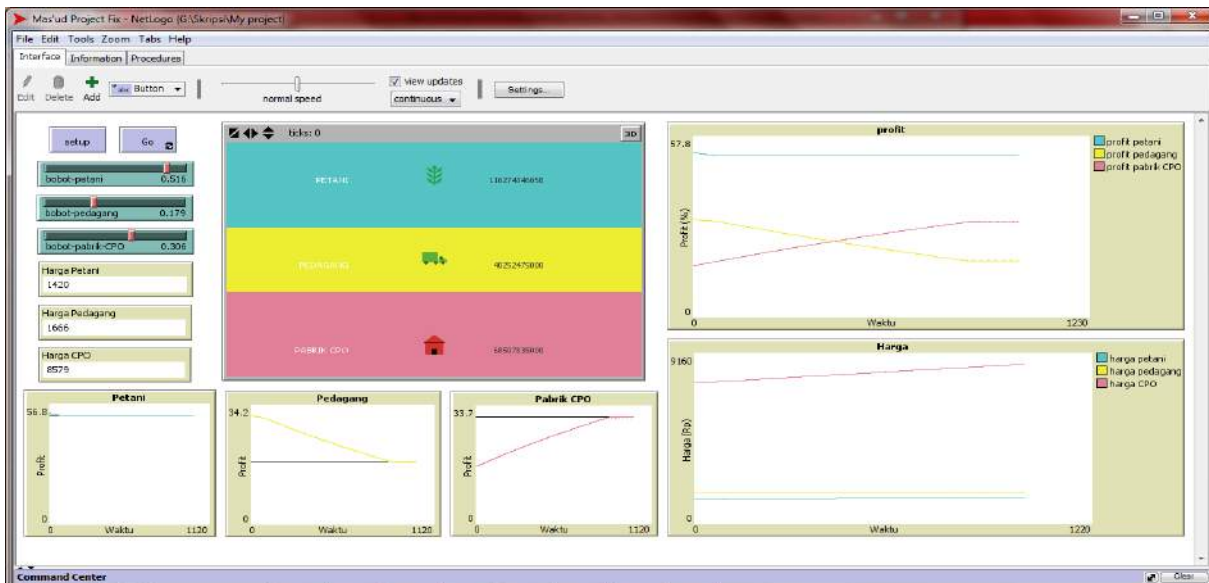


Figure 7 Display the results of agent-based modeling when executed

Based on simulation results, the balance of the added value gained by each of the following actors:

1. Farmers obtain equilibrium value when prices are in the range of Rp. 1420, - the profit is in the range between Rp. 116 274 346 058, -.
2. Traders gain equilibrium value when prices are in the range of Rp. 1666, - the profit is in the range between Rp. 40,252,475,000, -.
3. Factory CPO obtain equilibrium value when prices are in the range of Rp. 8579, - the profit is in the range between Rp. 68,507,835,000, -.

4.5. Validity Test

Internal Validity Test

Internal validity test performed to model ABM is to see if there are some error function on the main menu functions that include the functions file, edit, tools, zoom and tab; those functions display that includes a virtual world display, graphics, and monitor; the main key functions or interfaces that include setup, go and slider and command center functions that include observer, patches and turtles. From the ABM model results were performed using the software Netlogo not found error in all parts of the function. To determine the internal validity of the test results in more detail, can be seen in the attached Table 3.

External Validity Test

Based on the results of testing the validity of using SPSS version 16, that the data for fresh fruit bunches and profit of each supply chain actors upstream palm oil used in this study is valid. This conclusion is based on the following criteria:

1. Item scores for price Farmers, Merchants, and CPO Factory each have a score of 0573, 0884, and 0887. The magnitude of the correlation coefficient is larger item scores for critical r 0062 Total Score ($\alpha = 5\%$), means that the instrument is valid.
2. Item scores for Profit Farmers, Traders and CPO Factory each have a score of 0526, 0735, and 0770. The magnitude of the correlation coefficient is larger item scores for critical r 0062 Total Score ($\alpha = 5\%$), means that the instrument is valid.

Test Reliability

According to the table 4.7, calculate r values obtained for the variable selling price is equal to 0860 and calculate r values obtained for the variable profit is equal to 0791. According to Anwar (2001), the alpha value of more than 0.7; then the model is satisfactory and is considered reliable. So the model of balancing upstream value-added palm oil supply chain is reliable.

5. CONCLUSION

Based on FAHP calculations the result with the greatest risk were borne by the farmers [0.516], followed by the CPO mills [0.306] and the traders [0.179]

The reliability test results obtained for the sales price [variable count r value for the selling price] is 0860, for the profit [variable count r values obtained for the variable selling price] is 0791. Therefore the model for balancing the palm oil supply chain is reliable. Based on the test results the models are in accordance with the state in the real world.

The results of the simulation show that the balance of the added value gained by the farmers obtain equilibrium value when FFB prices around Rp. 1420, - with a total (farmers group) profit of Rp. 116.274.346.058. Traders obtain equilibrium value when FFB prices are around Rp. 1666, - with a lower profit of Rp. 40.252.475.000; CPO Factory obtains equilibrium at FFB price of Rp. 8579, - and a profit of Rp. 68.507.835.000.

6. REFERENCES

- (a) Axelrod, Robert dan Light Tesfatsion. 2005. *A Guide for Newcomers to Agent-based Modeling in the Social Sciences*. University of Michigan. Melalui: <http://www.econ.iastate.edu/tesfatsi/ace.htm>, halaman 1-13
- (b) Axelrod, R. 2003. Advancing the Art of Simulation in the Social Sciences. University of Michigan, *Japanese Journal for Management Information System*, Special Issue on Agent-Based Modeling : 12 (3), Dec. 2003.
- (c) Azwar, S. 2001. *Reliabilitas dan Validitas*. Pustaka Pelajar, Yogyakarta.
- (d) Chang, D.Y. 1996. *Application of The Extent Analysis Method on Fuzzy AHP*. European Journal of Operational Research 95:649-655.
- (e) Chopra, S. and Meindl, P. 2007. Supply Chain Management, Strategy, Planning, and Operation. Pearson Prentice Hall. Upper Saddle River, New Jersey.
- (f) Hayami, Y., and Barker., 1987, *Agricultural Marketing and Processing in Upland Java: Perspective From Sunda Village*, CGRPT Bogor.
- (g) Hidayat, Syarif. 2012. *Model Penyeimbangan Nilai Tambah berdasarkan Tingkat Risiko pada rantai pasok minyak sawit*. Disertasi. Institut Pertanian Bogor. Bogor.
- (h) Mikhailov, L dan Tsvetinov, P. 2003. *Evaluation of Services Using a Fuzzy Analytic Hierarchy Process*.
- (i) Railsback, Lytinen, dan Jackson. 2005. *Agent Based Simulation Platform: Review, and Development Recommendations*. USA: In Press at Simulation
- (j) Ramalingam, B, and Jones H. 2008. *Exploring the science of complexity: Ideas and implications for development and humanitarian efforts*. Overseas Development Institute, Westminster. London.
- (k) Sutrisno, L. dan R. Winahyu. 1991. *Kelapa Sawit : Kajian Sosial – Ekonomi*. Aditya Media. Yogyakarta. 136 hal.
- (l) Tesfatsion, L. 2002. *Agent- Based Computational Economics: Growing Economics from the Bottom Up*. Department of Economics. Iowa State University. ISU Economics Working Paper No. 1, 15 March 2002. Ames, Iowa
- (m) Twomay, P., and Richard Cadman. 2002. *Agent-Based Modeling of Customer Behavior in the Telecoms and Media Market*.
- (n) Wilensky, U. 2007. Netlogo 4.0.2. Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, IL.
- (o) Yasik, Yudi Limbar. 2008. *Pengaruh Kinerja Komunikasi Pemasaran dan Kelompok Rujukan Terhadap Perubahan Perilaku Konsumen Serta Dampaknya Pada Tingkat Penerimaan Voice Music SMS (VMS)*. Disertasi. Universitas Pajajaran. Bandung.
- (p) <http://ccl.northwestern.edu/Netlogo/>
http://en.wikipedia.org/wiki/Agent_based_model

ATTACHMENTS

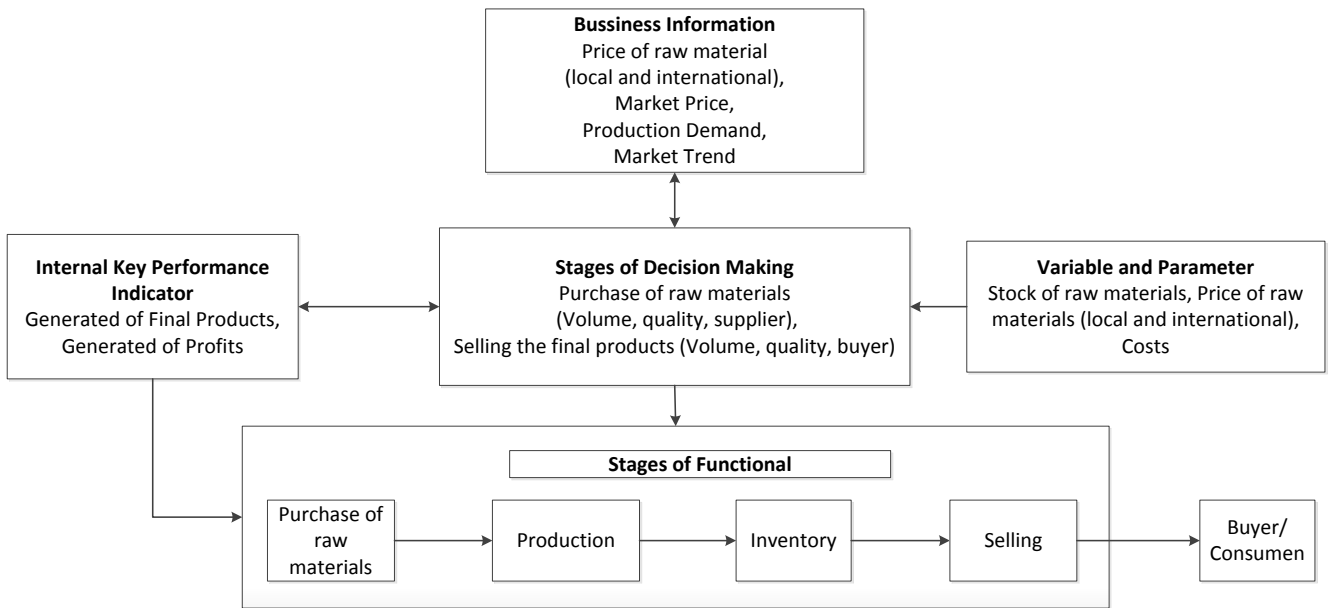


Figure 3 The business process of palm oil upstream supply chain actors

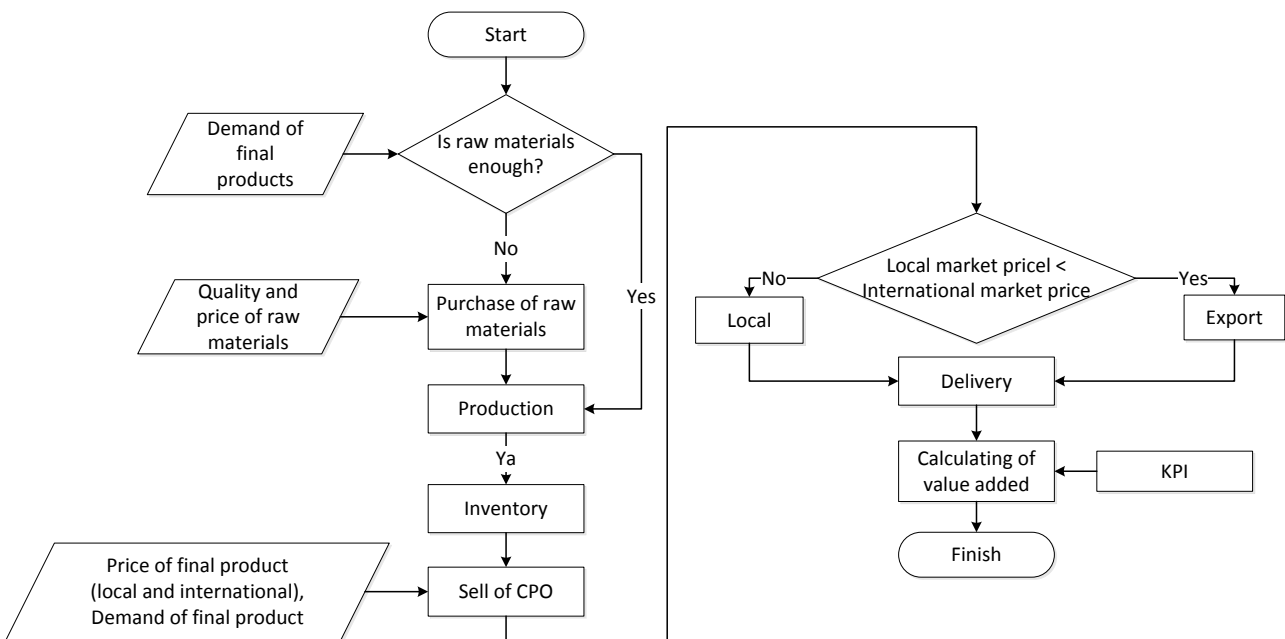


Figure 4 The Business Flowchart of palm oil upstream supply chain actors

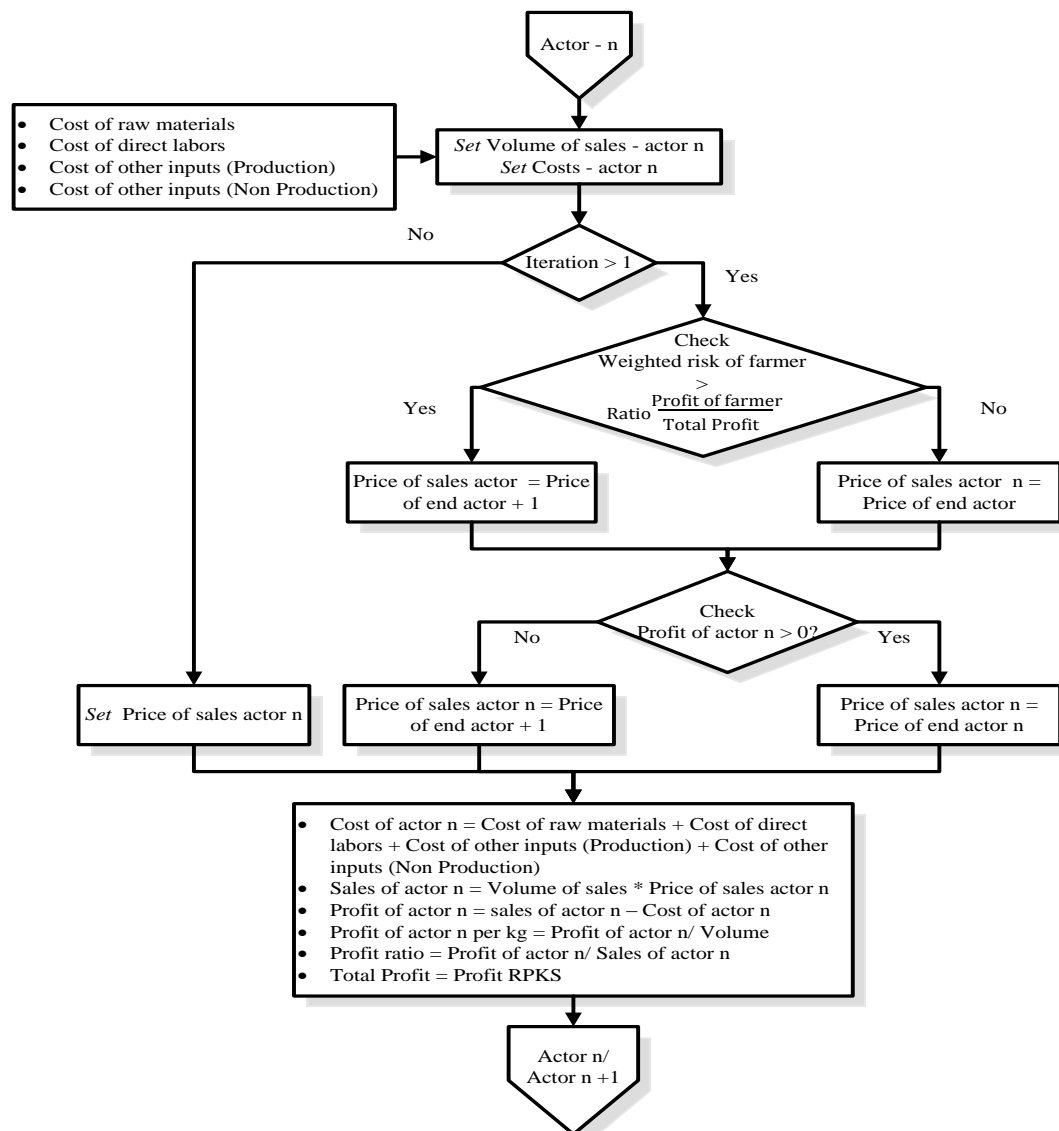


Figure 6 The flowchart of Agent Based Modeling

Table 3 Internal validity test result of agent based modeling using Netlogo

Test Sub	Measurement	Target	Result
Error	<ul style="list-style-type: none"> • Number Compiling Error • Number Running Error 	Error Free Error Free	No Error No Error
Main Menu Functions	<ul style="list-style-type: none"> • File Function, running/ not • Edit function, running/ not • Tool Function , running/ not • Zoom Function, running/ not • Tab Function, running/ not 	Running Running Running Running Running	Running Running Running Running Running
Display Function	<ul style="list-style-type: none"> • Display Agents "world", work/ not • Graphics Display Function, work/ not • Monitor Display Function, work/ not 	Work Work Work	Work Work Work
Main Key Function (Interface)	<ul style="list-style-type: none"> • Setup Button Function, work/ not • Go Button Function, work/ not • Slider Button Function, work or not 	Work Work Work	Work Work Work
Command Center	<ul style="list-style-type: none"> • Command Observer, work/ not • Command Turtles, work/ not • Comand Patch, work/ not 	Work Work Work	Work Work Work