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Calculation of Raw Material Costs for the Palm Oil Supply Chain Value Added Using Modified Hayami Method

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Calculation of Raw Material Costs for the Palm Oil Supply Chain Value Added Using Modified Hayami Method

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Abstract. The stakeholders in the palm oil supply chain (POSC) are the smallholder farmers who produce fresh fruit bunch (FFB), the traders, CPO factory who produces CPO from FFB, refinery who transformed CPO into frying oil, the distributors/retailers, and the consumers. The palm oil tree regularly produces FFB from its third until 24th year of life.The output of the farmers is measured in its weight (tonnes), so are the outputs of the trader, the CPO factory, the refinery, and the distributors/retailers. However the input to the farmer must be measured differently because the main raw materials are bought in the form of seedling or young palm-oil tree, to be planted on the field and regularly bear FFB to be later sold in tons. The objective of this study is to build a calculation model to allocate the raw material prices of the seedling. Original Hayami method to calculate single company added value was modified to facilitate calculation of the added value of supply chain network of companies. The calculation is based on the crude palm oil (CPO) factory capacity of processing 30 tons of FFB per hour, calculated for a year. The life-cycle-cost approach was used to calculate the appropriate cost of the raw material. Using this approach the raw material cost is IDR 1,012/kg, and the the total POSC added-value is IDR 13,011 per kg of product. It is expected that the modified Hayami added value calculation method can be later applied to larger and more complex industries.
Keywords: value added, supply chain, palm oil, Hayami method, life-cycle-cost

1. Introduction
A supply chain is a chain of interdependent companies operating in sequence and cooperate in handling, improving and controlling the flows of goods, money and information beginning with the supplier in the upstream all the way downstream until the end consumers [4] [8]. 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 [3]. The value adding processes may be applied to the quality, costs, delivery activities, flexibilities in sending the products, and innovations [7]. One of the most important supply chains in Indonesia is the palm oil supply chain (POSC). Export of palm oil and its derivatives has always been increasing. In 2010 the export value was USD 15,6 billions, which has shown an increase of 34,6 % compared to 2009. The export tax was US$ 2,8 billion. This value came second only to oil export.
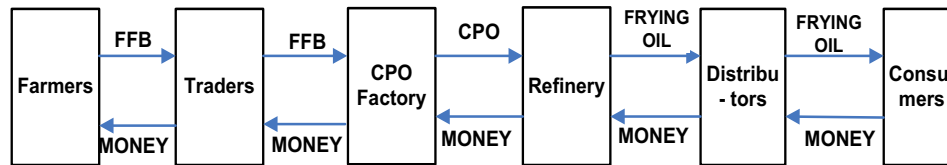
Figure 1. Palm oil supply chain actors

Figure 1 shows the 6 actors in the POSC. The smallholder farmers sell their fresh fruit bunch (FFB) to Crude Palm Oil (CPO) factory through traders. CPO factory converts the FFB into CPO. CPO is sold to the refinery, who converts CPO into frying oil and sends the product to the distributors. In this study only frying oil refinery is discussed, although CPO can be converted into many types of popular consumer products. The distributors subsequently sell them to the consumers through the retailers. This continuous process is required to ensure the consistent quantitative operating levels along the POSC from the upstream to the downstream. The output of the farmers are measured in its weight (tonnes or kgs), so are the outputs of the trader, the CPO factory, the refinery, and the distributors/retailers. However, the input to the farmer can not be measured in its weight because the main raw materials are in the form of seedling or young palm-oil trees bought in units, to be planted on the field and regularly bear FFB to be later sold in tons. Therefore there must be a specific procedure to calculate the raw material costs in rupiah. Original Hayami method to calculate single company added value was modified to facilitate calculation of the added value of supply chain network of companies [1].

The objective of this study is to build a model to allocate the raw material prices of the seed or young palm oil tree, while considering the successive investment and operational risk levels.

2. Method
Added value is a form of company's and supply chain performance measurement. It is defined as the margin in a certain stage and can be measured as Profit = total revenue – total raw materials and processing costs [5]. Total revenue is basically the multiplication of the unit selling price (UP) times the quantity sold (Q), while the processing costs are the sum of the total fixed cost and total variable cost. Hayami method [1] [2] is appropriate for use in a chain of companies linked in a supply chain. With this method we can measure the added value along the chain, output values, and some productivity measures, as well as the return to the investors. The method is easy to understand and use, and it provides sufficient useful information to the investors and the workers. The weakness of the original method is that it only measures the added value in one production cycle, one type of commodity and one business actor. Therefore the original method needs to be modified to suit the condition of a sequence of companies in a supply chain. Table 1 shows the three parts the original Hayami method. Formula listed under the column "Value" is used to compute the related variables listed under column "Variables".

In line with the objective, this study is organized into several parts as follows:
(1) Set the assumptions for the calculation. This is necessary in building a calculation model which later may be changed or adapted to suit the condition of the business.
(2) Modify the Hayami process to facilitate sequence of companies. This is necessary to enable calculation of a sequence of companies instead of a single company.
(3) Calculate the required raw materials in volumes and prices for the farmers. This is needed as the nature, the format or unit of the products in the chain may be different.
(4) Calculate the added values for the whole palm oil supply chain.

Figure 2 shows the procedure to calculate the raw material costs for use in calculating the added value along the POSC. The first step performed is the original method and n capacity of the CPO factory. Calculating the required FFB, area of the palm-oil estate, investment and operational costs are performed based on the assumptions of the productivities of the estate, and the CPO and frying-oil factories. The price of the palm-oil seeds is calculated using *Life Cycle Analysis* method with productive life of palm-oil of 25 years and its *Net Present Value (NPV)*. Then the process is continued with the CPO and frying

oil produced, the added values for each actor and their comparison. Also calculated is the return for each of the *stakeholders* [5].
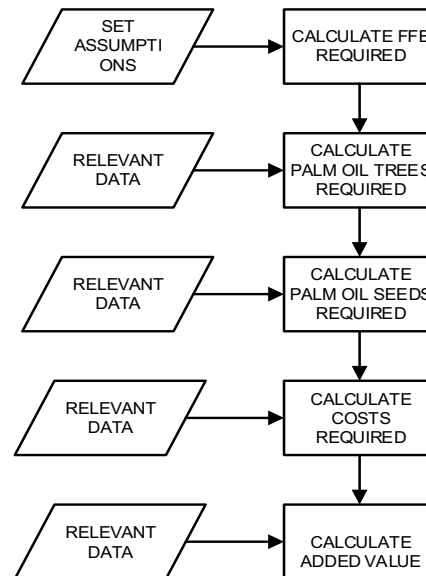

Figure 2. Flowchart for calculation

Table 1. Original Hayami Added-Value Worksheet

No.	Variables	Unit	Value
I. Output, Input, and Prices			
1	Output	kg	(1)
2	Main raw material	kg	(2)
3	Number of Main Direct Labor (Manday)	MD	(3)
4	Conversion Factor		(4) = (1) / (2)
5	Direct Labor Cost Coefficient (Manday/Kg)	MD/kg	(5) = (3) / (2)
6	Output price	IDR/kg	(6)
7	Direct Labor Costs (IDR/Manday)	IDR/MD	(7)
II. Income and Added Value			
8	Raw Material Costs	IDR/kg	(8)
9	Other Input Costs	IDR/kg	(9)
10	Output value (sales)	IDR	(10) = (4) x (6)
11	a. Added Value	IDR/kg	(11a) = (10) – (8) – (9)
	b. Added Value Ratio (%)	%	(11b) = (11ab) / (4b)
12	a. Direct labor cost income	IDR/kg	(12a) = (5) * (7)
	b. Direct labor cost ratio	%	(12b) = (12a) / (11a) x 100
13	a. Profit = added value	IDR/kg	(13a) = (11a) – (12a)
	b. Profit in %	%	(13b) = (13a) / (10) x 100
III. Reward for the Production Owner			
14	Margin	IDR/kg	(14) = (10) – (8)
	a. Direct labor income	%	(14a) = (12a) / (14) x 100
	b. Contribution from other input (%)	%	(14b) = (9) / (14) x 100
	c. Company Profit (%)	%	(14c) = (13a) / (14) x 100

Note: MD = mandays

   All information and data needed for this study are obtained and identified from recent literatures and by interviewing relevant managers in the subsequential palm oil industries. The quantitative results are taken from the authors previous study in the POSC [2]. In this study we used the Hayami Method wich are adopted with the supply chain characteristics of palm oil agroindustry, and try to reduce or delete the weaknesses of the method. With the modification, the basis for the calculation is the money (in rupiah) and not the weight of the products. The time basis for the process is a year to enable a total

investment and annual expenditures. The original Hayami method was only applied on one single company and one single product and one single production cycle [1].

The field data used for this study was obtained from some different areas of palm oil plantation in Sumatra, because no single company run the whole cycle of palm oil products. Data for the downstream companies were obtained from different companies. The primary palm oil field data were obtained from palm oil estates and processing companies in Tungkal Ulu Jambi, Dumai, Aceh Singkil, Lampung and Medan, while secondary data on frying oil refinery were obtained from distributors/retailers or from Biro Pusat Statistics (BPS) reports. For each agent in the supply chain we made business assumptions to ensure data consistency, i.e. the base for the calculation is the capacity of processing 30 ton FFB/hour of the CPO factory. The material balance along the complete network of supply chain was adapted to the amount of CPO produced, raw material and investment costs, processing costs, and the energy/utility and transportation costs.

3. Result and Discussion

3.1. Set the assumptions for the calculation.

Table 2 shows the assumptions for plam oil estate figures taken from Hidayat [2]. To maintain the consistency of calculation along the supply chain, the unit used is the most frequent and dominant units. In this case the dominant unit used is the weight of the product i.e. tons or kgs. The basis for overall calculation is the amount of FFB needed by the CPO factory which is 30 tons FFB/hour. This is then projected for the need for a year, and the required area of palm oil estate to supply this amount. Consequently the number of farmers and traders are calculated. The quantity of frying-oil yields from the Frying-Oil factory is calculated. All related costs are included and considered. Note: All data are assumptions only.

Table 2. Assumptions for the farmers estate

	Estate life time	25	year
	Working day/ year	300	day
	manhours/day	20	hours
	FFB required / year	90,000	ton
	FFB Production /year	90,000,000	kg
	FFB Production one life cycle	2,250,000,000	kg
	FFB Production /ha	29,680	kg
Estate area:	FFB Estate	3,032	ha
	Morbidity rate	1	
	Projected area of PO Estate	4,094	
	Number of seeds /ha	135	trees
Seedling cost:	seedling required	552,645	trees
	Price of seedling / unit	25,000	IDR
	Seedling costs for 25 years	13,816,121,968	IDR
	Seedling costs/year	552,644,879	IDR
	NPV	8	
	Seedling costs at year-4	4,328,093,632	IDR
	Seedling costs per kg FFB	48	IDR
Life cycle costs:	Operational costs	514,361,000	for 25 yrs
	Investment costs/ha	20,059,000	
	Life cycle costst/ha	534,420,000	
	Total life cycle costs	1,620,545,822,102	3032 ha
	Operational costs/year	64,821,832,884	
Investment costs/ha:	Quoted from SK DirjenBun 2011	20,059,000	IDR
	Land price/ha	122,472,000	IDR
	Total investment costs/ha	142,531,000	IDR
	Cost Breakdown		
Production costs:	Operational costs (IDR)	62,388,800,539	IDR
	Non Production costs		
	Investment costs (IDR)	17,288,126,685	IDR

The table shows the result of the calculation of related variables in the palm oil business.

3.2. *Modify the Hayami process to facilitate sequence of companies*

The general modification process to the Hayami method is shown by comparing Table 1 into Table 3. The first step performed is the original method and capacity of the CPO factory. Calculating the required FFB, area of the palm-oil estate, investment and operational costs are performed based on the assumptions of the productivities of the estate, the CPO and frying-oil factories. The price of the palm-oil seeds is calculated using Life Cycle Analysis method with productive life of palm-oil of 25 years and its Net Present Value (NPV). Then the process is continued with the CPO and frying oil produced, the added values for each actor and their comparison. Also calculated is the return for each of the stakeholders.

The modified Hayami Method is shown in Table 3. The top portion shows the summary of value added along the integrated supply chain. The first part of the method collects all facts and calculate all the revenues, products, inputs, outputs and all prices and costs. The second part the method calculates the level of revenues and useful business ratios based on the inputs from the first part. On the third part the method provide returns to the investors/owners in unit of percentages (%) for the investors and the workers. Note: All data are assumptions only.

The detail explanation of the modified worksheet follows:

a.   For the top portion of the worksheet: Palm Oil Supply Chain Interaction: the first 3 rows show the prices of the input raw material, product selling prices, and the total added value per kg of the product.   The figures show the values in sequence along the supply chain actors.

b.   For Part I: Output, Input and Prices, the information on the output was made in two rows i.e. in weight of tons and in rupiah. This is because the form of the material or product can not be processed in its original from, i.e. the palm-oil tree can not be processed, but it must be planted in order to yield the fruits (FFB).

c.   For Part II: Income and Added Value. The raw material costs is already entered in the top part of the worksheet. Other Input costs (line 10) refer to all required activities and products needed other than the direct production or operations. Values are entered using rupiah as the unit. Added value is the difference between the sold FFB process minus the raw material and other input costs. The ratios (in percentages) show the percentage of the added value from the product costs.

Table 3. Modified Hayami Worksheet

No.	Variables	Unit	Value
	Palm Oil Supply Chain Interaction		
1	Raw Material Costs (IDR/kg)	IDR/kg	(1)
2	Product selling price	IDR/kg	(2)
3	Total Added Value per kg	IDR/kg	(3) = (2 last actor) - (1)
	I. Output, Input, and Prices		
4	a. Output, Sales Volumes (kg)	kg	(4a)
	b. Output, Sales Values (IDR)	IDR	(4b)
5	Total Cost of Main Raw Materials (IDR)	IDR	(5)
6	Number of Main Direct Labor (Manday)	MD	(6)
7	Conversion Factor		(7) = (4b) / (5)
8	Direct Labor Cost Coefficient (Manday/Kg)	MD/kg	(8) = (4b) / (6)
9	Direct Labor Costs (Rp/Manday)	IDR/MD	(9)
	II. Income and Added Value		
10	a. Other Input Costs (Production)	IDR	(10a)
11	a. Added Value (IDR)	IDR	(11a) = (4b) - (5+10)
	b. Added Value Ratio (%)	%	(11b) = (11ab) / (4b)
	III. Reward for the Production Owner		
12	Margin (IDR/Kg)	IDR	(12) = (4b) - (5)
	a. Contribution from other input (%)	%	(12a) = (10) / (12)*100%
	b. Company Profit (%)	%	(12b) = (11a) / (12)*100%
	Note: MD = mandays		

d. For Part III: Reward for the Production Owner.
    Return for the Production Owner (= margin) is calculated as the difference between the output values minus the contribution of the production owner aside from the raw materials/seeds which are used in the production proses.

3.3. Calculate the required raw materials in volumes and prices for the farmers,

Calculation formula added value using modified Hayami Method was done as follows:
1. Six actors are involved in POSC: farmers, trader, CPO factory, frying-oil refinery, distributors/retailers and the consumers. In the original Hayami method there was only one actor.
2. The processing capacity of the CPO factory is 30 ton FFB/hour. Assuming 300 working-days and effective 8 hours /day, the factory needs 180.000.000 kg FFB/year. Assuming each hectare of palm oil estate produces 29,680 kg of FFB/hectare per year, that amount of FFB is to be supplied by palm-oil estate of 6.065 ha. With each farmer owning 2 hectares of estate then we need 3.032 farmers.
3. While we assume that the most efficient production of palm oil was produced in its period of 18 years of a total of 25 years of life, we must take into account and calculate all the investment, expenditures and operational and harvesting costs. These are all indicated on Table 2.
4. Products processed in the original Hayami method was only one type, while in the modified method are 6 types namely palm-oil tree, FFB, Palm kernel oil (PKO), CPO, Frying-oil, stearin and PFAD. Each of this product excepting the palm-oil tree have the same unit of business transaction namely tons or kgs. The palm-oil tree as the sole source of raw material must be bought in the form of tree and is not measured in kg but in unit of tree. Therefore, only the appropriated cost of the productive tree in terms of rupiah should be calculated and used in the supply chain added calue calculation.
5. The original Hayami method life-cycle is less than 1 year. The modified method spans this into the most productive years of the tree, which is 16 years. However, the practical life time of the palm-oil tree is 25 years. The CPO factory and frying-oil refinery life time is around the same period.
6. The cost of the seedling or the young palm-oil tree is calculated as shown on Table 4 as follows:

Table 4. Calculation/allocation for seedling cost per year

Variable	Quantity	Unit
Estate lifetime	25	yrs
Seedling costs:		
Needed seedling for 25 yrs	552,645	unit
Price of seedling/unit	15,000	IDR
Seedling costs for 25 yrs	8,289,673,181	IDR
Seedling costs/yr	331,586,927	IDR
Estate area	3,032	ha
Life cycle costs		
Operational costs/yr/ha	411,488,800	IDR
Operational costs/ha	10,287,220,000	IDR
Investment costs/ha	20,059,000	IDR
Life cycle costs/ha	10,307,279,000	IDR
Total life cycle costs	4,544,231,764,781	IDR
Operational costs/yr	181,769,270,591	IDR
Total seedling+life cycle costs	4,552,521,437,962	IDR
Total Production /yr	180,000,000	kg/yr
Seedling costs /kg product	25,292	IDR
Seedling costs /kg product/yr	1,012	IDR

3.4. Calculate the added values for the whole palm oil supply chain

Table 5 shows the complete Hayami Method to calculate the added-value along the POSC. It is essentially an extension of Table 3 by adding the next actors in the chain. The output of the first actor (farmer) becomes the input to the second actor (the trader). The selling price of teh farmer becomes the

Table 5. Complete Hayami Method for POSC

No.	Variables	Unit	Farmer	Trader	CPO Factory	Refinery	Distributor	Consumer
	Palm Oil Supply Chain Interaction							
1	Raw Material Costs (IDR/kg)	IDR/kg	1,012	1,220	1,270	7,200	13,000	14,023
2	Product selling price	IDR/kg	1,220	1,270	7,200	13,000	14,023	
3	Total Added Value per kg	IDR/kg	208	50	5,930	5,800	1,023	
	I. Output, Input, and Prices							
4	a. Output, Sales Volumes (kg)	kg	180,000,000	180,000,000	43,200,000	32,832,000	32,832,000	
	b. Output, Sales Values (IDR)	IDR	219,600,000,000	241,905,833,333	311,040,000,000	426,816,000,000	460,417,500,000	
5	Total Cost of Main Raw Materials (IDR)	IDR	458,490,566	219,600,000,000	241,905,833,333	311,040,000,000	426,816,000,000	
6	Number of Main Direct Labor (Manday)	MD	6	6	140	140	10	
7	Conversion Factor		479	1.10	1.29	1.37	1.08	
8	Direct Labor Cost Coefficient (Manday/Kg)	MD/kg	0.0000000131	0.000000000027	0.000000000579	0.000000000450	0.000000000023	
9	Direct Labor Costs (IDR/Manday)	Rp/MD	231,000,000	99,000,000	3,905,320,000	1,974,000,000	141,000,000	
	II. Income and Added Value							
10	Other Input Costs (IDR/kg)	IDR/kg	154,520,733,154	276,833,333	13,005,501,000	75,722,802,704	366,733,333	
11	a. Added Value (Rp)	Rp	64,620,776,280	22,029,000,000	56,128,665,667	40,053,197,296	33,234,766,667	216,066,405,910
	b. Added Value Ratio (%)	%	29%	9%	18%	9%	7%	
	III. Reward for the Production Owner							
12	Margin (IDR/Kg)	IDR/kg	219,141,509,434	22,305,833,333	69,134,166,667	115,776,000,000	33,601,500,000	
	b. Contribution from other input (%)	%	71%	1%	19%	65%	1%	
	c. Company Profit (%)	%	29%	99%	81%	35%	99%	

input buying cost for the trader. This is iterated all the way along the chain until the most downstream (the consumer). Note: All data are assumptions only.

The six actors in the POSC faces different levels of investment, technology and risks. The obtained added-value therefore should be different, but properly graded. This modified method was used to manage six types of products namely FFB, PKO, CPO, frying-oil, stearin and PFAD with diferent levels of selling prices. For simplicity of this report, Table 4 only shows the first product i.e. the frying-oil. The calculated appropriate cost of the seedling or young palm oil tree is IDR 1,012 per kg. This becomes the input cost into the POSC. While the end selling price to the consumer is IDR 14,023 per kg, then the total POSC added-value is IDR 14,023 – IDR 1,012 = IDR 13,011 per kg of product, which is the frying oil. Note: All data are assumptions only.

4. Conclusion

The original Hayami method has been successfully modified to facilitate more correlated products, multi-year horizon, and more than one actor involved in the supply-chain. The six actors in the POSC faces different levels of investment, technology and risks. The obtained added-value therefore should be different, but properly graded. This modified method was used to manage six types of products namely FFB, PK, CPO, frying-oil, stearin and PFAD wth diferent levels of selling prices.

With the assumed industrial processing capacity of CPO factory of 30 ton FFB/hour and FFB selling price of IDR 1.220/kg we obtain the comparative added values of Farmers: Trader: CPO Factory: Frying-Oil Factory: Distributor = 29%: 9%: 18%: 9%: 7%. With the assumption that each farmer owns 2 hectares of palm-oil estate, the added-value for each farmer is IDR 208 per kg.

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