

Effects of Output-Input Values on Factory Productivity

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Abstract

A sugarcane factory produces white sugar for national market. Measuring factory productivity is important to understand the factory performance. Factory productivity was measured using Multi Factor Productivity Measurement Model (MFPMM) based on an output input analysis. The results show that yearly factory productivity in the last period was lower than the previous period. The decrease of productivity was affected by decreasing company revenues and increasing input costs.

Keywords: Factory productivity; MFPMM, Multifactor; Sugarcane.

1. INTRODUCTION

Productivity is critical for a long-term competitiveness and profitability of organisations. The elements in the productivity cycle should always be done, namely productivity measurement, productivity evaluation, planning productivity, and productivity improvement (Sumanth, 1984).

Multifactor productivity is defined as output per unit of combined inputs of – capital, labor, energy, materials, and purchased business services. Multifactor productivity measurement model (MFPMM) is a comprehensive and analytical model for measuring productivity changes. This model is used to measure a total variation from the effects of price and productivity. Analysis is performed for both input and output in the form of more flexible. MFPMM offers a valid productivity model (Wazed and Ahmed, 2008).

Figure 1 shows that a change of company profits are affected by changes in prices, productivity, revenue, and expenses. Changes in the quantity of output affects the productivity and income. Changes in output price effect on revenue and price recovery. While the change in the quantity of inputs affect productivity and cost. Similarly, changes in unit costs have an impact on the amount of costs and price recovery.

Characteristics of MFPMM model are the revaluation, devaluation, and indexation. In essence models maintain a constant price and cost changes over time. This can be achieved

by the revaluation of actual output/input prior periods as a basis for comparison of the value of other periods. Company's productivity is measured then used to determine the position of productivity to take steps to increase the productivity of the company.

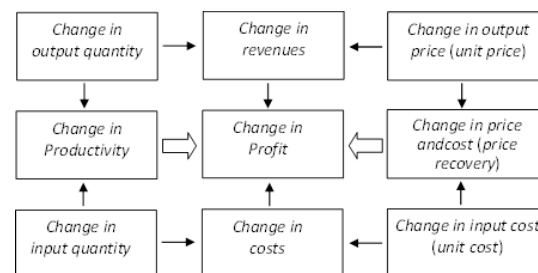


Figure 1: Nine Basic Components of MFPMM (Sink, 1985 in Phusavat, 2013)

A research study of productivity in the use of all the resources needed (inputs) to produce the desired output (output) is needed by companies who want to improve their performance and competitiveness. The measurement results can be used as an evaluation of the company's current performance and to benchmark performance improvements in the future.

Research Objectives

- 1) To measure factory's productivity using MFPMM model.
- 2) To analyse the results of productivity measurement across the study periods.
- 3) To develop a recommendation for factory productivity improvement.

2. MATERIALS AND METHODS

Outputs

The main products of the sugar factory are: 1) white crystal sugar (SHS I – *Superieure hoofd suiker* I), 2) molasses and 3) bagasse as a byproduct. Sugar crystals and molasses are sold as sources of income, while bagasse is not for sale but is used for fuel. Both outputs were recorded for period 1 year 2013 and period 2 year 2014 as seen on Table 1.

Output quantities of white sugar and molasses on period 2 were 311,060 quintal,

and 234,405 quintal, lower than on period 1 that were 350,528 and 281,820 quintal. This decrease in quantities was also followed by a decrease on their prices. Prices of white sugar and molasses on period 2 were Rp 771,803/ton and Rp 90,909/ton, lower than on period 1 that were Rp 881,871/ton and Rp 103,953/ton.

When we see on the output side, quantity and price levels for period 2 were lower when they are compared to the period 1 output condition. The data shows that both quantity and price levels decreased from period 1 to period 2.

Tabel 1. Factory Outputs 2013-2014

Outputs	Period 1 (2013)		Period 2 (2014)	
	Quantity (qu)	Price (Rp/qu)	Quantity (qu)	Price (Rp/qu)
	Col 1	Col 2	Col 4	Col 5
1 White sugar	350,528	881,871	311,060	771,803
2 Molasses	281,820	103,953	234,405	90,909

Qu = quintal = 0.1 ton = 100 kg

Inputs

The sugarcane factory uses three categories of inputs – labor, materials, and energy.

Labor: Table 2 shows that the numbers of labor for period 2 were lower than that of period 1. However, the labor price of period 2 was higher than period 1. For example, number of operator decreased from 307 persons in 2013 to 287 persons in 2014. However, labor prices increased from period 1

to period 2 of Rp 2,168,938 to Rp 2,366,735 per person per month.

Materials: Most quantities of input used for period 2 were lower compared to period 1, except the quantity of Trinitrium phosphate and Voltabio. Several prices/unit of input were also increased, some of prices were decreased.

Energy: Energy used in period 2 was lower for electricity, wood, and diesel oil, while higher use for oil Fo and *tatal*.

Table 2. Factory Inputs 2013-2014

Input	Period 1		Period 2	
	Quant.	Price/Unit	Quant.	Price/Unit
	Col 1	Col 2	Col 4	Col 5
1. Labor				
Executives (persons)	48	6,687,656	46	6,697,615
Operators (persons)	307	2,168,938	287	2,366,735
Supporting (KKWT) (persons)	1,182	1,515,647	1,114	1,524,642
2. Material				
Sugarcane (qu)	5,640,473	49,500	5,095,211	41,000
Lime (kg)	706,021	725	595,544	820
Sulphur (kg)	172,214	2,456	146,350	2,534
Superfloc (kg)	1,891	45,668	1,718	68,351
Phospat acid (kg)	66,570	9,776	55,790	12,123
Caustic soda (kg)	42,158	6,263	38,146	6,387

Trinatrium phosphat (kg)	16,025	3,223	16,735	3,708
Voltabio (l)	10,538	45,268	11,310	47,670
3. Energy				
Electricity (kwh)	5,796,910	840	4,694,362	1,041
Wood (kg)	3,342,070	372	2,418,860	383
Oil Fo (l)	228,000	4,757	547,000	5,871
Tatal (kg)	2,649,810	269	2,815,760	280
Diesel fuel (l)	26,476	4,500	4,100	5,500

MFPMM Model

The multifactor productivity measurement model (MFPMM) was originally developed in the 1970s during the APQC’s initial efforts in promoting productivity measurement at an organizational and/or plant level. Since then, the MFPMM has long been implemented for assessment of corporation profitability. The essential premise for the MFPMM is that the increase in profitability is based on the improvement of two specifically areas: productivity and price recovery.

Col 1 The quantities of outputs produced and /or sold and the quantities of input consumed in order to produce those outputs for period 1 (Q_{i1}). The term “i” indicates the different categories for both the output and input.

Col 2 Representing the outputs’ unit prices & the inputs’ unit cost in period 1 (P_{i1}).

Col 3 Reflecting the value (quantity unit price or unit cost) of period 1.

Col 4 Representing the quantities of outputs produced and/or sold and the quantities of input consumed in order to produce those outputs for period 2 (Q_{i2}).

Col 5 Representing the outputs’ unit prices & the inputs’ unit cost in period 1(P_{i2}).

Col 6 Reflecting the value (quantity unit price or unit cost) of period 2.

Col 6 = *Col 4* × *Col 5* (1)

Weighted Change Ratio (WCR)

Col 7 – Price weighted and base period price indexed changes quantities (both unit price and cost remained constant at period₁).

$$\frac{\sum_{i=1}^n(O_{i2})(P_{i1})}{\sum_{i=1}^n(O_{i1})(P_{i1})} \quad (2)$$

Col 8 – Quantity-weighted and current period indexed changes unit prices and costs (both output and input quantities remained constant at period₂).

$$\frac{\sum_{i=1}^n(O_{i2})(P_{i2})}{\sum_{i=1}^n(O_{i2})(P_{i1})} \quad (3)$$

Col 9 – Impact of changes in price and quantity from period 1 to 2 – quantity (outputs and inputs) and unit price/cost not held constant.

$$\frac{\sum_{i=1}^n(O_{i2})(P_{i2})}{\sum_{i=1}^n(O_{i1})(P_{i1})} \quad (4)$$

Cost to Revenue Ratio

Cost to revenue ratio (CRR) calculated and written at *Col 10* and *Col 11*.

Col 10 – Cost to revenue for period 1.

$$\frac{I_{ij1}}{\sum_{i=1}^n(O_{i1})(P_{i1})} \quad (5)$$

Col 11 – Cost to revenue for period 2.

$$\frac{I_{ij2}}{\sum_{i=1}^n(O_{i2})(P_{i2})} \quad (6)$$

Productivity Ratio

Productivity Ratio (PR) is calculated to measure output from input at certain period and written *Col 12* and *Col 13*.

Col 12 Output-to-input ratios for period 1.

$$\frac{\sum_{i=1}^n(O_{i1})(P_{i1})}{(I_{ij1})(P_{ij1})} \quad (7)$$

Col 13 Output-to-input ratios for period 2.

$$\frac{\sum_{i=1}^n(O_{i2})(P_{i1})}{(I_{ij2})(P_{ij1})} \quad (8)$$

Weighted Performance Indexes

Weighted Performance Index (WPI) is a measure of productivity when price held constant, quantity held constant, and when both price and quantity change.

Results of calculation are written at Col 14, 15, and 16.

Col 14 – Price weighted productivity indexes.

$$\frac{\frac{\sum_{i=1}^n (O_{i2})(P_{i1})}{\sum_{i=1}^n (O_{i1})(P_{i1})}}{\frac{(I_{j2})(P_{i1})}{(I_{j1})(P_{i1})}} \quad (9)$$

Col 15 – Quantity weighted price recovery indexes.

$$\frac{\frac{\sum_{i=1}^n (O_{i2})(P_{i2})}{\sum_{i=1}^n (O_{i2})(P_{i1})}}{\frac{(I_{j2})(P_{i2})}{(I_{j2})(P_{i1})}} \quad (10)$$

Col 16 – Profitability indexes, reflecting the rates of change on both the quantity produced /consumed and unit price/cost.

$$\frac{\frac{\sum_{i=1}^n (O_{i2})(P_{i2})}{\sum_{i=1}^n (O_{i1})(P_{i1})}}{\frac{(I_{j2})(P_{i2})}{(I_{j1})(P_{i1})}} \quad (11)$$

Rupiah Effect on Profit (ROP)

Col 17 – Opportunity gain/loss from a productivity change.

$$(I_{j1})(P_{i1}) \left[\frac{\sum_{i=1}^n (Q_{i2})(P_{i1})}{\sum_{i=1}^n (O_{i1})(P_{i1})} - \frac{(I_{j2})(P_{i1})}{(I_{j1})(P_{i1})} \right] \quad (12)$$

Col 18 – Impact from a price recovery change.

$$Col 18 = Col 19 - Col 17 \quad (13)$$

Col 19 Total impact on profits from productivity/price recovery.

$$(I_{j1})(P_{i1}) \left[\frac{\sum_{i=1}^n (Q_{i2})(P_{i2})}{\sum_{i=1}^n (O_{i1})(P_{i1})} - \frac{(I_{j2})(P_{i2})}{(I_{j1})(P_{i1})} \right] \quad (14)$$

3. RESULTS and DISCUSSION

Value of outputs are obtained from the sale of products for period 1 and period 2. As shown on Tabel 3, production of white sugar during the period 1 was 350,528 quintals and sold at the price of Rp 881,871 per kg. Output from selling sugar for the period 1 was Rp 309,120,477,888 and output from selling molasses was Rp 29,296,034,460. Total output value for period 1 was Rp 338,416,512,348. Using the same calculation method, output value for period 2 was Rp 261,386,565,325.

Table 3. Value of Outputs 2013-2014

Output	Period 1			Period 2		
	Quantity	Rp/Unit	Value (Rp)	Quantity	Rp/Unit	Value (Rp)
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
White sugar (qu)	350,528	881,871	309,120,477,888.00	311,060	771,803	240,077,041,180.00
Molasses (qu)	281,820	103,953	29,296,034,460.00	234,405	90,909	21,309,524,145.00
Total Output			338,416,512,348.00			261,386,565,325.00

Table 4. Value of Inputs 2013-2014

Input	Period 1			Period 2		
	Quantity	Rp/Unit	Value (Rp)	Quantity	Rp/Unit	Value (Rp)
	Col 1	Col 2	Col 3	Col 4	Col 5	Col 6
Labor						
Executive (24)	48	6,687,655.75	7,704,179,421.43	46	6,697,615	4,611,354,108.74
Operator (24)	307	2,168,937.55	15,980,731,865.42	287	2,366,735	10,188,795,186.24
KKWT (7 month)	1,182	1,515,647.28	12,540,465,594.70	1,114	1,524,642	10,190,704,580.56
Labor			36,225,376,881.55			24,990,853,875.54
Material						
Sugarcane (qu)	5,640,473	49,500	279,203,413,500	5,095,211	41,000	208,903,651,000
Lime (kg)	706,021	725	511,865,225	595,544	820	488,346,080
Sulphur (kg)	172,214	2,456	422,957,584	146,350	2,534	370,850,900
Superfloc (kg)	1,891	45,668	86,358,188	1,718	68,351	117,427,018
Phospat acid (kg)	66,570	9,776	650,788,320	55,790	12,123	676,342,170
Caustic soda (kg)	42,158	6,263	264,035,554	38,146	6,387	243,638,502
Trinatrium phosphat (kg)	16,025	3,223	51,648,575	16,735	3,708	62,053,380

Voltabio (ltr)	10,538	45,268	477,034,184	11,310	47,670	539,147,700
Material			281,668,101,130			211,401,456,750
Energy						
Electricity (kwh)	5,796,910	840	4,869,404,165.53	4,694,362	1,041	4,886,830,613.87
Wood (kg)	3,342,070	372	1,243,250,040.00	2,418,860	383	926,423,380.00
Oil Fo (ltr)	228,000	4,757	1,084,596,000.00	547,000	5,871	3,211,437,000.00
Tatal (kg)	2,649,810	269	712,798,890.00	2,815,760	280	788,412,800.00
Diesel fuel (ltr)	26,476	4,500	119,140,150.00	4,100	5,500	22,550,000.00
Water			95,248,906.96			85,787,324.70
Energy			8,124,438,152.49			9,921,441,118.57
Labor + Material + Energy			326,017,916,164.04			246,213,741,744.11

Weighted Change Ratio

Calculation of Weighted Change Ratio (WCR) is intended to measure the change in quantity, price and value for period 1 and period 2. The value of change ratio indicates the level of activity from each input element to the product output.

Components of the WCR are:

(a) *Change in Quantity (Col 7)* obtained by dividing the product at Col 4 (quantity period 2) with Col 2 (price for period 1), to Col 3 (value period 1).

(b) *Change in Price (Col 8)* obtained by dividing Col 6 (value period 2) of the product Col 4 (quantity of period 2) and Col 2 (price period 1).

(c) *Change in Value (Col 9)* obtained by dividing the Col 6 (value period 2) with 3 Col (value period 1).

Change in quantity (Col 7)

$$= \frac{\sum_{i=1}^n (Q_{i2})(P_{i1})}{\sum_{i=1}^n (Q_{i1})(P_{i1})} = \frac{\sum_{i=1}^n (311.060)(Rp 881.871,00)}{(Rp 309.120.477.888,00)} =$$

Change in price (Col 8):

$$= \frac{\sum_{i=1}^n (Q_{i2})(P_{i2})}{\sum_{i=1}^n (Q_{i2})(P_{i1})} = \frac{(Rp 240.077.041.180,00)}{\sum_{i=1}^n (311.060)(Rp 881.871,00)} = 0.88$$

Change in value

$$Col 9 = \frac{\sum_{i=1}^n (Q_{i2})(P_{i2})}{\sum_{i=1}^n (Q_{i1})(P_{i1})} = \frac{(Rp 240,077,041,180,00)}{(Rp 309.120.477.888,00)} = 0.78$$

Rupiah Effect On Profit (ROP)

Rupiah effect on Profit (ROP) was calculated to determine the level of rupiah gains due to changes in quantity, price and value. ROP was strongly correlated to the value of Weighted Performance Index (WPI).

Productivity Improvement

The amount of sugar output SHS can be enhanced by improving the efficiency of the sugar manufacturing process. Improving employee performance with job training, provision of incentives for high performing employees. Improving material productivity by using high quality sugarcane with high sugar content.

4. CONCLUSSIONS

It can be concluded that:

1. The productivity level of this sugar factory decreased slightly from period 1 (2013) to period 2 (2014).
2. Input factors that most influenced on the total productivity index was labor, materials, and energy.
3. Factory productivity may be improved by using high quality sugarcane as raw material, as well as maximizing the use of bagasse to produce electricity.

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