RESEARCH ARTICLE

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Optimizing Product Mix Using Linear Programming: A Case Study of 'Kopi Sembilan'

Andre Dwijanto Witjaksono[1,*], Erina Rahmadyanti[2], and Dwiarko Nugrohoseno[1]

[1]*Department of Management, Faculty of Economics, Universitas Negeri Surabaya, Surabaya 60231, Indonesia*
[2]*Department of Civil Engineering, Faculty of Engineering, Universitas Negeri Surabaya, Surabaya 60231, Indonesia*

Small and Medium Enterprises (SMEs) in East Java—Indonesia, has been proven to make a major contribution to the Gross Domestic Income. Nevertheless, production management that is applied often still traditional. This research is a case study conducted in one of the coffee bean processing SMEs is "Kopi Sembilan," and aims to determine the composition of the most optimal product sales of nine kinds of processed coffee products. The results using the method of linear programming showed that the most optimal products mix per day is Kopi Caffe Dos total of 133 boxes, Kopi Krishna "9" (20 packs), Kopi Aroma "9" (20 packs), Kopi Robusta "9" A1 (25 packs), Kopi Robusta Plastik (30 packs), Kopi Robusta Mantap (31 packs), Kopi Robusta Plus Jahe "9" (20 packs), Kopi Jawara "9" (14 packs), and Kopi Luwak "9" as much as 8 packs. These results provide the most optimal profit compared with the previous determination traditional product mix.

Keywords: Product Mix, Coffee, Linear Programming.

1. INTRODUCTION

It is undeniable that the Micro, Small, and Medium Enterprises (SMEs) has contributed greatly to the national income. There are approximately 56.54 million units of SMEs in Indonesia, which contribute about 60% of Gross Domestic Product.[1] Further stated that the field of SMEs which contribute most consecutive GDP is agriculture, followed by trade sector, hotels and restaurants, and the manufacturing sector. The previous study of three provinces in Java, namely West Java, Central Java and East Java showed that in general the Small and Medium Enterprises (SMEs) ownership is still domestically, managed traditionally, and still domestically oriented.[2]

"Kopi Sembilan" is one of the SMEs engaged in the processing of coffee beans and is located in Sukorejo, Pasuruan-Indonesia. It has had 9 product variants, namely Kopi Caffe Dos, Kopi Krishna "9", Kopi Aroma "9", Kopi Robusta "9" A1, Kopi Robusta Plastik, Kopi Robusta Mantap, Kopi Robusta Plus Jahe "9", Kopi Jawara "9", and Kopi Luwak "9". As the characteristics of SMEs in general, the typical business management is still a domestic with the use of technology is quite simple. Determination of the product mix sold during this variant also still use the traditional way by estimates only.

Several studies have shown that there are many factors that can improve the productivity and performance of SMEs, such as innovation, use of new technology, network and relational, linear programming implementation, and knowledge management.[3–6] Previous study has also shown that organizational innovation has a higher impact on small firms.[7]

Increased productivity of small and medium enterprises will develop the economic and industrial conditions. Linear programming techniques can be used in maximizing profits through increased productivity, not decision-making by trial and error by managers.[5] Under these conditions, the purpose of this study is to establish the most optimal product mix with linear programming method to obtain the maximum benefit with some restrictions faced.

2. METHOD

This research uses quantitative approach. Quantitative analysis is a scientific approach to managerial decision making.[8] Managerial decisions can be based on different methods, and usually starts from real world modeling. One popular method used is linear programming. Previous studies showed that 93.7% of SMEs do not have the knowledge of linear programming for decision making.[9]

Linear programming is a mathematical modeling technique in which has an objective function that includes variable decisions, as well as the function of the constraints of limited resources, which are used to achieve the optimal solution to a problem that has a series of constraints that bind a purpose. If the problems faced quite simple with only two decision variables, then approach the graphical method used. For more complex

*Author to whom correspondence should be addressed.

problems, with many variables and constraints, then used the simplex algorithm (simplex method).

This study was conducted in one of the SMEs engaged in the processing of coffee beans, namely Kopi Sembilan (Kopi 9). The owner named is Emanuel Nawa Sukrisna and his office located in Sukorejo, Pasuruan, East Java-Indonesia. As the name implies, these SMEs also have 9 ground coffee product variants. Hence the decision variables to be determined over two with a lot of obstacles, this study used the simplex method.

General Forms of Linear Equations Program:

Objective Function:

$$z_{\max} = c_1x_1 + c_2x_2 + \cdots + c_nx_n$$

Constraint Function:

$$a_{11}x_1 + a_{12}x_2 + \cdots a_{1n}x_n \le b_1$$
$$a_{21}x_1 + a_{22}x_2 + \cdots a_{2n}x_n \le b_2$$
$$\cdots$$
$$\cdots$$
$$a_{m1}x_1 + a_{m2}x_2 + \cdots a_{mn}x_n \le b_m$$

where: $m, n \ge 0$, m, n: $1, 2, 3, 4, \ldots$, $x_1 \ldots x_n$: decision variables, a_{mn}: coefficient of constraint functions, b_m: the maximum capacity of providing resources.

Simplex table

BV	z	x_1	x_2	…	x_n	s_1	s_2	…	s_n	Sol.
z	1	c_1	c_2	…	c_3	0	0	…	0	0
s_1	0	a_{11}	a_{12}	…	a_{1n}	1	0	…	0	b_1
s_2	0	a_{21}	a_{22}	…	a_{2n}	0	1	…	0	b_2
.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.
s_m	0	a_{m1}	a_{m2}	…	a_{mn}	0	0	…	1	b_m
↓										↓

Basic variable columns — Solution column

3. RESULTS AND DISCUSSION

From the results of identification, some of the things that set the boundaries and deals with the production of processed coffee beans among other types of packaging products ready for sale, selling prices, the raw material requirements and the price of robusta coffee beans, the raw material requirements and the price of arabica coffee beans, demand and prices of raw materials ginger, the raw material requirements and the price of aluminum foil, the need for raw materials and sticker price, the need for raw materials and the price of plastic seals, the need for raw materials of bean arabica civet, the needs of working hours of labor the packaging department, wage per day per person the packaging department, the number of workers the packaging department, work hours of labor needs an introductory section, the wage per day per person introductory section, the number of workers introductory part, LPG gas needs, the needs of the transportation costs.

There are 9 product variants, namely Kopi Caffe Dos (150 g), Kopi Krisna "9" (150 g), Kopi Aroma "9" (200 g), Kopi Robusta "9" A1 (200 g), Kopi Robusta Plastik (200 g), Kopi Robusta Mantap (200 g), Kopi Robusta Plus Jahe "9" (200 g), Kopi Jawara "9" (200 g), and Kopi Luwak "9" (100 g). The price of the packaging in a row is 15.000 IDR, 16.000 IDR, 16.000 IDR, 13.000 IDR, 11.000 IDR, 10.000 IDR, 13.000 IDR, 5.000 IDR, 90.000 IDR. The maximum capacity of the supply of raw materials robusta coffee beans is 865 kg, the raw material of arabica coffee beans at 500 kg, while the civet coffee beans are 20 kg. The maximum capacity of the supply of ginger at 500 kg, aluminum foil (5850 sheets), stickers (9050 pieces), plastic seals (11,500 pieces), labor hours packaging department (25 days), hours of labor section delivery (25 days), the supply of LPG (375.000 IDR), provision of transport (650.000 IDR). Kopi 9 have 2 Workers at the packing, the implementation of which could be carried out simultaneously between different products. The cost of each worker 25.000 IDR/day. Deliverymen who used a number of 1–2 people with a wage of 25.000 IDR/day. The production process is all done by the owners themselves.

The process of making coffee bean roasters done by machines (roasting) with a capacity of 15 kg/hour, as well as grinding machine with a capacity of 5 kg/hour with a power consumption of 250 watts. Cost per kWh amounting to 1.460 IDR. Production time in one month between 17–25 days. Especially for products Kopi Robusta Plus Ginger "9" (packaging 200 g), composition between coffee and ginger are 75% and 25%. As these data are complete can be shown in Tables I and II.

From Table I, then the adjustment will be made of modeling based on an analysis of resources in each phase of production, through the calculation to determine the capital raw materials per unit, the overhead per day, the overhead costs per unit of production, capital per unit, profit per unit, and capital capacity. Through analysis which includes the use of these resources, it can be analyzed further the objective function and constraints that will be used in the model.

From the analysis above, it can be explained as follows. The profit margin of 40% is no longer using any products (see Table I at the top) but using the results of the calculation of profit (see Table III). The constraints of working hours, used after the calculation of the use of time during the production process (see Table II). The constraint of raw materials can be used based on the weight of each package (in grams), while the production is obtained from the calculation in Table II.

Based on the analysis, it was composed of a linear programming model as follows.

$$\text{Max: } z = 8{,}856x_1 + 10{,}102x_2 + 11{,}436x_3 + 6{,}635x_4 + 5{,}385x_5 + 6{,}385x_6 + 4{,}075x_7 + 1{,}235x_8 + 68{,}875x_9$$

Constraint:

$$\text{Raw materials capital: } 9{,}144x_1 + 5{,}898x_2 + 8{,}564x_3 + 6{,}674x_4 + 5{,}842x_5 + 5{,}835x_6 + 10{,}527x_7 + 4{,}091x_8 + 70{,}387x_9 \le 4{,}929{,}885$$

$$\text{Working hours: } 2.4x_1 + 2.4x_2 + 3.2x_3 + 3.2x_4 + 3.2x_5 + 3.2x_6 + 3.2x_7 + 3.2x_8 + 1.6x_9 \le 1{,}920$$

$$\text{Packaging weight: } 150x_1 + 150x_2 + 200x_3 + 200x_4 + 200x_5 + 200x_6 + 200x_7 + 200x_8 + 100x_9 \le 74{,}200$$

Table I. The needs raw materials and production costs per month.

Requirement of raw materials and labor	Raw materials (kg) and the hours of labor max capacity				
	Kopi Caffe Dos	Kopi Krisna "9"	Kopi Aroma "9"	Kopi Robusta "9" A1	Kopi Robusta Plastik
Demand	**3333**	**500**	**500**	**625**	**750**
Profit margin (owner version) (%)	40	40	40	40	40
Packaging (g)	150	150	200	200	200
Selling price (IDR)	18.000	16.000	20.000	13.000	11.000
The average production per day	120	15	15	20	25
Raw material needs of robusta coffee beans (kg)		75	100	125	150
Purchase price (IDR) per kg		30.000	30.000	27.000	25.000
Purchase price (IDR) per gram pack		4.500	6.000	5.400	5.000
Capital raw materials of robusta coffee (IDR)		2.250.000	3.000.000	3.375.000	3.750.000
Raw material needs of arabica coffee beans (kg)	500				
Purchase price (IDR) per kg	50.000				
Purchase price (IDR) per gram pack	7.500	0	0	0	0
Capital raw materials of arabica coffee (IDR)	25.000.000	0	0	0	0
Raw material needs of ginger (kg)					
Purchase price (IDR) per kg					
The purchase price per package (IDR/packaging g)	0	0	0	0	0
Capital raw materials ginger (IDR)	0	0	0	0	0
Needs raw materials of aluminium foil (sheet)	300	1000	1200	500	500
Needs of aluminium foil per pack (sheets)	0.09	2	2.4	0.8	0.67
Purchase price (IDR) per sheet	1.300	800	1.500	700	350
Capital raw materials of aluminum foil (IDR)	390.000	800.000	1.800.000	350.000	175.000
Raw material needs of stickers (sheet)	500	1500	1500	700	700
Needs of sticker per pack (sheets)	0.15	3.0	3.0	1.12	0.93
Purchase price (IDR) per sheet	250	250	500	250	250
Capital raw materials of stickers (IDR)	125.000	375.000	750.000	175.000	175.000
Seals plastic raw material requirement (kg)	500	1200	1400	5100	600
Seals plastic needs per pack (gram)	150	2400	2800	8160	800
Purchase price (IDR) per kg	75	75	75	75	75
Purchase price per gram pack	11	11	15	15	15
Capital of seal plastic raw materials (IDR)	37.500	90.000	105.000	382.500	45.000
Raw material needs of civet arabica beans (kg)					
Purchase price (IDR/kg)					
Purchase price per package (IDR/gram pack)	0	0	0	0	0
Capital raw materials of arabica civet coffee (IDR)	0	0	0	0	0
Needs of work hours for workers packing section (days)	2	3	4	3	3
Wages/day (IDR/day)	25.000	25.000	25.000	25.000	25.000
Number of workers (man)	2	2	2	2	2
	100.000	150.000	200.000	150.000	150.000
Needs of work hours for workers delivery section (days)	2	2	2	2	2
Wages/day (IDR/day)	25.000	25.000	25.000	25.000	25.000
Number of workers (man)	2	2	2	2	2
	100,000	100,000	100,000	100,000	100,000
Needs of LPG gas (IDR)	45.000	45.000	45.000	45.000	45.000
Needs of transportation costs (IDR)	75.000	75.000	75.000	75.000	75.000

Raw materials (kg) and the hours of labor max capacity				
Kopi Robusta Mantap	Kopi Robusta + Jahe "9"	Kopi Jawara "9"	Kopi Luwak "9"	Max capacity
775	**375**	**350**	**20**	
40%	40%	40%	40%	
200	200	200	100	
12.000	14.000	5.000	130.000	
30	15	12	5	
155	100	70		775
25.000	25.000	20.000		
5.000	5.000	4.000	0	
3.875.000	2.500.000	1.400.000	0	
				500
0	0	0	0	
0	0	0	0	
	500			500
	19.000			
0	3.800	0	0	
0	9.500.000	0	0	
700	800	700	150	5,850
0.9	2.13	2.0	7.5	18.49
350	800	500	800	

Table I. Continued.

Raw materials (kg) and the hours of labor max capacity				
Kopi Robusta Mantap	Kopi Robusta + Jahe "9"	Kopi Jawara "9"	Kopi Luwak "9"	Max capacity
245.000	640.000	350.000	120.000	
800	1500	1000	850	9,050
1.03	4	2.86	42.50	58.59
250	250	250	250	
200.000	375.000	250.000	212.500	
800	900	800	200	11,500
1,032.26	2,400	2,285.71	10,000	30,028
75	75	75	75	
15	15	15	19	
60.000	67.500	60.000	15.000	
			20	20
			800.000	
0	0	0	60.000	
0	0	0	16.000.000	
3	3	2	2	25
25.000	25.000	25.000	25.000	
2	2	2	2	
150,000	150,000	100,000	100,000	
2	2	2	1	25 days
25.000	25.000	25.000	25.000	
2	2	2	1	
100.000	100.000	100.000	25.000	
45.000	45.000	45.000	15.000	375.000
75.000	75.000	75.000	50.000	650.000

Table II. Production per day for each packaging.

Type	Production per day for each package	Capacity/ packaging (g)	Required time per package (min)	Capacity/ packaging (g)
Kopi Caffe Dos	133.33	100	0.6	33.33
Kopi Krisna "9"	20	100	0.6	33.33
Kopi Aroma "9"	20	75	0.8	25
Kopi Robusta "9" A1	25	75	0.8	25
Kopi Robusta Plastik	30	75	0.8	25
Kopi Robusta Mantap	31	75	0.8	25
Kopi Robusta + Jahe "9"	20	75	0.8	25
Kopi Jawara "9"	14	75	0.8	25
Kopi Luwak "9"	8	150	0.4	50
		Roasting machine		
Capacity		15,000		Gram
Processing time		60		Minutes
		Milling machine		
Capacity		5,000		Gram
Processing time		60		Minutes
		Electricity cost		
Watt		250		Watt
In kwh		0.25		kwh
Cost/kwh		1.460		IDR
Required time per package (min)	Total cost of electricity per pack (IDR)	Cost of capital (IDR)/ packaging unit		Cost (IDR)/gram for each pack
1.8	10,95	9.061		60,41
1.8	10,95	5.561		37,08
2.4	14,60	8.075		40,38
2.4	14,60	6.365		31,83
2.4	14,60	5.615		28,08
2.4	14,60	5.615		28,08
2.4	14,60	9.925		49,63
2.4	14,60	3.765		18,83
1.2	7,30	61.125		611,25

Production per day: $x_1 \leq 133$; $x_2 \leq 20$; $x_3 \leq 20$; $x_4 \leq 25$;

$$x_5 \leq 30;\ x_6 \leq 31;\ x_7 \leq 20;\ x_8 \leq 14;\ x_9 \leq 8$$

$$x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9 \geq 0$$

Where: x_1: Kopi Caffe Dos (150 g), x_2: Kopi Krisna "9" (150 g), x_3: Kopi Aroma "9" (200 g), x_4: Kopi Robusta "9" A1 (200 g), x_5: Kopi Robusta Plastik (200 g), x_6: Kopi Robusta Mantap (200 g), x_7: Kopi Robusta Plus Jahe "9" (200 g), x_8: Kopi Jawara "9" (200 g), x_9: Kopi Luwak "9" (100 g).

By utilizing software QM for Windows version 3.2, the obtained optimum conditions as shown in Table IV. From Table IV, it can be shown that the relative product mix increases more than current production. For the production per day, Kopi Caffee Dos can be produced as many as 133 boxes, Kopi Krisna "9" as much as 20 packs, Kopi Aroma "9" as much as 20 packs, 25 packs for Kopi Robusta "9" A1, Kopi Robusta Plastik as much as 30 packs, Kopi Robusta Mantap produced as much as 31 packs, Kopi Robusta + Jahe "9" of 20 packs, Kopi Jawara "9" as many as 14 packs, and Kopi Luwak "9" although the market absorb the least, but is able to be produced as many as eight packs.

These results show that with the support of knowledge, especially operations research, managers can make more real decision-making and not just trial and error. It is therefore necessary to strengthen the quality and scope of entrepreneurial skills in the sector.[10] Training for managerial personnel in this sector needs to be given especially on improving understanding in applying operational research in decision making.

The determination of product mix through linear programming must be followed by other managerial actions, because one measure of success is whether small medium enterprises are able to sell their products in the market. In the face of increasingly fierce competition, a complete understanding of the statistics and the

Table III. Resource use and production per day.

	Selling price (IDR)	Capital (IDR)	Work hours (minutes)	Raw material (IDR)	Market demand (production per day)	Profit (IDR)
Kopi Caffe Dos	18.000	9.144	2.4	9.061	120	8.856
Kopi Krisna "9"	16.000	5.898	2.4	5.561	15	10.102
Kopi Aroma "9"	20.000	8.564	3.2	8.075	15	11.436
Kopi Robusta "9" A1	13.000	6.674	3.2	6.365	20	6.635
Kopi Robusta Plastik	11.000	5.842	3.2	5.615	25	5.385
Kopi Robusta Mantap	12.000	5.835	3.2	5.615	30	6.385
Kopi Robusta + Jahe "9"	14.000	10.527	3.2	9.925	15	4.075
Kopi Jawara "9"	5.000	4.091	3.2	3.765	12	1.235
Kopi Luwak "9"	130.000	70.387	1.6	61.125	5	68.875
Capacity		4.929.885	1,920		257	

Overhead cost calculation per day		
	a. Salaries of the employees packaging (2)	50.000
	b. Salary of employee delivery (2 persons)	48.529
	c. Machine maintenance costs (LPG, etc.) (IDR)	15.000
	d. Electricity cost (IDR)	4,67
	e. Transportation costs (IDR)	26.000
		139.534

		Package (gram)	Cost prod (IDR)/ packaging/g	Total (IDR)
Calc. of capital raw materials per unit	Kopi Caffe Dos	150	60,41	9.061,25
	Kopi Krisna "9"	150	37,08	5.561,25
	Kopi Aroma "9"	200	40,38	8.075
	Kopi Robusta "9" A1	200	31,83	6.365
	Kopi Robusta Plastik	200	28,08	5.615
	Kopi Robusta Mantap	200	28,08	5.615
	Kopi Robusta + Jahe "9"	200	49,63	9.925
	Kopi Jawara "9"	200	18,83	3.765
	Kopi Luwak "9"	100	611,25	61.125
Capital raw materials per day (IDR)				115,107.50

Overhead cost calculations (IDR)		
Kopi Caffe Dos		83
Kopi Krisna "9"		337
Kopi Aroma "9"		489
Kopi Robusta "9" A1		309
Kopi Robusta Plastik		227
Kopi Robusta Mantap		220
Kopi Robusta + Jahe "9"		602
Kopi Jawara "9"		326
Kopi Luwak "9"		9.262

Kopi Arabika	Kopi Caffe Dos	$133 \times 150 = 20.000$
Kopi Robusta	Kopi Krisna "9"	$20 \times 150 = 3.000$
	Kopi Aroma "9"	$20 \times 200 = 4.000$
	Kopi Robusta "9" A1	$25 \times 200 = 5.000$
	Kopi Robusta Plastik	$30 \times 200 = 6.000$
	Kopi Robusta Mantap	$31 \times 200 = 6.200$
	Kopi Robusta + Jahe "9"	$20 \times 200 = 4.000$
	Kopi Jawara "9"	$14 \times 200 = 2.800$
Kopi Arabika Luwak	Kopi Luwak "9"	$8.00 \times 100 = 800$

Calculation of capital remaining production (IDR)	
Kopi Arabika	The capital of raw materials remain $= 22.000 - 20.000 = 2.000$ $2.000 \times 60.408 = 120.817$
Kopi Robusta	The capital of raw materials remain $= 5.000 - 3.000 = 2.000$ $2.000 \times 37{,}08 = 74{,}150$
	The capital of raw materials remain $= 6.500 - 4.000 = 2.500$ $2.500 \times 40{,}38 = 100.938$
	The capital of raw materials remain $= 7.600 - 5.000 = 2.600$ $2.600 \times 31{,}83 = 82.745$
	The capital of raw materials remain $= 7.000 - 6.000 = 1.000$ $1.000 \times 28{,}08 = 28.075$
	The capital of raw materials remain $= 6.500 - 6.200 = 300$ $300 \times 28{,}08 = 8.423$
	The capital of raw materials remain $= 8.000 - 4.000 = 4.000$ $4.000 \times 49{,}63 = 198.500$
	The capital of raw materials remain $= 8.600 - 2.800 = 5.800$ $5.800 \times 18{,}83 = 109.185$

Table III. Continued.

Calculation of capital remaining production (IDR)		
Kopi Arabika Luwak		The capital of raw materials remain = 3.000 − 800 = 2.200 2.200 × 611,25 = 1.344.750
Total capital of raw materials remain (IDR)		2.067.582
Ability of capital provision	Kopi Caffe Dos	133 unit × 9.144 = 1.219.178
	Kopi Krisna "9"	20 unit × 5.898 = 117.966
	Kopi Aroma "9"	20 unit × 8.564 = 171.289
	Kopi Robusta "9" A1	25 unit × 6.674 = 166.841
	Kopi Robusta Plastik	30 unit × 5.842 = 175.257
	Kopi Robusta Mantap	31 unit × 5.835 = 180.872
	Kopi Robusta + Jahe "9"	20 unit × 10.527 = 210.531
	Kopi Jawara "9"	14 unit × 4.091 = 57.274
	Kopi Luwak "9"	8 unit × 70.387 = 563.096
	Total capital of raw materials remain = 2.067.582	
	Ability of capital provision	4.929.885

Table IV. Optimal product mix after adjustment.

Product	Before adjustment	After adjustment
Kopi Caffee Dos	120	133
Kopi Krisna "9"	15	20
Kopi Aroma "9"	15	20
Kopi Robusta "9" A1	20	25
Kopi Robusta Plastik	25	30
Kopi Robusta Mantap	30	31
Kopi Robusta + Jahe "9"	15	20
Kopi Jawara "9"	12	14
Kopi Luwak "9"	5	8
Optimal value (Z)		2.783.758 IDR

application of other operations research (for example in forecasting and inventory levels), would be of great value to the organization. Nevertheless, for the practitioners, there is still much to be gained by adopting 'best practices' even though the implementation obstacles remain substantial.[11]

Information and Communication Technologies (ICT) adoption is often a barrier to SMEs in running their organizations. Lack of ICTs skills and knowledge is more evident in small- and medium-sized enterprises (SMEs).[12] However, some studies show that the impact of ICT utilization will be further strengthened when combined with other complementary investments such as training, decentralized decision making, and total quality management.[13]

4. CONCLUSION

There are opportunities to increase production capacity after calculation of resource use is more complete. This means that the production capacity of Kopi Sembilan is still able to meet market demand, with the optimum benefit of 2.783.758 IDR per day. The results showed that the calculation of resource utilization more thorough, the organization was able to see the existing capabilities within their own organizations. This is important because it relates to seize opportunities in potential markets. Exploiting knowledge of Operations Research is very important to have for SMEs in setting strategy and policy. However, knowledge in other fields is also important for decision makers, so that further research can be directed to the conditions before the determination of the marketing mix that is about product forecasting. In addition, information and communication technologies (ICT) adoption, innovation, and knowledge management can be directed to the productivity and financial performance of SMEs.

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