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PARTIAL DIFFERENTIAL IN OPTIMIZATION SALES OF GOODS THROUGH THE USE OF CURVE FIT SOFTWARE – TOOLS

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ABSTRACT

It should be that a company in any field will follow the laws of capital economics that is getting the maximum profit with the smallest effort. This is where optimization as an attempt to get the maximum profit begins. This study aims to help determine the optimum value in a product sales mix by applying partial differential theory and analyzing the margins' contribution between variable costs, fixed costs, and sales volume. The method used in this research is a case study of partial differential theory using tools in Curve Fit - Tools version 1.6 which is used to obtain a suitable curve using the Least Square Approximation method. The results of the study are obtained the optimal composition value of the sales mix in the form of five types of shirts to produce the most optimal profit obtained by the company. From the calculations that have been done, it turns out that the profits obtained by the company from the sale of products after using partial differential theory are 22% higher than the profits obtained before using partial differential theory.

Keywords: math of economics, margin contributions, linear programs, independent variables, curve fit, sales mix

INTRODUCTION

The necessity in frugality, both in terms of effort and resources to achieve a certain set of goals in using the minimum amount of resources owned by the company is part that must be owned by a planning and control system in business organizations (Berry et al., 2019). This will be a strong consideration, especially when a company produces many products for maximum profit. Because profits in companies that produce many types of products will be determined by the mix of various products (Arif Yusuf Hamali, 2016).

In general, of course, a company producing various types of products often has different profit levels. That is why a careful calculation is needed to find an optimally good price point or break even price in marketing terms (Ayyub Mustofa, 2018). Where products with high penetration, branded and discounts in a particular category affect the profit obtained (Gauri et al., 2017). As is also said in economic theory, pricing is a direct exercise where marketers only set prices at points of the demand curve where marginal income equals marginal cost (Nagle & Müller, 2018).

This is where the role of management is required to try to achieve a combination of sales or sales mix so that the greatest profits are obtained. Moreover, in this case, each company certainly has a different strategy, some hold production concepts, product concepts, sales concepts, marketing concepts, and social marketing concepts (Novia Widya Utami, 2020). The important thing is not to let the opposite situation

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occur where, changes in the sales structure result in a previously high contribution to be low, causing a decrease in total profits.

To determine how much profit the company will get in a certain period, a profit indicator is usually used called the profit margin value (Novia Widya Utami, 2018). While the contribution margin is used to determine how each product contributes to the company's profit. This contribution margin takes value from net income minus variable costs (Iswara et al., 2023; Karunia Saputra Hidayat, 2019). The most profitable combination of variable costs, fixed costs and sales volume can be analyzed through the analysis of margin contribution. Moreover, the most commonly known thing about increasing profits is increasing the total margin contributions. However, when a company's management only uses an analysis of margin contribution to determine optimal returns, they will encounter obstacles because this analysis cannot determine the optimal proportion of sale.

The amount of unit margin contribution will strongly influence what steps the company will take to increase profits (Hanafi, 2006; Muhammad Sujai et al., 2022). For example, the greater the contribution of the unit margin of a product, the company will be willing to spend a larger amount to increase product sales by a certain percentage. This partly explains why companies with larger unit margin contributions (such as car manufacturers) advertise so heavily while companies with low contributions (such as glassware) tend to spend less on advertising.

Partial differential discusses the rate of change in a function caused by a very small change in one of the independent variables (e.g. X1) in another independent variable (e.g. X2, X3,, Xn of the function in question (Ginanjar Syamsuar, 2017). Differently, the specific positions of the studied functions can also be searched, such as maximum points, turning points and minimum points. Based on these benefits, this concept of differential becomes one of the analytical tools in business and economics that is very familiar with the problem of change, determining maximum and minimum levels.

The differentiation is the same as the principle for the function of a single independent variable. It is just that here will meet the partial or part-by-part differentiation principle. Generally, an economic variable will be functionally related to one type of variable and precisely to several types of variables simultaneously.

The derivative will be more than one kind for a function to contain more than one independent variable, according to the number of independent variables. So, if a function contains more than one kind, according to the number of independent variables, it will have n (number) kinds of derivatives. If Y=f(x,z) then there will be two kinds of derivatives, namely the derivative Y to X or ∂y/∂x and the derivative Y to Z or (∂y)/∂x (Martial, Sharinna Raini, t.t.) . Thus obtained the following derivatives:

$$Y = f(x,z) \quad (1)$$

$$y` \to a)\ fx(x,z) = \frac{\partial y}{\partial x}$$

$$b)\ fz(x,z) = \frac{\partial y}{\partial z}$$

$$y` = \frac{\partial y}{\partial x} + \frac{\partial y}{\partial z}$$

$$P = f(q,r,s) \quad (2)$$

$$P` \to a)\ fq(q,r,s) = \frac{\partial p}{\partial q}$$

$$b)\ fr(q,r,s) = \frac{\partial p}{\partial r}$$

$$c)\ fs(q,r,s) = \frac{\partial p}{\partial s}$$

$$P` = \frac{\partial p}{\partial q}dq + \frac{\partial p}{\partial r}dr + \frac{\partial p}{\partial s}ds$$

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As for the cost function, according to Dumairy there are two forms, namely: 1) Linear Functions and 2) Non-linear functions such as parabolic quadratic functions and cubic functions and others. In manufacturing companies, the cost function is generally nonlinear (quadratic equation). It has an extreme point where we can find out the minimum or maximum cost. The company will earn maximum profit when incurring minimum costs.

To determine the extreme (optimum) values of a function containing more than one independent variable can be searched by testing up to both derivatives (Alpha C. Chiang &; Kevin Wainwright, 2006); (Ginanjar Syamsuar, 2017, p. 9). For y=f(x,z), y reaches its extreme if:

$$Fx = \frac{\partial y}{\partial x} = 0 \text{ dan } Fx = \frac{\partial y}{\partial z} = 0.$$

These conditions are necessary for the function to reach the extreme. Meanwhile, to find out whether the extreme point in question is the maximum or minimum point, the following conditions are needed (Ginanjar Syamsuar, 2017):

$$\text{Maksimum bila } \frac{\partial^2 y}{\partial x^2} < 0 \text{ dan } \frac{\partial^2 y}{\partial z^2} < 0; \text{ Minimum bila } \frac{\partial^2 y}{\partial x^2} > 0 \text{ dan } \frac{\partial^2 y}{\partial z^2} > 0.$$

Through this partial differential equation we can optimize many products produced. Moreover, because the cost function in this partial differential is quadratic, it is solved by a linear program (Johannes & Handoko, 1986).

Therefore, this study is directed or aims to show how to determine the amount that must be produced by the company for each type of product so that the profit obtained is optimal by completing or cooperating with margin contribution analysis. Moreover, this research utilizes a mathematical model called partial differential to achieve optimal composition and maximum profit.

METHODS

This research uses the case study method against partial differential theory. Where partial differentials in economics are used to derive marginal cost, by deriving it from the total cost equation. Therefore, this partial differential formula is used to obtain the optimum cost with maximum profit. The steps taken to produce the expected optimal value are broadly three stages: 1) price and cost analysis 2) making formulas and functions 3) optimization process, in detail seen in Figure 1.

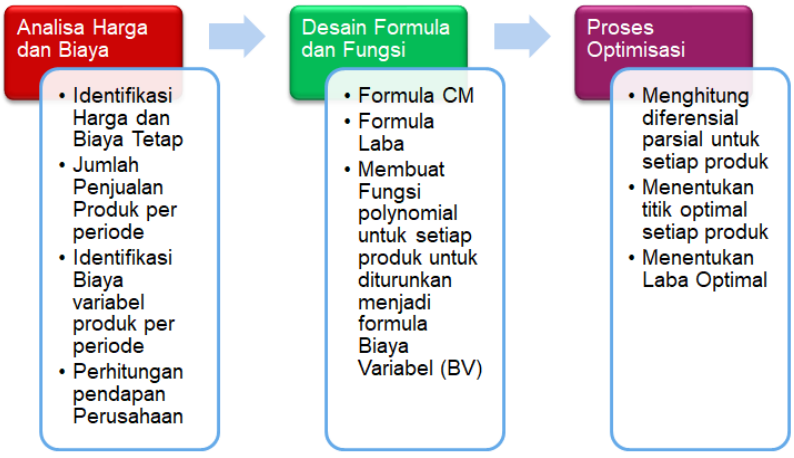

Figure 1.Steps to get maximum profit

To make it easier to find the variable cost (BV) formula for each product and partial differential for each of these formulas, a tool in the form of software called Curve Fit – Tools version 1.6 is used. Using this tool, suitable functions and curves are obtained according to previously obtained data regarding the sales value (from now on used as a value for variable X) and variable value (then used as a value for variable Y).

RESULTS AND DISCUSSION

The study was conducted on XX Garment Business companies that produce five types of shirts, namely BOSS (A), COLE (B), VALINO (C), ALISAN (D), and CARDINAL (E) with data as shown in Table 1 below:

Table 1. Price and Fixed Cost of Shirts

No	Jenis Kemeja	Harga Kemeja/ pcs	Biaya Tetap
1	BOSS (A)	84.000	13.660.000.000
2	COLE (B)	72.000	
3	VALINO (C)	92.000	
4	ALISAN (D)	64.500	
5	CARDINAL (E)	102.000	

Data source : PT. XX 2019 (Hedwigis Esti Riyanti, t.t.)

While each shirt has several sales for 5.5 years (11 semesters) as shown in Table 2a and Table 2b below:

Tabel 2a. Jumlah Penjualan Kemeja Per Enam Bulan

THN	BLN	A	B	C
2013	Juli-Des	91.500	105.900	93.500
2014	Jan-Juni	94.100	107.300	95.000
2014	Juli-Des	97.500	108.500	96.900
2015	Jan-Juni	102.100	109.900	98.500
2015	Juli-Des	108.000	111.800	100.800
2016	Jan-Juni	111.000	113.500	102.500
2016	Juli-Des	114.500	114.500	107.400
2017	Jan-Juni	117.500	115.800	107.000
2017	Juli-Des	120.500	117.500	109.800
2018	Jan-Juni	122.500	119.500	112.000
2018	Juli-Des	127.500	120.000	114.000

Tabel 2b. Jumlah Penjualan Kemeja Per Enam Bulan

THN	BLN	D	E
2013	Juli-Des	97.500	78.500
2014	Jan-Juni	98.800	79.400
2014	Juli-Des	100.500	80.400
2015	Jan-Juni	102.300	81.400
2015	Juli-Des	104.100	82.200
2016	Jan-Juni	105.500	83.300
2016	Juli-Des	104.200	84.300
2017	Jan-Juni	109.300	85.100
2017	Juli-Des	111.800	86.000
2018	Jan-Juni	114.000	87.000
2018	Juli-Des	116.000	88.000

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Moreover, the variable costs of each work for 11 semesters can be seen in Table 3a and Table 3b below:

Table 3a. Variable Cost of Shirts Per Six Months

THN	BLN	A (Rp) (000.000)	B (Rp) (000.000)	C (Rp) (000.000)
2013	Juli-Des	5.086.700	5.683.685	5.619.500
2014	Jan-Juni	5.221.510	5.991.200	5.999.400
2014	Juli-Des	5.595.370	6.385.000	6.595.200
2015	Jan-Juni	5.595.370	6.385.000	6.595.200
2015	Juli-Des	5.934.370	6.698.200	6.893.500
2016	Jan-Juni	6.105.460	6.945.700	7.235.000
2016	Juli-Des	6.569.300	7.034.250	7.487.500
2017	Jan-Juni	6.954.660	7.191.700	7.685.300
2017	Juli-Des	7.530.300	7.301.250	7.894.400
2018	Jan-Juni	7.975.100	7.425.900	8.078.000
2018	Juli-Des	8.399.900	7.454.100	8.194.000

Table 3b. Variable Cost of Shirts Per Six Months

THN	BLN	D (Rp) (000.000)	E (Rp) (000.000)
2013	Juli-Des	4.899.250	6.587.500
2014	Jan-Juni	4.902.500	6.623.600
2014	Juli-Des	4.985.200	6.692.000
2015	Jan-Juni	4.985.200	6.752.100
2015	Juli-Des	5.042.500	6.822.700
2016	Jan-Juni	5.057.150	6.923.850
2016	Juli-Des	5.188.500	7.032.600
2017	Jan-Juni	5.299.100	7.162.150
2017	Juli-Des	5.473.350	7.331.700
2018	Jan-Juni	5.745.500	7.526.500
2018	Juli-Des	6.145.500	7.698.500

Based on Table 2 and 3 data, the amount of sales and variable costs for July-December 2018 can be grouped as in Table 4 below:

Table 4. Comparison of Sales and Variable Costs July-December 2018

Jenis Kemeja	Penjualan	Biaya Variabel
BOSS (A)	127.500	8.399.900.000,00
COLE (B)	120.500	7.454.100.000,00
VALINO (C)	114.000	8.194.000.000,00
ALISAN (D)	116.000	6.145.500.000,00
CARDINAL (E)	88.000	7.698.500.000,00

Based on the data above, to find out whether the sales mix is optimal, obtain superior or optimal profits. Then the profit will be compared with the sales mix modified using Partial Differential.

The sales advantage of the five types of shirts can be found by adding the Contribution Margin (CM) for each type of shirt and then subtracting the fixed cost (Rp. 1,366,000,000). The following is the revenue calculation for July-December 2018 (see Table 5a and Table 5b).

Table 5a. Calculation of Company Revenue for July-December 2018

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Keterangan	Boss (A) (000.000)	Cole (B) (000.000)	Valino (C) (000.000)
Penjualan	10.710	8.676	10.545
B. Variabel	8.399,9	7.454,1	8.194
CM	2.310,1	1.221,9	2.351
B.Tetap			
Laba			

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Table 5b Company Revenue Calculation for July-December 2018

Keterangan	Alisan (D) (000.000)	Cardin (E) (000.000)	Total A-E (000.000)
Penjualan	7.482	8.976	46.433
B. Variabel	6.145,5	7.698	37.891,5
CM	1.336,5	1.278	8.497,5
B.Tetap			1.366
Laba			7.131,5

From the summary above, July-December 2018 profit was Rp. 7,131,500,000.00. This profit is not profit when the composition of sales is optimal, so if the composition of sales is changed to the optimal composition, it will get maximum profit by using Partial Differential.

To use partial differential, you must first know the relationship between profit, sales, variable costs, margin contribution (CM) and fixed costs (Agustina Shinta, 2011). Of the five types of shirts in the form of similarities as shown below:

$$CM = Penjualan - biaya\ variabel \qquad Laba = CM - biaya\ tetap$$

$$CM = P \cdot Q - f(Q) \qquad \pi = \left(P \cdot Q - f(Q)\right) - k$$

So each product must be formulated in the form of equations as above. The first step is determining the relationship between the number of products sold and variable costs. This can be done on each type of product. As seen in Table 6, the table illustrates the relationship between sales and variable costs of this type of product.

- Looking for Product Formulation A (Boss Shirt)

Table 6. Sales and Variable Cost Shirt Boss (A)

Tahun	Bulan	Penjualan (potong)	Biaya Variabel
2013	Juli-Des	91,500	5,086,700,000
2014	Jan-Juni	94,100	5,221,510,000
2014	Juli-Des	97,500	5,359,230,000
2015	Jan-Juni	102,100	5,595,370,000
2015	Juli-Des	108,000	5,934,370,000
2016	Jan-Juni	111,000	6,105,460,000
2016	Juli-Des	114,500	6,569,300,000
2017	Jan-Juni	117,500	6,954,660,000
2017	Juli-Des	120,500	7,530,300,000
2018	Jan-Juni	122,500	7,975,100,000
2018	Juli-Des	127,500	8,399,900,000

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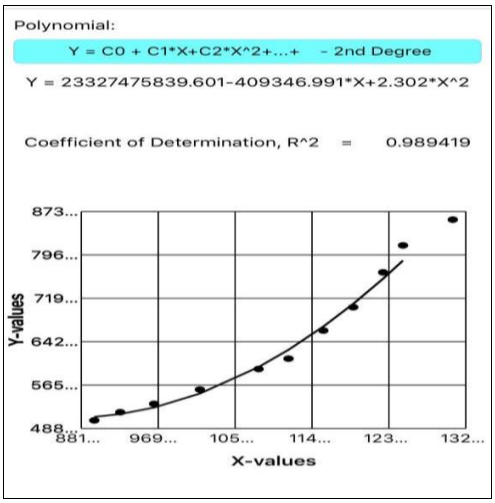

Figure 2. Boss Shirt Equation Graph (A)

Through the use of software called Curve Fit – Tools version 1.6, as a tool to get functions and graphs in the form of equation curves Boss Shirt (A) as in figure 2 above accompanied by the variable cost formula (BV) of Boss Shirt (A) as follows:

Y=2.302x^2-409.346.991x+23.327.475.839.601

BV=2.302A^2-409.346.991A+23.327.475.839.601

Find the variable cost formula of Cole (B), Valino (C), Alisan (D) and Cardin (E) shirts so that it is produced:

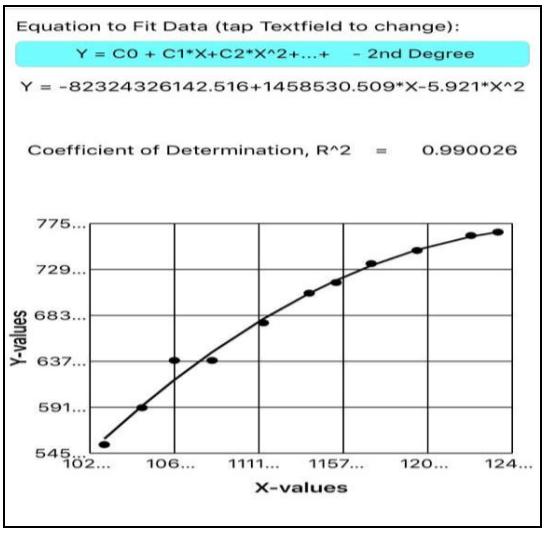

Figure 3. Cole Shirt equation graph (B)

Just like the variable cost formula of the Boss shirt product (A), through the use of Curve Fit – Tools, a graph of the Cole Shirt equation (B) as shown in Figure 3 above is obtained accompanied by the variable cost formula (BV) of the Cole Shirt (B) as follows:

Y=-5,921x^2+1,458,530,509x-82,324,326,142,516

BV=-5,921B^2+1,458,530,509B-82,324,326,142,516

As for the Valino Shirt (C), the graph in the form of an equation curve can be seen as Figure 4 below.

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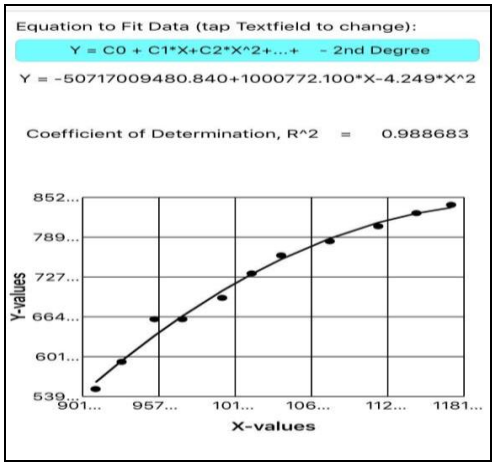

Figure 4. Valino Shirt equation graph (C)

While the variable cost (BV) formula of the chart is as follows:

Y= -4,249x^2+1,000,772,100x-50,717,009,480.840

BV= -4,249C^2+1.000.772,100C-50.717.009.480,840

For the Alisan Shirt (D), a graph in the form of an equation curve can be seen as Figure 5 below.

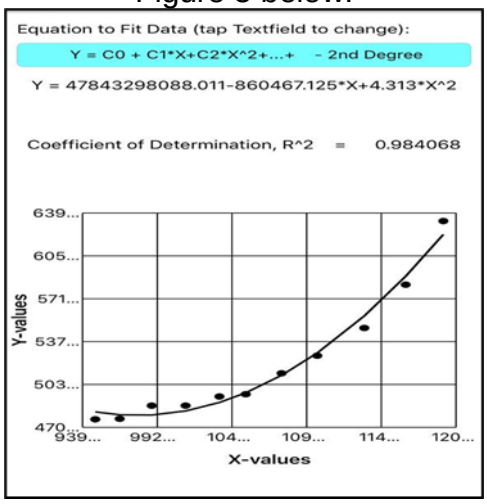

Figure 5. Graph of the equation Alisan Shirt (D)

Moreover, the vari-abel cost formula (BV) generated from the graph of the Alisan Shirt equation (D) is as follows:

Y=4,313x^2-860,467,125x+47,843,298,088.011

BV=4,313D^2-860.467,125D+47.843.298,088,011

Moreover, finally, for Cardin Shirt (E) the graph in the form of an equation curve can be seen as Figure 6 below.

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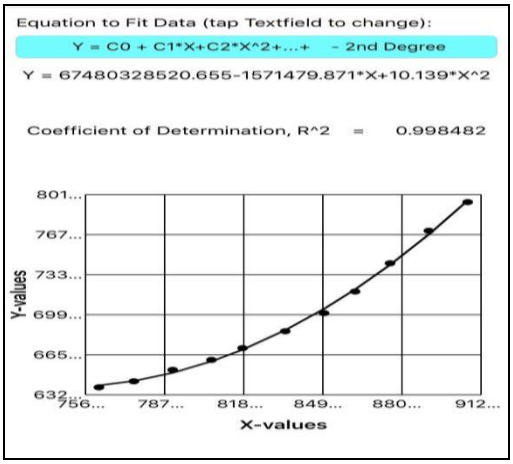

Gambar 6. Grafik persamaan Kemeja Cardin (E)

From the graph, the program generates the variable cost (BV) formula of the Alisan Shirt (E) as follows:

$$Y = 10{,}139x^2 - 1.571.479{,}871x + 67.47.480.328.520{,}655$$

$$BV = 10{,}139E^2 - 1.571.479{,}871E + 67.480.328.520{,}655$$

From the above equations, a profit formula is made for each type of shirt. Then from the formula is differential-partial so that the optimal product is obtained from each type of shirt. The formula is as follows (see table 7 below):

Table 7. Profit Formula All Types of Shirts

Jenis Kemeja	Formula
Boss (A)	$Penjualan = 84.000A$
	$BV = 2{,}302A^2 - 409.346{,}991\text{A} + 23.327.475.839{,}601$
	$CMa = -2{,}302A^2 + 493.346{,}991\text{A} - 23.327.475.839{,}601$
Cole (B)	$Penjualan = 72.000B$
	$BV = -5{,}921B^2 + 1.458.530.509\text{B} - 82.324.326.142{,}516$
	$\text{CMb} = 5{,}921B^2 - 1.386.530{,}509\text{B} + 82.324.326.142{,}516$
Valino (C)	$Penjualan = 92.000C$
	$BV = -4{,}249C^2 + 1.000.772{,}100C - 50.717.009.480{,}840$
	$CMc = 4{,}249C^2 - 908.772{,}1\text{C} + 50.717.009.480{,}840$
Alisan (D)	$Penjualan = 64.500D$
	$BV = 4{,}313D^2 - 860.467{,}125D + 47.843.298.088{,}011$
	$CMd = -4{,}313D^2 + 924.967{,}125D - 47.843.298.088{,}011$
Cardin (E)	$Penjualan = 102.000E$
	$BV = 10{,}139E^2 - 1.571.479{,}871E + 67.480.328.520{,}655$
	$CMe = -10{,}139E^2 + 1.673.479{,}871E - 67.480.328.520{,}655$

The above formulas can be partially dedifferentiated as follows (see table 8):

Table 8. Partial Differential Result Profit Formula

$$\boldsymbol{CMa = -2{,}302A^2 + 493.346{,}991\text{A} - 23.327.475.839{,}601}$$

$$\boldsymbol{\frac{\partial CMa}{\partial A} = -4{,}604A + 493.346{,}991 = 0}$$

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$$A = \frac{493.346,991}{4,604} = 107.156,167pcs$$

$$\frac{\partial^2 CMa}{\partial A^2} = -4,604$$

$-4,604 < 0$ ➔ **berarti penjualan A optimal**

$$\text{CMb} = 5,921B^2 - 1.386.530,509\text{B} + 82.324.326.142,516$$

$$\frac{\partial CMb}{\partial B} = 11,842\text{B} - 1.386.530,509 = 0$$

$$B = \frac{1.386.530,509}{11,842} = 117.085,840 \text{ pcs}$$

$$\frac{\partial^2 CMb}{\partial B^2} = 11,842$$

$11,842 > 0$ ➔ **berarti penjualan B minimal**

Karena B minimal, maka jumlah B dapat ditingkatkan, akan tetapi pemintaan pasar hanya 120.500 pasang berarti penjualan dapat ditingkatkan hingga 120.500 pasang (optimalnya).

$$CMc = 4,249C^2 - 908.772,1\text{C} + 50.717.009.480,840$$

$$\frac{\partial CMc}{\partial C} = 8.498C - 908.772,1 = 0$$

$$C = \frac{908.772,1}{8.498} = 106,936pcs$$

$$\frac{\partial^2 CMc}{\partial C^2} = 8.498$$

8.498 > 0 ➔ berarti penjualan C minimal

sehingga jumlah tersebut dapat ditingkatkan, akan tetapi pemintaan pasar hanya 114.000 pasang berarti penjualan dapat ditingkatkan hingga 114.000 pasang (optimalnya).

$$CMd = -4,313D^2 + 924.967,125D - 47.843.298.088,011$$

$$\frac{\partial CMd}{\partial D} = -8.626D + 924.967,125 = 0$$

$$D = \frac{924.967,125}{8.626} = 107.230,133pcs$$

$$\frac{\partial^2 CMd}{\partial D^2} = -8.626$$

- 8.626 < 0 ➔ Berarti penjualan D Optimal

$$CMe = -10,139E^2 + 1.673.479,871E - 67.480.328.520,655$$

$$\frac{\partial CMe}{\partial E} = -20,278E + 1.673.479,871 = 0$$

$$E = \frac{1.673.479,871}{20,278} = 82.526,870pcs$$

$$\frac{\partial^2 CMe}{\partial E^2} = -20,278$$

-20,278 < 0 ➔ Berarti penjualan E Optimal

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Profit or profit will be optimal if the composition of sales (sales mix) is Shirt type A = 107,156pcs, B = 120,500pcs, C = 114,000pcs, D = 107,230pcs, E = 82,527pcs. To get the optimal profit resulting from the composition, the following equation is used:

$$Laba\ optimal = CMa + CMb + CMc + CMd + CMe - k$$

$$Laba\ optimal = 54.975.035.525.965$$

So that finally obtained an optimal profit of Rp. 54,975. 035.525.965; or higher Rp.54,967,904. 025,965.00 from July-December 2018 profit (Rp. 7,131,500,000, 00).

CONCLUSION

To get maximum profit from a sale of blended products, several steps are needed before obtaining the optimal composition value using partial differentials. The step starts by adding the margin contribution values for each product, then determining the formula for each product and the variable costs for each product.

The result of the study is the optimal composition value of the sales mix in the form of five types of shirts to produce the most optimal profit obtained by the company. From the calculations that have been done, it turns out that the profit obtained by the company from the sale of products after using the partial differential theory is 22% higher than the profit obtained before using the partial differential theory.

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