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LAMPIRAN 1

Variabel keputusan:

x_1 : jumlah dimsum ayam (pcs).

x_2 : jumlah dimsum ayam cabai (pcs).

x_3 : jumlah dimsum jamur (pcs).

x_4 : jumlah dimsum udang (pcs).

Fungsi tujuan:

$$Z = 3P_1(d_1^-) + 2P_2\left(\sum_{i=2}^3 d_i^+\right) + P_3(d_4^-) + P_4(d_5^-) + P_5(d_6^-) + P_6(d_7^-)$$

Fungsi kendala:

Biaya produksi:

$$1.081,75x_1 + 841,75x_2 + 1.083,99x_3 + 625,19x_4 + d_1^- - d_1^+ = 360.000$$

Waktu proses 1:

$$10x_1 + 10x_2 + 10x_3 + 10x_4 + d_2^- - d_2^+ = 3600$$

Waktu proses 2:

$$20x_1 + 20x_2 + 20x_3 + 20x_4 + d_3^- - d_3^+ = 9000$$

Target produksi:

$$x_1 + d_4^- - d_4^+ = 180$$

$$x_2 + d_5^- - d_5^+ = 60$$

$$x_3 + d_6^- - d_6^+ = 30$$

$$x_4 + d_7^- - d_7^+ = 40$$

Kendala bahan baku:

$$5,56x_1 + 5,56x_2 + 5,56x_3 + 5,56x_4 \leq 2000$$

$$0,42x_1 + 0,42x_2 + 0,42x_3 + 0,42x_4 \leq 250$$

$$0,69x_1 + 0,69x_2 + 0,69x_3 + 0,69x_4 \leq 250$$

$$3,33x_1 + 3,33x_2 + 3,33x_3 + 3,33x_4 \leq 1500$$

$$0,04x_1 + 0,04x_2 + 0,04x_3 + 0,04x_4 \leq 250$$

$$0,03x_1 + 0,03x_2 + 0,03x_3 + 0,03x_4 \leq 250$$

$$\begin{aligned}
0,01x_1 + 0,01x_2 + 0,01x_3 + 0,01x_4 &\leq 50 \\
0,08x_1 + 0,08x_2 + 0,08x_3 + 0,08x_4 &\leq 200 \\
2,78x_1 + 2,78x_2 + 2,78x_3 + 2,78x_4 &\leq 1000 \\
0,33x_1 + 0,33x_2 + 0,33x_3 + 0,33x_4 &\leq 270 \\
0,16x_1 + 0,16x_2 + 0,16x_3 + 0,16x_4 &\leq 300 \\
0,19x_1 + 0,19x_2 + 0,19x_3 + 0,19x_4 &\leq 140 \\
5,56x_4 &\leq 500 \\
1,37x_1 + 1,37x_2 &\leq 500 \\
2,08x_3 &\leq 250 \\
2,5x_2 &\leq 250 \\
2,5x_1 + 2,5x_2 + 2,5x_3 + 2,5x_4 &\leq 1000
\end{aligned}$$

$$x_1, x_2, x_3, x_4, d_1^-, d_1^+, d_2^-, d_2^+, d_3^-, d_3^+, d_4^-, d_4^+, d_5^-, d_5^+, d_6^-, d_6^+, d_7^-, d_7^+ \geq 0$$

Input Lingo Contoh *Multi-Objective* dengan *Goal Programming* (GP):

```

MIN = 3*d1minus + 2*(d2plus + d3plus) + d4minus + d5minus
+ d6minus + d7minus;

!Goal 1 (BIAYA PRODUKSI) ;
1081.75*x1 + 841.75*x2 + 1083.99*x3 + 625.19*x4 + d1minus
- d1plus = 360000;

!GOAL 2 (WAKTU PROSES 1) ;
10*x1 + 10*x2 + 10*x3 + 10*x4 + d2minus - d2plus = 3600;

!GOAL 3 (WAKTU PROSES 2) ;
20*x1 + 20*x2 + 20*x3 + 20*x4 + d3minus - d3plus = 9000;

!GOAL 4, 5, 6, 7 (TARGET PRODUKSI) ;
x1 + d4minus - d4plus = 180;
x2 + d5minus - d5plus = 60;
x3 + d6minus - d6plus = 30;
x4 + d7minus - d7plus = 40;

!KENDALA BAHAN BAKU ;
5.56*x1 + 5.56*x2 + 5.56*x3 + 5.56*x4 <= 2000;
0.42*x1 + 0.42*x2 + 0.42*x3 + 0.42*x4 <= 250;
0.69*x1 + 0.69*x2 + 0.69*x3 + 0.69*x4 <= 250;
3.33*x1 + 3.33*x2 + 3.33*x3 + 3.33*x4 <= 1500;
0.04*x1 + 0.04*x2 + 0.04*x3 + 0.04*x4 <= 250;
0.03*x1 + 0.03*x2 + 0.03*x3 + 0.03*x4 <= 250;
0.01*x1 + 0.01*x2 + 0.01*x3 + 0.01*x4 <= 50;
0.08*x1 + 0.08*x2 + 0.08*x3 + 0.08*x4 <= 200;

```

```

2.78*x1 + 2.78*x2 + 2.78*x3 + 2.78*x4 <= 1000;
0.33*x1 + 0.33*x2 + 0.33*x3 + 0.33*x4 <= 270;
0.16*x1 + 0.16*x2 + 0.16*x3 + 0.16*x4 <= 300;
0.19*x1 + 0.19*x2 + 0.19*x3 + 0.19*x4 <= 140;
5.56*x4 <= 500;
1.37*x1 + 1.37*x2 <= 500;
2.08*x3 <= 250;
2.5*x2 <= 250;
2.5*x1 + 2.5*x2 + 2.5*x3 + 2.5*x4 <= 1000;

!NON-NEGATIVE ;
x1 >= 0; x2 >= 0; x3 >= 0; x4 >= 0;

d1plus >= 0; d1minus >= 0;
d2plus >= 0; d2minus >= 0;
d3plus >= 0; d3minus >= 0;
d4plus >= 0; d4minus >= 0;
d5plus >= 0; d5minus >= 0;
d6plus >= 0; d6minus >= 0;
d7plus >= 0; d7minus >= 0;

END

```

Output Lingo Contoh *Multi-Objective* dengan *Goal Programming* (GP):

Variable	Value	Reduced Cost
D1MINUS	0.000000	2.997820
D2PLUS	0.000000	2.000000
D3PLUS	0.000000	2.000000
D4MINUS	0.000000	0.9951177
D5MINUS	0.000000	0.4720139
D6MINUS	0.000000	1.000000
D7MINUS	7.334655	0.000000
X1	180.0000	0.000000
X2	60.00000	0.000000
X3	87.04688	0.000000
X4	32.66535	0.000000
D1PLUS	0.000000	0.2179599E-02
D2MINUS	2.877698	0.000000
D3MINUS	1805.755	0.000000
D4PLUS	0.000000	0.4882302E-02
D5PLUS	0.000000	0.5279861
D6PLUS	57.04688	0.000000
D7PLUS	0.000000	1.000000

LAMPIRAN 2

Variabel keputusan:

x_1 : jumlah produk A yang diproduksi.

x_2 : jumlah produk B yang diproduksi.

Fungsi tujuan:

$$\min Z = P_1 d_1^- + P_2 d_2^- + P_3 d_3^-$$

Fungsi kendala:

$$x_1 + 2x_2 + d_1^- - d_1^+ = 40$$

$$4x_2 + 5x_2 + d_2^- - d_2^+ = 160$$

$$4x_2 + 3x_2 + d_3^- - d_3^+ = 120$$

$$x_1, x_2, d_1^-, d_1^+, d_2^-, d_2^+, d_3^-, d_3^+ \geq 0$$

Berikut merupakan tahap iterasi untuk penyelesaian contoh *Goal Programming* (GP) simpleks modifikasi:

Tabel.1 Tabel Iterasi 1 GP dengan Simpleks Modifikasi

P_i	c_j	c_j	0	0	1	1	1	0	0	0	RHS
		VB	x_1	x_2	d_1^-	d_2^-	d_3^-	d_1^+	d_2^+	d_3^+	
P_1	1	d_1^-	1	2	1	0	0	-1	0	0	40
P_2	1	d_2^-	4	5	0	1	0	0	-1	0	160
P_3	1	d_3^-	4	3	0	0	1	0	0	-1	120
Z_j		P_1	1	2	1	0	0	-1	0	0	40
		P_2	4	5	0	1	0	0	-1	0	160
		P_3	4	3	0	0	1	0	0	-1	120
$Z_j - c_j$		P_1	1	2	0	-1	-1	-1	0	0	
		P_2	4	5	-1	0	-1	0	-1	0	
		P_3	4	3	-1	-1	0	0	0	-1	

Iterasi 1:

$$B_1'' = B_1' \begin{pmatrix} 1 \\ 2 \end{pmatrix}$$

$$B_2'' = B_2' - 5(B_1'')$$

$$B_3'' = B_3' - 3(B_1'')$$

Tabel 2. Tabel Iterasi 2 GP dengan Simpleks Modifikasi

P_i	c_j	c_j	0	0	1	1	1	0	0	0	RHS
		VB	x_1	x_2	d_1^-	d_2^-	d_3^-	d_1^+	d_2^+	d_3^+	
	0	x_2	$\frac{1}{2}$	1	$\frac{1}{2}$	0	0	$-\frac{1}{2}$	0	0	20
P_2	1	d_2^-	$\frac{3}{2}$	0	$-\frac{5}{2}$	1	0	$\frac{5}{2}$	-1	0	60
P_3	1	d_3^-	$\frac{5}{2}$	0	$-\frac{3}{2}$	0	1	$\frac{3}{2}$	0	-1	60
Z_j	P_2		$\frac{3}{2}$	0	$-\frac{5}{2}$	1	0	$\frac{5}{2}$	-1	0	60
	P_3		$\frac{5}{2}$	0	$-\frac{3}{2}$	0	1	$\frac{3}{2}$	0	-1	60
$Z_j - c_j$	P_2		$\frac{3}{2}$	0	$-\frac{7}{2}$	0	-1	$\frac{5}{2}$	-1	0	
	P_3		$\frac{5}{2}$	0	$-\frac{5}{2}$	-1	0	$\frac{3}{2}$	0	-1	

Iterasi 2:

$$B_2''' = B_2'' \left(\frac{2}{5} \right) \quad B_1''' = B_1'' + \frac{1}{2} (B_2''') \quad B_3''' = B_3'' - \frac{3}{2} (B_2''')$$

Tabel 3. Tabel Iterasi 3 GP dengan Simpleks Modifikasi

P_i	c_j	c_j	0	0	1	1	1	0	0	0	RHS
		VB	x_1	x_2	d_1^-	d_2^-	d_3^-	d_1^+	d_2^+	d_3^+	
	0	x_2	$\frac{4}{5}$	1	0	$\frac{1}{5}$	0	0	$-\frac{1}{5}$	0	32
	0	d_1^+	$\frac{3}{5}$	0	-1	$\frac{2}{5}$	0	1	$-\frac{2}{5}$	0	24
P_3	1	d_3^-	$\frac{8}{5}$	0	0	$-\frac{3}{5}$	1	0	$\frac{3}{5}$	-1	24
Z_j	P_3		$\frac{8}{5}$	0	0	$-\frac{3}{5}$	1	0	$\frac{3}{5}$	-1	24
$Z_j - c_j$	P_3		$\frac{8}{5}$	0	-1	$-\frac{8}{5}$	0	0	$\frac{3}{5}$	-1	

Iterasi 3:

$$B_3'''' = B_3''' \left(\frac{5}{8} \right) \quad B_1'''' = B_1''' - \frac{4}{5} (B_3''''') \quad B_2'''' = B_2''' - \frac{3}{5} (B_3''''')$$

LAMPIRAN 3

Variabel keputusan:

x_1 : jumlah produksi produk 1.

x_2 : jumlah produksi produk 2.

x_3 : jumlah produksi produk 3.

Fungsi tujuan:

$$\min Z = d_1^+ + 5d_1^- + e_1^+ + e_1^- + 3d_2^+ + e_2^+ + e_2^-$$

Fungsi kendala:

Goal Constraint 1:

$$\begin{aligned} 12x_1 + 9x_2 + 15x_3 + d_1^- - d_1^+ &= y_1 \\ 125 \leq y_1 &\leq 155 \\ y_1 - e_1^+ + e_1^- &= 155 \end{aligned}$$

Goal Constraint 2:

$$\begin{aligned} 5x_1 + 7x_2 + 8x_3 + d_2^- - d_2^+ &= y_2 \\ 40 \leq y_2 &\leq 55 \\ y_2 - e_2^+ + e_2^- &= 40 \\ x_1, x_2, x_3, d_1^-, d_1^+, d_2^-, d_2^+ &\geq 0 \end{aligned}$$

Berikut merupakan tahap iterasi untuk penyelesaian contoh *Multi-Choice Goal Programming* (MCGP) Simpleks Modifikasi:

Tabel 4. Tabel Iterasi 1 MCGP Simpleks Modifikasi

c_j		0	0	0	5	1	1	1	0	3	1	1	b_i	
c_j	VB	x_1	x_2	x_3	d_1^-	d_1^+	e_1^-	e_1^+	d_2^-	d_2^+	e_2^-	e_2^+		
5	d_1^-	12	9	15	1	-1	0	0	0	0	0	0	125	
1	e_1^-	0	0	0	0	0	1	-1	0	0	0	0	155	
3	d_2^+	5	7	8	0	0	0	0	1	-1	0	0	55	
1	e_2^+	0	0	0	0	0	0	0	0	0	1	-1	40	
Z_j		60	45	75	5	-5	0	0	0	0	0	0	625	
		0	0	0	0	0	1	-1	0	0	0	0	155	
		15	21	24	0	0	0	0	0	3	-3	0	0	165
		0	0	0	0	0	0	0	0	0	0	1	-1	40
$Z_j - c_j$		60	45	75	0	-6	-1	-1	0	-3	-1	-1		
		0	0	0	-5	-1	0	-2	0	-3	-1	-1		
		15	21	24	-5	-1	-1	-1	3	-6	-1	-1		
		0	0	0	-5	-1	-1	-1	0	-3	0	-2		

Iterasi 1:

$$B_3'' = B_3' \left(\frac{1}{8} \right) \quad B_1'' = B_1' - 15(B_3'') \quad B_2'' = B_2' \quad B_4'' = B_4'$$

Tabel 5. Tabel Iterasi 2 MCGP Simpleks Modifikasi

c_j		0	0	0	5	1	1	1	0	3	1	1	b_i
c_j	VB	x_1	x_2	x_3	d_1^-	d_1^+	e_1^-	e_1^+	d_2^+	d_2^+	e_2^-	e_2^+	
5	d_1^-	$\frac{21}{8}$	$-\frac{33}{8}$	0	1	-1	0	0	$-\frac{15}{8}$	$\frac{15}{8}$	0	0	$\frac{175}{8}$
1	e_1^-	0	0	0	0	0	1	-1	0	0	0	0	155
0	x_3	$\frac{5}{8}$	$\frac{7}{8}$	1	0	0	0	0	$\frac{1}{8}$	$-\frac{1}{8}$	0	0	$\frac{55}{8}$
1	e_2^+	0	0	0	0	0	0	0	0	0	1	-1	40
Z_j		$\frac{105}{8}$	$-\frac{165}{8}$	0	5	-5	0	0	$-\frac{75}{8}$	$\frac{75}{8}$	0	0	175
		0	0	0	0	0	1	-1	0	0	0	0	155
		0	0	0	0	0	0	0	0	0	1	-1	40
$Z_j - c_j$		$\frac{105}{8}$	$-\frac{165}{8}$	0	0	-6	-1	-1	$-\frac{75}{8}$	$\frac{51}{8}$	-1	-1	
		0	0	0	-5	-1	0	-2	0	-3	-1	-1	
		0	0	0	-5	-1	-1	-1	0	-3	0	-2	

Iterasi 2:

$$B_1''' = B_1'' \left(\frac{8}{21} \right) \quad B_2''' = B_2'' \quad B_3''' = B_3'' - \frac{5}{8}(B_1''') \quad B_4''' = B_4''$$

LAMPIRAN 4

Input Lingo Contoh *Multi-Choice Goal Programming* (MCGP):

```

MIN = 5*D1minus + D1plus + E1plus + E1minus + 3*D2plus +
E2plus + E2minus ;

!GOAL 1 : KEUNTUNGAN (MCGP-RLUF) ;
12*X1 + 9*X2 + 15*X3 - D1plus + D1minus = Y1 ;
Y1 - E1plus + E1minus = 155 ;
Y1 >= 125 ;
Y1 <= 155 ;

!GOAL 2 : INVESTASI MODAL (MCGP-LLUF) ;
5*X1 + 7*X2 + 8*X3 - D2plus + D2minus = Y2 ;
Y2 - E2plus + E2minus = 40 ;
Y2 >= 40 ;
Y2 <= 55 ;

!NON-NEGATIVITY ;
X1 >= 0 ;
X2 >= 0 ;
X3 >= 0 ;

D1plus >= 0 ; D1minus >= 0 ;
D2plus >= 0 ; D2minus >= 0 ;

E1plus >= 0 ; E1minus >= 0 ;
E2plus >= 0 ; E2minus >= 0 ;

END

```

Output Lingo Contoh *Multi-Choice Goal Programming* (MCGP):

Variable	Value	Reduced Cost
D1MINUS	0.000000	4.000000
D1PLUS	0.000000	2.000000
E1PLUS	0.000000	2.000000
E1MINUS	23.00000	0.000000
D2PLUS	0.000000	0.600000
E2PLUS	15.00000	0.000000
E2MINUS	0.000000	2.000000
X1	11.00000	0.000000
X2	0.000000	7.800000
X3	0.000000	4.200000
Y1	132.0000	0.000000
D2MINUS	0.000000	2.400000
Y2	55.00000	0.000000

LAMPIRAN 5

Input PuLP Contoh *Multi-Choice Goal Programming* (MCGP):

```
import pulp
model = pulp.LpProblem("MCGP_Model", pulp.LpMinimize)
# Decision Variables
X1 = pulp.LpVariable("X1", lowBound=0)
X2 = pulp.LpVariable("X2", lowBound=0)
X3 = pulp.LpVariable("X3", lowBound=0)
# Aspirational Variables
Y1 = pulp.LpVariable("Y1", lowBound=0)
Y2 = pulp.LpVariable("Y2", lowBound=0)
# Deviation Variables
D1plus = pulp.LpVariable("D1plus", lowBound=0)
D1minus = pulp.LpVariable("D1minus", lowBound=0)
D2plus = pulp.LpVariable("D2plus", lowBound=0)
E1plus = pulp.LpVariable("E1plus", lowBound=0)
E1minus = pulp.LpVariable("E1minus", lowBound=0)
E2plus = pulp.LpVariable("E2plus", lowBound=0)
E2minus = pulp.LpVariable("E2minus", lowBound=0)
# Objective Function
model += (5*D1minus + D1plus + E1plus + E1minus + 3*D2plus +
E2plus + E2minus)
# GOAL 1 - PROFIT
model += 12*X1 + 9*X2 + 15*X3 - D1plus + D1minus == Y1
model += Y1 - E1plus + E1minus == 155
model += Y1 >= 125
model += Y1 <= 155
# GOAL 2 - INVESTMENT
model += 5*X1 + 7*X2 + 8*X3 - D2plus + D2minus == Y2
model += Y2 - E2plus + E2minus == 40
model += Y2 >= 40
model += Y2 <= 55
# Solve Model
model.solve()
# Print Results
print("Status:", pulp.LpStatus[model.status])
for var in model.variables():
    print(var.name, "=", var.varValue)
print("Objective Value =", pulp.value(model.objective))
```

Output PuLP Contoh *Multi-Choice Goal Programming* (MCGP):

```
Status: Optimal
D1minus = 0.0
D1plus = 0.0
D2minus = 0.0
D2plus = 0.0
E1minus = 23.0
E1plus = 0.0
E2minus = 0.0
E2plus = 15.0
X1 = 11.0
X2 = 0.0
X3 = 0.0
Y1 = 132.0
Y2 = 55.0
Objective Value = 38.0
```

LAMPIRAN 6

Variabel keputusan:

x_1 : jumlah produksi produk 1.

x_2 : jumlah produksi produk 2.

x_3 : jumlah produksi produk 3.

Fungsi tujuan:

$$\min Z = d_1^+ + 5d_1^- + f_1^- + 3d_2^+ + f_2^-$$

Goal Constraint 1:

$$12x_1 + 9x_2 + 15x_3 + d_1^- - d_1^+ = y_1$$

$$125 \leq y_1 \leq 155$$

$$\lambda_1 \leq \frac{155 - y_1}{155 - 125}$$

$$\lambda_1 + f_1^- = 1$$

Goal Constraint 2:

$$5x_1 + 7x_2 + 8x_3 + d_2^- - d_2^+ = y_2$$

$$40 \leq y_2 \leq 55$$

$$\lambda_2 \leq \frac{y_2 - 40}{55 - 40}$$

$$\lambda_2 + f_2^- = 1$$

$$x_1, x_2, d_1^-, d_1^+, d_2^-, d_2^+ \geq 0$$

Berikut merupakan tahap iterasi untuk penyelesaian contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U) Simpleks Modifikasi:

Tabel 6. Tabel Iterasi 1 MCGP-U Simpleks Modifikasi

C_j		0	0	0	5	1	1	0	3	1	b_i
c_j	VB	x_1	x_2	x_3	d_1^-	d_1^+	f_1^-	d_2^-	d_2^+	f_2^-	
5	d_1^-	12	9	15	1	-1	0	0	0	0	125
1	f_1^-	0	0	0	0	0	1	0	0	0	1
3	d_2^+	5	7	8	0	0	0	1	-1	0	55
1	f_2^-	0	0	0	0	0	0	0	0	1	1
Z_j		60	45	75	5	-5	0	0	0	0	625
		0	0	0	0	0	1	0	0	0	1
		15	21	24	0	0	0	3	-3	0	165
		0	0	0	0	0	0	0	0	1	1
$Z_j - c_j$		60	45	75	0	-6	-1	0	-3	-1	
		0	0	0	-5	-1	0	0	-3	-1	
		15	21	24	-5	-1	-1	3	-6	-1	
		0	0	0	-5	-1	-1	0	-3	0	

Iterasi 1:

$$B_3'' = B_3' \left(\frac{1}{8} \right) \quad B_1'' = B_1' - 15(B_3'') \quad B_2'' = B_2' \quad B_4'' = B_4'$$

Tabel 7. Tabel Iterasi 2 MCGP-U Simpleks Modifikasi

C_j		0	0	0	5	1	1	0	3	1	b_i
c_j	VB	x_1	x_2	x_3	d_1^-	d_1^+	f_1^-	d_2^-	d_2^+	f_2^-	
5	d_1^-	$\frac{21}{8}$	$-\frac{33}{8}$	0	1	-1	0	$-\frac{15}{8}$	$\frac{15}{8}$	0	$\frac{175}{8}$
1	f_1^-	0	0	0	0	0	1	0	0	0	1
0	x_3	$\frac{5}{8}$	$\frac{7}{8}$	1	0	0	0	$\frac{1}{8}$	$-\frac{1}{8}$	0	$\frac{55}{8}$
1	f_2^-	0	0	0	0	0	0	0	0	1	1
Z_j		$\frac{105}{8}$	$-\frac{165}{8}$	0	5	-5	0	$-\frac{75}{8}$	$\frac{75}{8}$	0	$\frac{875}{8}$
		0	0	0	0	0	1	0	0	0	1
		0	0	0	0	0	0	0	0	1	1
$Z_j - c_j$		$\frac{105}{8}$	$-\frac{165}{8}$	0	0	-6	-1	$-\frac{75}{8}$	$\frac{51}{8}$	-1	
		0	0	0	-5	-1	0	0	-3	-1	
		0	0	0	-5	-1	-1	0	-3	0	

Iterasi 2:

$$B_1''' = B_1'' \left(\frac{8}{21} \right) \quad B_2''' = B_2'' \quad B_3''' = B_3'' - \frac{5}{8}(B_1''') \quad B_4''' = B_4''$$

LAMPIRAN 7

Input Lingo Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U):

```
MIN = D1plus + 5*D1minus + F1minus + 3*D2plus +
F2minus ;

! GOAL 1 (PROFIT) ;
12*X1 + 9*X2 + 15*X3 + D1minus - D1plus = Y1;
!INTERVAL TARGET ;
Y1 >= 125;
Y1 <= 155;
! FUNGSI UTILITAS RLUF ;
L1 <= (Y1 - 125) / (155 - 125);
L1 + F1minus = 1;

! GOAL 2 (INVESTMENT);
5*X1 + 7*X2 + 8*X3 + D2minus - D2plus = Y2;
! INTERVAL TARGET ;
Y2 >= 40;
Y2 <= 55;
! FUNGSI UTILITAS LLUF ;
L2 <= (55 - Y2) / (55 - 40);
L2 + F2minus = 1;

! VARIABEL KEPUTUSAN ;
X1 >= 0;
X2 >= 0;
X3 >= 0;

! NON NEGATIVITY ;
X1 >= 0 ;
X2 >= 0 ;
X3 >= 0 ;
D1plus >= 0 ;
D1minus >= 0 ;
D2plus >= 0 ;
D2minus >= 0 ;
F1minus >= 0 ;
F2minus >= 0 ;
L1 >= 0 ;
L1 <= 1 ;
L2 >= 0 ;
L2 <= 1 ;

END
```

Output Lingo Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U):

Variable	Value	Reduced Cost
D1PLUS	0.000000	1.033333
D1MINUS	0.000000	4.966667
F1MINUS	0.7666667	0.000000
D2PLUS	0.000000	2.920000
F2MINUS	1.000000	0.000000
X1	11.00000	0.000000
X2	0.000000	0.2600000
X3	0.000000	0.1400000
Y1	132.0000	0.000000
L1	0.2333333	0.000000
D2MINUS	0.000000	0.8000000E-01
Y2	55.00000	0.000000
L2	0.000000	0.000000

LAMPIRAN 8

Input PuLP Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U):

```
import pulp
# MODEL
model = pulp.LpProblem("MCGP_Utility", pulp.LpMinimize)
# VARIABEL KEPUTUSAN
X1 = pulp.LpVariable('X1', lowBound=0)
X2 = pulp.LpVariable('X2', lowBound=0)
X3 = pulp.LpVariable('X3', lowBound=0)
# VARIABEL SASARAN
Y1 = pulp.LpVariable('Y1')
Y2 = pulp.LpVariable('Y2')
# DEVIASI
D1plus = pulp.LpVariable('D1plus', lowBound=0)
D1minus = pulp.LpVariable('D1minus', lowBound=0)
D2plus = pulp.LpVariable('D2plus', lowBound=0)
D2minus = pulp.LpVariable('D2minus', lowBound=0)
# UTILITY
L1 = pulp.LpVariable('L1', lowBound=0, upBound=1)
F1minus = pulp.LpVariable('F1minus', lowBound=0)
L2 = pulp.LpVariable('L2', lowBound=0, upBound=1)
F2minus = pulp.LpVariable('F2minus', lowBound=0)
# GOAL 1: PROFIT (MCGPU - RLUF)
model += 12*X1 + 9*X2 + 15*X3 - D1plus + D1minus == Y1
model += Y1 >= 125
model += Y1 <= 155
# FUNGSI UTILITAS (RLUF)
model += L1 <= (Y1 - 125) / 30
model += L1 + F1minus == 1
# GOAL 2: INVESTMENT (MCGPU - LLUF)
model += 5*X1 + 7*X2 + 8*X3 - D2plus + D2minus == Y2
model += Y2 >= 40
model += Y2 <= 55
model += L2 <= (55 - Y2) / 15
model += L2 + F2minus == 1
# OBJECTIVE FUNCTION
model += ( D1plus + 5*D1minus + F1minus + 3*D2plus +
F2minus )
# SOLVE
model.solve()
# OUTPUT
print("\n===== HASIL =====")
for v in model.variables():
    print(v.name, "=", v.varValue)
```

Output PuLP Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U):

```
===== HASIL =====  
D1minus = 0.0  
D1plus = 0.0  
D2minus = 0.0  
D2plus = 0.0  
F1minus = 0.76666667  
F2minus = 1.0  
L1 = 0.23333333  
L2 = 0.0  
X1 = 11.0  
X2 = 0.0  
X3 = 0.0  
Y1 = 132.0  
Y2 = 55.0
```

LAMPIRAN 9

Input Lingo Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U) Versi 1:

```
MIN = D1plus + D1minus + E1plus + E1minus + D2plus +
D2minus + F1minus + D3plus + D3minus + F2minus ;

! GOAL (1): KEUNTUNGAN (MCGP) ;
8*X1 + 9*X2 + 6.5*X3 - D1plus + D1minus = Y1 ;
Y1 >= 50 ;
Y1 <= 100 ;
Y1 - E1plus + E1minus = 100 ;

! GOAL (2): TENAGA KERJA (MCGPU-LLUF) ;
X1 + 0.2*X2 + 0.5*X3 - D2plus + D2minus = Y2 ;
Y2 >= 5 ;
Y2 <= 8 ;
L1 <= (8 - Y2) / 3 ;
L1 + F1minus = 1 ;

! GOAL (3): INVESTASI MODAL KUALITAS (MCGPU-RLUF) ;
2*X1 + 3*X2 + 2.4*X3 - D3plus + D3minus = Y3 ;
Y3 >= 20 ;
Y3 <= 100 ;
L2 <= (Y3 - 20) / 80 ;
L2 + F2minus = 1 ;

! KENDALA KERAS ;
5*X1 + 7*X2 + 5.5*X3 <= 40 ;
X1 >= 2 ;
X2 >= 2 ;
X3 >= 2 ;

! NON-NEGATIVITY ;
X1 >= 0 ;
X2 >= 0 ;
X3 >= 0 ;
D1plus >= 0 ;
D1minus >= 0 ;
E1plus >= 0 ;
E1minus >= 0 ;
D2plus >= 0 ;
D2minus >= 0 ;
D3plus >= 0 ;
D3minus >= 0 ;
```

```

F1minus >= 0 ;
F2minus >= 0 ;

L1 >= 0 ;
L1 <= 1 ;
L2 >= 0 ;
L2 <= 1 ;

END

```

Output Lingo Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U) Versi 1:

Variable	Value	Reduced Cost
D1PLUS	0.000000	2.000000
D1MINUS	0.000000	0.000000
E1PLUS	0.000000	2.000000
E1MINUS	45.000000	0.000000
D2PLUS	0.000000	2.000000
D2MINUS	0.600000	0.000000
F1MINUS	0.000000	0.000000
D3PLUS	0.000000	2.000000
D3MINUS	3.200000	0.000000
F2MINUS	1.000000	0.000000
X1	3.000000	0.000000
X2	2.000000	0.000000
X3	2.000000	0.000000
Y1	55.000000	0.000000
Y2	5.000000	0.000000
L1	1.000000	0.000000
Y3	20.000000	0.000000
L2	0.000000	0.000000

LAMPIRAN 10

Input PuLP Contoh Multi-Choice Goal Programming dengan fungsi utilitas (MCGP-U) Versi 1:

```
import pulp
# MODEL MCGPU VERSI 1 SEBELUM REVISI
model = pulp.LpProblem("MCGP_Utility", pulp.LpMinimize)
# VARIABEL KEPUTUSAN
X1 = pulp.LpVariable('X1', lowBound=2)
X2 = pulp.LpVariable('X2', lowBound=2)
X3 = pulp.LpVariable('X3', lowBound=2)
# VARIABEL SASARAN
Y1 = pulp.LpVariable('Y1')
Y2 = pulp.LpVariable('Y2')
Y3 = pulp.LpVariable('Y3')
# DEVIASI
D1plus = pulp.LpVariable('D1plus', lowBound=0)
D1minus = pulp.LpVariable('D1minus', lowBound=0)
D2plus = pulp.LpVariable('D2plus', lowBound=0)
D2minus = pulp.LpVariable('D2minus', lowBound=0)
D3plus = pulp.LpVariable('D3plus', lowBound=0)
D3minus = pulp.LpVariable('D3minus', lowBound=0)
E1plus = pulp.LpVariable('E1plus', lowBound=0)
E1minus = pulp.LpVariable('E1minus', lowBound=0)
# UTILITY
L1 = pulp.LpVariable('L1', lowBound=0, upBound=1)
L2 = pulp.LpVariable('L2', lowBound=0, upBound=1)
F1minus = pulp.LpVariable('F1minus', lowBound=0)
F2minus = pulp.LpVariable('F2minus', lowBound=0)
# GOAL 1 (PROFIT)
model += 8*X1 + 9*X2 + 6.5*X3 - D1plus + D1minus == Y1
model += Y1 >= 50
model += Y1 <= 100
model += Y1 - E1plus + E1minus == 100
# GOAL 2 (TENAGA KERJA)
model += X1 + 0.2*X2 + 0.5*X3 - D2plus + D2minus == Y2
model += Y2 >= 5
model += Y2 <= 8
# FUNGSI UTILITAS (LLUF)
model += L1 <= (8 - Y2)/3
model += L1 + F1minus == 1
# GOAL 3 (INVESTASI MODAL)
model += 2*X1 + 3*X2 + 2.4*X3 - D3plus + D3minus == Y3
model += Y3 >= 20
model += Y3 <= 100
# FUNGSI UTILITAS (RLUF)
```

```

model += L2 <= (Y3 - 20)/80
model += L2 + F2minus == 1
# KENDALA KERAS
model += 5*X1 + 7*X2 + 5.5*X3 <= 40
# OBJECTIVE (UTILITY PRIORITY)
model += (D1plus + D1minus + E1plus + E1minus + D2plus +
D2minus + F1minus + D3plus + D3minus + F2minus)
# SOLVE
model.solve()
# OUTPUT
print("\n===== HASIL =====")
for v in model.variables():
    print(v.name, "=", v.varValue)

```

Output PuLP Contoh Multi-Choice Goal Programming dengan fungsi utilitas (MCGP-U) Versi 1:

```

===== HASIL =====
D1minus = 0.0
D1plus = 0.0
D2minus = 0.6
D2plus = 0.0
D3minus = 3.2
D3plus = 0.0
E1minus = 45.0
E1plus = 0.0
F1minus = -0.0
F2minus = 1.0
L1 = 1.0
L2 = 0.0
X1 = 3.0
X2 = 2.0
X3 = 2.0
Y1 = 55.0
Y2 = 5.0
Y3 = 20.0

```

LAMPIRAN 11

Input Lingo Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U) Versi 2:

```
MIN = D1plus + D1minus + E1plus + E1minus + D2plus + D2minus
+ F1minus + D3plus + D3minus + F2minus ;

! GOAL (1): KEUNTUNGAN (MCGP) ;
8*X1 + 9*X2 + 6.5*X3 - D1plus + D1minus = Y1 ;
Y1 >= 50 ;
Y1 <= 100 ;
Y1 - E1plus + E1minus = 100 ;

! GOAL (2): TENAGA KERJA (MCGPU) ;
! LLUF versi Chang 2014 (piecewise linear) ;
X1 + 0.2*X2 + 0.5*X3 - D2plus + D2minus = Y2 ;
Y2 >= 0 ;
Y2 <= 8 ;
! fungsi utilitas (Chang 2014) ;
! segmen:
!Y2 <= 5 (puas penuh) ;
!5 < Y2 < 7 (kepuasan turun linear) ;
!Y2 >= 7 (tidak puas) ;
L1 <= 1 ;
L1 <= (7 - Y2) / 2 ;
L1 + F1minus = 1 ;

! GOAL (3): INVESTASI MODAL (MCGPU) ;
! RLUF versi Chang 2014 (piecewise linear) ;
2*X1 + 3*X2 + 2.4*X3 - D3plus + D3minus = Y3 ;
Y3 >= 0 ;
Y3 <= 100 ;
! fungsi utilitas (Chang 2014) ;
! segmen:
!Y3 <= 35 (tidak puas) ;
!35 < Y3 < 100 (kepuasan naik linear) ;
!Y3 >= 100 (puas penuh) ;
L2 <= 1 ;
L2 <= (Y3 - 35) / 65 ;
L2 + F2minus = 1 ;

! KENDALA KERAS ;
5*X1 + 7*X2 + 5.5*X3 <= 40 ;
X1 >= 2 ;
X2 >= 2 ;
X3 >= 2 ;
```

```

! NON-NEGATIVITY ;
X1 >= 0 ;
X2 >= 0 ;
X3 >= 0 ;

D1plus >= 0 ;
D1minus >= 0 ;
E1plus >= 0 ;
E1minus >= 0 ;
D2plus >= 0 ;
D2minus >= 0 ;
D3plus >= 0 ;
D3minus >= 0 ;

F1minus >= 0 ;
F2minus >= 0 ;

END

```

Output Lingo Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U) Versi 2:

Variable	Value	Reduced Cost
D1PLUS	0.000000	2.000000
D1MINUS	0.000000	0.000000
E1PLUS	0.000000	2.000000
E1MINUS	45.00000	0.000000
D2PLUS	0.000000	1.000000
D2MINUS	0.000000	1.000000
F1MINUS	0.000000	0.000000
D3PLUS	0.000000	2.000000
D3MINUS	18.20000	0.000000
F2MINUS	1.000000	0.000000
X1	3.000000	0.000000
X2	2.000000	0.000000
X3	2.000000	0.000000
Y1	55.00000	0.000000
Y2	4.400000	0.000000
L1	1.000000	0.000000
Y3	35.00000	0.000000
L2	0.000000	64.00000

LAMPIRAN 12

Input PuLP Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U) Versi 2:

```
import pulp
# MODEL MCGPU VERSI 2 SESUDAH REVISI
model = pulp.LpProblem("MCGP_Utility", pulp.LpMinimize)
# VARIABEL KEPUTUSAN
X1 = pulp.LpVariable('X1', lowBound=2)
X2 = pulp.LpVariable('X2', lowBound=2)
X3 = pulp.LpVariable('X3', lowBound=2)
# VARIABEL SASARAN
Y1 = pulp.LpVariable('Y1')
Y2 = pulp.LpVariable('Y2')
Y3 = pulp.LpVariable('Y3')
# DEVIASI
D1plus = pulp.LpVariable('D1plus', lowBound=0)
D1minus = pulp.LpVariable('D1minus', lowBound=0)
D2plus = pulp.LpVariable('D2plus', lowBound=0)
D2minus = pulp.LpVariable('D2minus', lowBound=0)
D3plus = pulp.LpVariable('D3plus', lowBound=0)
D3minus = pulp.LpVariable('D3minus', lowBound=0)
E1plus = pulp.LpVariable('E1plus', lowBound=0)
E1minus = pulp.LpVariable('E1minus', lowBound=0)
# UTILITY
L1 = pulp.LpVariable('L1', lowBound=0, upBound=1)
L2 = pulp.LpVariable('L2', lowBound=0, upBound=1)
F1minus = pulp.LpVariable('F1minus', lowBound=0)
F2minus = pulp.LpVariable('F2minus', lowBound=0)
# GOAL 1 (PROFIT)
model += 8*X1 + 9*X2 + 6.5*X3 - D1plus + D1minus == Y1
model += Y1 >= 50
model += Y1 <= 100
model += Y1 - E1plus + E1minus == 100
# GOAL 2 (TENAGA KERJA)
model += X1 + 0.2*X2 + 0.5*X3 - D2plus + D2minus == Y2
model += Y2 >= 0
model += Y2 <= 8
# FUNGSI UTILITAS (LLUF)
model += L1 <= (7 - Y2)/2
model += L1 + F1minus == 1
# GOAL 3 (INVESTASI MODAL)
model += 2*X1 + 3*X2 + 2.4*X3 - D3plus + D3minus == Y3
model += Y3 >= 0
model += Y3 <= 100
# FUNGSI UTILITAS (RLUF)
```

```

model += L2 <= (Y3 - 35)/65
model += L2 + F2minus == 1
# KENDALA KERAS
model += 5*X1 + 7*X2 + 5.5*X3 <= 40
# OBJECTIVE (UTILITY PRIORITY)
model += (D1plus + D1minus + E1plus + E1minus + D2plus +
D2minus + F1minus + D3plus + D3minus + F2minus)
# SOLVE
model.solve()
# OUTPUT
print("\n===== HASIL =====")
for v in model.variables():
    print(v.name, "=", v.varValue)

```

Output PuLP Contoh *Multi-Choice Goal Programming* dengan fungsi utilitas (MCGP-U) Versi 2:

```

===== HASIL =====
D1minus = 0.0
D1plus = 0.0
D2minus = 0.0
D2plus = 0.0
D3minus = 18.2
D3plus = 0.0
E1minus = 45.0
E1plus = 0.0
F1minus = -0.0
F2minus = 1.0
L1 = 1.0
L2 = 0.0
X1 = 3.0
X2 = 2.0
X3 = 2.0
Y1 = 55.0
Y2 = 4.4
Y3 = 35.0

```

LAMPIRAN 13

Untuk memudahkan akses terhadap kode program dan hasil optimasi secara lengkap, disediakan QR Code yang mengarahkan pembaca ke dokumen berisi kode program Python (PuLP), model Lingo, serta hasil penyelesaian penelitian ini.



Dengan demikian, seluruh kode program dan hasil optimasi yang digunakan dalam penelitian ini dapat diakses secara mudah melalui QR Code yang telah disediakan.