LAMPIRAN

Lampiran 1 Data Jarak dari Depot ke Customer dan dari Customer ke Customer (KM)

No	Kode lokasi	depot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Depot	0	10,5	5	8,8	8,8	7	4,5	11	4,8	4	5	6,3	4,9	4,4	8	8,5	4,3	6	6,5	6,9	5
2	K1	10,5	0	6	4,2	5,2	1,8	6,2	12,2	5,7	5,9	7,3	4,5	7	4,2	2,5	1.2	7	5,5	3,6	2,5	4,7
3	K2	5	6,5	0	2,9	2,7	5,5	4	9,4	1	3,5	5,4	2	4,7	3,4	6,5	7,5	5	4,9	12,5	5,5	3,6
4	K3	8,8	7,6	1,5	0	4	5,5	2,7	10	1,4	2.3	4	3	3,4	1,8	5	6,7	3,6	3,5	11	3,8	2,2
5	K4	9,8	4,5	1,8	1,5	0	4,5	6,4	8,4	2,5	5	6,7	1	6,5	4,8	6,3	5,6	6,5	6,1	13,2	4,5	2,9
6	K5	7	1,4	4,1	3,4	4	0	5,5	11,4	4,6	5,2	6,6	4	6,3	4,5	2	1	6,7	5,5	10	2	4,3
7	K6	4,5	7,3	5	3,3	6,6	5,5	0	11,7	4,5	1	1,5	5,3	1,3	2	5,4	6,6	1	2,5	8,7	4	2,4
8	K7	11	11,4	8,5	9	7,6	10,5	11	0	9	10,5	12,5	9,7	11,8	10,5	13	12,4	12,2	12	19	11,5	9,7
9	K8	4,8	6,7	1	1,2	3,4	6,4	3,7	9,5	0	3,2	5,2	1,6	4,5	3	6,4	7,8	4,8	4,9	4,5	5	3,5
10	K9	4	7	4	2,8	6,4	5,3	1,5	11	4	0	2,7	5	2,5	1,8	5	6,5	2,5	2,4	9,7	3,8	2,4
11	K10	5	8,2	5,4	4	7,8	7	1,5	15	5,6	2	0	6,5	1	3,5	6,5	7,6	2	3	3,8	5,4	3,6
12	K11	6,3	6,8	3	3,5	3,1	6	5,2	7,8	1,8	4,9	6,8	0	6	6,2	8,5	6,5	6	6,5	6,6	8	5
13	K12	4,9	8	5,3	3,8	7.5	6,4	1	14,8	5	1,6	1	6	0	3	6,4	7,4	1,5	2,8	3,5	4,8	3,5
14	K13	4,4	5,4	4	3,1	4,8	4	2,8	11,5	4,5	2,5	3,8	4,5	3,5	0	3,5	4,5	3,5	1,5	1,8	2	1,5
15	K14	8	3,4	6	5,3	6,4	2	5,4	13,5	6,5	5	6,4	6	6,2	4,2	0	2,8	6,5	3,4	3	2,2	4,5
16	K15	8,5	2	4,1	3,2	3,8	1	6	11,3	4,5	5,6	7,2	3,8	6,8	4,8	2,5	0	5,8	5,4	4,5	2,5	4
17	K16	4,2	8,2	5,6	4,6	7,7	6,5	1	15	5,6	1,7	2	6,4	1,5	3	6,5	7,7	0	3,8	4,5	5	3,4
18	K17	6	5,4	5,5	4,2	6,2	4	2,5	12,4	5,4	2,8	3	5,6	2,8	1,3	3,4	4,6	3,5	0	1,2	2	2,7
19	K18	6,5	5	6	4,6	6,6	3,7	3,5	12,8	5,8	3,3	3,7	6	3,5	2,5	3,4	4,5	4,3	1,2	0	2,5	3,3
20	K19	6,9	3	4,5	5,7	4,6	2,3	4	12,2	5	3,6	5,4	4,6	4,8	2,8	1,8	3	5	2	2,3	0	3
21	K20	6	5,7	2,8	4,3	3,8	3,8	2,7	10,5	3,3	2,2	3,7	3	3,5	1,8	3,6	5	3,6	3	3,5	2,3	0

Lampiran 2 Data Waktu Tempuh antar Lokasi (menit)

Kode lokasih	depot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Depot	0	12.6	6	10.56	10.2	8.4	5.4	13.2	5.76	4.8	6	7.56	5.88	5.28	9.6	10.2	5.16	7.2	7.8	8.28	6
K1	12.6	0	7.2	5.04	6.24	2.16	7.44	14.64	6.84	7.08	8.76	5.4	8.4	5.04	3	1.44	8.4	6.6	4.32	3	5.64
K2	6	7.8	0	3.48	3.24	6.6	4.8	11.28	1.2	4.2	6.48	2.4	5.64	4.08	7.8	9	6	5.88	15	6.6	4.32
K3	10.56	9.12	1.8	0	4.8	6.6	3.24	12	1.68	2.76	4.8	3.6	4.08	2.16	6	8.04	4.32	4.2	13.2	4.56	2.64
K4	10.2	5.4	2.16	1.8	0	5.4	7.68	10.08	3	6	8.04	1.2	7.8	5.76	7.56	6.72	7.8	7.32	15.84	5.4	3.48
K5	8.4	1.68	4.92	4.08	4.8	0	6.6	13.68	5.52	6.24	7.92	4.8	7.56	5.4	2.4	1.2	8.04	6.6	12	2.4	5.16
K6	5.4	8.76	6	3.96	7.92	6.6	0	14.04	5.4	1.2	1.8	6.36	1.56	2.4	6.48	7.92	1.2	3	10.44	4.8	2.88
K7	13.2	13.68	10.2	10.8	9.12	12.6	13.2	0	10.8	12.6	15	11.64	14.16	12.6	15.6	14.88	14.64	14.4	22.8	13.8	11.64
K8	5.76	8.04	1.2	1.44	4.08	7.68	4.44	11.4	0	3.84	6.24	1.92	5.4	3.6	7.68	9.36	5.76	5.88	5.4	6	4.2
K9	4.8	8.4	4.8	3.36	7.68	6.36	1.8	13.2	4.8	0	3.24	6	3	2.16	6	7.8	3	2.88	11.64	4.56	2.88
K10	6	9.84	6.48	4.8	9.36	8.4	1.8	18	6.72	2.4	0	7.8	1.2	4.2	7.8	9.12	2.4	3.6	4.56	6.48	4.32
K11	7.56	8.16	3.6	4.2	37.2	7.2	6.24	9.36	2.16	5.88	8.16	0	7.2	7.44	10.2	7.8	7.2	7.8	7.92	9.6	6
K12	5.88	9.6	6.36	4.56	9	7.68	1.2	17.76	6	1.92	1.2	7.2	0	3.6	7.68	8.88	1.8	3.36	4.2	5.76	4.2
K13	5.28	6.48	4.8	3.72	5.76	4.8	3.36	13.8	5.4	3	4.56	5.4	4.2	0	4.2	5.4	4.2	1.8	2.16	2.4	1.8
K14	9.6	4.08	7.2	6.36	7.68	2.4	6.48	16.2	7.8	6	7.68	7.2	7.44	5.04	0	3.36	7.8	4.08	3.6	2.64	5.4
K15	10.2	2.4	4.92	3.84	4.56	1.2	7.2	13.56	5.4	6.72	8.64	4.56	8.16	5.76	3	0	6.96	6.48	5.4	3	4.8
K16	5.04	9.84	6.72	5.52	9.24	7.8	1.2	18	6.72	2.04	2.4	7.68	1.8	3.6	7.8	9.24	0	4.56	5.4	6	4.08
K17	7.2	6.48	6.6	5.04	7.44	4.8	3	14.88	6.48	3.36	3.6	6.72	3.36	1.56	4.08	5.52	4.2	0	1.44	2.4	3.24
K18	7.8	6	7.2	5.52	7.92	4.44	4.2	15.36	6.96	3.96	4.44	7.2	4.2	3	4.08	5.4	5.16	1.44	0	3	3.96
K19	8.28	3.6	5.4	6.84	5.52	2.76	4.8	14.64	6	4.32	6.48	5.52	5.76	3.36	2.16	3.6	6	2.4	2.76	0	3.6
K20	7.2	6.84	3.36	5.16	4.56	4.56	3.24	12.6	3.96	2.64	4.44	3.6	4.2	2.16	4.32	6	4.32	3.6	4.2	2.76	0

Lampiran 3 biaya pengiriman (ribuh)

Kode lokasi	depot	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Depot	0	26250	12500	22000	21250	17500	11250	27500	12000	10000	12500	15750	12250	11000	20000	21250	10750	15000	16250	17250	12500
K1	26250	0	15000	10500	13000	4500	15500	30500	14250	14750	18250	11250	17500	10500	6250	3000	17500	13750	9000	6250	11750
K2	12500	16250	0	7250	6750	13750	10000	23500	2500	8750	13500	5000	11750	8500	16250	18750	12500	12250	31250	13750	9000
K3	22000	19000	3750	0	10000	13750	6750	25000	3500	5750	10000	7500	8500	4500	12500	16750	9000	8750	27500	9500	5500
K4	21250	11250	4500	3750	0	11250	16000	21000	6250	12500	16750	2500	16250	12000	15750	14000	16250	15250	33000	11250	7250
K5	17500	3500	10250	8500	10000	0	13750	28500	11500	13000	16500	10000	15750	11250	5000	2500	16750	13750	25000	5000	10750
K6	11250	18250	12500	8250	16500	13750	0	29250	11250	2500	3750	13250	3250	5000	13500	16500	2500	6250	21750	10000	6000
K7	27500	28500	21250	22500	19000	26250	27500	0	22500	26250	31250	24250	29500	26250	32500	31000	30500	30000	47500	28750	24250
K8	12000	16750	2500	3000	8500	16000	9250	23750	0	8000	13000	4000	11250	7500	16000	19500	12000	12250	11250	12500	8750
K9	10000	17500	10000	7000	16000	13250	3750	27500	10000	0	6750	12500	6250	4500	12500	16250	6250	6000	24250	9500	6000
K10	12500	20500	13500	10000	19500	17500	3750	37500	14000	5000	0	16250	2500	8750	16250	19000	5000	7500	9500	13500	9000
K11	15750	17000	7500	8750	77500	15000	13000	19500	4500	12250	17000	0	15000	15500	21250	16250	15000	16250	16500	20000	12500
K12	12250	20000	13250	9500	18750	16000	2500	37000	12500	4000	2500	15000	0	7500	16000	18500	3750	7000	8750	12000	8750
K13	11000	13500	10000	7750	12000	10000	7000	28750	11250	6250	9500	11250	8750	0	8750	11250	8750	3750	4500	5000	3750
K14	20000	8500	15000	13250	16000	5000	13500	33750	16250	12500	16000	15000	15500	10500	0	7000	16250	8500	7500	5500	11250
K15	21250	5000	10250	8000	9500	2500	15000	28250	11250	14000	18000	9500	17000	12000	6250	0	14500	13500	11250	6250	10000
K16	10500	20500	14000	11500	19250	16250	2500	37500	14000	4250	5000	16000	3750	7500	16250	19250	0	9500	11250	12500	8500
K17	15000	13500	13750	10500	15500	10000	6250	31000	13500	7000	7500	14000	7000	3250	8500	11500	8750	0	3000	5000	6750
K18	16250	12500	15000	11500	16500	9250	8750	32000	14500	8250	9250	15000	8750	6250	8500	11250	10750	3000	0	6250	8250
K19	17250	7500	11250	14250	11500	5750	10000	30500	12500	9000	13500	11500	12000	7000	4500	7500	12500	5000	5750	0	7500
K20	15000	14250	7000	10750	9500	9500	6750	26250	8250	5500	9250	7500	8750	4500	9000	12500	9000	7500	8750	5750	0

Lampiran 4 Data Times Windows

No	Nama Toko	Jam buka	Jam tutup
1	Toko Petis JY	06.00	15.00
2	Toko Nur	05.00	11.00
3	Toko Joses	07.00	15.00
4	Toko Kamto	05.00	11.00
5	Toko Abah	04.00	10.00
6	Toko Mumtaza	06.00	10.00
7	Toko Kusen	06.00	17.00
8	Toko Ida	06.00	18.00
9	Toko Soleh	06.00	16.00
10	Toko Jamali	06.00	18.00
11	Toko Pajiyo	08.00	20.00
12	Toko Valfar	05.00	11.00
13	Toko Kurnia	06.00	17.00
14	Toko Rahayu	06.00	18.00
15	Toko Ningrum	07.00	16.00
16	Toko Safira	06.00	16.00
17	Toko Asti	06.00	18.00
18	Toko Fitri	06.00	15.00
19	Toko Anam	05.00	12.00
20	Toko Akbar	06.00	17.00

Lampiran 5 model matematis cluster 1 jarak

```
model:

!parameter model:

      Bongkar     =waktu loading/unloadig di customer
      Durasi      =durasi pengiriman
      D           =jarak antar customer
      t           =waktu mulai pelayanan pada customer
      R           =bilangan rill yag benilai besar
;
!variabel keputusan:
      x(i,j)=1 jka kendaraan k beroperasi dari i ke j
;

sets:
customer/1..4/: Bongkar,buka,tutup,T;
rute(customer,customer):x,D,durasi;
endsets

data:
bongkar =20 20 20 20;
R = 10000000;
D =
!customer;
```

0	10.5	5	9.8
10.5	0	10.5	5
5	9.8	0	10.5
9.8	5	9.8	0

```
;
durasi =
```

0	3.84	3.24	1.8
6	0	1.8	3.24
10.56	1.8	0	2.16
10.2	2.6	2.16	0

```
;

@text()=@write("rute yang paling optimal adalah:",
```

```
@newline(1));

@text()=@writefor(rute(i,j) | x(i,j) #NE# 0:"rute
pengiriman dari customer",i,"ke
customer",j,"sebesar",D(i,j),"km",
@newline(1));

enddata

!fungsi objektif;
MIN =
@SUM (customer(i):
      @SUM(customer(j)|i#NE#j:D(i,j)*x(i,j))
);

!fungsi batasan;

!setiap customer dikunjungi satu kali;
@FOR(customer (j) | j#GT# 1:
      @SUM (customer(i)|i#NE#j:x(i,j))=1
);

!perjalanan diawali dari depot;
@FOR(customer(i)|i#EQ# 1:
      @SUM (customer(J)|j #GT# 1 :X(i,j))=1
);

!perjalanan diawali dari depot menuju customer;
@FOR(customer (i)|i#EQ#1:
      @SUM(customer(J)|j#GT#1:x(i,j))=1
);

!perjalanan akan berakhir di depot;
@FOR(customer(j)|j#EQ# 1:
      @SUM(customer(i)|i#GT# 1:x(i,j))=1
);

!pelaksanaan;
@FOR(customer(i)|i#NE# 1:
      @FOR(customer(j):T(j)>= T(i)+ Bongkar(i)+
durasi(i,j)- R*(1-x(i,j)))
);

!rute;
```

```
@FOR(customer(z):
      @SUM(customer(i)|i#NE# z:x(i,z))-
@SUM(customer(j)|j#NE# z:x(z,j))=0
);

!time windows;
@FOR(customer(i)|i#NE#1:buka(i)<=T(i)
);

@FOR(customer(i)|i#NE#1:tutup(i)>=T(i)+ bongkar(i)
);

!variabel keputusan yang memiliki variabel biner;
@FOR(rute(i,j):
      @BIN(x(i,j)));

End
```

Lampiran 6 hasil Solution report pada cluster 1 jarak

Global optimal solution found.

Objective value:	58250.00
Objective bound:	58250.00
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	10
Elapsed runtime seconds:	0.07
Model Class:	MILP
Total variables:	28
Nonlinear variables:	0
Integer variables:	16
Total constraints:	29
Nonlinear constraints:	0
Total nonzeros:	96
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
jumlah_kendaraan	2.000000	0.000000
R	0.1000000E+08	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BONGKAR(4)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000
BUKA(4)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	63.96000	0.000000
TUTUP(3)	42.16000	0.000000
TUTUP(4)	20.00000	0.000000
T(1)	69.96000	0.000000
T(2)	43.96000	0.000000
T(3)	22.16000	0.000000
T(4)	0.000000	0.000000

Variable	Value	Reduced Cost
X(1, 1)	0.000000	0.000000
X(1, 2)	0.000000	12500.00
X(1, 3)	0.000000	22500.00
X(1, 4)	1.000000	22000.00
X(2, 1)	1.000000	12500.00
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	15500.00
X(2, 4)	0.000000	12500.00
X(3, 1)	0.000000	22000.00
X(3, 2)	1.000000	3750.000
X(3, 3)	0.000000	0.000000
X(3, 4)	0.000000	21125.00
X(4, 1)	0.000000	21125.00
X(4, 2)	0.000000	12500.00
X(4, 3)	1.000000	20000.00
X(4, 4)	0.000000	0.000000
COST(1, 1)	0.000000	0.000000
COST(1, 2)	12500.00	0.000000
COST(1, 3)	22500.00	0.000000
COST(1, 4)	22000.00	0.000000
COST(2, 1)	12500.00	0.000000
COST(2, 2)	0.000000	0.000000
COST(2, 3)	15500.00	0.000000
COST(2, 4)	12500.00	0.000000
COST(3, 1)	22000.00	0.000000
COST(3, 2)	3750.000	0.000000
COST(3, 3)	0.000000	0.000000
COST(3, 4)	21125.00	0.000000
COST(4, 1)	21125.00	0.000000
COST(4, 2)	12500.00	0.000000
COST(4, 3)	20000.00	0.000000
COST(4, 4)	0.000000	0.000000
DURASI(1, 1)	0.000000	0.000000
DURASI(1, 2)	3.840000	0.000000
DURASI(1, 3)	3.240000	0.000000
DURASI(1, 4)	1.800000	0.000000
DURASI(2, 1)	6.000000	0.000000
DURASI(2, 2)	0.000000	0.000000

Variable	Value	Reduced Cost
DURASI(2, 3)	1.800000	0.000000
DURASI(2, 4)	3.240000	0.000000
DURASI(3, 1)	10.56000	0.000000
DURASI(3, 2)	1.800000	0.000000
DURASI(3, 3)	0.000000	0.000000
DURASI(3, 4)	2.160000	0.000000
DURASI(4, 1)	10.20000	0.000000
DURASI(4, 2)	2.600000	0.000000
DURASI(4, 3)	2.160000	0.000000
DURASI(4, 4)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	58250.00	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.000000	0.000000
9	9999980.	0.000000
10	9999956.	0.000000
11	9999933.	0.000000
12	0.1000002	0.000000
13	0.000000	0.000000
14	9999980.	0.000000
15	9999956.	0.000000
16	0.1000004	0.000000
17	0.1000002	0.000000
18	0.000000	0.000000
19	9999980.	0.000000
20	0.000000	0.000000
21	0.000000	0.000000
22	0.000000	0.000000
23	0.000000	0.000000
24	43.96000	0.000000
25	22.16000	0.000000

Row	Slack or Surplus	Dual Price
26	0.000000	0.000000
27	0.000000	0.000000
28	0.000000	0.000000
29	0.000000	0.000000

Lampiran 7 hasil Solution report pada cluster 1 biaya

Global optimal solution found.

Objective value:	58250.00
Objective bound:	58250.00
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	10
Elapsed runtime seconds:	0.58
Model Class:	MILP
Total variables:	28
Nonlinear variables:	0
Integer variables:	16
Total constraints:	29
Nonlinear constraints:	0
Total nonzeros:	96
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
Jumlah_Kendaraan	2.000000	0.000000
R	0.1000000E+08	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BONGKAR(4)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000
BUKA(4)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	63.96000	0.000000
TUTUP(3)	42.16000	0.000000
TUTUP(4)	20.00000	0.000000
T(1)	69.96000	0.000000
T(2)	43.96000	0.000000

Variable	Value	Reduced Cost
T(3)	22.16000	0.000000
T(4)	0.000000	0.000000
X(1, 1)	0.000000	0.000000
X(1, 3)	0.000000	22500.00
X(1, 4)	1.000000	22000.00
X(2, 1)	1.000000	12500.00
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	15500.00
X(2, 4)	0.000000	12500.00
X(3, 1)	0.000000	22000.00
X(3, 2)	1.000000	3750.000
X(3, 3)	0.000000	0.000000
X(3, 4)	0.000000	21125.00
X(4, 1)	0.000000	21125.00
X(4, 2)	0.000000	12500.00
X(4, 3)	1.000000	20000.00
X(4, 4)	0.000000	0.000000
COST(1, 1)	0.000000	0.000000
COST(1, 2)	12500.00	0.000000
COST(1, 3)	22500.00	0.000000
COST(1, 4)	22000.00	0.000000
COST(2, 1)	12500.00	0.000000
COST(2, 2)	0.000000	0.000000
COST(2, 3)	15500.00	0.000000
COST(2, 4)	12500.00	0.000000
COST(3, 1)	22000.00	0.000000
COST(3, 2)	3750.000	0.000000
COST(3, 3)	0.000000	0.000000
COST(3, 4)	21125.00	0.000000
COST(4, 1)	21125.00	0.000000
COST(4, 2)	12500.00	0.000000
COST(4, 3)	20000.00	0.000000
COST(4, 4)	0.000000	0.000000
DURASI(1, 1)	0.000000	0.000000

Variable	Value	Reduced Cost
DURASI(1, 2)	3.840000	0.000000
DURASI(1, 3)	3.240000	0.000000
DURASI(1, 4)	1.800000	0.000000
DURASI(2, 1)	6.000000	0.000000
DURASI(2, 2)	0.000000	0.000000
DURASI(2, 3)	1.800000	0.000000
DURASI(2, 4)	3.240000	0.000000
DURASI(3, 1)	10.56000	0.000000
DURASI(3, 2)	1.800000	0.000000
DURASI(3, 3)	0.000000	0.000000
DURASI(3, 4)	2.160000	0.000000
DURASI(4, 1)	10.20000	0.000000
DURASI(4, 2)	2.600000	0.000000
DURASI(4, 3)	2.160000	0.000000
DURASI(4, 4)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	58250.00	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.000000	0.000000
9	9999980.	0.000000
10	9999956.	0.000000
11	9999933.	0.000000
12	0.1000002E+08	0.000000
13	0.000000	0.000000
14	9999980.	0.000000
15	9999956.	0.000000
16	0.1000004E+08	0.000000
17	0.1000002E+08	0.000000
18	0.000000	0.000000

Row	Slack or Surplus	Dual Price
19	9999980.	0.000000
20	0.000000	0.000000
21	0.000000	0.000000
22	0.000000	0.000000
23	0.000000	0.000000
24	43.96000	0.000000
25	22.16000	0.000000
26	0.000000	0.000000
27	0.000000	0.000000
28	0.000000	0.000000
29	0.000000	0.000000

LAMPIRAN 7 model matematis dalam bahasa *Lingo cluster 2 jarak*

```
model:

!parameter model:

      Bongkar     =waktu loading/unloadig di customer
      Durasi      =durasi pengiriman
      D           =jarak antar customer
      t           =waktu mulai pelayanan pada customer
      R           =bilangan rill yag benilai besar
;
!variabel keputusan:
      x(i,j)=1 jka kendaraan k beroperasi dari i ke j
;

sets:
customer/1..4/: Bongkar,buka,tutup,T;
rute(customer,customer):x,D,durasi;
endsets

data:
bongkar =20 20 20 20;
R = 10000000;
D =
!customer;
```

0	7	4.9	8.8
7	0	4.7	6.6
4.9	6.8	0	7.8
8.8	2	4.5	0

```
;
durasi =
```

0	8.4	5.76	10.2
8.4	0	5.2	1.5
5.76	5.50	0	9.36
10.2	1.5	5.5	0

```
;

@text()=@write("rute yang paling optimal adalah:",
@newline(1));
```

```
@text()=@writefor(rute(i,j) | x(i,j) #NE# 0:"rute
pengiriman dari customer",i,"ke
customer",j,"sebesar",D(i,j),"km",
@newline(1));

enddata

!fungsi objektif;
MIN =
@SUM (customer(i):
      @SUM(customer(j)|i#NE#j:D(i,j)*x(i,j))
);

!fungsi batasan;

!setiap customer dikunjungi satu kali;
@FOR(customer (j) | j#GT# 1:
      @SUM (customer(i)|i#NE#j:x(i,j))=1
);

!perjalanan diawali dari depot;
@FOR(customer(i)|i#EQ# 1:
      @SUM (customer(J)|j #GT# 1 :X(i,j))=1
);

!perjalanan diawali dari depot menuju customer;
@FOR(customer (i)|i#EQ#1:
      @SUM(customer(J)|j#GT#1:x(i,j))=1
);

!perjalanan akan berakhir di depot;
@FOR(customer(j)|j#EQ# 1:
      @SUM(customer(i)|i#GT# 1:x(i,j))=1
);

!pelaksanaan;
@FOR(customer(i)|i#NE# 1:
      @FOR(customer(j):T(j)>= T(i)+ Bongkar(i)+
durasi(i,j)- R*(1-x(i,j)))
);

!rute;
@FOR(customer(z):
```

```
      @SUM(customer(i)|i#NE# z:x(i,z))-
@SUM(customer(j)|j#NE# z:x(z,j))=0
);

!time windows;
@FOR(customer(i)|i#NE#1:buka(i)<=T(i)
);

@FOR(customer(i)|i#NE#1:tutup(i)>=T(i)+ bongkar(i)
);

!variabel keputusan yang memiliki variabel biner;
@FOR(rute(i,j):
      @BIN(x(i,j)));

End
```

Lampiran 8 hasil solution report pada cluster 2 jarak

Global optimal solution found.

Objective value:	20.40000
Objective bound:	20.40000
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	58
Elapsed runtime seconds:	0.68

rute yang paling optimal adalah:
rute pengiriman dari customer 1 ke customer 4 sebesar 8.800000000000001km
rute pengiriman dari customer 2 ke customer 3 sebesar 4.7 km
rute pengiriman dari customer 3 ke customer 1 sebesar 4.9 km
rute pengiriman dari customer 4 ke customer 2 sebesar 2 km

Model Class:	MILP
Total variables:	28
Nonlinear variables:	0
Integer variables:	16
Total constraints:	29
Nonlinear constraints:	0
Total nonzeros:	96
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
R	0.1000000E+08	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BONGKAR(4)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000

Variable	Value	Reduced Cost
BUKA(4)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	41.50000	0.000000
TUTUP(3)	66.70000	0.000000
TUTUP(4)	20.00000	0.000000
T(1)	72.46000	0.000000
T(2)	21.50000	0.000000
T(3)	46.70000	0.000000
T(4)	0.000000	0.000000
X(1, 1)	0.000000	0.000000
X(1, 2)	0.000000	7.000000
X(1, 3)	0.000000	4.900000
X(1, 4)	1.000000	8.800000
X(2, 1)	0.000000	7.000000
X(2, 2)	0.000000	0.000000
X(2, 3)	1.000000	4.700000
X(2, 4)	0.000000	6.600000
X(3, 1)	1.000000	4.900000
X(3, 2)	0.000000	6.800000
X(3, 3)	0.000000	0.000000
X(3, 4)	0.000000	7.800000
X(4, 1)	0.000000	8.800000
X(4, 2)	1.000000	2.000000
X(4, 3)	0.000000	4.500000
X(4, 4)	0.000000	0.000000
D(1, 1)	0.000000	0.000000
D(1, 2)	7.000000	0.000000
D(1, 3)	4.900000	0.000000
D(1, 4)	8.800000	0.000000
D(2, 1)	7.000000	0.000000
D(2, 2)	0.000000	0.000000
D(2, 3)	4.700000	0.000000
D(2, 4)	6.600000	0.000000
D(3, 1)	4.900000	0.000000
D(3, 2)	6.800000	0.000000
D(3, 3)	0.000000	0.000000

Variable	Value	Reduced Cost
D(3, 4)	7.800000	0.000000
D(4, 1)	8.800000	0.000000
D(4, 2)	2.000000	0.000000
D(4, 3)	4.500000	0.000000
D(4, 4)	0.000000	0.000000
DURASI(1, 1)	0.000000	0.000000
DURASI(1, 2)	8.400000	0.000000
DURASI(1, 3)	5.760000	0.000000
DURASI(1, 4)	10.20000	0.000000
DURASI(2, 1)	8.400000	0.000000
DURASI(2, 2)	0.000000	0.000000
DURASI(2, 3)	5.200000	0.000000
DURASI(2, 4)	1.500000	0.000000
DURASI(3, 1)	5.760000	0.000000
DURASI(3, 2)	5.500000	0.000000
DURASI(3, 3)	0.000000	0.000000
DURASI(3, 4)	9.360000	0.000000
DURASI(4, 1)	10.20000	0.000000
DURASI(4, 2)	1.500000	0.000000
DURASI(4, 3)	5.500000	0.000000
DURASI(4, 4)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	20.40000	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.1000002	0.000000
9	9999980.	0.000000
10	0.000000	0.000000

11	9999957.	0.000000
12	0.000000	0.000000
13	9999949.	0.000000
14	9999980.	0.000000
15	9999924.	0.000000
16	0.100000	0.000000
17	0.000000	0.000000
18	0.1000002	0.000000
19	9999980.	0.000000
20	0.000000	0.000000
21	0.000000	0.000000
22	0.000000	0.000000
23	0.000000	0.000000
24	21.50000	0.000000
25	46.70000	0.000000
26	0.000000	0.000000
27	0.000000	0.000000
28	0.000000	0.000000
29	0.000000	0.000000

Lampiran 9 model matematis dalam bahasa Lingo cluster 2 biaya

```
DATA:
JUMLAH_KENDARAAN = 2;
ENDDATA

!parameter model:

      Bongkar     =waktu loading/unloadig di customer
      Durasi      =durasi pengiriman
      D           =jarak antar customer
      t           =waktu mulai pelayanan pada customer
      R           =bilangan rill yag benilai besar
;
!variabel keputusan:
      x(i,j)=1 jka kendaraan k beroperasi dari i ke j
;

sets:
customer/1..4/: Bongkar,buka,tutup,T;
rute(customer,customer):x,cost,durasi;
endsets

data:
bongkar =20 20 20 20;
R = 10000000;

cost=
!customer;
```

0	17500	12000	21250
17500	0	11500	2500
12000	16000	0	19500
21250	2500	11250	0

;
durasi =

0	8.4	5.76	10.2
8.4	0	5.2	1.5
5.76	5.50	0	9.36
10.2	1.5	5.5	0

```
;
ENDDATA

!fungsi objektif;
MIN =
@SUM (customer(i):
      @SUM(customer(j)|i#NE#j:cost(i,j)*x(i,j))
);

!fungsi batasan;

!setiap customer dikunjungi satu kali;
@FOR(customer (j) | j#GT# 1:
      @SUM (customer(i)|i#NE#j:x(i,j))=1
);

!perjalanan diawali dari depot;
@FOR(customer(i)|i#EQ# 1:
      @SUM (customer(J)|j #GT# 1 :X(i,j))=1
);

!perjalanan diawali dari depot menuju customer;
@FOR(customer (i)|i#EQ#1:
      @SUM(customer(J)|j#GT#1:x(i,j))=1
);

!perjalanan akan berakhir di depot;
@FOR(customer(j)|j#EQ# 1:
      @SUM(customer(i)|i#GT# 1:x(i,j))=1
);

!pelaksanaan;
@FOR(customer(i)|i#NE# 1:
      @FOR(customer(j):T(j)>= T(i)+ Bongkar(i)+
durasi(i,j)- R*(1-x(i,j)))
);

!rute;
@FOR(customer(z):
      @SUM(customer(i)|i#NE# z:x(i,z))-
@SUM(customer(j)|j#NE# z:x(z,j))=0
);

!time windows;
```

```
@FOR(customer(i)|i#NE#1:buka(i)<=T(i)
);

@FOR(customer(i)|i#NE#1:tutup(i)>=T(i)+ bongkar(i)
);

!variabel keputusan yang memiliki variabel biner;
@FOR(rute(i,j):
      @BIN(x(i,j)));

End
```

Lampiran 10 hasil solution report pada cluster 2 biaya

Global optimal solution found.

Objective value:	43250.00
Objective bound:	43250.00
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	52
Elapsed runtime seconds:	1.81
Model Class:	MILP
Total variables:	28
Nonlinear variables:	0
Integer variables:	16
Total constraints:	29
Nonlinear constraints:	0
Total nonzeros:	96
Nonlinear nonzeros:	0

Variable	**Value**	**Reduced Cost**
Jumlah_Kendaraan	2.000000	0.000000
R	0.1000000E+08	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BONGKAR(4)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000
BUKA(4)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	20.00000	0.000000
TUTUP(3)	67.00000	0.000000
TUTUP(4)	41.50000	0.000000
T(1)	72.76000	0.000000
T(2)	0.000000	0.000000
T(3)	47.00000	0.000000
T(4)	21.50000	0.000000

Variable	Value	Reduced Cost
X(1, 1)	0.000000	0.000000
X(1, 2)	1.000000	17500.00
X(1, 3)	0.000000	12000.00
X(1, 4)	0.000000	21250.00
X(2, 1)	0.000000	17500.00
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	11500.00
X(2, 4)	1.000000	2500.000
X(3, 1)	1.000000	12000.00
X(3, 2)	0.000000	16000.00
X(3, 3)	0.000000	0.000000
X(3, 4)	0.000000	19500.00
X(4, 1)	0.000000	21250.00
X(4, 2)	0.000000	2500.000
X(4, 3)	1.000000	11250.00
X(4, 4)	0.000000	0.000000
COST(1, 1)	0.000000	0.000000
COST(1, 2)	17500.00	0.000000
COST(1, 3)	12000.00	0.000000
COST(1, 4)	21250.00	0.000000
COST(2, 1)	17500.00	0.000000
COST(2, 2)	0.000000	0.000000
COST(2, 3)	11500.00	0.000000
COST(2, 4)	2500.000	0.000000
COST(3, 1)	12000.00	0.000000
COST(3, 2)	16000.00	0.000000
COST(3, 3)	0.000000	0.000000
COST(3, 4)	19500.00	0.000000
COST(4, 1)	21250.00	0.000000
COST(4, 2)	2500.000	0.000000
COST(4, 3)	11250.00	0.000000
COST(4, 4)	0.000000	0.000000
DURASI(1, 1)	0.000000	0.000000
DURASI(1, 2)	8.400000	0.000000

Variable	Value	Reduced Cost
DURASI(1, 3)	5.760000	0.000000
DURASI(1, 4)	10.20000	0.000000
DURASI(2, 1)	8.400000	0.000000
DURASI(2, 2)	0.000000	0.000000
DURASI(2, 3)	5.200000	0.000000
DURASI(2, 4)	1.500000	0.000000
DURASI(3, 1)	5.760000	0.000000
DURASI(3, 2)	5.500000	0.000000
DURASI(3, 3)	0.000000	0.000000
DURASI(3, 4)	9.360000	0.000000
DURASI(4, 1)	10.20000	0.000000
DURASI(4, 2)	1.500000	0.000000
DURASI(4, 3)	5.500000	0.000000
DURASI(4, 4)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	43250.00	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.1000004	0.000000
9	9999980.	0.000000
10	0.1000002	0.000000
11	0.000000	0.000000
12	0.000000	0.000000
13	9999928.	0.000000
14	9999980.	0.000000
15	9999945.	0.000000
16	0.1000002	0.000000
17	9999957.	0.000000
18	0.000000	0.000000
19	9999980.	0.000000

Row	Slack or Surplus	Dual Price
20	0.000000	0.000000
21	0.000000	0.000000
22	0.000000	0.000000
23	0.000000	0.000000
24	0.000000	0.000000
25	47.00000	0.000000
26	21.50000	0.000000
27	0.000000	0.000000
28	0.000000	0.000000
29	0.000000	0.000000

Lampiran 11 model matematis dalam bahasa Lingo cluster 3 jarak

```
model:

!parameter model:

      Bongkar     =waktu loading/unloadig di customer
      Durasi      =durasi pengiriman
      D           =jarak antar customer
      t           =waktu mulai pelayanan pada customer
      R           =bilangan rill yag benilai besar
;
!variabel keputusan:
      x(i,j)=1 jka kendaraan k beroperasi dari i ke j
;

sets:
customer/1..3/: Bongkar,buka,tutup,T;
rute(customer,customer):x,D,durasi;
endsets

data:
bongkar =20 20 20;
R = 10000000;
D =
!customer;
```

0	**4**	**4.5**
4	**0**	**2**
4.5	**2**	**0**

```
;
durasi =
```

0	**4.8**	**5.4**
4.8	**0**	**2**
5.4	**12.6**	**0**

```
;

@text()=@write("rute yang paling optimal adalah:",
@newline(1));

@text()=@writefor(rute(i,j) | x(i,j) #NE# 0:"rute
pengiriman dari customer",i,"ke
customer",j,"sebesar",D(i,j),"km",
@newline(1));
```

```
enddata

!fungsi objektif;
MIN =
@SUM (customer(i):
      @SUM(customer(j)|i#NE#j:D(i,j)*x(i,j))
);

!fungsi batasan;

!setiap customer dikunjungi satu kali;
@FOR(customer (j) | j#GT# 1:
      @SUM (customer(i)|i#NE#j:x(i,j))=1
);

!perjalanan diawali dari depot;
@FOR(customer(i)|i#EQ# 1:
      @SUM (customer(J)|j #GT# 1 :X(i,j))=1
);

!perjalanan diawali dari depot menuju customer;
@FOR(customer (i)|i#EQ#1:
      @SUM(customer(J)|j#GT#1:x(i,j))=1
);

!perjalanan akan berakhir di depot;
@FOR(customer(j)|j#EQ# 1:
      @SUM(customer(i)|i#GT# 1:x(i,j))=1
);

!pelaksanaan;
@FOR(customer(i)|i#NE# 1:
      @FOR(customer(j):T(j)>= T(i)+ Bongkar(i)+
durasi(i,j)- R*(1-x(i,j)))
);

!rute;
@FOR(customer(z):
      @SUM(customer(i)|i#NE# z:x(i,z))-
@SUM(customer(j)|j#NE# z:x(z,j))=0
);
```

```
!time windows;
@FOR(customer(i)|i#NE#1:buka(i)<=T(i)
);

@FOR(customer(i)|i#NE#1:tutup(i)>=T(i)+ bongkar(i)
);

!variabel keputusan yang memiliki variabel biner;
@FOR(rute(i,j):
      @BIN(x(i,j)));

End
```

Lampiran 12 hasil solution report pada cluster 3 jarak

Global optimal solution found.
Objective value: 10.50000
Objective bound: 10.50000
Infeasibilities: 0.000000
Extended solver steps: 0
Total solver iterations: 0
Elapsed runtime seconds: 0.20
rute yang paling optimal adalah:
rute pengiriman dari customer 1 ke customer 3 sebesar 4.5 km
rute pengiriman dari customer 2 ke customer 1 sebesar 4 km
rute pengiriman dari customer 3 ke customer 2 sebesar 2 km
Model Class: MILP

Total variables:	18
Nonlinear variables:	0
Integer variables:	9
Total constraints:	19
Nonlinear constraints:	0
Total nonzeros:	50
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
R	0.1000000	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	52.60000	0.000000
TUTUP(3)	20.00000	0.000000
T(1)	57.40000	0.000000

Variable	Value	Reduced Cost
T(2)	32.60000	0.000000
T(3)	0.000000	0.000000
X(1, 1)	0.000000	0.000000
X(1, 2)	0.000000	4.000000
X(1, 3)	1.000000	4.500000
X(2, 1)	1.000000	4.000000
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	2.000000
X(3, 1)	0.000000	4.500000
X(3, 2)	1.000000	2.000000
X(3, 3)	0.000000	0.000000
D(1, 1)	0.000000	0.000000
D(1, 2)	4.000000	0.000000
D(1, 3)	4.500000	0.000000
D(2, 1)	4.000000	0.000000
D(2, 2)	0.000000	0.000000
D(2, 3)	2.000000	0.000000
D(3, 1)	4.500000	0.000000
D(3, 2)	2.000000	0.000000
D(3, 3)	0.000000	0.000000
DURASI(1, 1)	0.000000	0.000000
DURASI(1, 2)	4.800000	0.000000
DURASI(1, 3)	5.400000	0.000000
DURASI(2, 1)	4.800000	0.000000
DURASI(2, 2)	0.000000	0.000000
DURASI(2, 3)	2.000000	0.000000
DURASI(3, 1)	5.400000	0.000000
DURASI(3, 2)	12.60000	0.000000
DURASI(3, 3)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	10.50000	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000

Row	Slack or Surplus	Dual Price
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	9999980.	0.000000
9	9999945.	0.000000
10	0.1000003	0.000000
11	0.000000	0.000000
12	9999980.	0.000000
13	0.000000	0.000000
14	0.000000	0.000000
15	0.000000	0.000000
16	32.60000	0.000000
17	0.000000	0.000000
18	0.000000	0.000000
19	0.000000	0.000000

Lampiran 13 model matematis dalam bahasa Lingo cluster 3 biaya

```
DATA:
JUMLAH_KENDARAAN = 2;
ENDDATA

!parameter model:

      Bongkar     =waktu loading/unloadig di customer
      Durasi      =durasi pengiriman
      D           =jarak antar customer
      t           =waktu mulai pelayanan pada customer
      R           =bilangan rill yag benilai besar
;
!variabel keputusan:
      x(i,j)=1 jka kendaraan k beroperasi dari i ke j
;

sets:
customer/1..3/: Bongkar,buka,tutup,T;
rute(customer,customer):x,cost,durasi;
endsets

data:
bongkar =20 20 20;
R = 10000000;

cost=
!customer;
```

0	**10000**	**11250**
10000	**0**	**3750**
11250	**2500**	**0**

```
;
durasi =
```

0	**4.8**	**5.4**
4.8	**0**	**2**
5.4	**12.6**	**0**

```
;
ENDDATA

!fungsi objektif;
MIN =
@SUM (customer(i):
```

```
      @SUM(customer(j)|i#NE#j:cost(i,j)*x(i,j))
);

!fungsi batasan;

!setiap customer dikunjungi satu kali;
@FOR(customer (j) | j#GT# 1:
      @SUM (customer(i)|i#NE#j:x(i,j))=1
);

!perjalanan diawali dari depot;
@FOR(customer(i)|i#EQ# 1:
      @SUM (customer(J)|j #GT# 1 :X(i,j))=1
);

!perjalanan diawali dari depot menuju customer;
@FOR(customer (i)|i#EQ#1:
      @SUM(customer(J)|j#GT#1:x(i,j))=1
);

!perjalanan akan berakhir di depot;
@FOR(customer(j)|j#EQ# 1:
      @SUM(customer(i)|i#GT# 1:x(i,j))=1
);

!pelaksanaan;
@FOR(customer(i)|i#NE# 1:
      @FOR(customer(j):T(j)>= T(i)+ Bongkar(i)+
durasi(i,j)- R*(1-x(i,j)))
);

!rute;
@FOR(customer(z):
      @SUM(customer(i)|i#NE# z:x(i,z))-
@SUM(customer(j)|j#NE# z:x(z,j))=0
);

!time windows;
@FOR(customer(i)|i#NE#1:buka(i)<=T(i)
);

@FOR(customer(i)|i#NE#1:tutup(i)>=T(i)+ bongkar(i)
);
```

```
!variabel keputusan yang memiliki variabel biner;
@FOR(rute(i,j):
      @BIN(x(i,j)));

End
```

Lampiran 14 hasil solution report pada cluster 3 biaya

Global optimal solution found.

Objective value:	23750.00
Objective bound:	23750.00
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.13
Model Class:	MILP
Total variables:	18
Nonlinear variables:	0
Integer variables:	9
Total constraints:	19
Nonlinear constraints:	0
Total nonzeros:	50
Nonlinear nonzeros:	0

Variable	**Value**	**Reduced Cost**
Jumlah_Kendaraan	2.000000	0.000000
R	0.1000000	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	52.60000	0.000000
TUTUP(3)	20.00000	0.000000
T(1)	57.40000	0.000000
T(2)	32.60000	0.000000
T(3)	0.000000	0.000000
X(1, 1)	0.000000	0.000000
X(1, 2)	0.000000	10000.00
X(1, 3)	1.000000	11250.00

Variable	Value	Reduced Cost
X(2, 1)	1.000000	10000.00
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	3750.000
X(3, 1)	0.000000	11250.00
X(3, 2)	1.000000	2500.000
X(3, 3)	0.000000	0.000000
COST(1, 1)	0.000000	0.000000
COST(1, 2)	10000.00	0.000000
COST(1, 3)	11250.00	0.000000
COST(2, 1)	10000.00	0.000000
COST(2, 2)	0.000000	0.000000
COST(2, 3)	3750.000	0.000000
COST(3, 1)	11250.00	0.000000
COST(3, 2)	2500.000	0.000000
COST(3, 3)	0.000000	0.000000
DURASI(1, 1)	0.000000	0.000000
DURASI(1, 2)	4.800000	0.000000
DURASI(1, 3)	5.400000	0.000000
DURASI(2, 1)	4.800000	0.000000
DURASI(2, 2)	0.000000	0.000000
DURASI(2, 3)	2.000000	0.000000
DURASI(3, 1)	5.400000	0.000000
DURASI(3, 2)	12.60000	0.000000
DURASI(3, 3)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	23750.00	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	9999980.	0.000000
9	9999945.	0.000000

Row	Slack or Surplus	Dual Price
10	0.1000003	0.000000
11	0.000000	0.000000
12	9999980.	0.000000
13	0.000000	0.000000
14	0.000000	0.000000
15	0.000000	0.000000
16	32.60000	0.000000
17	0.000000	0.000000
18	0.000000	0.000000
19	0.000000	0.000000

Lampiran 15 model matematis dalam bahasa Lingo cluster 4 jarak

```
model:

!parameter model:

      Bongkar     =waktu loading/unloadig di customer
      Durasi      =durasi pengiriman
      D           =jarak antar customer
      t           =waktu mulai pelayanan pada customer
      R           =bilangan rill yag benilai besar
;
!variabel keputusan:
      x(i,j)=1 jka kendaraan k beroperasi dari i ke j
;

sets:
customer/1..4/: Bongkar,buka,tutup,T;
rute(customer,customer):x,D,durasi;
endsets

data:
bongkar =20 20 20 20;
R = 10000000;
D =
!customer;
```

0	5	4.8	4.8
5	0	2	1.5
4.2	1.5	0	5
4.8	1	6.5	0

```
;
durasi =
```

0	6	5.6	5.88
6	0	2.4	1.8
5.6	2.4	0	1.2
5.88	1.2	1.8	0

```
;

@text()=@write("rute yang paling optimal adalah:",
@newline(1));
```

```
@text()=@writefor(rute(i,j) | x(i,j) #NE# 0:"rute
pengiriman dari customer",i,"ke
customer",j,"sebesar",D(i,j),"km",
@newline(1));

enddata

!fungsi objektif;
MIN =
@SUM (customer(i):
      @SUM(customer(j)|i#NE#j:D(i,j)*x(i,j))
);

!fungsi batasan;

!setiap customer dikunjungi satu kali;
@FOR(customer (j) | j#GT# 1:
      @SUM (customer(i)|i#NE#j:x(i,j))=1
);

!perjalanan diawali dari depot;
@FOR(customer(i)|i#EQ# 1:
      @SUM (customer(J)|j #GT# 1 :X(i,j))=1
);

!perjalanan diawali dari depot menuju customer;
@FOR(customer (i)|i#EQ#1:
      @SUM(customer(J)|j#GT#1:x(i,j))=1
);

!perjalanan akan berakhir di depot;
@FOR(customer(j)|j#EQ# 1:
      @SUM(customer(i)|i#GT# 1:x(i,j))=1
);

!pelaksanaan;
@FOR(customer(i)|i#NE# 1:
      @FOR(customer(j):T(j)>= T(i)+ Bongkar(i)+
durasi(i,j)- R*(1-x(i,j)))
);

!rute;
@FOR(customer(z):
```

```
      @SUM(customer(i)|i#NE# z:x(i,z))-
@SUM(customer(j)|j#NE# z:x(z,j))=0
);

!time windows;
@FOR(customer(i)|i#NE#1:buka(i)<=T(i)
);

@FOR(customer(i)|i#NE#1:tutup(i)>=T(i)+ bongkar(i)
);

!variabel keputusan yang memiliki variabel biner;
@FOR(rute(i,j):
      @BIN(x(i,j)));

End
```

Lampiran 16 hasil solution report pada cluster 4 jarak

Global optimal solution found.

Objective value:	12.00000
Objective bound:	12.00000
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	43
Elapsed runtime seconds:	0.14

rute yang paling optimal adalah:
rute pengiriman dari customer 1 ke customer 4 sebesar 4.8 km
rute pengiriman dari customer 2 ke customer 3 sebesar 2 km
rute pengiriman dari customer 3 ke customer 1 sebesar 4.2 km
rute pengiriman dari customer 4 ke customer 2 sebesar 1 km

Model Class: MILP

Total variables:	28
Nonlinear variables:	0
Integer variables:	16
Total constraints:	29
Nonlinear constraints:	0
Total nonzeros:	96
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
R	0.1000000	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BONGKAR(4)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000
BUKA(4)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	9999976.	0.000000
TUTUP(3)	9999999.	0.000000

Variable	Value	Reduced Cost
TUTUP(4)	20.00000	0.000000
T(1)	0.1000000	0.000000
T(2)	9999956.	0.000000
T(3)	9999979.	0.000000
T(4)	0.000000	0.000000
X(1, 1)	0.000000	0.000000
X(1, 2)	0.000000	5.000000
X(1, 3)	0.000000	4.800000
X(1, 4)	1.000000	4.800000
X(2, 1)	0.000000	5.000000
X(2, 2)	0.000000	0.000000
X(2, 3)	1.000000	2.000000
X(2, 4)	0.000000	1.500000
X(3, 1)	1.000000	4.200000
X(3, 2)	0.000000	1.500000
X(3, 3)	0.000000	0.000000
X(3, 4)	0.000000	5.000000
X(4, 1)	0.000000	4.800000
X(4, 2)	1.000000	1.000000
X(4, 3)	0.000000	6.500000
X(4, 4)	0.000000	0.000000
D(1, 1)	0.000000	0.000000
D(1, 2)	5.000000	0.000000
D(1, 3)	4.800000	0.000000
D(1, 4)	4.800000	0.000000
D(2, 1)	5.000000	0.000000
D(2, 2)	0.000000	0.000000
D(2, 3)	2.000000	0.000000
D(2, 4)	1.500000	0.000000
D(3, 1)	4.200000	0.000000
D(3, 2)	1.500000	0.000000
D(3, 3)	0.000000	0.000000
D(3, 4)	5.000000	0.000000
D(4, 1)	4.800000	0.000000
D(4, 2)	1.000000	0.000000
D(4, 3)	6.500000	0.000000
DURASI(1, 1)	0.000000	0.000000
DURASI(1, 2)	6.000000	0.000000
DURASI(1, 3)	5.600000	0.000000
DURASI(1, 4)	5.880000	0.000000

Variable	Value	Reduced Cost
DURASI(2, 1)	6.000000	0.000000
DURASI(2, 2)	0.000000	0.000000
DURASI(2, 3)	2.400000	0.000000
DURASI(2, 4)	1.800000	0.000000
DURASI(3, 1)	5.600000	0.000000
DURASI(3, 2)	2.400000	0.000000
DURASI(3, 3)	0.000000	0.000000
DURASI(3, 4)	1.200000	0.000000
DURASI(4, 1)	5.880000	0.000000
DURASI(4, 2)	1.200000	0.000000
DURASI(4, 3)	1.800000	0.000000
DURASI(4, 4)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	12.00000	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.1000002	0.000000
9	9999980.	0.000000
10	0.000000	0.000000
11	21.80000	0.000000
12	0.000000	0.000000
13	9999955.	0.000000
14	9999980.	0.000000
15	0.000000	0.000000
16	0.1999998	0.000000
17	9999935.	0.000000
18	0.1999996	0.000000
19	9999980.	0.000000
20	0.000000	0.000000
21	0.000000	0.000000
22	0.000000	0.000000

Row	Slack or Surplus	Dual Price
23	0.000000	0.000000
24	9999956.	0.000000
25	9999979.	0.000000
26	0.000000	0.000000
27	0.000000	0.000000
28	0.000000	0.000000
29	0.000000	0.000000

Lampiran 17 model matematis dalam bahasa Lingo cluster 4 biaya

```
DATA:
JUMLAH_KENDARAAN = 2;
ENDDATA

!parameter model:

      Bongkar     =waktu loading/unloadig di customer
      Durasi      =durasi pengiriman
      D           =jarak antar customer
      t           =waktu mulai pelayanan pada customer
      R           =bilangan rill yag benilai besar
;
!variabel keputusan:
      x(i,j)=1 jka kendaraan k beroperasi dari i ke j
;

sets:
customer/1..4/: Bongkar,buka,tutup,T;
rute(customer,customer):x,cost,durasi;
endsets

data:
bongkar =20 20 20 20;
R = 10000000;

cost=
!customer;
```

0	12500	10500	12500
12500	0	5000	2500
10500	5000	0	3750
12500	2500	3750	0

```
;
durasi =
```

0	6	5.6	5.88
6	0	2.4	1.8
5.6	2.4	0	1.2
5.88	1.2	1.8	0

```
;
```

```
ENDDATA

!fungsi objektif;
MIN =
@SUM (customer(i):
      @SUM(customer(j)|i#NE#j:cost(i,j)*x(i,j))
);

!fungsi batasan;

!setiap customer dikunjungi satu kali;
@FOR(customer (j) | j#GT# 1:
      @SUM (customer(i)|i#NE#j:x(i,j))=1
);

!perjalanan diawali dari depot;
@FOR(customer(i)|i#EQ# 1:
      @SUM (customer(J)|j #GT# 1 :X(i,j))=1
);

!perjalanan diawali dari depot menuju customer;
@FOR(customer (i)|i#EQ#1:
      @SUM(customer(J)|j#GT#1:x(i,j))=1
);

!perjalanan akan berakhir di depot;
@FOR(customer(j)|j#EQ# 1:
      @SUM(customer(i)|i#GT# 1:x(i,j))=1
);

!pelaksanaan;
@FOR(customer(i)|i#NE# 1:
      @FOR(customer(j):T(j)>= T(i)+ Bongkar(i)+
durasi(i,j)- R*(1-x(i,j)))
);

!rute;
@FOR(customer(z):
      @SUM(customer(i)|i#NE# z:x(i,z))-
@SUM(customer(j)|j#NE# z:x(z,j))=0
);

!time windows;
@FOR(customer(i)|i#NE#1:buka(i)<=T(i)
```

```
);

@FOR(customer(i)|i#NE#1:tutup(i)>=T(i)+ bongkar(i)
);

!variabel keputusan yang memiliki variabel biner;
@FOR(rute(i,j):
      @BIN(x(i,j)));

End
```

Lampiran 18 hasil solution report pada cluster 4 biaya

Global optimal solution found.

Objective value:	29250.00
Objective bound:	29250.00
Infeasibilities:	0.000000
Extended solver steps:	19
Total solver iterations:	163
Elapsed runtime seconds:	0.38
Model Class:	MILP
Total variables:	28
Nonlinear variables:	0
Integer variables:	16
Total constraints:	29
Nonlinear constraints:	0
Total nonzeros:	96
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
Jumlah_Kendaraan	2.000000	0.000000
R	0.1000000	0.000000
BONGKAR(1)	20.00000	0.000000
BONGKAR(2)	20.00000	0.000000
BONGKAR(3)	20.00000	0.000000
BONGKAR(4)	20.00000	0.000000
BUKA(1)	0.000000	0.000000
BUKA(2)	0.000000	0.000000
BUKA(3)	0.000000	0.000000
BUKA(4)	0.000000	0.000000
TUTUP(1)	0.000000	0.000000
TUTUP(2)	62.40000	0.000000
TUTUP(3)	20.00000	0.000000
TUTUP(4)	41.20000	0.000000
T(1)	68.40000	0.000000
T(2)	42.40000	0.000000
T(3)	0.000000	0.000000
T(4)	21.20000	0.000000

Variable	Value	Reduced Cost
X(1, 1)	0.000000	0.000000
X(1, 2)	0.000000	12500.00
X(1, 3)	1.000000	10500.00
X(1, 4)	0.000000	12500.00
X(2, 1)	1.000000	12500.00
X(2, 2)	0.000000	0.000000
X(2, 3)	0.000000	5000.000
X(2, 4)	0.000000	2500.000
X(3, 1)	0.000000	10500.00
X(3, 2)	0.000000	5000.000
X(3, 3)	0.000000	0.000000
X(3, 4)	1.000000	3750.000
X(4, 1)	0.000000	12500.00
X(4, 2)	1.000000	2500.000
X(4, 3)	0.000000	3750.000
X(4, 4)	0.000000	0.000000
COST(1, 1)	0.000000	0.000000
COST(1, 2)	12500.00	0.000000
COST(1, 3)	10500.00	0.000000
COST(1, 4)	12500.00	0.000000
COST(2, 1)	12500.00	0.000000
COST(2, 2)	0.000000	0.000000
COST(2, 3)	5000.000	0.000000
COST(2, 4)	2500.000	0.000000
COST(3, 1)	10500.00	0.000000
COST(3, 2)	5000.000	0.000000
COST(3, 3)	0.000000	0.000000
COST(3, 4)	3750.000	0.000000
COST(4, 1)	12500.00	0.000000
COST(4, 2)	2500.000	0.000000
COST(4, 3)	3750.000	0.000000
COST(4, 4)	0.000000	0.000000
DURASI(1, 1)	0.000000	0.000000
DURASI(1, 2)	6.000000	0.000000

Variable	Value	Reduced Cost
DURASI(1, 3)	5.600000	0.000000
DURASI(1, 4)	5.880000	0.000000
DURASI(2, 1)	6.000000	0.000000
DURASI(2, 2)	0.000000	0.000000
DURASI(2, 3)	2.400000	0.000000
DURASI(2, 4)	1.800000	0.000000
DURASI(3, 1)	5.600000	0.000000
DURASI(3, 2)	2.400000	0.000000
DURASI(3, 3)	0.000000	0.000000
DURASI(3, 4)	1.200000	0.000000
DURASI(4, 1)	5.880000	0.000000
DURASI(4, 2)	1.200000	0.000000
DURASI(4, 3)	1.800000	0.000000
DURASI(4, 4)	0.000000	0.000000

Row	Slack or Surplus	Dual Price
1	29250.00	-1.000000
2	0.000000	0.000000
3	0.000000	0.000000
4	0.000000	0.000000
5	0.000000	0.000000
6	0.000000	0.000000
7	0.000000	0.000000
8	0.000000	0.000000
9	9999980.	0.000000
10	9999935.	0.000000
11	9999957.	0.000000
1	0.1000004	0.000000
13	0.1000002	0.000000
14	9999980.	0.000000
15	0.000000	0.000000
16	0.1000002	0.000000
17	0.000000	0.000000
18	9999957.	0.000000
19	9999980.	0.000000
20	0.000000	0.000000
21	0.000000	0.000000
22	0.000000	0.000000
23	0.000000	0.000000
24	42.40000	0.000000
25	0.000000	0.000000
26	21.20000	0.000000
27	0.000000	0.000000
28	0.000000	0.000000
29	0.000000	0.000000

BIOGRAFI

Konstantinus Sabe
lahir di Todo Manggarai Flores NTT 11 Maret 1999, Anak pertama dari dua bersaudara, buah kasih pasangan dari Ayanda "Laurensius Pora" dan Ibunda(alm)"Rosalia Bumbus". Penulis pertama kali menempuh pendidikan tepat pada umur 7 tahun di Sekolah Dasar katolik Todo II Manggarai NTT 2006 Dan selesai padaTahun 2012.

Pada tahun yang sama penulis melanjutkan di sekolah Menengah Pertama di SMPN 2 Satar Mese Utara Manggarai NTT dan selesai pada Tahun 2015, dan pada tahun yang sama penulis melanjutkan Pendidikan Sekolah Menengah Atas di SMAK Setia Bakti Ruteng NTT. Penulis mengambil jurusan IPA dan selesai Tahun 2018. Pada Tahun 2018 penulis terdaftar pada salah satu kampus swasta jurusan Teknik Industri Fakultas Teknik Universitas 17 Agustus 1945 Surabaya dan Puji Tuhan selesai pada Tahun 2022.

Dengan ketekunan, motivasi tinggi untuk terus belajar dan berusaha penulis berhasil menyelesaikan pengerjaan tugas akhir ini. Semoga dengan penulisan tugas akhir ini mampu memberikan kontibusi positif bagi dunia pendidikan.

Akhir kata mengucapkan rasa syukur kepada Tuhan Yang Maha Esa ataspenulis terselesaikannya skipsi yang berjudul **Usulan Rute Distribusi Produk Gula Pasir Dengan Menggunakan Metode *Vehicle Routing Problem* Pada Distributor CV Makmur Jaya Surabaya.**