

OREGON STATE UNIVERSITY

Project Group 21

CS 325: Project 3

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1 PROBLEM 1

Part A:

i. Linear Problem Formulation

Let each route be represented as variables of the form "SourceDestination." For example a route from Plant 1 to Warehouse 1 would be "p1w1."

Objective function:

Minimize:

$$10 \text{ p1w1} + 15 \text{ p1w2} + 11 \text{ p2w1} + 8 \text{ p2w2} + 13 \text{ p3w1} + 8 \text{ p3w2} + 9 \text{ p3w3} + 14 \text{ p4w2} + 8 \text{ p4w3} + 5 \text{ w1r1} + 6 \text{ w1r2} + 7 \text{ w1r3} + 10 \text{ w1r4} + 12 \text{ w2r3} + 8 \text{ w2r4} + 10 \text{ w2r5} + 14 \text{ w2r6} + 14 \text{ w3r4} + 12 \text{ w3r5} + 12 \text{ w3r6} + 6 \text{ w3r7}$$

Subject To:

Supply Constraints:

$$\text{p1w1} + \text{p1w2} = 150$$

$$\text{p2w1} + \text{p2w2} = 450$$

$$\text{p3w1} + \text{p3w2} + \text{p3w3} = 250$$

$$\text{p4w2} + \text{p4w3} = 150$$

Demand Constraints:

$$\begin{aligned}w1r1 &= 100 \\w1r2 &= 150 \\w1r3 + w2r3 &= 100 \\w1r4 + w2r4 + w3r4 &= 200 \\w2r5 + w3r5 &= 200 \\w2r6 + w3r6 &= 150 \\w3r7 &= 100\end{aligned}$$

Balancing Constraints:

$$\begin{aligned}p1w1 + p2w1 + p3w1 - w1r1 - w1r2 - w1r3 - w1r4 &\leq 0 \\p1w2 + p2w2 + p3w2 + p4w2 - w2r3 - w2r4 - w2r5 - w2r6 &\leq 0 \\p3w3 + p4w3 - w3r4 - w3r5 - w3r6 - w3r7 &\leq 0\end{aligned}$$

Non-negativity Constraints:

$$\begin{aligned}p1w1, p1w2, p2w1, p2w2, p3w1, p3w2, p3w3, p4w2, p4w3, w1r1, w1r2, w1r3, w1r4, \\w2r3, w2r4, w2r5, w2r6, w3r4, w3r5, w3r6, w3r7 &\geq 0\end{aligned}$$

ii. LINDO Code and Output

```
MIN 10 p1w1 + 15 p1w2 + 11 p2w1 + 8 p2w2 + 13 p3w1 + 8 p3w2 + 9 p3w3
    + 14 p4w2 + 8 p4w3 + 5 w1r1 + 6 w1r2 + 7 w1r3 + 10 w1r4 + 12 w2r3
    + 8 w2r4 + 10 w2r5 + 14 w2r6 + 14 w3r4 + 12 w3r5 + 12 w3r6 + 6 w3r7
ST
    p1w1 + p1w2 = 150
    p2w1 + p2w2 = 450
    p3w1 + p3w2 + p3w3 = 250
    p4w2 + p4w3 = 150
    w1r1 = 100
    w1r2 = 150
    w1r3 + w2r3 = 100
    w1r4 + w2r4 + w3r4 = 200
    w2r5 + w3r5 = 200
    w2r6 + w3r6 = 150
    w3r7 = 100
    p1w1 + p2w1 + p3w1 - w1r1 - w1r2 - w1r3 - w1r4 <= 0
    p1w2 + p2w2 + p3w2 + p4w2 - w2r3 - w2r4 - w2r5 - w2r6 <= 0
    p3w3 + p4w3 - w3r4 - w3r5 - w3r6 - w3r7 <= 0
    p1w1 > 0
    p1w2 > 0
    p2w1 > 0
    p2w2 > 0
    p3w1 > 0
    p3w2 > 0
```

```

p3w3 > 0
p4w2 > 0
p4w3 > 0
w1r1 > 0
w1r2 > 0
w1r3 > 0
w1r4 > 0
w2r3 > 0
w2r4 > 0
w2r5 > 0
w2r6 > 0
w3r4 > 0
w3r5 > 0
w3r6 > 0
w3r7 > 0
END

```

LP OPTIMUM FOUND AT STEP 13

OBJECTIVE FUNCTION VALUE

1) 17100.00

| VARIABLE | VALUE | REDUCED COST |
|----------|------------|--------------|
| P1W1 | 150.000000 | 0.000000 |
| P1W2 | 0.000000 | 8.000000 |
| P2W1 | 200.000000 | 0.000000 |
| P2W2 | 250.000000 | 0.000000 |
| P3W1 | 0.000000 | 2.000000 |
| P3W2 | 150.000000 | 0.000000 |
| P3W3 | 100.000000 | 0.000000 |
| P4W2 | 0.000000 | 7.000000 |
| P4W3 | 150.000000 | 0.000000 |
| W1R1 | 100.000000 | 0.000000 |
| W1R2 | 150.000000 | 0.000000 |
| W1R3 | 100.000000 | 0.000000 |
| W1R4 | 0.000000 | 5.000000 |
| W2R3 | 0.000000 | 2.000000 |
| W2R4 | 200.000000 | 0.000000 |
| W2R5 | 200.000000 | 0.000000 |
| W2R6 | 0.000000 | 1.000000 |
| W3R4 | 0.000000 | 7.000000 |
| W3R5 | 0.000000 | 3.000000 |

| | | |
|------|------------|----------|
| W3R6 | 150.000000 | 0.000000 |
| W3R7 | 100.000000 | 0.000000 |

| ROW | SLACK OR SURPLUS | DUAL PRICES |
|-----|------------------|-------------|
| 2) | 0.000000 | -10.000000 |
| 3) | 0.000000 | -11.000000 |
| 4) | 0.000000 | -11.000000 |
| 5) | 0.000000 | -10.000000 |
| 6) | 0.000000 | -5.000000 |
| 7) | 0.000000 | -6.000000 |
| 8) | 0.000000 | -7.000000 |
| 9) | 0.000000 | -5.000000 |
| 10) | 0.000000 | -7.000000 |
| 11) | 0.000000 | -10.000000 |
| 12) | 0.000000 | -4.000000 |
| 13) | 0.000000 | 0.000000 |
| 14) | 0.000000 | 3.000000 |
| 15) | 0.000000 | 2.000000 |
| 16) | 150.000000 | 0.000000 |
| 17) | 0.000000 | 0.000000 |
| 18) | 200.000000 | 0.000000 |
| 19) | 250.000000 | 0.000000 |
| 20) | 0.000000 | 0.000000 |
| 21) | 150.000000 | 0.000000 |
| 22) | 100.000000 | 0.000000 |
| 23) | 0.000000 | 0.000000 |
| 24) | 150.000000 | 0.000000 |
| 25) | 100.000000 | 0.000000 |
| 26) | 150.000000 | 0.000000 |
| 27) | 100.000000 | 0.000000 |
| 28) | 0.000000 | 0.000000 |
| 29) | 0.000000 | 0.000000 |
| 30) | 200.000000 | 0.000000 |
| 31) | 200.000000 | 0.000000 |
| 32) | 0.000000 | 0.000000 |
| 33) | 0.000000 | 0.000000 |
| 34) | 0.000000 | 0.000000 |
| 35) | 150.000000 | 0.000000 |
| 36) | 100.000000 | 0.000000 |

NO. ITERATIONS= 13

iii. Optimal Shipping Routes and Minimum Cost

The optimal shipping routes and quantity of refrigerators per route are:

| Route | Refrigerators |
|-------|---------------|
| P1W1 | 150 |
| P2W1 | 200 |
| P2W2 | 250 |
| P3W2 | 150 |
| P3W3 | 100 |
| P4W3 | 150 |
| W1R1 | 100 |
| W1R2 | 150 |
| W1R3 | 100 |
| W2R4 | 200 |
| W2R5 | 200 |
| W3R6 | 150 |
| W3R7 | 100 |

The optimal minimum cost is \$17,100

Part B:

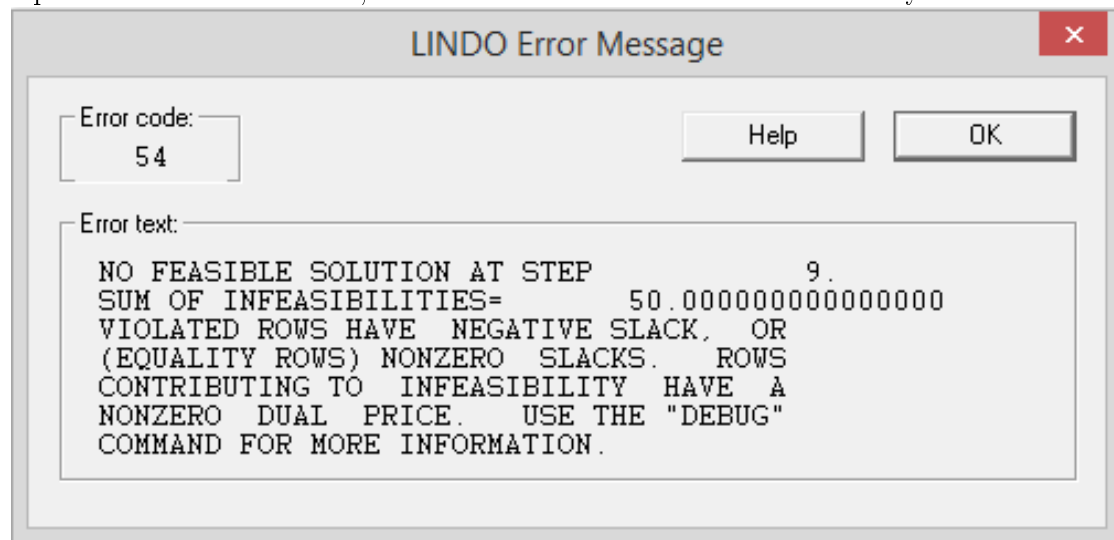
To remove Warehouse 2 and all its associated routes, we remove all variables in our equation that contain "w2" in it. The resulting LINDO code is as follows:

```
MIN 10 p1w1 + 11 p2w1 + 13 p3w1 + 9 p3w3 + 8 p4w3 + 5 w1r1 + 6 w1r2
    + 7 w1r3 + 10 w1r4 + 14 w3r4 + 12 w3r5 + 12 w3r6 + 6 w3r7
ST
p1w1 = 150
p2w1 = 450
p3w1 + p3w3 = 250
p4w3 = 150
w1r1 = 100
w1r2 = 150
w1r3 = 100
w1r4 + w3r4 = 200
w3r5 = 200
w3r6 = 150
w3r7 = 100
p1w1 + p2w1 + p3w1 - w1r1 - w1r2 - w1r3 - w1r4 <= 0
p3w3 + p4w3 - w3r4 - w3r5 - w3r6 - w3r7 <= 0
p1w1 > 0
p2w1 > 0
p3w1 > 0
```

```
p3w3 > 0
p4w3 > 0
w1r1 > 0
w1r2 > 0
w1r3 > 0
w1r4 > 0
w3r4 > 0
w3r5 > 0
w3r6 > 0
w3r7 > 0
```

END

Upon execution of the code, we are met with these solution infeasibility notices:



LINDO Solver Status

×

Optimizer Status

Status:Infeasible

Iterations:4

Infeasibility:50

Objective:18800

Best IP:N/A

IP Bound:N/A

Branches:N/A

Elapsed Time:00:00:18

Update Interval:

1

Interrupt Solver

Close

There is no feasible solution here because Warehouse 3's total possible supply (400) is not capable of supporting the combined demand of R4, R5, R6, and R7 (650). On the other hand, Warehouse 1 is in fact capable of supporting R1, R2, R3, and R4 with its 850 supply to 550 demand ratio, but that still does not solve the larger supply chain deficit and feasibility issue. Overall, we need Warehouse 2 to supplement the supply to

R3, R4, R5, and R6 and sufficiently "spread the load" on the warehouses.

Part C:

Part D:

2 PROBLEM 2

Part A:

i.

ii.

iii.

Part B:

i.

ii.

iii.

Part C:

i.

ii.

iii.

3 PROBLEM 3

Part A:

i.

ii.

iii.

Part B:

i.

ii.

iii.

iv.

Part C: