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IE 400 Project

Bilkent University

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PART A

Sets:

Product: 1, 2, … , 45

Market: 1, 2, 3, 4, 5

Need: 1, 2, 3, 4

Beverage: 1, 2, 3, … , 18

Carbodydrate: 19, 20, … , 29

Cheese: 30, 31, … , 39

Breakfast: 40, 41, 42, 43, 44, 45

Parameters:

$C_{\text{i in product}}$: unit price of product i

$S_{\text{i in product}}$: unit satisfaction of product i

$A_{\text{i in product}}$: unit amount of product i

T : max travel limit = 1200

$d_{\text{k in market l in market}}$: distance between markets

$D_{\text{n in need}}$: demand for each need

B : budget = 175

$M_{i\,k}$: binary 1 if product i belongs to market k

BigM : 100000

Decision Variables:

$P_{\text{i in product}}$: # of packets bought

Z1 : linearization decision variable for constraints

$X_{k\,l}$: $\begin{cases} 1, if\ market\ l\ is\ visited\ right\ after\ market\ k \\ 0, otherwise \end{cases}$

Objective Function:

$$\sum_{i\ in\ product} S_i * P_i + B\ - \sum_{i\ in\ product} P_i *\ C_i$$

Total satisfaction we get from the products we bought equals to satisfaction per unit times packets.

Constraints:

- Travel limit should be satisfied.

$$\sum_{l\ in\ market} \sum_{k\ in\ market} X_{k\,l} * d_{k\,l}\ \leq T$$

- Budget limit should be satisfied.

$$\sum_{i\ in\ product} C_i * P_i\ \leq B$$

- Demand for each product should be satisfied.

$$\sum_{i\ in\ beverage} P_i * A_i\ \geq D_1$$

$$\sum_{i\ in\ carbodydrate} P_i * A_i\ \geq D_2$$

$$\sum_{i\ in\ cheese} P_i * A_i\ \geq D_3$$

$$\sum_{i\ in\ breakfast} P_i * A_i\ \geq D_4$$

- Travel should start from the house and end in house

$$\sum_{l\ in\ market: l\neq 5} X_{5\,l}\ = 1$$

$$\sum_{l\ in\ market: l\neq 5} X_{l\,5}\ = 1$$

- We are able to travel to only one market at a time

$$\sum_{l\ in\ market} X_{k\,l}\ \leq 1\ \forall\ k\ \in market$$

- We cannot buy a product from a market which is not visited. Either we should visit the market or we should not buy a product from that market.

$$P_i * M_{i\,k} \leq bigM * Z1 \quad \forall\, i \in product, k \in market: k \neq 5$$

$$\sum_{l\ in\ mar\ :\, l \neq k} X_{l\,k} - 1 \geq bigM * (1 - Z1) \quad \forall\, i \in product, k \in market: k \neq 5$$

Results:

- Objective Function Value: 5298
- Market Visit Order: 5-1-3-2-4-5
- Products Bought: $P_{39} = 2$, $P_{43} = 1$, $P_{23} = 1$, $P_8 = 1$, $P_4 = 1$

PART B

Results:

- Objective Function Value: 5298
- Market Visit Order: 5-1-3-2-4-5
- Products Bought: $P_{39} = 2$, $P_{43} = 1$, $P_{23} = 1$, $P_8 = 1$, $P_4 = 1$

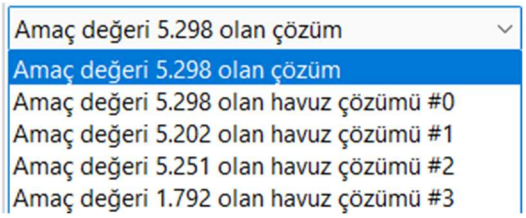

Image 1

product ...lük 45)	Değer
39	2
43	1
23	1
8	1
4	1

Image 2

market (büyüklük 5)	market (büyüklük 5)				
	1	2	3	4	5
1	0	0	0	0	1
2	0	0	1	0	0
3	1	0	0	0	0
4	0	1	0	0	0
5	0	0	0	1	0

Image 3

PART C

Sets:

Product: 1, 2, … , 45

Market: 1, 2, 3, 4 5

Need: 1, 2, 3, 4

Beverage: 1, 2, 3, … , 18

Carbodydrate: 19, 20, … , 29

Cheese: 30, 31, … , 39

Breakfast: 40, 41, 42, 43, 44, 45

Parameters:

$C_{\text{i in product}}$: unit price of product i

$S_{\text{i in product}}$: unit satisfaction of product i

$A_{\text{i in product}}$: unit amount of product i

T : max travel limit = 1200

$d_{\text{k in market l in market}}$: distance between markets

$D_{\text{n in need}}$: demand for each need

B : budget = 175

$M_{i\,k}$: binary 1 if product i belongs to market k

BigM : 100000

Decision Variables:

$P_{\text{i in product}}$: # of packets bought

Z1 : linearization decision variable for constraints

Z2 : linearization decision variable for constraints

$X_{k\,l}$: $\begin{cases} 1, if\ market\ l\ is\ visited\ right\ after\ market\ k \\ 0, otherwise \end{cases}$

Objective Function:

$$\sum_{i\ in\ product} S_i * P_i + B \ - \sum_{i\ in\ product} P_i * \ C_i$$

Total satisfaction we get from the products we bought equals to satisfaction per unit times packets.

Constraints:

- Travel limit should be satisfied.

$$\sum_{l\ in\ market} \sum_{k\ in\ market} X_{k\,l} * d_{k\,l} \ \leq T$$

- Budget limit should be satisfied.

$$\sum_{i\ in\ product} C_i * P_i \ \leq B$$

- Demand for each product should be satisfied.

$$\sum_{i\ in\ beverage} P_i * A_i \ \geq D_1$$

$$\sum_{i\ in\ carbodydrate} P_i * A_i \ \geq D_2$$

$$\sum_{i\ in\ chees} P_i * A_i \ \geq D_3$$

$$\sum_{i\ in\ breakfast} P_i * A_i \ \geq D_4$$

- Travel should start from the house and end in house

$$\sum_{l\ in\ market: l \neq 5} X_{5\,l} \ = 1$$

$$\sum_{l\ in\ market: l \neq 5} X_{l\,5} \ = 1$$

- We are able to travel to only one market at a time

$$\sum_{l\ in\ market} X_{k\,l} \ \leq 1 \ \forall \ k \in market$$

- We cannot buy a product from a market which is not visited. Either we should visit the market or we should not buy a product from that market.

$$P_i * M_{i\,k} \ \leq bigM * Z1 \quad \forall\, i \in product, k \in market: k \neq 5$$

$$\sum_{l\ in\ market:\ l \neq k} X_{l\,k} - 1 \geq bigM * (1 - Z1) \quad \forall\, i \in product, k \in market: k \neq 5$$

- Either we do not buy product 39, or we buy product 35

$$P_{39} \leq bigM * Z2$$

$$1 - P_{35} \leq bigM * (1 - Z2)$$

Results:

- Objective Function Value: 5279
- Market Visit Order: 5-1-3-2-4-5
- Products Bought: $P_{39} = 2$, $P_{44} = 1$, $P_{35} = 1$, $P_{28} = 1$, $P_{11} = 1$

PART D

Sets:

Product: 1, 2, … , 45

Market: 1, 2, 3, 4 5

Need: 1, 2, 3, 4

Beverage: 1, 2, 3, … , 18

Carbodydrate: 19, 20, … , 29

Cheese: 30, 31, … , 39

Breakfast: 40, 41, 42, 43, 44, 45

Parameters:

$C_{\text{i in product}}$: unit price of product i

$S_{\text{i in product}}$: unit satisfaction of product i

$A_{\text{i in product}}$: unit amount of product i

T : max travel limit = 1200

$d_{\text{k in market l in market}}$: distance between markets

$D_{\text{n in need}}$: demand for each need

B : budget = 175

$M_{i\,k}$: binary 1 if product i belongs to market k

BigM : 100000

Decision Variables:

$P_{\text{i in product}}$: # of packets bought

Z1 : linearization decision variable for constraints

Z2 : linearization decision variable for constraints

$X_{k\,l}$: $\begin{cases} 1, if\ market\ l\ is\ visited\ right\ after\ market\ k \\ 0, otherwise \end{cases}$

Objective Function:

$$\sum_{i\ in\ product} S_i * P_i + B \ - \sum_{i\ in\ product} P_i * \ C_i$$

Total satisfaction we get from the products we bought equals to satisfaction per unit times packets.

Constraints:

- Travel limit should be satisfied.

$$\sum_{l\ in\ market} \sum_{k\ in\ market} X_{k\,l} * d_{k\,l} \ \leq T$$

- Budget limit should be satisfied.

$$\sum_{i\ in\ product} C_i * P_i \ \leq B$$

- Demand for each product should be satisfied.

$$\sum_{i\ in\ beverage} P_i * A_i \ \geq D_1$$

$$\sum_{i\ in\ carbodydrate} P_i * A_i \ \geq D_2$$

$$\sum_{i\ in\ cheese} P_i * A_i \ \geq D_3$$

$$\sum_{i\ in\ breakfast} P_i * A_i \ \geq D_4$$

- Travel should start from the house and end in house

$$\sum_{l\ in\ market : l \neq 5} X_{5\,l} \ = 1$$

$$\sum_{l\ in\ market : l \neq 5} X_{l\,5} \ = 1$$

- We are able to travel to only one market at a time

$$\sum_{l \text{ in } market} X_{k\,l} \quad \leq 1 \quad \forall\ k\ \in market$$

- We cannot buy a product from a market which is not visited. Either we should visit the market or we should not buy a product from that market.

$$P_i * M_{i\,k} \quad \leq bigM * Z1 \quad \forall\, i \in product, k\ \in market: k \neq 5$$

$$\sum_{l \text{ in } market:\, l \neq k} X_{l\,k} - 1 \geq\ bigM * (\,1 - Z1\,) \quad \forall\, i \in product, k\ \in market: k \neq 5$$

- Either we do not buy product 4, or we do not buy product 8

$$P_4 \leq bigM * Z2$$

$$P_8 \leq bigM * (\,1 - Z2\,)$$

Results:

- Objective Function Value: 5289
- Market Visit Order: 5-1-3-2-4-5
- Products Bought: $P_{28} = 3$, $P_{39} = 2$, $P_{44} = 1$, $P_9 = 1$

PART E

Sets:

Product: 1, 2, … , 45

Market: 1, 2, 3, 4 5

Need: 1, 2, 3, 4

Beverage: 1, 2, 3, … , 18

Carbodydrate: 19, 20, … , 29

Cheese: 30, 31, … , 39

Breakfast: 40, 41, 42, 43, 44, 45

Parameters:

$C_{\text{i in product}}$: unit price of product i

$S_{\text{i in product}}$: unit satisfaction of product i

$A_{\text{i in product}}$: unit amount of product i

T : max travel limit = 1200

$d_{\text{k in market l in market}}$: distance between markets

$D_{\text{n in need}}$: demand for each need

B : budget = 175

$M_{i\,k}$: binary 1 if product i belongs to market k

BigM : 100000

T_d : time limit = 350

$Time_k$: time spent in market

V : speed = 5

Decision Variables:

$P_{\text{i in product}}$: # of packets bought

Z1 : linearization decision variable for constraints

Z2 : linearization decision variable for constraints

$x_{k\,l}$: $\begin{cases} 1, if\ market\ l\ is\ visited\ right\ after\ market\ k \\ 0, otherwise \end{cases}$

$\text{loc}_k : \begin{cases} 1, if\ market\ k\ is\ visited \\ 0, otherwise \end{cases}$

Objective Function:

$$\sum_{i\ in\ product} S_i * P_i + B - \sum_{i\ in\ product} P_i * C_i$$

Total satisfaction we get from the products we bought equals to satisfaction per unit times packets.

Constraints:

- Travel limit should be satisfied.

$$\sum_{l\ in\ market} \sum_{k\ in\ market} X_{k\,l} * d_{k\,l} \leq T$$

- Budget limit should be satisfied.

$$\sum_{i\ in\ product} C_i * P_i \leq B$$

- Demand for each product should be satisfied.

$$\sum_{i\ in\ beverage} P_i * A_i \geq D_1$$

$$\sum_{i\ in\ carbodydrate} P_i * A_i \geq D_2$$

$$\sum_{i\ in\ cheese} P_i * A_i \geq D_3$$

$$\sum_{i\ in\ breakfast} P_i * A_i \geq D_4$$

- Travel should start from the house and end in house

$$\sum_{l\ in\ market : l \neq 5} X_{5\,l} = 1$$

$$\sum_{l \text{ in } market: l \neq 5} X_{l\,5} \quad = 1$$

- We are able to travel to only one market at a time

$$\sum_{l \text{ in } market} X_{k\,l} \quad \leq 1 \quad \forall\ k\ \in market$$

- We cannot buy a product from a market which is not visited. Either we should visit the market or we should not buy a product from that market.

$$P_i * M_{i\,k} \ \leq bigM * Z1 \ \ \forall\, i \in product, k\ \in market: k \neq 5$$

$$\sum_{l \text{ in } market:\, l \neq k} X_{l\,k} \ - 1 \geq \ bigM * (\,1 - Z1\,) \ \ \forall\, i \in product, k\ \in market: k \neq 5$$

- Decision variable loc[k] should be equal to 1 if market k is visited

$$\sum_{l \text{ in } market} X_{l\,k} \ \leq \ bigM * Z2 \ \ \forall\, k \in market$$

$$1 - \ loc_k \ \leq bigM * (\,1 - Z2\,) \ \ \forall\, k \in market$$

- Time limit should be satisfied.

$$\sum_{l \text{ in } market: k \neq 1} \ \sum_{k \text{ in } market} loc_{\,k} * time_{\,k} \ + \ X_{k\,l} * \ d_{\,k\,l} \,/\, V \ \leq \ T_d$$