

MMCS Assessment3

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1 Exercise 1 *Model*

- Index sets

A : different activities (1-3 present plant 3 crops, 4 present rearing), $a \in A = \{1, 2, 3, 4\}$

L : different land block, $l \in L = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$

C : different crops (1: grain, 2: beans, 3: wheat), $c \in C = \{1, 2, 3\}$

Y : different years, $y \in Y = \{1, 2, 3, 4, 5, 6, 7, 8, 9, 10\}$

- Variables

$plant_{c,y,l}$: the area to plant c crop on l block in y year

$rear_{y,l}$: the amount of cows rear on l block of land in y year

$calf_y$: the amount of calf in the start of y year

$plant_hour_grain_y$: the weight of grain plant for feeding cows.

$bought_grain_y$: the weight of grain bought for feeding cows.

- Auxiliary Variables

$x_{a,l,y} \in \{1, 0\}$

– $x_{a,l,y} = 1$: use l block of land in y year for activity a

– $x_{a,l,y} = 0$: do not use l block of land in y year for activity a

- Parameters

$land_size_l$: the size of each block of land (m_2)

$crops_yield_c$: the yield of different crops grown in 1 unit of land (kg/m_2)

$crops_sewing_costs_c$: the sewing cost for 1 m_2 for different crops ($pound/m_2$)

$crops_price_c$: the price of selling different crops($1kg$)

$cows_sell_price_y$: the price for sell cows bought in different years, here I made a modification: $crops_price_y : [1700, 1400, 1250, 1100, 950, 700, 600, 550, 450, 350]$

$calf_purchase = 200$

$cows_space = 5$

$cows_grain = 15$

$grain_price = 50$

- Objective function

$$\max \text{cows_profit} + \text{crops_profit} - \text{cows_costs} - \text{plant_costs} - \text{grain_costs} \quad (1)$$

$$\text{cows_profit} = \sum_{y \in Y} \text{calf}_y \times \text{cows_sell_price}_y \quad (2)$$

$$\text{crops_profit} = \sum_{c \in C, y \in Y, l \in L} \text{plant}_{c,y,l} \times \text{crops_yield}_c \times \text{crops_price}_c \quad (3)$$

$$\text{cows_costs} = \sum_{y \in Y} \text{calf}_y \times \text{calf_purchase} \quad (4)$$

$$\text{plant_costs} = \sum_{c \in C, y \in Y, l \in L} \text{plant}_{c,y,l} \times \text{crops_sewing_costs}_c \quad (5)$$

$$\text{grain_costs} = \sum_{y \in Y} \text{plant_grain}_y * \text{crops_price}_1 + \sum_{y \in Y} \text{bought_grain}_y * \text{grain_price} \quad (6)$$

- Constraints

s.t.

$$\sum_{a \in A} x_{a,l,y} \leq 1, l \in L, y \in Y$$

(1 block of land only be used in 1 activity in 1 year)

$$\sum_{l \in L} \text{rear}_{y,l} = \text{calf}_y, y = 1$$

$$\sum_{l \in L} \text{rear}_{y,l} = \text{rear}_{y-1} + \text{calf}_y, y \in Y \setminus \{1\}$$

(the relation between total cows amount and new calf)

$$\sum_{y \in Y} \text{rear}_{y,l} \times \text{cows_grain} \leq \text{bought_grain}_y, y = 1, l \in L$$

$$\sum_{y \in Y} \text{rear}_{y,l} \times \text{cows_grain} \leq \text{plant_grain}_{y-1,l} + \text{bought_grain}_y, y \in Y \setminus \{1\}, l \in L$$

$$\sum_{l \in L} \text{plant}_{c,y,l} * \text{crops_yield}_c \geq \text{plant_grain}_y, c = 1, y \in Y, l \in L$$

(relation between bought grain and planted grain, grain to feed and grain to sell)

$$\text{plant}_{c,y,l} \leq \text{land_size}_l \times x_{a,y,l}, y \in Y, l \in L, c \in C, a \in A \setminus \{4\}, c = a$$

$$\text{rear}_{y,l} \times \text{cows_space} \leq \text{land_size}_l \times x_{a,y,l}, y \in Y, l \in L, a = 4$$

(the land size limitation)

$$\sum_{l \in L} \text{plant}_{c,y,l} \leq \sum_{l \in L} \text{land_size}_l \times 0.5, c \in C, y \in Y$$

$$\sum_{l \in L} \text{rear}_{y,l} \times \text{cows_space} \leq \sum_{l \in L} \text{land_size}_l \times 0.5, c \in C, y \in Y$$

(1 activity use no more than 50% of total land size per year)

$$x_{a,l,y} \in \{1, 0\}$$

$$\text{calf}_y \in Z, \text{rear}_{y,l} \in Z$$

$$plant_{c,y,l} \geq 0, rear_{y,l} \geq 0, calf_y \geq 0, plant_grain_y \geq 0, bought_grain_y \geq 0$$

$$y \in Y, l \in L, c \in C, a \in A$$

2 Exercise 2 *Solve*

Files and code are attached in the assessment_3.zip package.

As the code need a few minutes to run in my laptop, I display the result below.

The maximum profit is 212307.5 for total 10 years.

| year\land | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------------|-----|-----|-----|-----|-----|----|-----|-----|-----|----|
| year 1 | 0 | 250 | 0 | 125 | 0 | 0 | 900 | 0 | 465 | 90 |
| year 2 | 100 | 0 | 500 | 0 | 800 | 75 | 0 | 355 | 0 | 0 |
| year 3 | 0 | 250 | 0 | 125 | 0 | 0 | 900 | 0 | 465 | 90 |
| year 4 | 95 | 0 | 500 | 0 | 800 | 75 | 0 | 360 | 0 | 0 |
| year 5 | 0 | 250 | 0 | 125 | 0 | 0 | 900 | 0 | 465 | 90 |
| year 6 | 100 | 250 | 0 | 125 | 800 | 0 | 0 | 0 | 465 | 90 |
| year 7 | 100 | 0 | 500 | 0 | 795 | 75 | 0 | 360 | 0 | 0 |
| year 8 | 100 | 250 | 0 | 125 | 800 | 0 | 0 | 0 | 465 | 90 |
| year 9 | 0 | 0 | 495 | 0 | 0 | 75 | 900 | 360 | 0 | 0 |
| year 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 1: Planting plan for grain

| year\land | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------------|---|---|---|---|---|---|---|---|---|----|
| year 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 2: Planting plan for beans

| year\land | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------------|-----|---|-------|---|-----|----|-------|-----|---|----|
| year 1 | 100 | 0 | 497.5 | 0 | 800 | 75 | 0 | 360 | 0 | 0 |
| year 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 10 | 0 | 0 | 500 | 0 | 0 | 75 | 897.5 | 360 | 0 | 0 |

Table 3: Planting plan for wheat

| years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|-------------|---|-----|---|---|---|---|---|---|---|----|
| calf | 0 | 366 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 4: Plan for buying calf

| year\land | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------------|----|----|----|----|-----|----|-----|----|----|----|
| year 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| year 2 | 0 | 50 | 0 | 25 | 0 | 0 | 180 | 0 | 93 | 18 |
| year 3 | 20 | 0 | 99 | 0 | 160 | 15 | 0 | 72 | 0 | 0 |
| year 4 | 0 | 50 | 0 | 25 | 0 | 0 | 180 | 0 | 93 | 18 |
| year 5 | 20 | 0 | 99 | 0 | 160 | 15 | 0 | 72 | 0 | 0 |
| year 6 | 0 | 0 | 99 | 0 | 0 | 15 | 180 | 72 | 0 | 0 |
| year 7 | 0 | 50 | 0 | 25 | 0 | 0 | 180 | 0 | 93 | 18 |
| year 8 | 0 | 0 | 99 | 0 | 0 | 15 | 180 | 72 | 0 | 0 |
| year 9 | 20 | 50 | 0 | 25 | 160 | 0 | 0 | 0 | 93 | 18 |
| year 10 | 20 | 50 | 0 | 25 | 160 | 0 | 0 | 0 | 93 | 18 |

Table 5: Plan for rearing cows

| years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---------------------|---|---|---|---|---|---|---|---|---|----|
| bought_grain | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

Table 6: Plan for buying grain