Sequence 2 : The farm model

Unit 2.2 : Specificities of the agricultural model

Lesson 15 : Crop rotations

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Contents

Knowing how to model	Knowing how to use GAMS
Two ways to model rotations	SUBSET

Introduction

- Disease prevention
- Weed control
- Maintaining soil fertility

Crop rotations

Rotation = Succession of crops on the same plot over the years

Different ways to model :

- Annual model
  - Cropping pattern constraint
  - Rotations as “activities”
- Dynamic model

Example of arable crop rotations

- UAA : 110 ha
- Irrigation water : 60 000 m^3
- Possible Activities : wheat, barley, rapeseed, apple trees

- Oilseed crops cannot be cultivated more than once every three years on the same plot
- Straw cereal crops (wheat and barley) cannot be cultivated more than two years in a row

- How can these constraints be represented in the model ?

Cropping pattern constraints

Maximize $Z = 900X_1 + 750\,X_2 + 1030\,X_3 + 820\,X_4$

With
$$X_1 + X_2 + X_3 + X_4 \leq 110$$
$$175X_1 + 700\,X_2 + 0\,X_3 + 50\,X_4 \leq 60000$$
$$X_1 + X_2 \leq 2/3\,(X_1 + X_2 + X_3)$$
$$X_3 \leq 1/3\,(X_1 + X_2 + X_3)$$
$$X_1, X_2, X_3, X_4 \geq 0$$

Rotation

Maximum twice every 3 years for cereal crops
Maximum once every 2 years for oilseed crops

X_1 : area dedicated to wheat
X_2 : area dedicated to barley
X_3 : area dedicated to rapeseed
X_4 : area dedicated to apple trees

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In GAMS

```
SET C crops /wheat, barley, rapeseed, apple trees/
    CA(C) /wheat, barley, rapeseed/ ;

[…]


ROTATION_OILS..      X('rapeseed') =l= sum(CA, X(CA)) * 1/3 ;

ROTATION_CERE..      X('wheat') + X('barley') =l= sum(CA, X(CA)) * 2/3 ;
```

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Rotations as activities

- Oilseed crops cannot be cultivated more than once every three years on the same plot
- Straw cereal crops (wheat and barley) cannot be cultivated more than two years in a row

3 possible rotations :

- Wheat – Wheat – Rapeseed
- Wheat – Barley – Rapeseed
- Barley – Barley – Rapeseed

Calculation of water needs and gross margin per rotation :

$$WATERN_{WWR} = (WATERN_{W} + WATERN_{W} + WATERN_{R}) / 3$$

$$GM_{WWR} = (GM_{W} + GM_{W} + GM_{R}) / 3$$

Rotations as activities

$(GM_W+GM_W+GM_R)/3=(900+900+1030)/3$

Maximize $Z = 943\ X_{WWR} + 893\ X_{WBR} + 843\ X_{BBR} + 820\ X_4$

With $X_{WWR} + X_{WBR} + X_{BBR} + X_4 \leq 110$

$117X_{WWR} + 292\ X_{WBR} + 467\ X_{BBR} + 50\ X_4 \leq 60000$

$X_{WWR}, X_{WBR}, X_{BBR}, X_4 \geq 0$

Activities

{wheat, wheat, rapeseed}
{wheat, barley, rapeseed}
{barley, barley, rapeseed}

X_{WWR} : activity wheat-wheat-rapeseed
X_{WBR} : activity wheat-barley-rapeseed
X_{BBR} : activity barley-barley-rapeseed
X_4 : apple trees

Solution :
Z = 103 770
X_{WWR} = 110 ⟹ Wheat : 110 * 2/3 = 73.33
Rapeseed : 110 * 1/3 = 36,67

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