Sequence 2 : The farm model

Unit 2.3 : Simulating a public policy

Lesson 19 : The CAP and the agri-environment

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CAP and the environment

Initial objectives of the CAP :

- to modernize European agriculture
- to increase labour and land productivity
- to improve the income of farmers

- Guaranteed-high-prices policy
- Intensification of practices via the use of chemical inputs
- Encouraging farm restructuring and expansion
- Farm specialization

- Water and soil pollution
- Loss of biodiversity
- Overexploitation of water resources

Regulations

How is it possible to revert to more environmentally-friendly production systems and practices ?

❑ Regulations

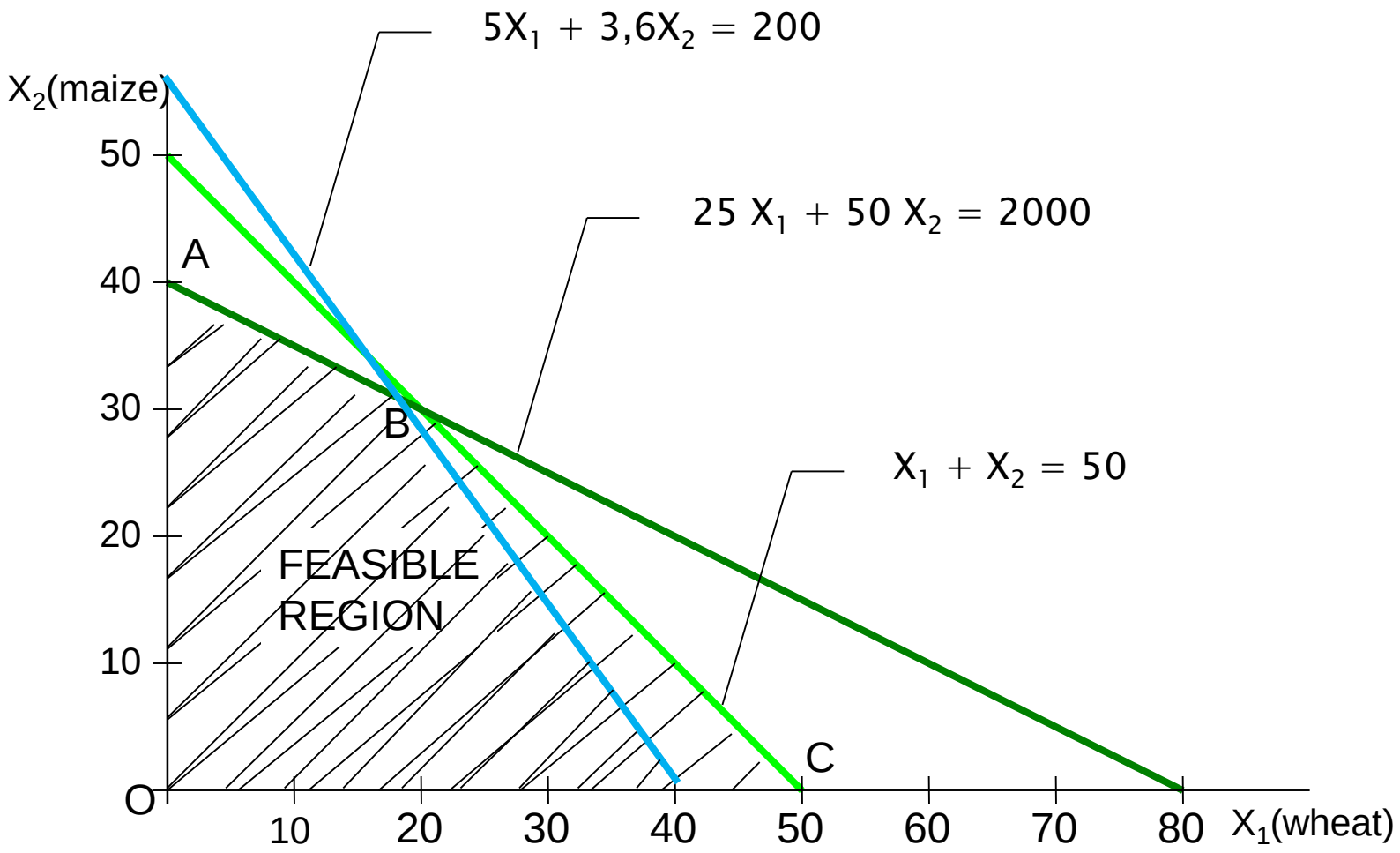
Imposing stricter rules

The rules can concern :

- Forbidden products or practices
- Compulsory practices
- They may be applicable everywhere or only on vulnerable territories

Regulations- Example

Returns to adding a constraint



$$\text{Max} \quad Z = 450\ X_1 + 1000\ X_2$$

subject to

$$X_1 + X_2 \leq 50$$

$$25\ X_1 + 50\ X_2 \leq 2000$$

$$X_1 \geq 0\ ;\ X_2 \geq 0$$

What are the impacts of different levels of regulation?

Subsidies

How is it possible to revert to more environmentally-friendly production systems and practices ?

- **Subsidies**
  - → *e.g. : Agro-environment-climate measures (AECM)*

Respecting environmental specifications

contract

control

Agri-environmental payments

Compensate farmers who opt for more environmentally-friendly practices, which can be more costly or cause yield losses

Subsidies – Example

Two possibilities, the farmer chooses the best solution

if and only if the constraint is respected

Max r $Z = 450\ X_1 + 1000\ X_2$

subject to

$X_1 + X_2 \leq 50$

$25\ X_1 + 50\ X_2 \leq 2000$

$X_1 \geq 0\ ;\ X_2 \geq 0$

Max r $Z = 450\ X_1 + 1000\ X_2$ + (X_1 + X_2) * subs

subject to

$X_1 + X_2 \leq 50$

$25\ X_1 + 50\ X_2 \leq 2000$

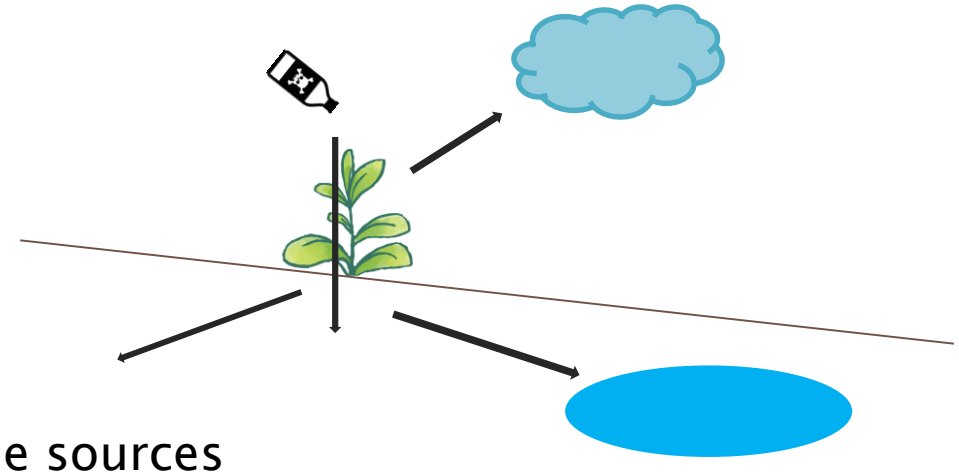
$X_1 \geq 0\ ;\ X_2 \geq 0$

$5\ X_1 + 3.6\ X_2 \leq$ MAXTFI

Taxes

How is it possible to revert to more environmentally-friendly production systems and practices ?

❑ Taxes



Taxing farmers who cause environmental damage (polluter pays principle)

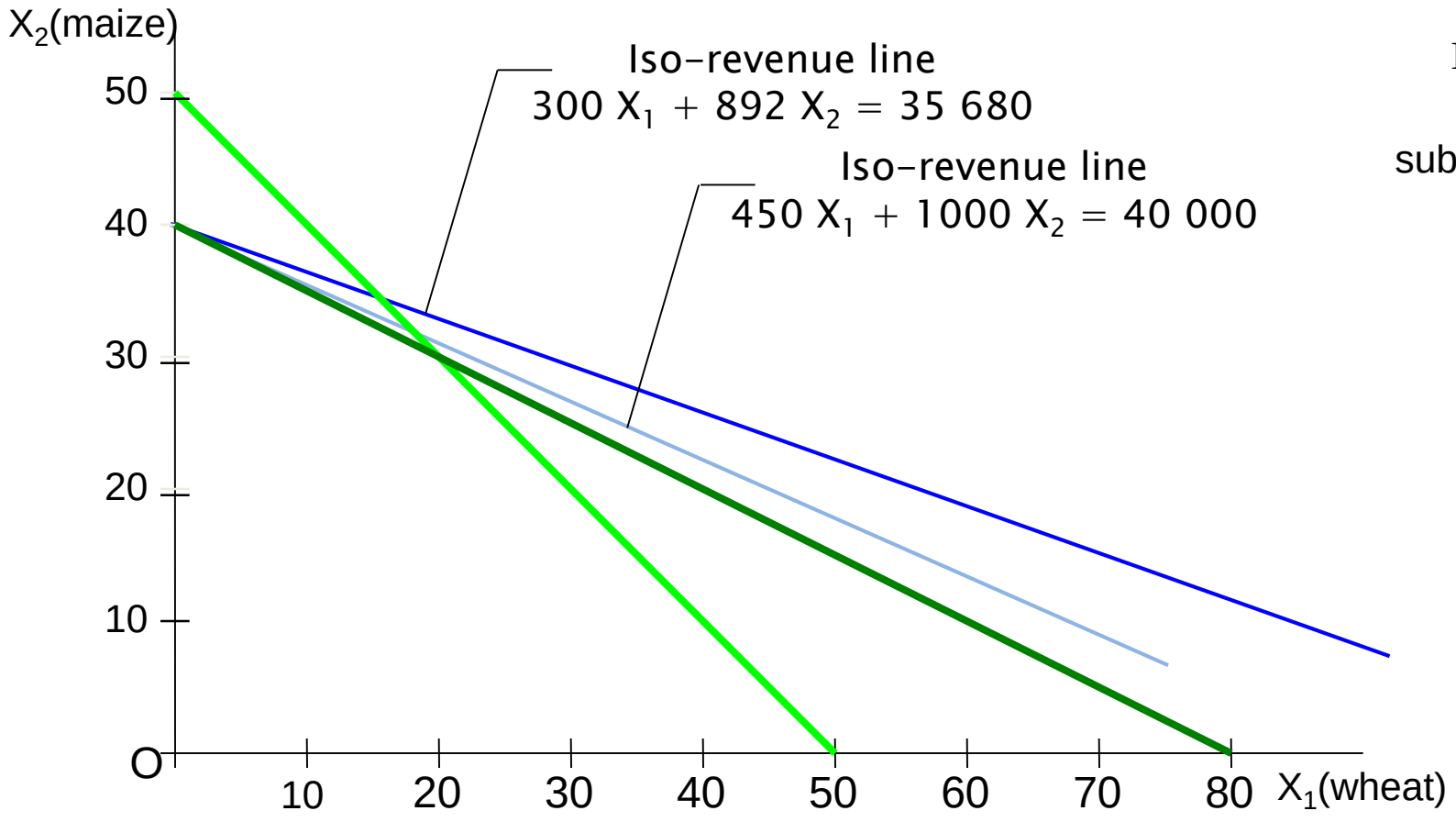
But agricultural pollution comes from many diffuse sources

Alternative : Taxing polluting products in order to make them more expensive and therefore less attractive

→ *e.g. : « non-point source pollution tax » levied by water agencies*

price + tax

Modifies the gross margin and therefore the slope of the isorevenue lines



Taxes – Example

$$Z = 300\,X_1 + 892\,X_2$$

$$\text{Max} \quad \sout{Z = 450\,X_1 + 1000\,X_2}$$

subject to

$$X_1 + X_2 \leq 50$$

$$25\,X_1 + 50\,X_2 \leq 2000$$

$$X_1 \geq 0\,;\, X_2 \geq 0$$

Tax on the use of phytosanitary products: 30€/unit

Additional costs :
5*30=150 for wheat
3.6*30=108 for maize

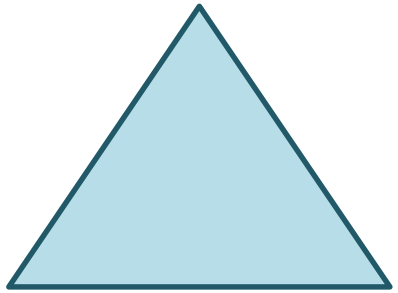
Assessing and comparing different options

Objectives ⟷ Costs

- Reduce pesticide use by x%
- Lower nitrate rate in catchment area

- Budget for subsidies
- Administrative and control costs
- Costs for farmers

Effectiveness:
Meeting the objective



Efficiency :
Meeting the objective
at the lowest possible cost

Acceptability

Modelling and simulating in order to help public decision-making !

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Example

- Cereal farm (lesson 11)
  - 2 crops : wheat, maize
  - 2 technologies : intensive, extensive
  - 2 constraints : land and labour
  - To measure pesticide use, the treatment frequency index (IFT) is used

- **Policy :**

1. **Regulations** : Prohibition to exceed a threshold

How to make the simulation of several price levels automatic ?

GAMS: LOOP

2. **Subsidy** :Subject to compliance with a maximum of 140 IFT/ha

How to introduce an « if… then… » condition in equations ?

GAMS: binary variable

Regulations - Example

Policy: Regulations -> Prohibition to exceed more than 140IFT/ha

```
*----------                              DECLARATIONS
sets
C crops  /wheat,maize/
;


*----------                              DATA
scalar
LAND_A      land availability in hectares              /50/
LABOUR_A    labour availability in hours             /2000/
RTFI        regulatory limit for operation           /140/
;

LN(C) labour needs per hectare and per crop (hours)
/wheat   25
 maize   50/

GM(C) gross margin per crop (euros)
/wheat   450
 maize  1000/


;
```

```
*----------                              MODEL
 variables
Z    total farm income  (euros)
;

positive variables

X area per crop (hectares)
;

equations
OBJECTIVE       objective function
LAND            land equation
LABOUR          labour equation

;

OBJECTIVE..  sum(c, GM(c)*X(c)) =E= Z ;

LAND..       sum(c, X(c)) =l= LAND_A ;

LABOUR..     sum(c, LN(c)*X(c)) =L= LABOUR_A  ;


model example first example /all/;

*----------                              SOLUTION
solve example using LP maximizing Z;
```

Policy: Regulations -> Prohibition to exceed more than ?TFI/ha
Simulation of several price levels automatic

Regulations – Example

```
*----------                                DECLARATIONS
sets
C crops  /wheat,maize/

;

*----------                                DATA
scalar
LAND_A      land availability in hectares              /50/
LABOUR_A    labour availability in hours              /2000/
RTFI        regulatory limit for operation            /140/
;


parameter
LN(C) labour needs per hectare and per crop (hours)
/wheat   25
 maize   50/

GM(C) gross margin per crop (euros)
/wheat   450
 maize  1000/

TFI(C) tfi per hectare and per crop
/wheat 5, maize 3.6/
;
```

```
*----------                                MODEL
 variables
Z    total farm income  (euros)
;
positive variables
X area per crop (hectare
;

equations
OBJECTIVE       objectiv
LAND            land equ
LABOUR          labour equation
TFIMax          reglementation
;

OBJECTIVE..  sum(c, GM(c)*X(c)) =E= Z ;

LAND..       sum(c, X(c)) =l= LAND_A ;

LABOUR..     sum(c, LN(c)*X(c)) =L= LABOUR_A  ;

TFIMax..   sum(c, X(c)*TFI(C)) =l= RTFI ;

model example first example /all/;


solve example using LP maximizing Z;
```

Pause the slideshow and introduce this policy into the primal0.gms model yourself and study the impact on crop rotation and income

Subsidies – Example

Two possibilities, the farmer chooses the best solution

$$\text{Max} \quad r \quad Z = 450\ X_1 + 1000\ X_2$$

subject to

$$X_1 + X_2 \leq 50$$

$$25\ X_1 + 50\ X_2 \leq 2000$$

$$X_1 \geq 0\ ;\ X_2 \geq 0$$

if and only if the constraint is respected

$$\text{Max} \quad r \quad Z = 450\ X_1 + 1000\ X_2 \quad + (X_1 + X_2) * subs$$

subject to

$$X_1 + X_2 \leq 50$$

$$25\ X_1 + 50\ X_2 \leq 2000$$

$$X_1 \geq 0\ ;\ X_2 \geq 0$$

$$5\ X_1 + 3.6\ X_2 \leq MAXTFI$$

$$\text{Max} \quad r \quad Z = 450\ X_1 + 1000\ X_2 \quad + (X_1 + X_2) * subs$$

subject to

$$X_1 + X_2 \leq 50$$

$$25\ X_1 + 50\ X_2 \leq 2000$$

$$X_1 \geq 0\ ;\ X_2 \geq 0 \qquad B = \{0;1\} \qquad bigM = 1000$$

$$5\ X_1 + 3.6\ X_2 \leq MAXTFI + bigM * (1-B)$$

If B=1 then there is the subsidy
the constraint is respected
$5\ X_1 + 3.6\ X_2 \leq MAXTFI$
If B=0 then no subsidy
the constraint is disabled
$5\ X_1 + 3.6\ X_2 \leq MAXTFI + 1000$
because always true

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Subsidies – Example – En GAMS

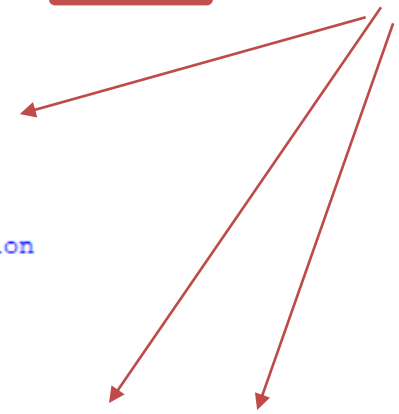
Policy : if the farmer has no intensive practices then he receives a per-hectare premium

```
*----------                              DECLARATIONS
sets
C crops  /wheat,maize/
;


*----------                                DATA
scalar
LAND_A      land availability in hectares          /50/
LABOUR_A    labour availability in hours          /2000/
RTFI        regulatory limit for operation        /140/

;

parameter
LN(C) labour needs per hectare and per crop (hours)
/wheat   25
 maize

GM(C)
/wheat
 maize

TFI(C)
/wheat 5,
;
```

Pause the slideshow and introduce this policy into the primal0.gms model yourself, with a 100€ per-hectare premium and a constraint at 140 TFI/ha

```
 variables
Z    total farm income  (euros)
;

positive variables
X area per crop (hectares)
;



equations
OBJECTIVE       objective function
LAND            land equation
LABOUR          labour equation
TFIMax          reglementation
;

OBJECTIVE..  sum(c, GM(c)*X(c))                    =E= Z ;

LAND..       sum(c, X(c)) =l= LAND_A ;

LABOUR..     sum(c, LN(c)*X(c)) =L= LABOUR_A  ;

TFIMax..   sum(c, X(c)*TFI(C)) =l= RTFI

model example first example /all/;

*----------                              SOLUTION
solve example using       maximizing Z;
```

2 variables multiplied together + binary variable -> model type MINLP



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