

## 2.3. Overview Supply model

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# Overview

- Reminder: agricultural supply analysis
- Structure of the supply module
  - Objective function
  - Constraints
  - Decision variables & Reporting
  - Data
- Technical implementation

# Background: specification procedures different between PM and SE

## Mathematical Programming (PM)

**Approach:** Input allocation to various production activities using an **explicit optimisation** often characterized as normative

**Pros:** PM can be used to explicitly model technological/policy constraints

### Cons:

- no statistical estimation, data demanding
- can yield in corner solutions and calibration is difficult -> Howitt (1995a) presented 'Positive Mathematical Programming', PMP now a widely used approach also in CAPRI
- see Davit's session on PMP calibration

## System of equations (SE)

**Approach:** **System of equations**, closed-form solutions, with **behavioural function**

**Pros:** SE can use econometric techniques, parametric specification based on observed supply and demand

### Cons:

- Particular as constraints (water, land, ..) cannot be easily incorporated and the choice of functional form is restricted
- This limit the model's complexity -> and limits for differentiated analysis

# Structure of the capri supply model

- Each Nuts2 region in the EU (including Norway, Balkan, ...) is presented by a mathematical programming model and maximizes profit
- A regional MP model operate **independent**
- To obtain the supply for the EU, all 270 Nuts2 optimization results need to sum up (by product)
- All Nuts2 models are **calibrated to** the **observed** or **projected** values, as in 2030

# Didactic structure of the supply module

- Linear Programming model

3. Decision Variable	Wheat	Barley	Potato	Maize			
GVA	1200	800	1300	1300		1. Object function	
	4. Data or Parameter					2. Constraints	
	1	1	1		<	10	Quota
	20	24	50	13	<	2000	Labour
	1	1	1	1	<	100	Land



## **Objective function**

Max profits =

gross value added

+ subsidies

- PMP

# Gross value added

Revenues – variable costs

## Revenues

Primary crop products such as cereals, oil seeds, ...

- Young animals
- Meat: Slaughter takes place on farm
- Raw milk: the dairy is in the market model

Note: Manure and roughage (gras, silage) are not traded but handled on farm via constraints

## Variable costs

- Purchased inputs:
  - Fertilizers
  - Plant protection
  - Seed
  - Certain maintenance
- Young animals
- Feed concentrates incl. cereals

## Revenues

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## **Variable costs**

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  - Plant protection
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  - Certain maintenance
- Young animals
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# Subsidies

Nominal amount per unit

List of eligible activities  
All activities eligible =>  
decoupled payment  
Top-ups for selected  
production techniques

Ceilings

- Value ceilings (envelopes)
- Quantitative (entitlements)

IF ceiling overshoot  
THEN cut payment to fit  
ceiling

## Coupled payments

- First pillar: Voluntary coupled support (VCS) Crop specific (Cotton), Complementary National Direct Payments (CNDP)
- Second pillar: Agri-Env Payments, N2k, LFA

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## Decoupled farm payments

- Coupled but everything eligible (BPS)
- Greening requirements
  - Crop diversity
  - Grassland share
  - Winter green
  - Eco. focus areas
- 30% of payment can be reduced

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All activities eligible => decoupled payment  
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- Value ceilings (envelopes)
- Quantitative (entitlements)

IF ceiling overshoot  
THEN cut payment to fit ceiling

## **Decoupled farm payments**

- **Coupled but everything eligible (BPS)**
- **Greening requirements**
  - Crop diversity
  - Grassland share
  - Winter green
  - Eco. focus areas
- 30% of payment can be reduced

## **PMP**

- Additional cost or revenue
- for activities
- for land classes
- for feeding
- Estimated from time series for crops

## Constraints

Equations constraining the model

- Technical (feeding, nutrients...)
- Political and environmental (set-aside, greening, ...)

## **Crop nutrients**

Nutrient supply = nutrient removal

- Nitrogen (N)
- Phosphorous (P)
- Potassium (K)

## **Feeding**

- Using regional fodder
- Using purchased feed
- Cover animal requirements of
  - Energy
  - Protein
  - Various fibres
  - Dry matter

## Political

- Greening requirements

Eco. focus area <

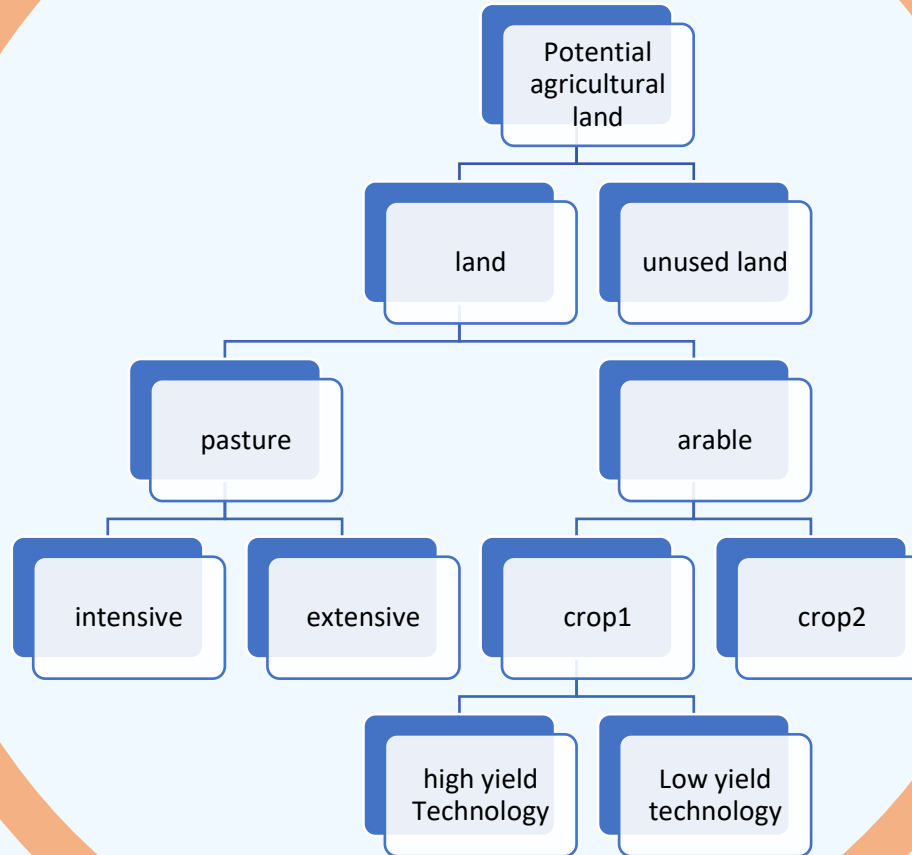
+ Grassland share

+ Crop diversity

+ Winter greening

+ Set-aside

# Land Balance



# Decision variable

```
Gams\supply\Supply_model.gms
Variables/
v_obje "Objective value"
v_actLevl (RALL, COLS, *) "Level of Production activities in 1000 ha or 1000 heads"
v_youngAnimUse (RALL, OM) "Intra-sectoral use of young animals in 1000 heads"
v_feedQuantReg (RALL, *) "Regional feed use in 1000 t per year and herd"
v_feedImpCoeff (RALL, MACT, A, *) "Feeding per head and day in kg fresh weight"
v_netPutQuant (RALL, *) "Selling and buying activities in 1000 t, neg means
buying"
v_lossQuant (RALL, ROWS) "Losses of straw and organic fertiliser in 1000 t"
v_fertDist (RALL, *, FNUT, *) "Distribution of organic and mineral N to groups of crops, in 1000 t"
v_ManureNPK (RALL, *) "Total N,P,K at tail net of gasecus v_lossQuant in 1000 t"
-
/;
```

```
Gams\supply\Supply_model.gms
```

```
Variables/
```

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...  
/;
```

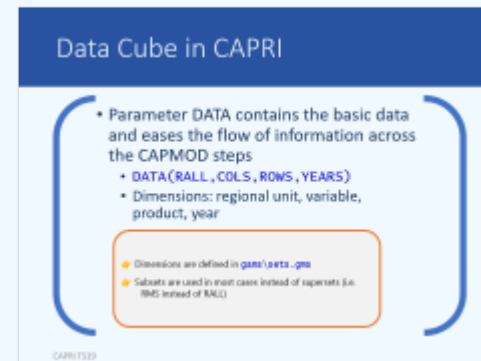
# Data

## Parameters of the supply module

- Prices for all products
- Yields, young animal replacement
- Feed requirements
- Nutrient requirements per crop
- Nutrient content of fodder and crops

Most data are organized in the parameter Data

More next presentation



The slide titled "Data Cube in CAPRI" contains the following text:

- Parameter DATA contains the basic data and eases the flow of information across the CAPMOD steps
  - DATA (RALL, COLS, ROWS, YEARS)
  - Dimensions: regional unit, variable, product, year

Additional notes in a box:

- Dimensions are defined in `gama\verts.gms`
- Subsets are used in most cases instead of operators (i.e. RNS instead of RALL)

CAPRI/ISE

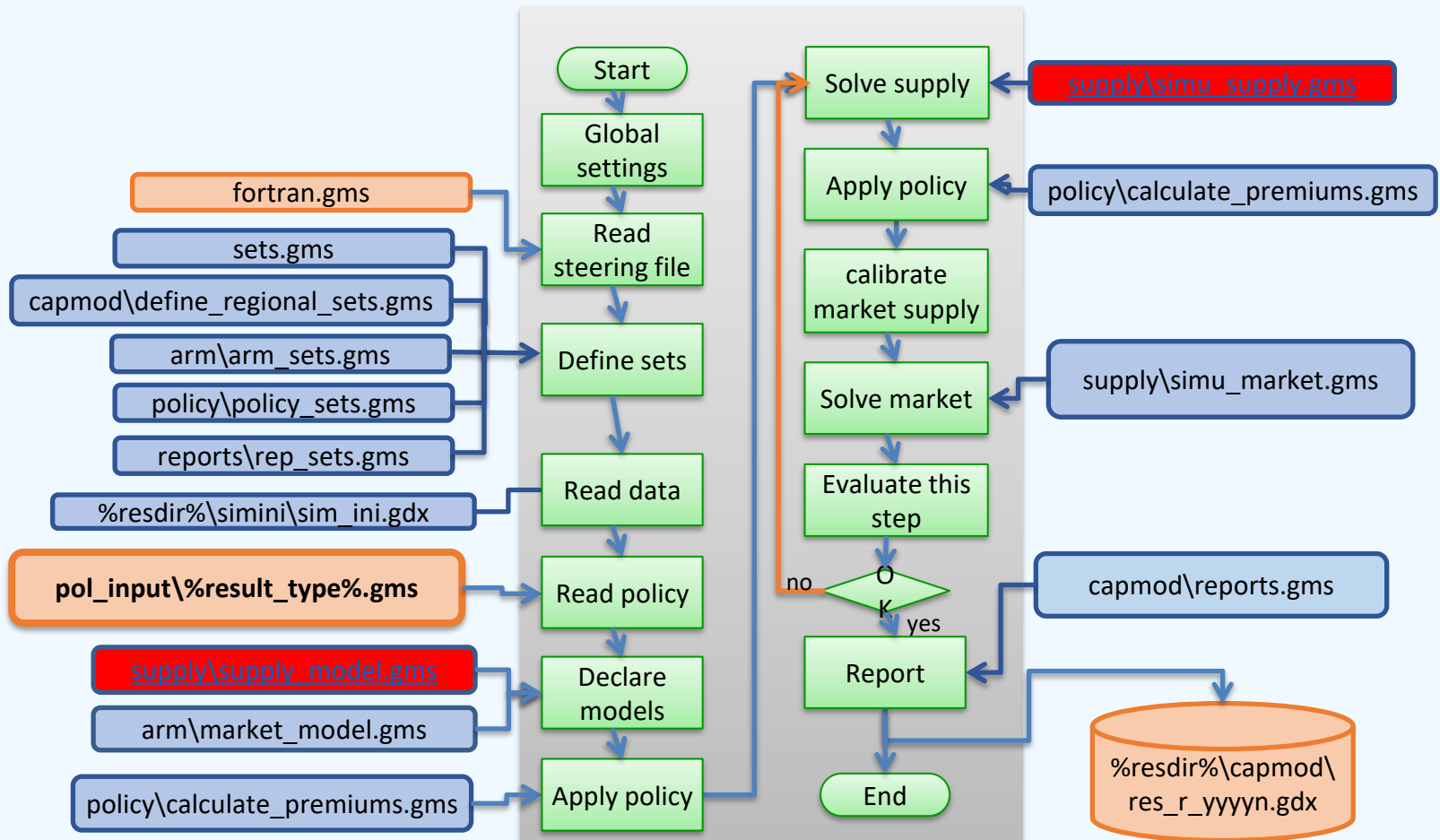
# Data Cube in CAPRI

- Parameter DATA contains the basic data and eases the flow of information across the CAPMOD steps
  - `DATA(RALL, COLS, ROWS, YEARS)`
  - Dimensions: regional unit, variable, product, year

☞ Dimensions are defined in `gams\sets.gms`

☞ Subsets are used in most cases instead of supersets (i.e. RMS instead of RALL)

# Technical implementation: CAPMOD Reminder



# Supply\_model.gms

@purpose : Definition and declaration of variables,  
VARIABLES

```
v_obje "Objective value"  
v_actLevl(RALL, COLS, *) "Level of Production activities in 1000 ha or 1000 heads"  
v_netPutQuant(RALL, *) "Selling and buying activities in 1000 t, neg means buying"
```

Definition of decision variables

EQUATIONS

```
OBJEQF_ "Objective: Income of agriculture + PQP-terms + PQP-feed-terms"  
SUPBAL_ "Supply balances for final outputs"  
NUTNED_ "Nutrient need of crops must be covered by fertilizing"  
permGrasGreening_(RALL) "Greening requirement to keep permanent grass lands"  
ecoSetAside_(RALL) "Greening ecological set-aside"  
winterCover_(RALL) "Winter cover requirement"  
LandBal_ "Land balances - either fixed endowments or market clearing"  
REQSE_ "Requirements of animals written as equality"
```

Definition of equations for the objective function

Definition of equations for defining constraints

```
LandBal_(RUNR, landTypesBal) ..  
* --- sum of crops using that land type = total area of that type  
SUM( (landTypes_to_pact(landTypesBal, MPACT), A) v_actLevl(RUNR, MPACT, A)) =L=  
+ v_actLevl(RUNR, landTypesBal, "T");
```

constraint: land balance nest 2  
crop1 + crop2 = arable  
intensive and extensive grassland = grassland

MODEL m\_capMod/

```
OBJEQF_  
SUPBAL_  
REQSE_  
NUTNED_  
SETAN_  
winterCover_  
ecoSetAside_  
cropDivGreening_
```

MP model  
definition LP

```
...  
/  
*  
mm_capMod.RESLIM = 1*60 * 100/6;  
m_capMod.ITERLIM = 10000;  
m_capMod.SOLPRINT = 2;  
m_capMod.SOLVELINK = 2;
```

model NLP with  
PMP terms

```
MODEL m_capModQ/ m_capMod,  
QUADRF_  
LandBal_  
...
```

# simu\_supply.gms

```
$include supply\def_start_value_and_data.gms
$setglobal CAPMOD m_capModQ
*
%capMod%.iterlim = 10000;
%capMod%.tolinfeas = 1.E-5;
INFES(RU,"SUPPLY") = NO;
%capMod%.holdfixed = 1;
%capMod%.solprint = 2;
%capMod%.sysout = 2;
%capMod%.limrow = 0;
%capMod%.limcol = 0;

LOOP(RU_SMALL(RU),

    if (SUM(RU_MS(RU,MSACT),1) eq 0,
        option kill=MSACT;
        MSACT(MS) $ RU_MS(RU,MS) = YES;
    );

    --- include current regional unit in dynamic set on which
    equations are defined in supply.gms

    option kill=RUNR;
    RUNR(RU) = YES;

    SOLVE %capMod% USING NLP MAXIMIZING v_obje;

    --- if the region was not feasible or not optimally solved
    resolve, and eventually widen bounds (should normally
    not happen)

    $
    batinclude 'supply\widen_bounds.gms' RU
);
```

Set Start values for the decision variable like  
v\_actLevl

Define the NLP model name as global and  
related default settings to the model

Loop over all Nuts2 region of the selected MS

Solve the model

Include a file which checks if the model run



Thank you! Questions?

slido



**Scenario snippets files are stored in the following folder**

ⓘ Start presenting to display the poll results on this slide.

slido



**Scenario files which can be selected from the task (run scenario with and without market model) are stored in the folder**

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# slido



**Additional result type identifier (debug option) allows to add to the.gdx result file name located in `\output\results\capmod\`**

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**The equation of the supply model are defined in the file:**

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**What are the two main modules (models) of CAPRI?**

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**What is the regional  
disaggregation in the supply  
module?**

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## What is the coverage of the supply models

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## The regional MP model ..

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## What are the advantages of mathematical programming models?

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**What are the most important constraints in the supply model?**

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**The objective function  
contains ..**

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**What are the consequences of a tax for production of mineral fertilizer in the EU?**

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