Calibration of the Supply Model

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LP Problem

	Wheat	Barley	Rapeseed	Sugarbeet
Expected gross margin (pesos)	253	443	284	516
Price	293	503	319	596
cost	40	60	35	80
Labor (hours/ha)	25	36	27	87

- Land availability: 200 ha
- Labor availability: 10,000 hours
- X_i : land devoted to crop i (in ha)
- How to allocate the land to maximize the total gross margin?

Mathematical Formulation

- Objective function:

  $$\text{Max } Z = 253 \times X_{wheat} + 443 \times X_{barley} + 284 \times X_{rapeseed} + 516 \times X_{sugarbeet}$$

- Subject to:
  - $X_{wheat}; X_{barley}; X_{rapeseed}; X_{sugarbeet} \geq 0$ (non-negativity constraint)
  - $X_{wheat} + X_{barley} + X_{rapeseed} + X_{sugarbeet} \leq 200$ (land)
  - $25 \times X_{wheat} + 36 \times X_{barley} + 27 \times X_{rapeseed} + 87 \times X_{sugarbeet} \leq 10000$ (labor)

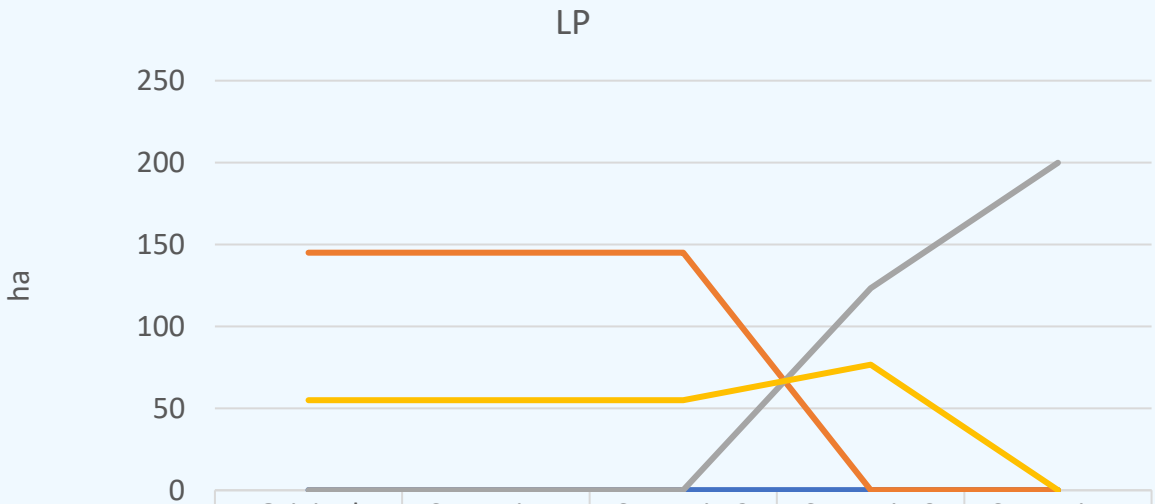
Hands-on Exercise

- Open the file called “PMP.xlsx”
- Go to Sheet “LP”
- Solve the LP model for
  - The original set of prices
  - For the 4 alternative sets of prices

<u>Questions for discussion</u>

- What can you say about the responsiveness of the model with respect to changes in gross margins?
- Are the results realistic?

Solution in Excel



	Original	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Wheat	0	0	0	0	0
Barley	145	145	145	0	0
Rapeseed	0	0	0	123	200
Sugarbeet	55	55	55	77	0

Positive Mathematical Programing

- Methodology that calibrates programming models to observed quantities to specify appropriate non-linear objective functions.
- PMP is operationalized in 3 steps:
  1. The model is forced to reproduce the observed activity levels.
  2. The dual values (shadow prices) of the constraints are used to modify the objective function.
  3. The new model is employed for simulations.

Positive Mathematical Programing. Step 1

$maxZ = \sum_{j=1}^{n} p_j X_j - k_j X_j$

Subject to:

$\sum_{j=1}^{n} a_{i,j} X_j \leq b_i$ [λ]

$X_j \geq 0$ j = 1,…,n

$maxZ = \sum_{j=1}^{n} p_j X_j - k_j X_j$

Subject to:

$\sum_{j=1}^{n} a_{i,j} X_j \leq b_i$ [λ]

$X_j \geq 0$ j = 1,…,n

$X_j \leq (X_j^0 + e)$ [ρ]

Resource constraint

Marginal activities: X^m

Calibration constraint

Preferable activities: X^p

Positive Mathematical Programing. Step 2

- ρ^p used to specify a non-linear objective function
  - such that $MC_{X^p} = P_X^0$

$$C^v = \sum_{j=1}^{n} d_j X_j + \frac{1}{2}\sum_{j=1}^{n} X_j q_{j,j} X_j$$

where d - parameters of the linear cost term
q – parameters of the quadretic cost term

Linear term

Quadratic term

Parameters are specified such that the following holds:

$$MC^v = \frac{\partial C^v(X^0)}{\partial X} = \sum_{j=1}^{n}\left[d_j + q_{j,j}X_j^0\right] = \sum_{j=1}^{n}[k_j + \rho_j]$$

Positive Mathematical Programing. Step 3

- The final non linear objective function reads:

$$maxZ = \sum_{j=1}^{n} [p_j X_j - d_j X_j - \frac{1}{2} X_j q_{j,j} X_j]$$

Subject to:

$$\sum_{j=1}^{n} a_{i,j} X_j \leq b_i \ [\lambda]$$

$$X_j \geq 0 \quad j = 1,\ldots,n$$

Specifying the PMP Parameters

	d	Q
Standard approach	$d_j = k_j$	$q_{j,j} = \frac{\rho_j}{X_j^0}$
Average cost approach	$d_j = k_j - \rho_j$	$q_{j,j} = \frac{2\rho_j}{X_j^0}$
Paris approach	$d_j = 0$	$q_{j,j} = \frac{k_j + \rho_j}{X_j^0}$
Exogenous elasticities	$d_j = k_j + \rho_j - q_{j,j} X_j^0$	$q_{j,j} = \frac{1}{\varepsilon_j} \frac{p_j^0}{X_j^0}$

Hands-on Exercise. Excel

- **PMP reveal dual values**
  - Open the solver
  - Maximize the objective function subject to calibration constraints as well as land and labor constraints
- **Questions for discussion**
  - How much land is allocated to each crop?
  - What are the dual values for wheat, barley, rapeseed and sugar beet?
  - Are land and labor fully used?

Reveal Dual Values

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B4	Land allocation (ha) Wheat	54.9997	0	253	31	253
C4	Land allocation (ha) Barley	30.0001	0	443	1E+30	190
D4	Land allocation (ha) Rapeseed	85.0001	0	284	1E+30	31
E4	Land allocation (ha) Sugarbeet	30.0001	0	516	1E+30	263

Constraints

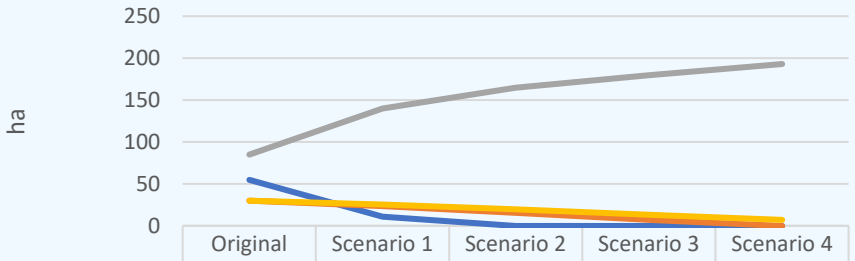
Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
F16	Land (ha) Total	200	253	200	0.0004	54.9997
F17	Labor (hours) Total	7360.0075	0	10000	1E+30	2639.9925
F18	PMP1 Total	54.9997	0	55.0001	1E+30	0.0004
F19	PMP2 Total	30.0001	190	30.0001	54.9997	0.0004
F20	PMP3 Total	85.0001	31	85.0001	54.9997	0.0004
F21	PMP4 Total	30.0001	263	30.0001	42.58052419	0.0004

Hands-on Exercise. Excel

- **PMP1_Standard**
  - Solve the PMP problem using the standard approach
  - What is the land allocation to each crop under the given scenraios (different price levels)?
- **PMP2_Average_cost**
  - Solve the PMP problem using the average cost approach
  - What is the land allocation to each crop under the given scenraios (different price levels)?
- **PMP3_Paris**
  - Solve the PMP problem using the Paris approach
  - What is the land allocation to each crop under the given scenraios (different price levels)?
- **PMP4_Exogenous_elasticities**
  - Solve the PMP problem using the exogenous elasticities approach
  - What is the land allocation to each crop under the given scenraios (different price levels)?

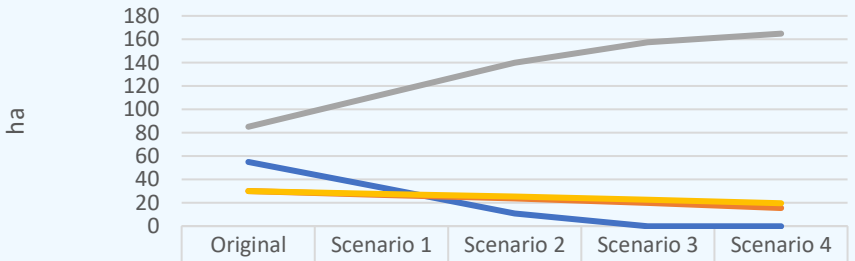
Results

Standard



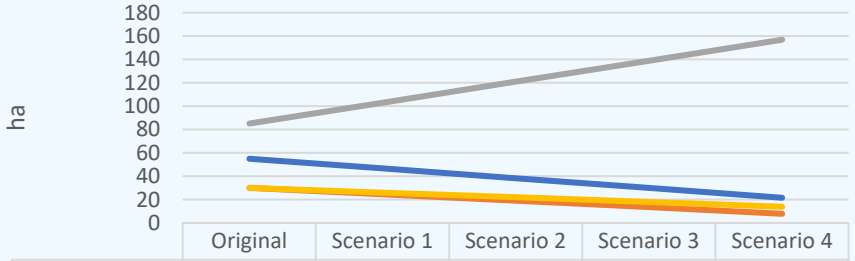
	Original	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Wheat	55	11	0	0	0
Barley	30	24	16	7	0
Rapeseed	85	140	165	180	193
Sugarbeet	30	25	20	13	7

Average Cost



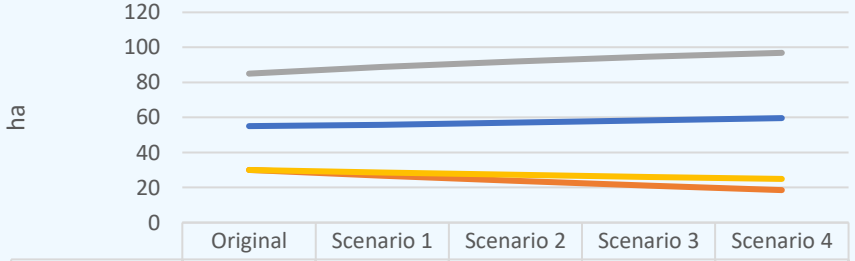
	Original	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Wheat	55	33	11	0	0
Barley	30	27	24	20	16
Rapeseed	85	112	140	157	165
Sugarbeet	30	28	25	23	20

Paris



	Original	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Wheat	55	47	38	30	22
Barley	30	24	19	13	8
Rapeseed	85	103	121	139	157
Sugarbeet	30	26	22	18	14

Exogenous Elasticities



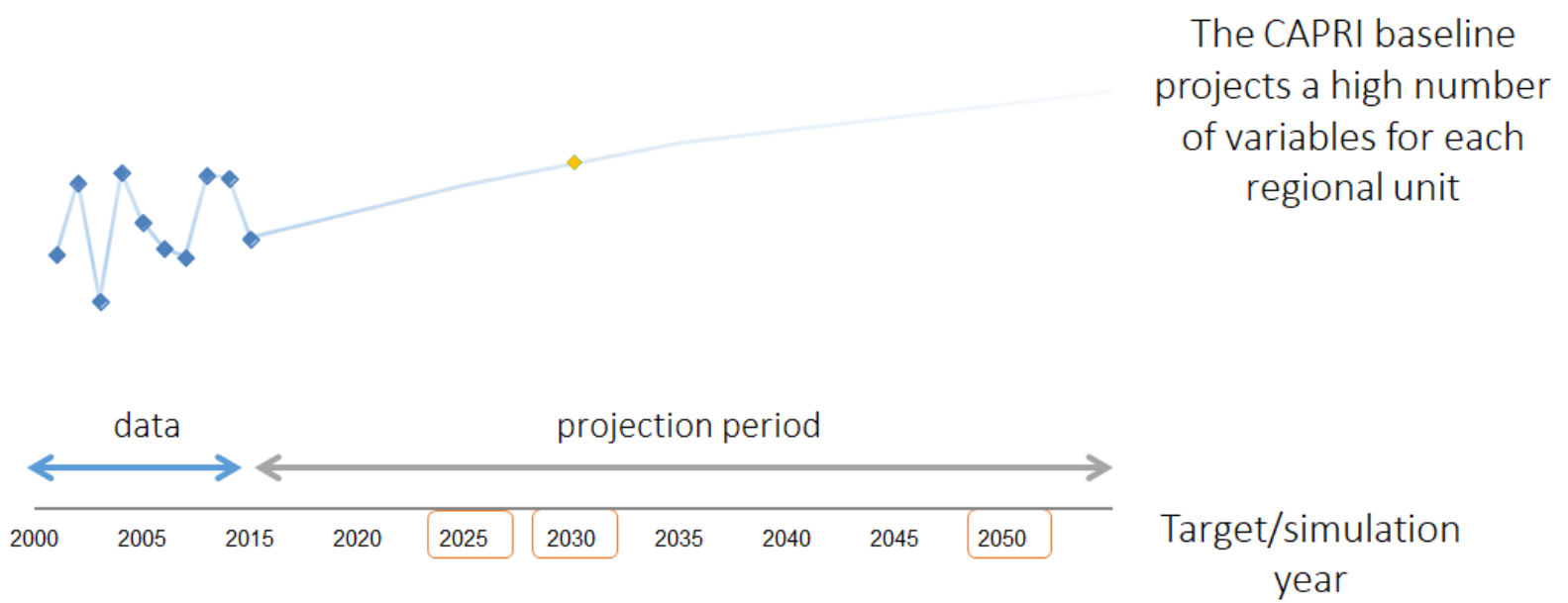
	Original	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Wheat	55	56	57	58	60
Barley	30	27	24	21	19
Rapeseed	85	89	92	95	97
Sugarbeet	30	29	27	26	25

Hands-on Exercise. GAMS

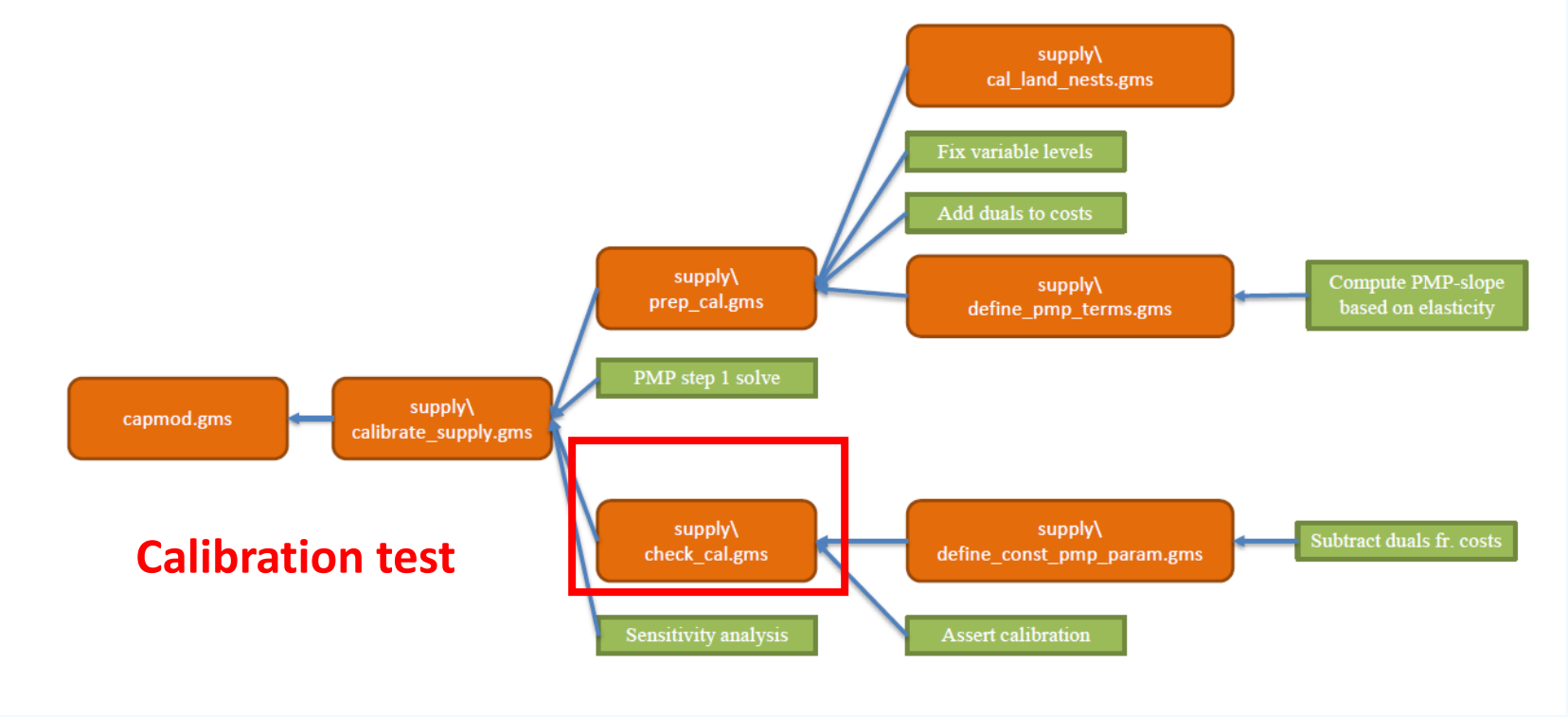
- Session_A3.2_Advanced_PMP_example.gms

Calibration of the Supply Module in CAPRI

- Finding meaningful trend estimates
- Calibrate the economic models supply and market model to the meaningful trends (observation in the future)



Calibration of the Supply Module in CAPRI



Test Calibration

- Look inside gams\baseline\check_cal.gms
  - There is an ”abort” if a calibration test fails. Explain the code.
- Run baseline calibration for Denmark
- Run a simulation of the same policy for Denmark
  - Make sure you set ”Additional result type identifier to ”_dk”
  - Open the .LST file and check ”p_itemsInIters”

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What is the purpose of a model calibration?

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Which of the following is not a step of PMP calibration?

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When selecting the linear and quadratic pmp terms which of the following conditions should hold?

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Which of the following is not a characteristic of preferable activities?

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What values is the CAPRI model calibrated to?

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Which of the following PMP specification methods is used in CAPRI?

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