Calibration of the Supply Model

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LP Problem

Item	Wheat	Barley	Rapeseed	Sugar beet
Gross margin in €/ha	253	443	284	516
Labor requirement 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:

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

- 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)

Solution in Excel

	P_Wheat	P_Barley	P_Rapeseed	P_Sugarbeet
Original	253	443	284	516
Scenario 1	293	443	344	516
Scenario 2	333	443	404	516
Scenario 3	373	443	464	516
Scenario 4	413	443	524	516

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

1. Overspecialization
2. Wide divergence between model outcomes and actual production patterns

Hands-on Exercise

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

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 $MC_{X^p} = P_X^0$

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

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:

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

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:

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

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

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
  - By changing the hectares of land allocated to each crop
  - Subject to land, labor and observed production levels constraints
  - What are the dual values for wheat, barley, rapeseed and sugar beet?
- **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)?

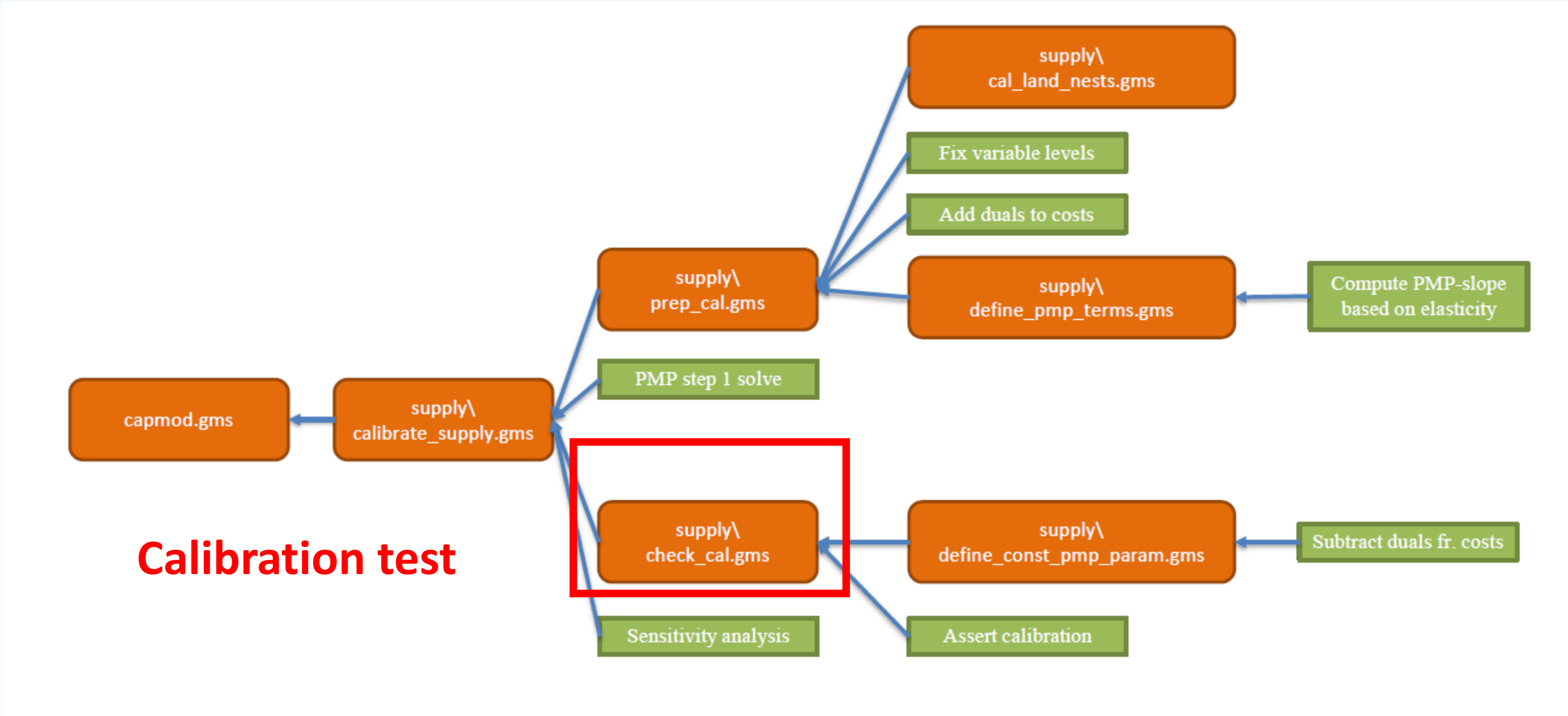
Hands-on Exercise. Excel

- **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)?

Hands-on Exercise. GAMS

- Session_A3.2_Advanced_PMP_example.gms

Calibration of the Supply Module in CAPRI



Calibration of the Supply Module in CAPRI

KEDIT - [D:\public\stepanyan\2020\STAR2.6\gams\baseline\check_cal.gms]

File Edit Actions Options Window Help

abort

```
====>
      [...+.|..1....+....2....+....3....+....4....+....5....+....6....+....7.]..+....8....+....9....+...10....+...11....+...12....+...13
=====
===== * --- Restart if not optimal - first try
=====   if ((m_capModQ.solvestat eq 2) or (m_capModQ.solvestat eq 3) or (m_capModQ.modelstat eq 7),
=====     $$batinclude 'util\title.gms' "'PMP: test for calibration for (restarting after non-normal termination) '" %1.tl
=====     SOLVE m_capModQ USING NLP MAXIMIZING v_obje;
=====   );
=====
===== * --- Restart again if still not "normal completion" or if not "reduced gradient less than tolerance" is the status
=====   if ((m_capModQ.solvestat gt 1) or (m_capModQ.modelstat gt 2),
=====     $$batinclude 'util\title.gms' "'PMP: test for calibration for (restart 2 after non-optimal) '" %1.tl
=====     SOLVE m_capModQ USING NLP MAXIMIZING v_obje;
=====   );
=====
=====
===== * --- Restart if infeasible
=====   IF ( m_capModQ.numinfes or ((m_capModq.MODELSTAT eq 4)),
=====      m_capModQ.SOLPRINT = 1;
===== *     $$include "fert\solve_only_inner_fertdist_model.gms"
=====      SOLVE m_capModQ USING NLP MAXIMIZING v_obje;
=====   );
=====
=====
===== $ifi %generateAllValuesofSupplymodel%==on $include 'farmtype\compare.gms'
=====
===== *  Test calibration
=====   p_caliDif(%REGIONS%,"Obs",EACT,A)       = p_technFact(%REGIONS%,EACT,"LEVL",A)*DATA(%REGIONS%,EACT,"LEVL","Y");
=====   p_caliDif(%REGIONS%,"cal",EACT,A)       = v_actLevl.L(%REGIONS%,EACT,A);
=====   p_caliDif(%REGIONS%,"dif",EACT,A)       = p_caliDif(%REGIONS%,"Obs",EACT,A) - p_caliDif(%REGIONS%,"cal",EACT,A);
=====   p_caliDif(%REGIONS%,"dif","SUM","SUM") = SUM((EACT,A),ABS(p_caliDif(%REGIONS%,"dif",EACT,A)));
=====   if( p_caliDif(%REGIONS%,"dif","SUM","SUM") gt 0.001 ,
=====       abort "Some supply models do not calibrate properly.", %REGIONS%, p_caliDif
=====   );
=====
=====   INFES(%REGIONS%,"Supply") $ (not INFES(%REGIONS%,"Supply") ) = m_capModQ.numinfes + 1 $ (m_capModq.MODELSTAT eq 4);
=====
===== * --- Assert that the parameters of the fertilizer distribution are identical to those in the calibration point
=====   $$batinclude "fert\assert_that_fertdist_parameters_are_properly_set.gms" %regions%
=====
===== * --- Assert that fertilizer distribution exactly reproduces the calibration point
=====   $$include "fert\assert_perfect_calibration_of_fertdist.gms"
=====
===== * --- Assert that feed distribution exactly reproduces the calibration point
=====   $$include "feed\assert_perfect_calibration_of_feed_input.gms"
===== * * * End of File * * *
```

Test Calibration

- 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”