EU-wide Individual Farm Model for CAP Analysis (IFM-CAP):
Application to Crop Diversification Policy

Louhichi K., Ciaian P., Espinosa M., Colen L., Perni A., Gomez Y Paloma S.

European Commission, Joint Research Centre, Seville - Spain

23rd Pacioli Workshop
Belgrade; 27th-30th September

Outline

I. Model description

Motivation

Overview on IFM-CAP model

(Estimations modules in IFM-CAP)

Input allocation

Sugar-beet estimation

II. Application

Scenario

Results

Conclusions & Limitations

Motivation

European Commission

- *The CAP has undergone a gradual change from market intervention instruments to farm specific measures attempting to enhance the environmental performance.*

- *Evidence with the introduction of the greening measures in the 2013 CAP reform: (i) crop diversification, (ii) grassland maintenance and (iii) ecological focus areas.*

- *The eligibility and uptake of these measures pose new challenges and raise the need for new modelling tools.*

- *Farm level workshop (Brussels, June 2012)*

  - **Most farm models available in the literature (FARMIS, FSSIM, AGRIPOLIS, SAPIM) are developed for a specific purpose and/or location and are not easily adaptable and reusable for other applications (EU level) and contexts.**

  - **Out of a large number of EU based representative farm models, only two have full EU coverage: CAPRI-FT (Gocht and Britz, 2011) and AROPAj (De Cara and Jayet, 2011) => but are subject to aggregation bias. (farm group!!)**

IFM-CAP model

European Commission

- Modelling **Pan-European commercial farms (FADN)**
- Accurate analysis of **welfare and (environmental) effects** of farm-specific CAP measures
- Full **farm heterogeneity** in term of policy representation (e.g. CAP greening) and impacts (e.g. small versus big farms)
- Covering all major **agricultural and livestock production** activities in the EU (however due to sample=> over/under represented)
- **Detailed** socio-economic and (environmental) **results** (i.e. average and distribution over farm population)
- Flexibility in **aggregating results** by any dimension relevant for the policy maker (e.g. farm types, farm size, regions, MS…)

IFM-CAP prototype

- *Individual farm model running for each single farm in FADN (about 60 500 farms=> constant sample)*

- *Comparative static & non-linear optimisation model*

- *Calibrated for the three-year average around 2008 (moving to 2012 single year)*

- *Objective function: max. farm level profit function:*

  - *Revenues from selling products + Pillar I subsidies – Accounting costs – PMP terms*

- *Constraints: Land (arable & grassland), set-aside, quotas and animal feeding at farm level*

- *Modelling compensation payments: coupled and decoupled payments are calculated from FADN (Pillar 2 to be incorporated!!)*

- *Full use of EU-FADN data, completed by others datasets when needed (EUROSTAT, CAPRI,…)*

IFM-CAP's structure

European Commission

$$\max_{x \geq 0} \boldsymbol{\pi} = \mathbf{p}'(\mathbf{y} \circ \mathbf{x}) + \mathbf{s}'x - \mathbf{C}x - \mathbf{d}'x - 0.5x'\mathbf{Q}x$$

S.t.

$$\mathbf{A}x \leq \mathbf{b} \quad [\boldsymbol{\rho}]$$

- **π** farm profit
- **y** yields
- **p** prices
- **s** subsidies
- **X** activity levels
- **C** accounting unit costs
- **d** linear term of behavioural function
- **Q** quadratic term of behavioural function
- **A** matrix of coefficients for constraints
- **b** land availability & upper/lower bound of policy restrictions
- **ρ** dual values of constraints

Model parameterization

DATA

- **FADN data**
  - Utilized Agricultural Area (arable & grassland)
  - Obligatory set-aside rate
  - Milk quota right
  - Set of crop and livestock activities
  - Yields, Prices & Subsidies
  - Observed activity levels
  - Farm level feed costs
  - Farm weighting factor
  - Land rental prices (prior)
- **EUROSTAT data**
  - Yields for fodder crops at MS level
  - Carcass weights
- **CAPRI data**
  - Prices for fodder crops at MS level
  - Feed prices at MS level
  - Feed nutrient content
  - Prices and Yields trend
  - Animal feed requirement functions (prior)
  - Elasticities for feed demand at NUTS2 level (prior)
- **Others data (prior)**
  - Out-of quota prices for sugar beet (Agrosynergie, 2011)
  - Share of in-quota production on total production at MS level for sugar beet (DG-AGRI)
  - In- quota prices for sugar beet (Agrosynergie, 2011)
  - Share of in-quota production on total production at MS level for sugar beet (DG-AGRI)
  - Supply elasticities at NUTS2 level (Jansson and Heckelei, 2011)

MODEL

- **Optimize farm's objectives:** profit maximisation = linear gross margin - quadratic behavioural function
- **Subject to:**
- Land constraints (arable & grassland)
- Policy constraints (CAP 1 pillar - decoupling, quotas, seta-side, greening)
- Feeding constraints (feed availability vs. feed requirement, max share of roughage & concentrates)

OUTPUTS

- Activity levels (ha & head)
- Production (Tons)
- Land use (ha)
- Input use
- Farm profit (€)
- Shannon index
- ...

ESTIMATION

- Accounting unit costs for crops
- Behavioural function's parameters
- Animal feed requirement & costs
- Sugar beet quota & prices

IFM-CAP's calibration method

European Commission

*Estimation of the behavioural function's parameters (**d, Q**) using:*

- *Cross-sectional analysis (i.e. **multiple observations**)*
- *Highest Posterior Density (**HPD**) estimator (Heckelei et al., 2005) with prior information on NUTS2 **supply elasticities** and **dual values of resources** (e.g. land rental prices).*
- ***Non-myopic** calibration (effects dual values=>simulation response)*
- ***d** and **Q** are farm specific (**Q=sBs'**)*
  - **s** is a scaling factor (Heckelei and Britz, 2000)
  - **B** is a common (full) matrix across farms belonging to the same type of farming (using TF14 grouping)

Outline

I. Model description

- Motivation
- Overview on IFM-CAP model
- Estimations modules in IFM-CAP
  - Input allocation
  - Sugar-beet estimation

II. Application

- Scenario
- Results
- Conclusions & Limitations

Scenarios

European Commission

- *We developed an EU-wide individual farm-level model (IFM-CAP) for assessing micro-level impacts of CAP across Europe*

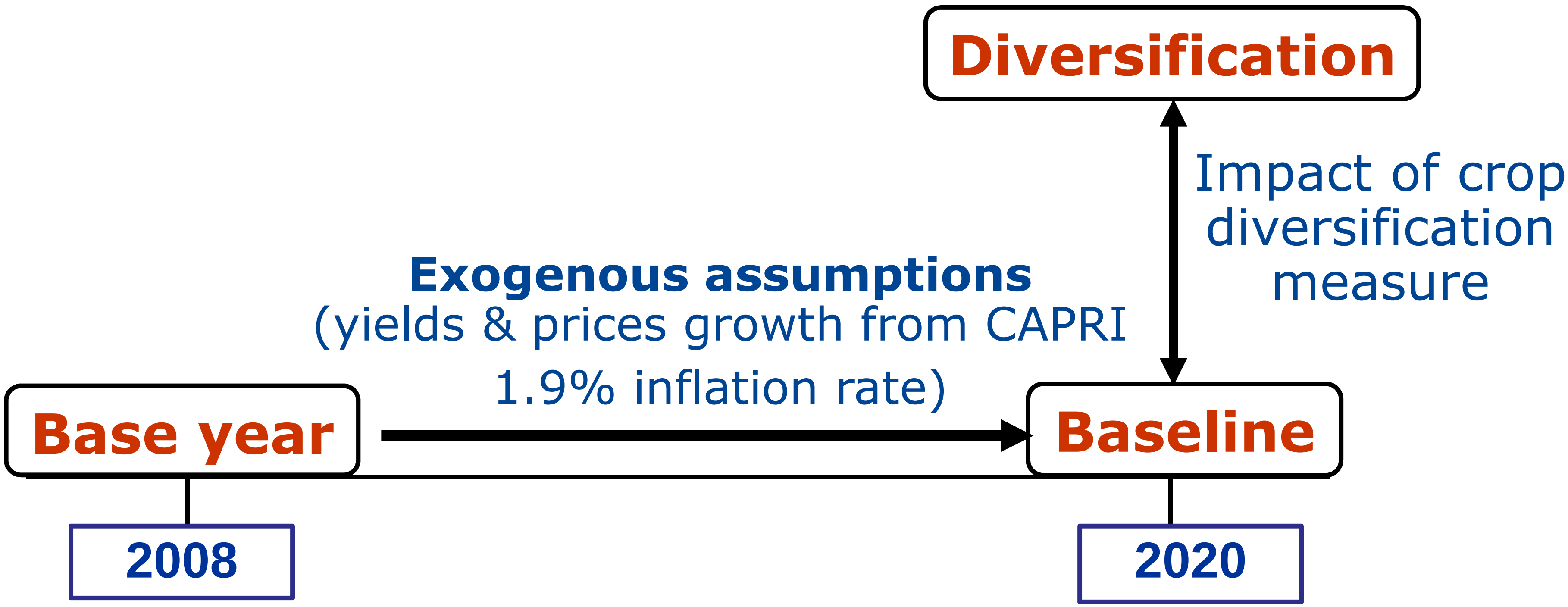
- *Model capability was illustrated by simulating the impact of the crop diversification requirement (one of the 3 greening measures=30% direct payments) for EU-27 (no Croatia!!)*

- *We focus on crop diversification because it is the most challenging greening measure to model (in case of EFA=>NO DATA) and its implementation and impacts are farm specific:*

  - *Crop diversification measure targets land allocation at farm level*
  - *The eligibility and uptake of this measure largely depends on farm-specific characteristics (size, cropping pattern, etc.)*

Scenarios

- Baseline (reference scenario)
- Diversification (Crop diversification scenario)



Crop diversification

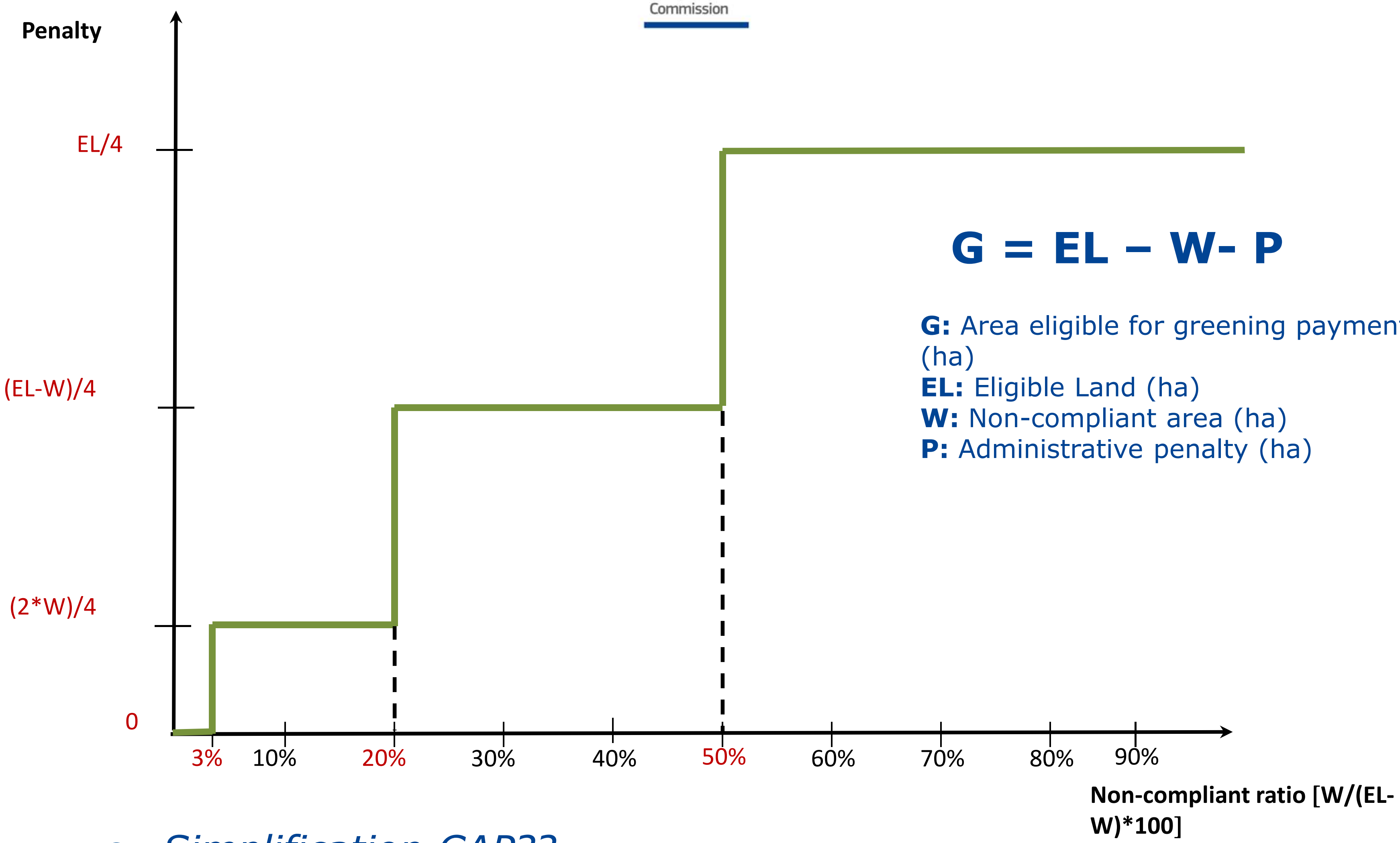
European Commission

o Implementation of scenario considering that farmers can (fully/partially) **comply or not** depending on the costs of compliance (sanctions) => another scenario currently on-going assuming full enforcement

	Exempt farms	**Farms group 1**	**Farms group 2**
Arable land (*AL*)	< 10 ha*	10–30 ha	≥ 30 ha
Minimum number of cultivated crops	–	2	3
Maximum proportion of main crop in *AL* (%)	–	75 %	
Maximum proportion of two main crops in *AL* (%)	–	–	95 %
Non-compliant area = Withdrawal (*W*)		$W = \min[1,(X_{75}\% / 25\% + X_{95}\% / 5\%)]*AL*0.50$	

$X_{75}\%$ = percentage of the main crop going beyond 75%
$X_{95}\%$ = percentage of the 2 main crops going beyond 95%

Penalty



G = EL – W- P

G: Area eligible for greening payment (ha)
EL: Eligible Land (ha)
W: Non-compliant area (ha)
P: Administrative penalty (ha)

- *Simplification CAP??*

Simulation Results

European Commission

Out of 5 million commercial farms represented in IFM-CAP for the EU-27:

- **31 %** are subject to the crop diversification measure (i.e. concerned farms)

- the remaining **69 %** (mainly smaller farms) are exempted from the measure

Affected farms by MS (% of total farms)

	Exempt farms	Concerned farms
BL	35.6	64.4
DK	9.8	90.1
DE	26.1	73.4
EL	86.2	13.8
ES	71.8	28.2
FR	39.8	60.2
IR	93.2	6.8
IT	79.4	20.6
NL	70.8	29.2
AT	51.1	48.9
PT	87.5	12.5
SE	27.8	72.2
FI	23.3	69.7
UK	55.8	44.1
CY	86.7	13.3
CZ	32.7	67.2
EE	46.7	53.3
HU	50.1	49.8
LT	38.9	61.1
LV	61.0	38.8
MT	99.0	1.0
PL	59.9	40.1
SI	90.3	9.7
SK	9.8	88.4
BG	87.4	12.6
RO	87.6	12.4
EU-27	**68.9**	**31.0**

Simulation Results

European Commission

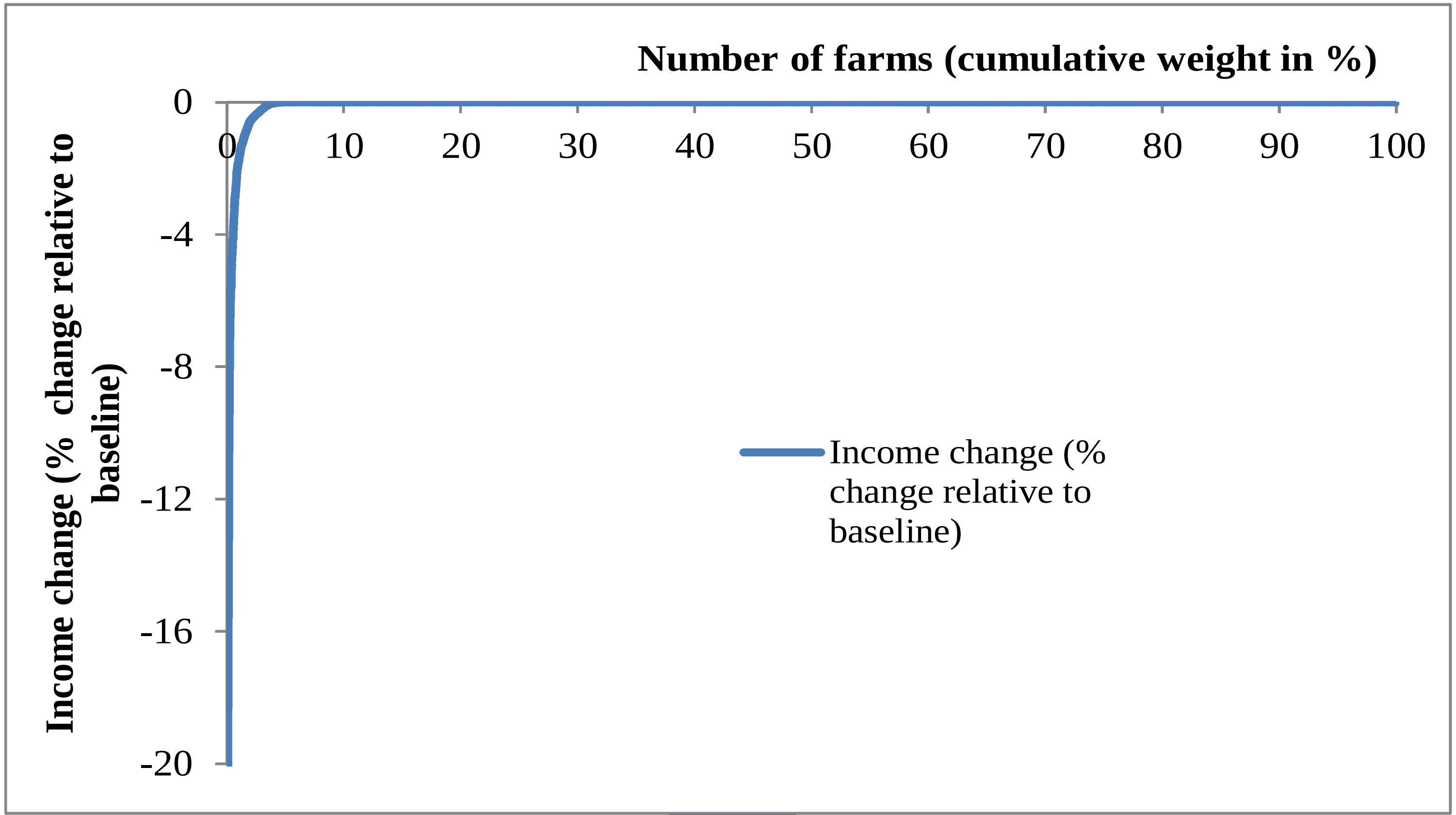
- **Of these 31% concerned farms:**
  - **85 %** comply with the diversification requirement under the baseline
  - Under the crop diversification scenario (i.e. the introduction of a conditional 'greening payment') **90 %** comply
  - Of the **10 %** non-complying farms, **7 %** does increase the level of compliance, even though not achieving full compliance

	Baseline		Diversification measure		
	Compliant	Non-compliant	Compliant	Non-compliant	
				All	Increased compl.
EU-27	85	15	90	10	7

Results: income

Income effect is limited

- Average income declines less than **1%** at MS level
- For some farm specializations and farm sizes income effects are somewhat larger
- Only around **5%** of the total farm population experiences a negative income effect



Results: area

Reallocated area is limited:

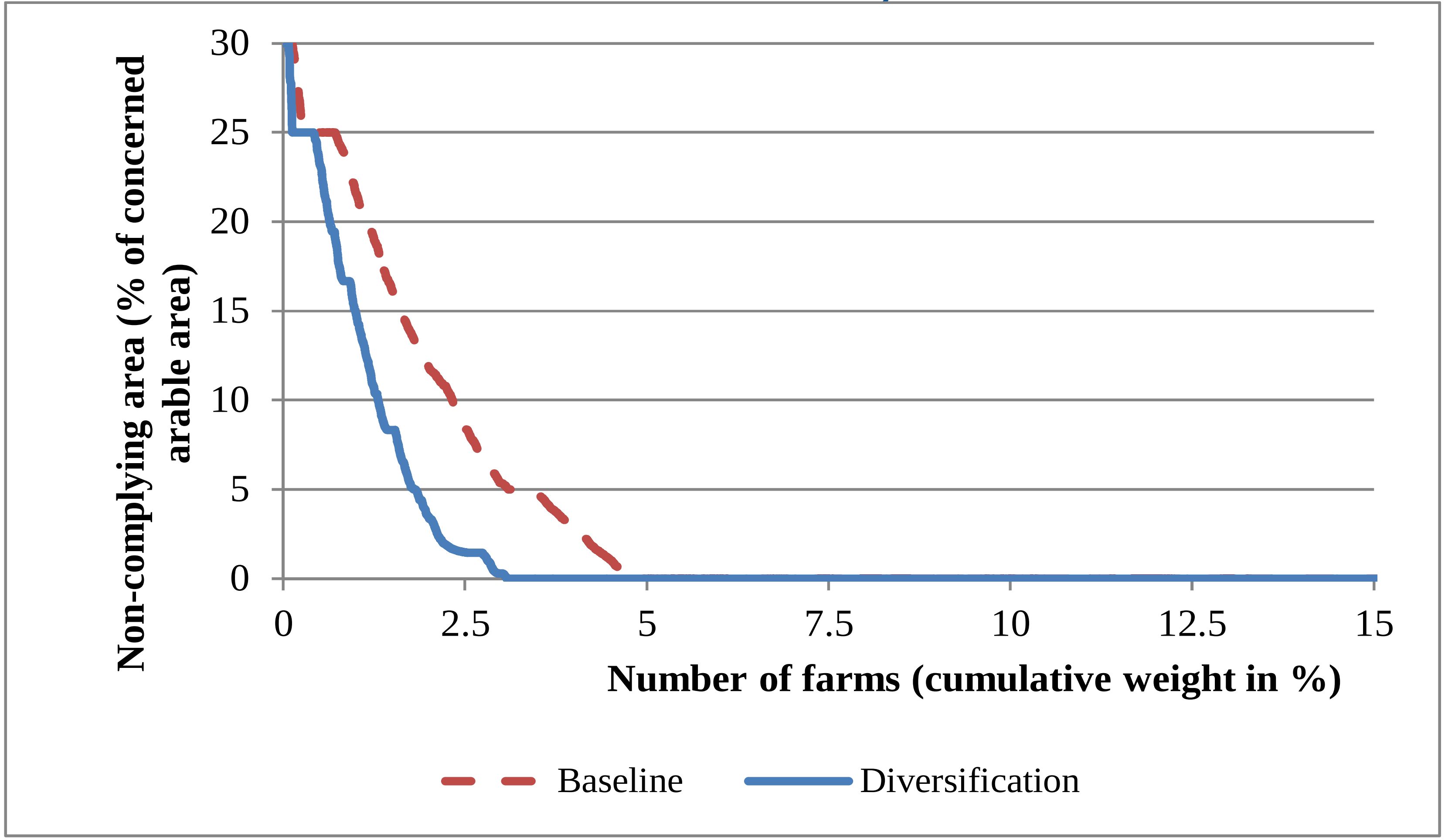
- Share in **total UAA** not complying with diversification measure
  - **0.63 %** under baseline, **0.31 %** after reallocation under crop diversification scenario

- Share in **concerned arable area** not complying with diversification measure
  - **0.98 %** under baseline, **0.47 %** after reallocation under crop diversification scenario
  - Larger shares for some farm specializations and farm sizes

- Share of individual farms having some non-complying area
  - **5%** under baseline, **2.7%** after reallocation under crop diversification scenario

European Commission

Distribution of non-compliant area by individual farm (% of concerned arable area)



Conclusions

- *Out of 5 million farms, 31% are subject to the crop diversification measure; the remainder (69%) are exempted*
- *Small economic impacts =>At the aggregate level income decreases by less than 1%*
- *Farm level impact could be bigger but few farms are affected (5% of population)*
- *The reallocated area due to the measure represents less than 0.5% of UAA (this low number similar to other studies: "greening to "greenwash")*
- *The most constraining component of the measure is the 75% threshold*
- *Most non-compliant farms (80%) choose to reduce their non-compliance level with the introduction of the measure.*

Limitations

European
Commission

- *Model scenario in which **full enforcem**ent is applied (DG-AGRI request)*

- *We do not take into account the fact that if farm is non-compliant for three years the penalty is harsher => hence we underestimate the penalty.*

- *Penalty system is complex implying that in reality farmers may not fully understand it => hence we over/underestimate the number of non-compliant farms.*

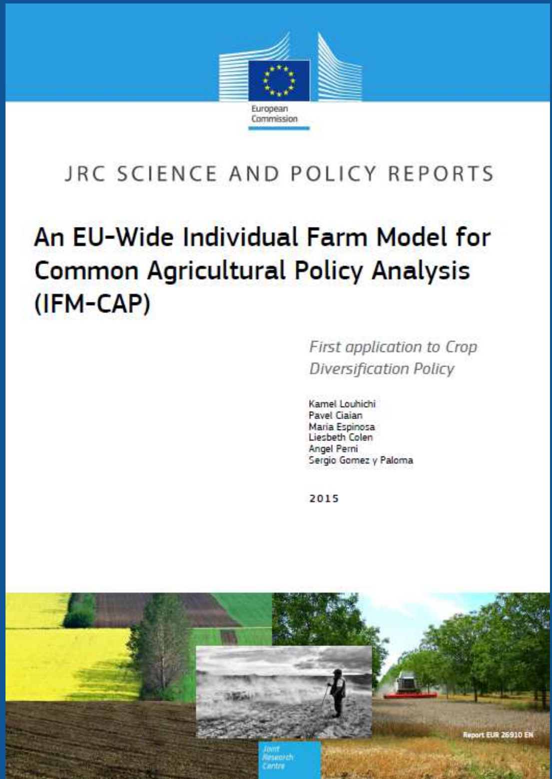
- *The model is calibrated on the average 2007-2009 instead of single year data => hence we underestimate the number of farms and the area of land that will be affected => we are moving to single year 2012 for crop allocation*

- *We do not model interactions among farms, implying that total land is considered fixed => in some MS (at least SP) farmers are renting marginal land to comply with crop diversification*

Limitations (cont.)

European Commission

- *Other greening measures are not considered (that may interact with farmers choices)*
- *No market feedbacks (=> link market model)*
- *Some crop activities are aggregated in the model*
- *The greening payment/penalty is calculated based on the old CAP*
- *Not all implementation specificities are considered in the model:*
  - **Organic producers (data in FADN), 'small farmers' scheme => exempted**
  - **Equivalence practices for greening (AEC measures & certification)**
  - **North 62 parallel; if more 75% EL is crops under water (rice) =>exempted**


European Commission

JRC SCIENCE AND POLICY REPORTS

An EU-Wide Individual Farm Model for Common Agricultural Policy Analysis (IFM-CAP)

First application to Crop Diversification Policy

Kamel Louhichi
Pavel Ciaian
Maria Espinosa
Liesbeth Colen
Angel Perni
Sergio Gomez y Paloma

2015

Joint Research Centre

Report EUR 26910 EN

European Commission

Louhichi K., Ciaian P., Espinosa M., Colen L., Perni A., Gomez Y Paloma S

Maria.espinosa@ec.europa.eu

http://publications.jrc.ec.europa.eu/repository/bitstream/JRC92574/jrcreport_jrc92574.pdf

Input allocation

Aim: estimation of crop-specific accounting unit costs (**C**) using:

- Highest Posterior Density (HPD) estimator (Heckelei et al., 2005) with prior information on input output coefficients ($\overline{\mathbf{H}}$) estimated by DG-L3 using the share of activity output value in total output value.
- Variable costs by input category (seed, fertilizer, plant protection and other specific costs) at farm level recorded in FADN (**Z**).
- Assuming Leontief technology as well as a common technology by farm type (FT14 grouping)

Input allocation

$$\text{Min}\left[\frac{(\mathbf{H}-\overline{\mathbf{H}})^2}{(\boldsymbol{\sigma}^{H})^2}+\psi\frac{(\mathbf{u}_f)^2}{(\boldsymbol{\sigma}^{u})^2}\right]$$

$$\mathbf{Z}=\mathbf{H}\mathbf{v}+\mathbf{u} \qquad (1)$$ ← **Leontief technology**

$$\mathbf{l}'\mathbf{H}=\mathbf{1} \qquad (2)$$ ← **Common technology**

- **Z** variable costs by input category at farm level
- **v** output value of crop activity
- **H** input-output coefficients - common across farms belonging to the same region and same type of farming (using TF14 grouping)-
- **U** error term
- ψ is the vector of farm weight within the NUTS 2 region

Input allocation

Accuracy of input-allocation estimates for the alternative estimation approaches (Meuse, France)

Estimation method	SUR	Cross Entropy				HPD			
Design		1	2	3	4	1	2	3	4
MAPE	218	204	245	107	138	160	109	114	119
RMSE	824	748	786	545	554	595	531	528	540
PCORR	0.7	0.84	0.84	0.87	0.87	0.87	0.91	0.89	0.88

SUR: Seemingly Unrelated Regressions
MAPE: Mean average percentage error (between observed and predicted values)
RMSE: Root mean squared error (between observed and predicted values)
PCORR: Pearson's correlation index (between observed and predicted values)

Sugar-beet (on-going activity)

European Commission

- **Objective**: Estimating in quota/out of quota sugar beet prices/production using FADN data

- **Data sources:**
  - Farm level average prices and total production of sugar-beet: FADN
    - ➢FADN reports higher values for sugar beet production and area than FSS (~25%). Particularly high difference is in ES, RO and UK.
  - Sugar Quota at MS level: DG-AGRI.
  - Reliable quota data at farm level for the complete time-series 2007-2012 only for the DE and BL.

    These data are used to validate the estimation approach.
  - Average EU sugar-beet in-quota and out-of-quota prices: Agrosynergie, 2011.

HPD estimator

European Commission

$$\textbf{Min}\left[\frac{1}{F_{MS}}\frac{\left(\mathbf{q}_f^q-\overline{q_f^q}\right)^2}{\left(\sigma_f^q\right)^2}+\frac{1}{F_{MS}}\frac{\left(\mathbf{c}_f^q-\overline{c_f^q}\right)^2}{\left(\sigma_f^{cq}\right)^2}+\frac{1}{F_{MS}}\frac{\left(\mathbf{c}_f^w-\overline{c_f^w}\right)^2}{\left(\sigma_f^{cw}\right)^2}+\frac{\left(P_{MS}^q-\overline{P_{EU}^q}\right)^2}{\left(\sigma_{EU}^{Pq}\right)^2}+\frac{\left(P_{MS}^w-\overline{P_{EU}^w}\right)^2}{\left(\sigma_{EU}^{Pw}\right)^2}\right]$$

$$\overline{q_f^q};\sigma_f^q = (Q_{MS}/TOT_{MS}).q_f;0.20.\overline{q_f^q}$$

$$\overline{c_f};\sigma_f^c = 0;\ 5\ €/\text{ton}$$

$$\overline{p_{MS}^w};\sigma_{MS}^{p^w} = 20;\ 4\ €/\text{ton}$$

$$\overline{p_{MS}^q};\sigma_{MS}^{p^q} = 30;\ 6\ €/\text{ton}$$

q_f, p_f^{SUGB}, wf_f =FADN

Q_{MS} =DG-AGRI

$$q_f^{SUGB} p_f^{SUGB} = (p_f{}^q (q_f{}^q - u_f^q) + p_f{}^w q_f{}^w)/S_{MS}$$ **(1) Production**

$$q_f^{SUGB} = ((q_f{}^q - u_f^q) + q_f{}^w)/S_{MS}$$ **(2) Revenue**

$$\sum_{i\subset MS} q_f^q \cdot wf_f / \sum_{i\subset MS} q_f^{SUGB} \cdot wf_f = Q_{MS} / \sum_{\subset MS} q_f^{SUGB} \cdot wf_f$$ **(3) Ratio in quota/out-quota**

$$p_f{}^q = p_{MS}^q + (x)c_f \quad p_f^w = p_{MS}^w + (x)c_f \quad p_f{}^q \geq p_f^w \qquad p_f^q > 26.29$$ **(4) Prices**

Sugar-beet

- **Different model specification has been tested based on:**
  - Prices
  - Restriction in-quota/out of quota
  - Prior information based on FADN/ESTAT

- **Two variants of the model:**
  - Fixed quotas over time (2007-2012)=> long term contracts
  - No fixed quota over time =>FADN reported data (cv time-series 2007-2012; DE=17%, BL=12%).

Sugar-beet

- **Results:**

  - Best model in terms of accuracy test (cc, RMSE, bias) and in-line with sugar sector is the one assuming:
    - Ratio and prior information based on FADN data
    - Additive/multiplicative prices only slightly change results.

  - As the accuracy and price estimations are very similar for Fixed/No-fixed variant => suggestion to run another model specification in which it is assumed that the in-quota production cannot deviate among years more than a threshold value (to be determined based on FADN data).

IFM-CAP's calibration method(cont)

European Commission

$$\text{Min}\left[\psi_f{}'\frac{(\rho_f-\bar{\rho}_r)^2}{(\sigma_r^\rho)^2}+\hat{x}_r{}'\frac{(\varepsilon_r-\bar{\varepsilon}_r)^2}{(\sigma_r^\varepsilon)^2}\right]$$

Minimize deviation between estimated farm dual values & NUTS2 elasticities and the prior

FOC

$$\mathbf{y}'_f\,\mathbf{p}_f+\mathbf{s}_f-\mathbf{C}_f-\mathbf{d}_f-\mathbf{Q}_f x_f^0-\mathbf{A}_f\boldsymbol{\rho}_f=0 \qquad (1)$$

$$\mathbf{b}_f-\mathbf{A}_f x_f^0=0 \qquad (2)$$

$$\varepsilon_f=\left[\mathbf{Q}_f^{-1}-\mathbf{Q}_f^{-1}\mathbf{A}_f(\mathbf{A}_f{}'\mathbf{Q}_f^{-1}\mathbf{A}_f)^{-1}\mathbf{A}_f{}'\mathbf{Q}_f^{-1}\right]\frac{\mathbf{gm}_f}{\mathbf{x}_f^0} \qquad (3)$$

$$\varepsilon_r=\frac{\sum_f \varepsilon_f \mathbf{x}_f^0 \mathbf{w}_f}{\sum_f \mathbf{x}_f^0 \mathbf{w}_f} \qquad (4)$$

Supply elasticities at farm & NUTS2 levels

$$\mathbf{Q}_f=\delta_f\mathbf{B}\delta'_f \qquad (5)$$

Q farm specific matrix

$$\mathbf{B}=\mathbf{L}\mathbf{L}' \qquad (6)$$

Cholesky's decomposition