

2015 AIEAA Conference

Innovation, Productivity and Growth: Towards Sustainable Agri-Food Production

Ancona, 11-12 June 2015



Assessing Farm Production Costs Using PMP: Theoretical Foundation And Empirical Validation

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Objectives

- The aim of this presentation is to develop farm based mathematical programming models able **to represent specific marginal cost per activity** on the basis of data and information available in national FADN systems and EU FADN database.
- The core methodology is the PMP which is considered able to reproduce farmers behaviour with poor information.
- The foundation of PMP is based on the idea that is more convenient to know production level than production cost (Paris-Howitt, 1998).
- Limits with the standard approach:
 - ▣ Need in term of information about specific marginal costs
 - ▣ Maximum entropy approach very sensitive to support values

Methodologies Employed

For estimating the specific accounting costs, we have adopted:

- **Positive Mathematical Programming (PMP)** to reproduce the economic characteristics of farms (holders) included in the EU FADN and estimate the specific marginal costs (MC) for their crops
- **Cluster analysis, according to the K-mean technique**, to improve on the degree of homogeneity of the sample of farms employed in the estimation process
- **t-Student tests** for measuring the degree of fitness of the estimates with respect to observed values

Basic Methodology – PMP (for n farms)

1. Shadow prices associated with farm observed activities

$$\max_x GM = (\mathbf{p} - \mathbf{c})' \mathbf{x}$$

$$\mathbf{Ax} \leq \mathbf{b} \quad (\boldsymbol{\gamma})$$

$$\mathbf{x} \leq \bar{\mathbf{x}} + \boldsymbol{\varepsilon} \quad (\boldsymbol{\lambda})$$

$$\mathbf{x} \geq 0 \quad (\boldsymbol{\mu})$$

Activity-specific costs known in **Nat.** FADN (i.e. IT RICA)

Structural constraints

Calibrating constraints

Non-negativity constraints

2. Non-linear cost function estimation

$$\boldsymbol{\lambda} + \mathbf{c} = \mathbf{Q}\bar{\mathbf{x}}$$

$$(\boldsymbol{\lambda} + \mathbf{c})' \bar{\mathbf{x}} = \frac{1}{2} \bar{\mathbf{x}}' \mathbf{Q} \bar{\mathbf{x}}$$

Marginal costs

Total cost function

3. Calibration of the observed situation

$$\max_x GM = \mathbf{p}' \mathbf{x} - \frac{1}{2} \mathbf{x}' \mathbf{Q} \mathbf{x}$$

$$\mathbf{Ax} \leq \mathbf{b} \quad (\boldsymbol{\gamma})$$

$$\mathbf{x} \geq 0 \quad (\boldsymbol{\mu})$$

Objective function

Structural constraints

Non-negativity constraint

Generalized PMP MC Estimation

The Generalised PMP MC estimator retrieves **two** components of the MC associated to each activity recorded in the **EU** FADN:

- The activity-specific vector of accounting costs (\mathbf{c}_n)
- The activity-specific vector of implicit costs ($\boldsymbol{\lambda}_n$)

$$mc(\mathbf{x}_n) \equiv \mathbf{c}_n + \boldsymbol{\lambda}_n = \mathbf{Q}\bar{\mathbf{x}}_n + \mathbf{u}_n \longrightarrow \text{Individual marginal costs to estimate}$$

Accounting cost **Implicit cost**

The diagram illustrates the equation for individual marginal costs. The left side shows the marginal cost function $mc(\mathbf{x}_n)$ as the sum of an accounting cost vector \mathbf{c}_n and an implicit cost vector $\boldsymbol{\lambda}_n$. Both \mathbf{c}_n and $\boldsymbol{\lambda}_n$ are enclosed in red boxes. Arrows point from the labels 'Accounting cost' and 'Implicit cost' below to their respective boxes. The right side of the equation shows the linear model $\mathbf{Q}\bar{\mathbf{x}}_n + \mathbf{u}_n$, with an arrow pointing from this model to the text 'Individual marginal costs to estimate'.

The accounting cost is the part of the MC derived from the Farm Total Variable (SE281) Cost recorded by the EU FADN

The implicit cost is the part of the MC not explained by the farm cost breakdown but that farmers take into account in the decision process

Generalized PMP MC Estimation

Estimates activity-specific costs through the reconstruction of a nonlinear function of the total variable costs

$\min_x LS = \frac{1}{2} \mathbf{u}'\mathbf{u}$	Objective function
$\mathbf{c} + \boldsymbol{\lambda} = \mathbf{R}'\mathbf{R}\bar{\mathbf{x}} + \mathbf{u} \quad \text{if } \bar{\mathbf{x}} > 0$	Relationship between marginal costs derived from a linear function and marginal costs derived from a quadratic cost function
$\mathbf{c} + \boldsymbol{\lambda} \leq \mathbf{R}'\mathbf{R}\bar{\mathbf{x}} + \mathbf{u} \quad \text{if } \bar{\mathbf{x}} = 0$	
$\mathbf{c}'\bar{\mathbf{x}} \leq TVC$	Relation between estimated and observed TVC
$\mathbf{u}'\bar{\mathbf{x}} + \frac{1}{2} \bar{\mathbf{x}}'(\mathbf{R}'\mathbf{R})\bar{\mathbf{x}} \geq TVC$	
$\mathbf{c} + \boldsymbol{\lambda} + \mathbf{A}'\mathbf{y} \geq \mathbf{p} + \mathbf{A}'\mathbf{s}$	Economic equilibrium condition
$\mathbf{b}'\mathbf{y} + \boldsymbol{\lambda}'\bar{\mathbf{x}} = \mathbf{p}'\bar{\mathbf{x}} + \mathbf{s}'\bar{\mathbf{h}} - \mathbf{c}\bar{\mathbf{x}}$	Optimality condition
$\mathbf{R} = \mathbf{L}\mathbf{D}^{1/2}$	Cholesky decomposition
$\sum_{n=1}^N u_{n,j} = 0$	Deviation condition

The Data: the FADN Sample

The data belong to the 2007 FADN sample of farms in the FT1 farm type (field crops)

Sample weights are not employed in this specific application. However, the methodology is not impacted by their use too

Samples	N. of Farms	AV. UAA (ha)	Cereals/Tot (%)	GSP/Ha (€)	TVC/Ha (€)
Veneto	220	44	62	1,956	656
Lombardia	165	46	40	1,763	370
Piemonte	353	56	36	1,689	661
Total	738	50	43	1,774	600

Estimation Strategy

The Italian sample(s) has(have) been subject to estimation according to different data stratifications:

- **Three regions** taken together (Results I)
- **Each single region** independently (Results II)
- **Homogenous farms**, detected by means of cluster analysis (Results III)

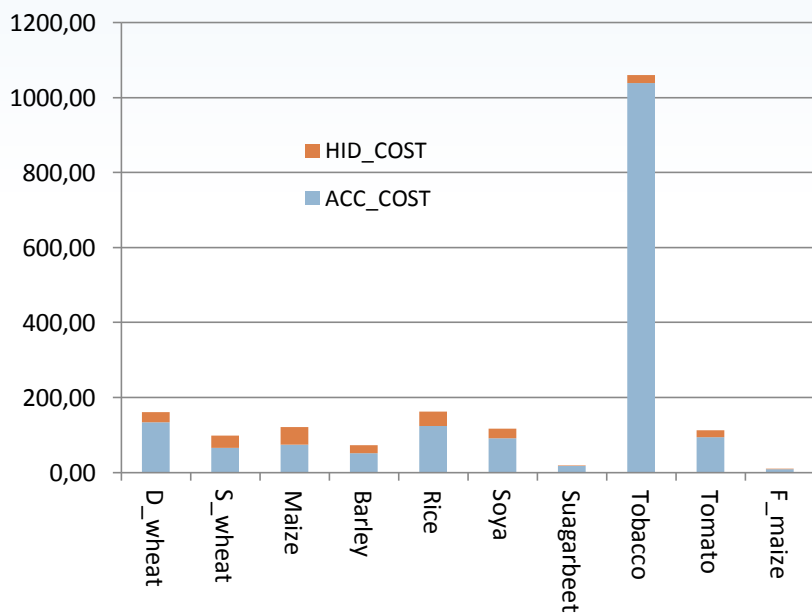
The estimated activity-specific variable costs are compared with the observed activity-specific variable costs through *t-tests*

Cost Estimation Results – Results I

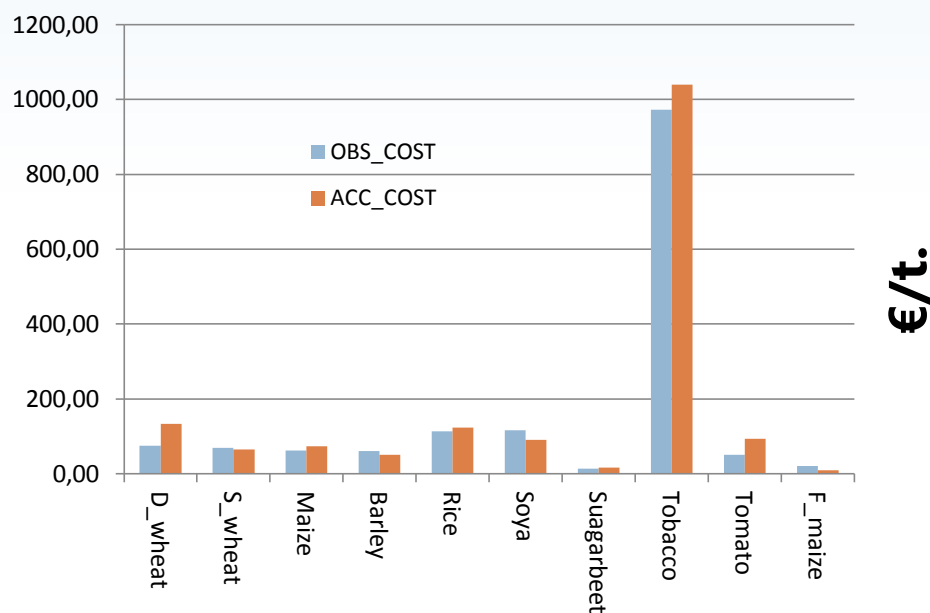
Crop	N. Obs.	Obs. Cost (RICA)	Estimated Accounting MC (FADN)	Implicit (Hidden) MC	Total MC (FADN)
Durum Wheat	35	0.076	0.134	0.027	0.161
Soft Wheat	335	0.070	0.066	0.033	0.099
Maize	502	0.062	0.074	0.047	0.121
Barley	115	0.061	0.051	0.021	0.072
Rice	142	0.114	0.124	0.038	0.162
Soya	118	0.117	0.091	0.025	0.116
Sugarbeet	44	0.014	0.017	0.001	0.018
Tobacco	4	0.973	1.039	0.022	1.060
Tomato	23	0.051	0.094	0.018	0.112
Fodder Maize	12	0.021	0.009	0.001	0.011

Cost Estimation Results – Result I

Macro-region



Estimated accounting and implicit marginal costs



Observed and estimated accounting costs

€/t.

Cost Estimation Results – Result I

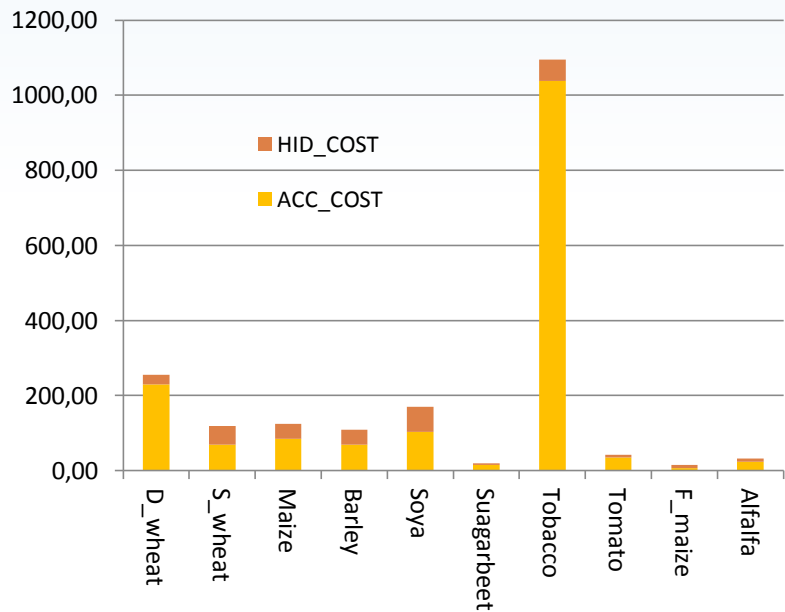
Crop	Obs. Cost (RICA) (A)	Estimated Accounting MC (FADN) (B)	(B-A) (%)	H ₀ : B-A=0 H ₁ : B-A≠0 (P-value 2 Tails)
Durum Wheat	0.076	0.134	77.2	0.004
Soft Wheat	0.070	0.066	-5.9	0.694
Maize	0.062	0.074	19.3	0.000
Barley	0.061	0.051	-15.2	0.331
Rice	0.114	0.124	8.2	0.014
Soya	0.117	0.091	-21.6	0.018
Sugarbeet	0.014	0.017	22.4	0.045
Tobacco	0.973	1.039	6.8	0.180
Tomato	0.051	0.094	84.0	0.452
Fodder Maize	0.021	0.009	-55.2	0.283

Cost Estimation Results – Results II

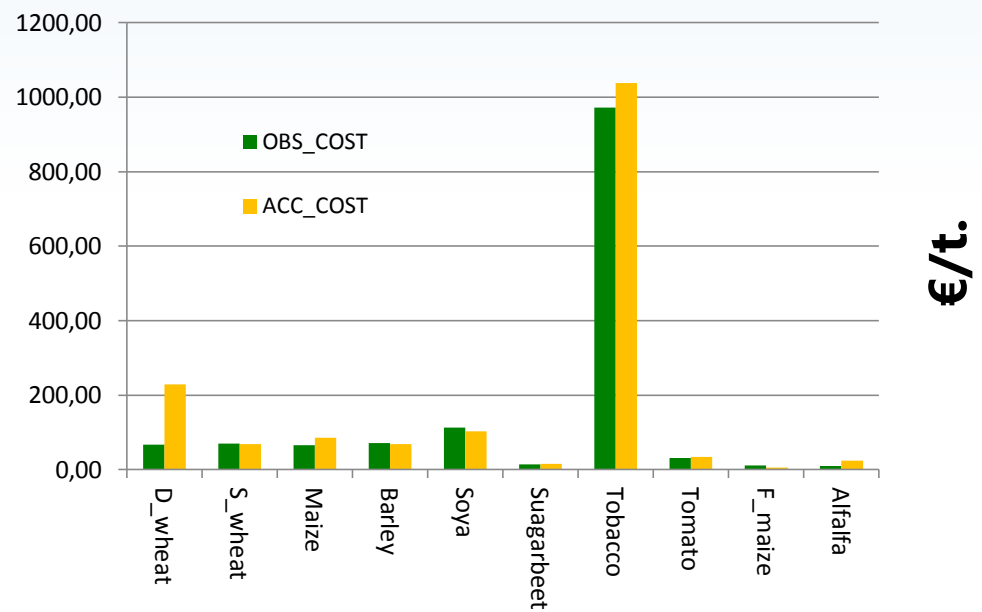
Crop	N. Obs.	Obs. Cost (RICA)	Estimated Accounting MC (FADN)	Implicit (Hidden) MC	Total MC (FADN)
Durum Wheat	11	0.06730	0.22931	0.02513	0.25444
Soft Wheat	110	0.07020	0.06853	0.04956	0.11809
Maize	184	0.06557	0.08523	0.03895	0.12418
Barley	17	0.07180	0.06843	0.04060	0.10903
Rice	6	0.12074	0.14119	0.18740	0.32859
Soya	82	0.11336	0.10317	0.06615	0.16933
Sugarbeet	42	0.01426	0.01538	0.00330	0.01868
Tobacco	4	0.97254	1.03875	0.05621	1.09496
Tomato	7	0.03133	0.03477	0.00740	0.04217
Fodder Maize	8	0.01120	0.00601	0.00940	0.01541
Alfalfa	13	0.00937	0.02387	0.00827	0.03213

Cost Estimation Results – Results II

Veneto



Estimated accounting and implicit marginal costs



Observed and estimated accounting costs

€/t.

Cost Estimation Results – Results II

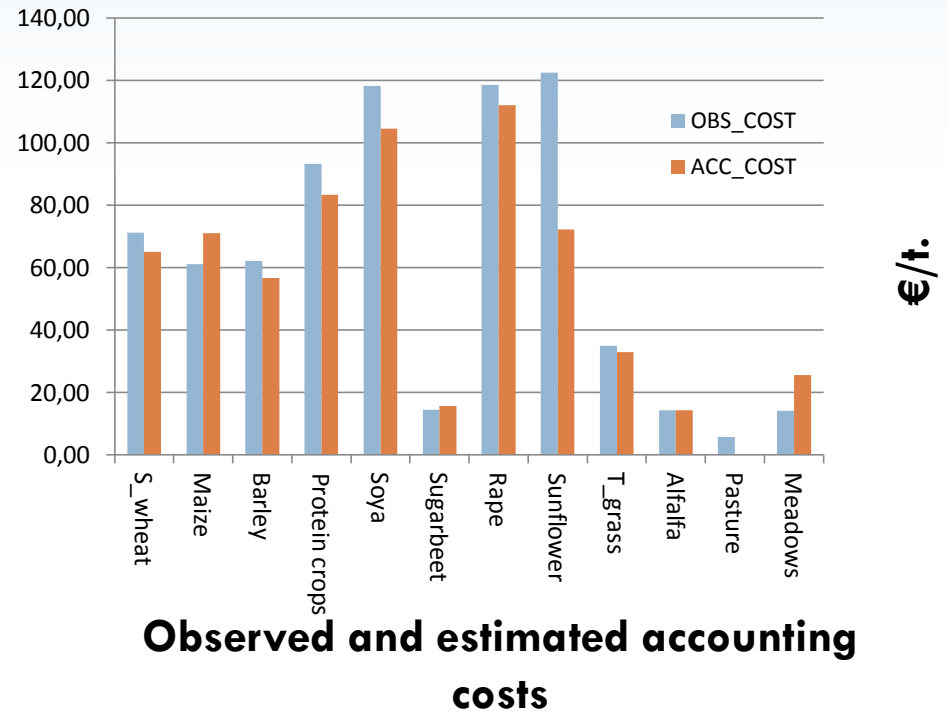
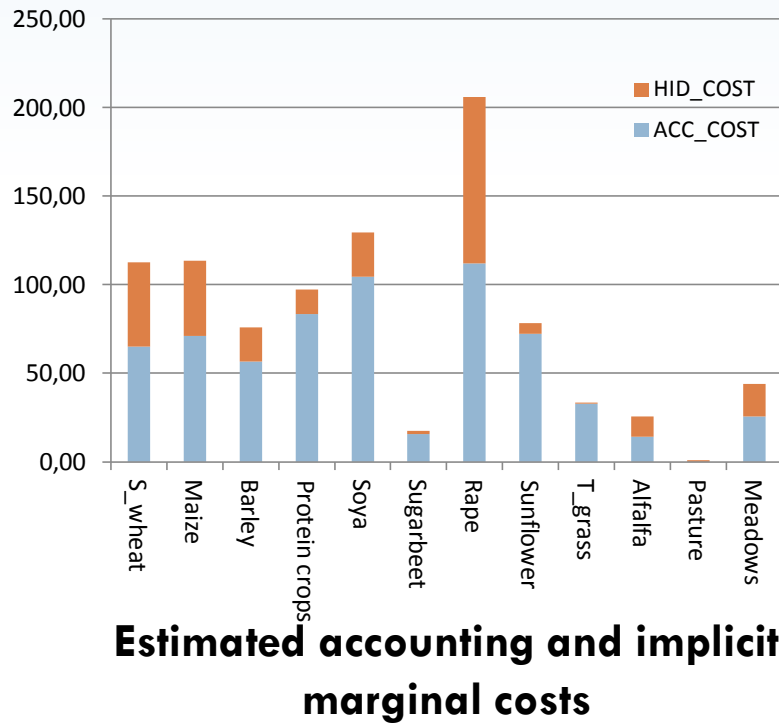
Crop	Obs. Cost (RICA) (A)	Estimated Accounting MC (FADN) (B)	(B-A) (%)	H ₀ : B-A=0 H ₁ : B-A≠0 (P-value 2 Tails)
Durum Wheat	0.06730	0.22931	240.7	0.000
Soft Wheat	0.07020	0.06853	-2.3	0.934
Maize	0.06557	0.08523	29.9	0.000
Barley	0.07180	0.06843	-4.6	0.963
Rice	0.12074	0.14119	16.9	0.669
Soya	0.11336	0.10317	-8.9	<i>0.101</i>
Sugarbeet	0.01426	0.01538	7.8	0.471
Tobacco	0.97254	1.03875	6.8	0.180
Tomato	0.03133	0.03477	10.9	0.850
Fodder Maize	0.01120	0.00601	-46.3	0.318
Alfalfa	0.00937	0.02387	154.7	0.373

Cost Estimation Results – Results III

Crop	N. Obs.	Obs. Cost (RICA)	Estimated Accounting MC (FADN)	Implicit (Hidden) MC	Total MC (FADN)
Soft Wheat	197	0.07113	0.06501	0.04752	0.11254
Maize	311	0.06106	0.07100	0.04258	0.11357
Barley	62	0.06208	0.05673	0.01929	0.07602
Protein crops	11	0.09320	0.08331	0.01383	0.09714
Soya	74	0.11812	0.10452	0.02489	0.12941
Sugarbeet	17	0.01452	0.01569	0.00179	0.01747
Rape	6	0.11845	0.11202	0.09389	0.20591
Sunflower	8	0.12248	0.07227	0.00601	0.07828
Temporary Grass	5	0.03504	0.03290	0.00040	0.03331
Alfalfa	6	0.01432	0.01423	0.01149	0.02572
Meadows	77	0.01404	0.02553	0.01834	0.04387

Cost Estimation Results – Results III

6th Cluster



Cost Estimation Results – Results III

Crop	Obs. Cost (RICA) (A)	Estimated Accounting MC (FADN) (B)	(B-A) (%)	H ₀ : B-A=0 H ₁ : B-A≠0 (P-value 2 Tails)
Soft Wheat	0.07113	0.06501	-8.6	0.298
Maize	0.06106	0.07100	16.2	0.000
Barley	0.06208	0.05673	-8.6	0.558
Protein crops	0.09320	0.08331	-10.6	0.528
Soya	0.11812	0.10452	-11.5	0.318
Sugarbeet	0.01452	0.01569	8.0	0.556
Rape	0.11845	0.11202	-5.4	0.484
Sunflower	0.12248	0.07227	-40.9	0.382
Temporary Grass	0.03504	0.03290	-6.1	0.905
Alfalfa	0.01432	0.01423	-0.6	0.079
Meadows	0.01404	0.02553	81.8	0.018

Conclusions

