



FAERE 6th annual conference

Recovering cropping management practices specific production functions: clustering and latent approaches

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Outline

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A call for chemical inputs reduction

Methodology

Data for CMPs identification

Clustering and latent class approaches

Empirical application

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Context: A call for chemical inputs reduction

Negative externalities associated with chemical inputs: ¹²

- ❖ Human health effects (direct & indirect) ;
- ❖ Reducing agricultural sustainability ;
- ❖ Environmental effects: soil & water contamination, pest resistance, biodiversity loss, *etc.*

⇒ **"Why farmers continue to use pesticides** despite environmental, health and sustainability costs"? ²

¹Pimentel *et al*, 1992

²Wilson and Tisdell, 2001

Context: A call for chemical inputs reduction

EU policy objective to **regulate pollutions due to the chemical inputs use**

- ❖ Standard economists' answer: taxation or subsidies *i.e.* economic tool ;
- ❖ However, pesticide use not very responsive to price changes³ ;
- ❖ For agricultural scientists, a change in chemical inputs use requires a change in production practices (*e.g.* CMPs⁴)
⇒ **Changes in chemical inputs use = mid to long run adjustment**

³Skevas *et al*, 2013 ; Böcker *et al*, 2017

⁴CMP = cropping management practices

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Methodology: Data for CMPs identification

CMP = ordered sequence of yield production decisions aimed to produce a given crop (e.g. soil preparation operation, seeding type, date and density, fertilization and pesticide application)⁵

Problem: **No information** about such practices in economists' data set.

⇒ CMPs can be defined by the **targeted yield** and the **chemical inputs use** levels⁶

⁵Sébillotte, 1990

⁶Meynard, 1985 and 1991

Methodology: Data for CMPs identification

Assumption: CMP specific production functions

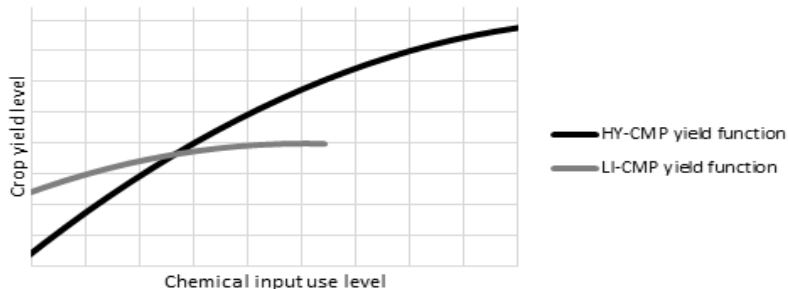


Figure: Yield functions and CMPs

Methodology: Clustering and latent class approaches

2 approaches to identify and to account for CMPs:

❖ A two-step approach:

1. **Clustering approaches** (k-means or AHC) to identify CMP types⁷ ;
2. Estimate the CMP specific production functions e.g.
$$y = f_c(\mathbf{x}^c) = b^c - (1/2) \times (\mathbf{d}^c - \mathbf{x})' \mathbf{A}^c (\mathbf{d}^c - \mathbf{x})$$
 with $b > 0$ and $\mathbf{d} > \mathbf{0}$

❖ A one-step approach: **latent production function** with latent production technologies corresponding to CMPs \Rightarrow use of EM algorithm.

⁷Renaud-Gentié *et al*, 2014 ; Blazy *et al*, 2009 ; Bellon *et al*, 2001.

Methodology: a latent class approach insight

At n^{th} iteration of the EM algorithm, we have:

1. **E step:** calculate the expectation of the sample "complete information" likelihood *i.e.*

$$E_{(n)} [\ln \mathcal{L}_N^C(\alpha, \beta, \pi) | \mathcal{E}_N] = \sum_{i=1}^N \sum_{j \in \mathcal{J}} w_{i,(n)}^j \left(\sum_{t=1}^T \ln l_{i,t}(\alpha^j, \beta_t^j) + \ln \pi^j \right);$$

2. **M step:** re-calculate the estimates of $(\alpha_0, \beta_0, \pi_0)$ thanks to

$$(\alpha_{(n+1)}, \beta_{(n+1)}, \pi_{(n+1)}) = \arg \max_{(\alpha, \beta, \pi)} E_{(n)} [\ln \mathcal{L}_N^C(\alpha, \beta, \pi) | \mathcal{E}_N]$$

⇒ Get $w_{i,(n)}^j$ (*i.e.* the probability of choosing CMP j) and $(\alpha_0, \beta_0, \pi_0)$ (*i.e.* the parameters of the production function) **simultaneously**.

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Data: description of the data set

- ❖ **Accounting data** from French farmers located in *la Marne crayeuse*, from 1998 to 2014 ; [Go to map](#)
- ❖ Focus on **wheat** crops ;
- ❖ Balanced **4-years subpanels** (14 subpanels with 342 farmers on average) ;
- ❖ Variables : yield ; fertilizers expenses ; quantities of N, P, K ; pesticides expenses (overall and also share between herbicides, fungicides and insecticides).

Data: 2008 fertilizer instability

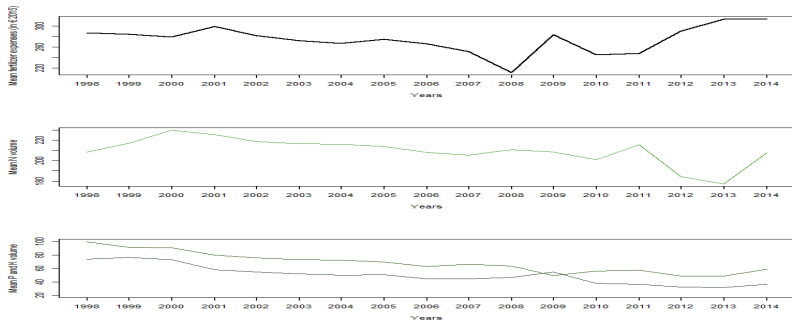


Figure: Instability of fertilizers expenses versus stability of fertilizers use

⇒ Better to use a stable variable: **nitrogen expenses**

EM results: Clusters' characteristics - Yield



Figure: Mean yield in EM (with AHC inits) clusters

⇒ Average difference in yield about 7%

EM results: Clusters' characteristics - Nitrogen expenses

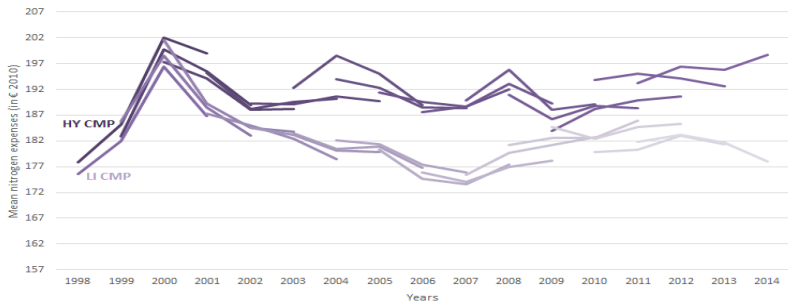


Figure: Mean nitrogen expenses (in € 2010) in EM (with AHC inits) clusters

⇒ Average difference in nitrogen expenses about 5%

EM results: Clusters' characteristics - Pesticide expenses

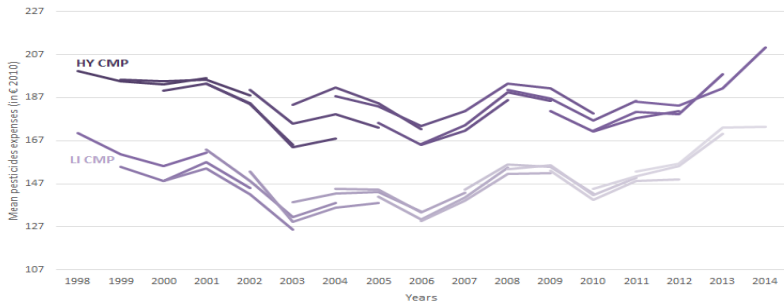


Figure: Mean pesticide expenses (in € 2010) in EM (with AHC inits) clusters

⇒ Average difference in pesticide expenses about 19%

Clustering results

EM results: Clusters' characteristics - Pesticide expenses

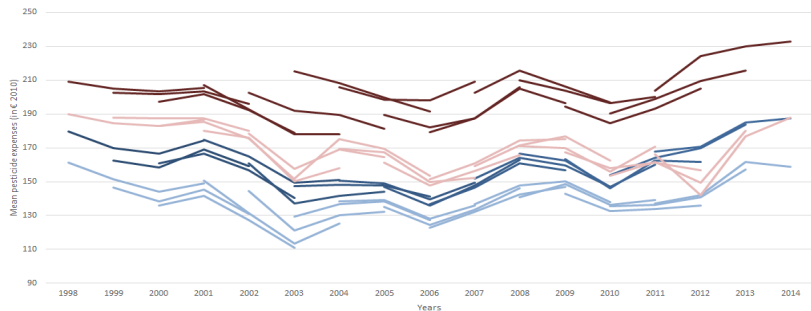


Figure: Confidence interval for pesticide expenses (in € 2010) in EM (with AHC inits) clusters

⇒ **Groups are significantly different for pesticide expenses**

EM results: Clusters' size

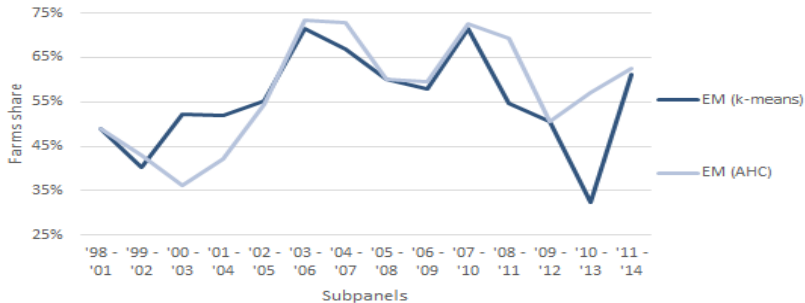


Figure: Evolution of the EM low-input cluster's size

⇒ **A growing LI cluster** destabilized by the 2007 crisis Clustering results

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1. Use all years at the same time in the EM algorithm ;
2. Control for weather conditions and soil characteristics in the yield and inputs use functions ;
 - ▶ Weather data: rainfall, heat and radiance data mainly ;
 - ▶ Soil data: organic carbon content, pH, clay content and cationic exchange capacity.
3. Determinants of the CMP choice.



Thank you for your attention!

Any questions?



Supplementary material

La Marne crayeuse

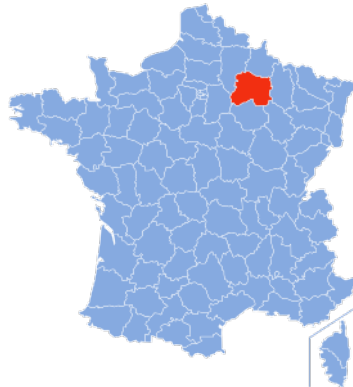


Figure: Map of French departments

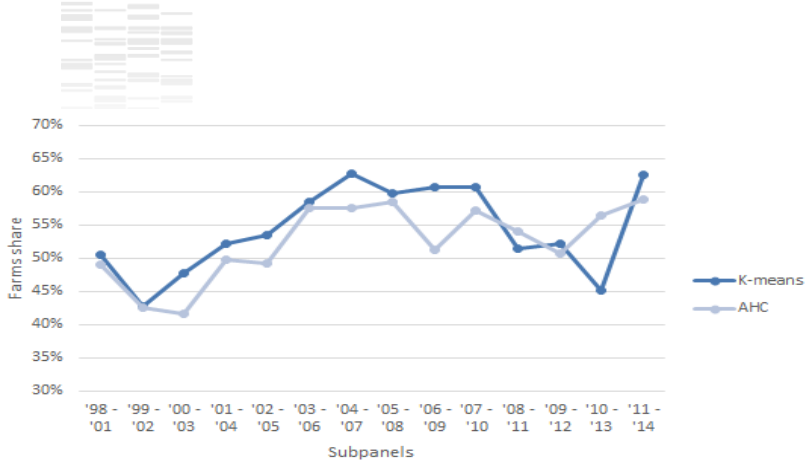


Figure: Evolution of the low-input cluster size

[← Back to EM results](#)

Clustering results: AHC yields



Figure: Mean yields in AHC clusters

⇒ Average difference in yields about 8%

Clustering results: AHC fertilizer expenses



Figure: Mean nitrogen expenses (in € 2010) in AHC clusters

⇒ Average difference in nitrogen expenses about 6%

Clustering results: AHC pesticide expenses



Figure: Mean pesticide expenses (in € 2010) in AHC clusters

⇒ Average difference in pesticide expenses about 19%

Clustering results: K-means yields

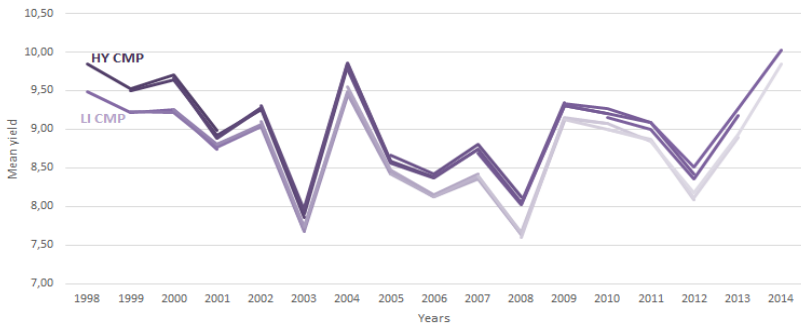


Figure: Mean yields in k-means clusters

⇒ Average difference in yields about 3%

Clustering results: K-means fertilizer expenses

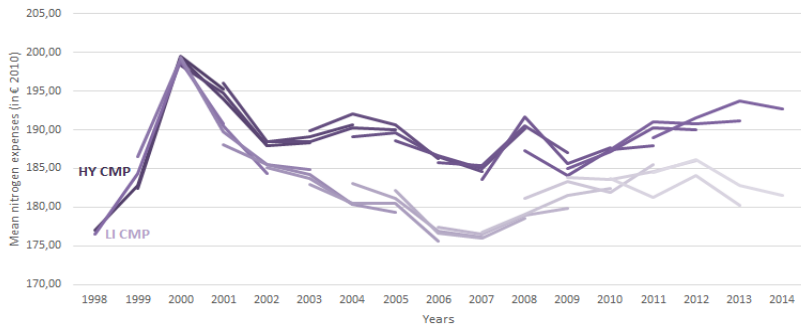


Figure: Mean nitrogen expenses (in € 2010) in k-means clusters

⇒ Average difference in nitrogen expenses about 3%

Clustering results: K-means pesticide expenses

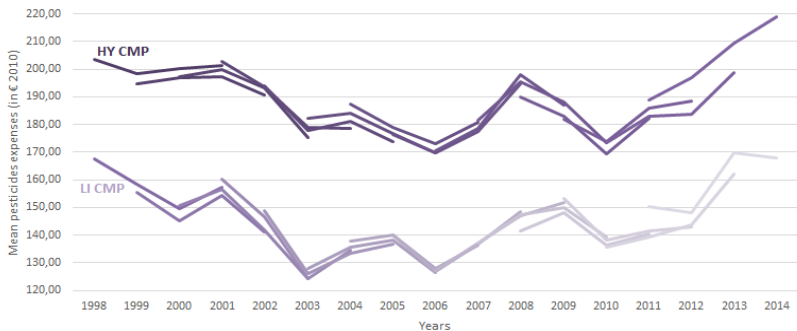


Figure: Mean pesticide expenses (in € 2010) in k-means clusters

⇒ Average difference in pesticide expenses about 23%

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