Building a typology of farms based on their performance. A tool to support agricultural policy-making

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- **Heterogeneity within agricultural systems**; farm-level differences based on structural features, production management, socio-demographic characteristics, etc.
- Wide range of **variations in farms' economic and environmental performance**.
- **Agricultural policy** should account for this heterogeneity within every agricultural system to properly design policy instruments (**tailoring**) and to implement them accurately (**targeting**).
- Agricultural heterogeneity is usually addressed through **farm typologies based on geographical, size, and types of farming criteria**.
- However, these typologies **do not necessarily give information about actual farms' performance** (i.e., their contribution to achieving policy objectives).

Objetives

- To propose **a typology-building approach** that identifies a manageable number of farm categories within a specific agricultural system, where each category contains **farms exhibiting a similar economic and environmental performance**.
- The delineated farm types could be considered as **differentiated target groups** facilitating the design and implementation (**tailoring and targeting**) of more effective and **efficient policy instruments**.
- The **Spanish rainfed field crops agricultural system** has been chosen as a case study to illustrate the empirical implementation.

Source of information: RECAN

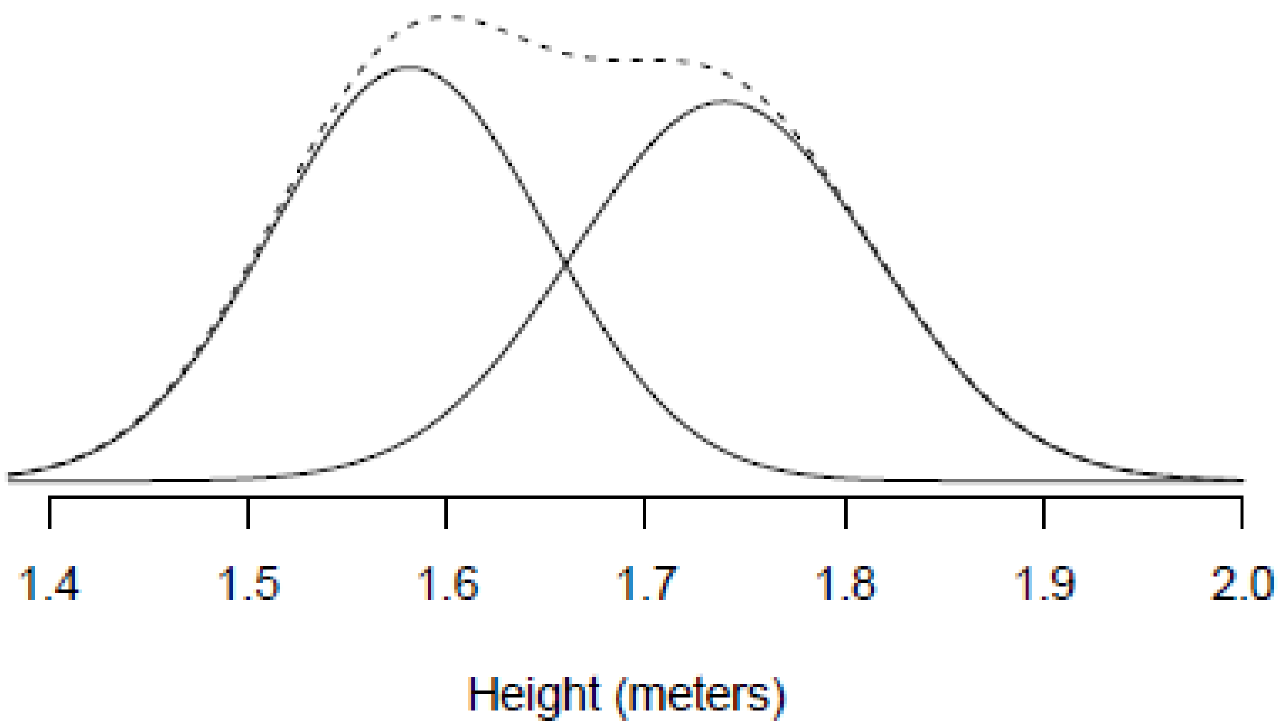
- **RECAN** (Spanish brand of the FADN) as source of microeconomic data at the farm level.
- **Microdata** from **TF 15 and 16** (COP and general field cropping) at the **national level**, restricted to farms whose total area is **rainfed**.
- **559 farms** in the three-year panel sample (2019-2021).
- Average values **(2019-2021)** for key performance indicators (**economic and environmental performance as farms' "structural" features**).

Economic and environmental performance indicators

Dimension	Indicator (ACRONYM)	Formula	Formula based on RECAN microdata	Units
Economic performance indicators				
Productivity	Land productivity (**LAND_PROD**)	$\frac{\text{Total output}}{\text{Utilised Agricultural Area}}$	$\frac{SE131}{SE025}$	€/ha
Profitability	Return on Assets (**ROA**)	$\frac{\text{EBIT}}{\text{Total assets}}$	$\frac{SE420 + SE380 + SE390}{SE436}$	%
Viability	Economic viability (**VIABILITY**)	$\frac{\text{FNI}}{\text{Total Opportunity Costs}}$	$\frac{SE420}{OC_{land} + OC_{labor} + OC_{non-land\ assets}}$	Dimensionless
Environmental performance indicators				
Biodiversity	Shannon Diversity Index (**SDI**)	$-\sum p_i \times \ln(p_i)$	p_i based on RECAN microdata regarding farmland use	Dimensionless
GHG emissions	GHG emissions (**GHG_EM**)	$\frac{\text{GHG emissions}}{\text{Utilised Agricultural Area}}$	$\frac{\sum_i input_i \times \text{kg CO2e/unit}_i}{SE025}$	kg CO2e/ha
Pollution emissions	Nitrogen inputs (**NITROG**)	$\frac{\text{Nitrogen in inputs}}{\text{Utilised Agricultural Area}}$	$\frac{(SE296 \times 100) + N_{organic}}{SE025}$	kg N/ha

Econometric modelling

- **Latent profile analysis** (LPA).
- LPA foundation. An example of human beings' height:



Econometric modelling

- Laten profile analysis **model**:

$$f(y_i) = \sum_{k=1}^{G} \pi_k f_k(y_i | \theta_k)$$

- For a given number of **G profiles**, parameters can be estimated by maximizing the following likelihood function :

$$L(\theta_k, \pi_k | y_i) = \prod_{i=1}^{n} \sum_{k=1}^{G} \pi_k f(y_i | \theta_k)$$

- A multivariate normal distribution is assumed for $\boldsymbol{f_k}$ whose **parameters** are the **means** of the classifying variables considered for each profile *k* (μ_k) and their **variance-covariance matrices (Σ_k)**.

Econometric modelling

- **Classification variables**: key economic and environmental farm performance indicators.
- **Number of profiles (G)**: BIC criteria, statistical parsimony, and facility to interpret the results → **3 Profiles**
- Assessment of **synergies/trade-offs among indicators** based on the variance-covariance matrices:

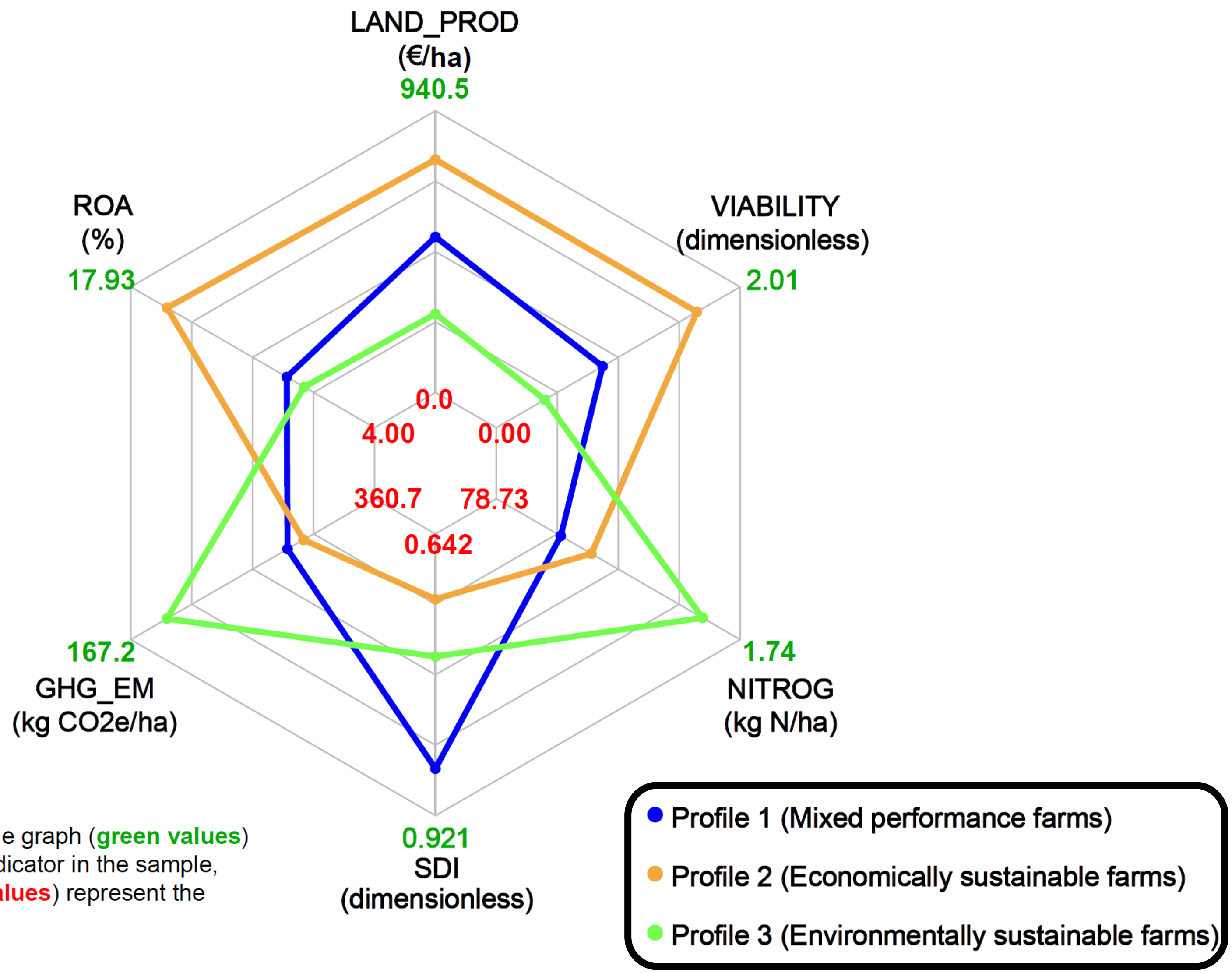
$$Y = a_{x,y} + b_{x,y}\, X + \varepsilon \quad \rightarrow \quad b_{x,y} = \frac{dY}{dX} = \frac{cov(X,Y)}{var(X)}$$

- **Profile membership related to covariates** (three-step model).
- Software: **Latent Gold 6.0**.

Covariates (ACRONYMS)	Formula	RECAN code	Units
Farmer's characteristics			
Age (AGE)	-	-	Years
Gender (GENDER)	1= female, 0= male	-	-
Agricultural training (TRAIN)	1= formal academic, 0= practical experience	-	-
Full-time farmer (FULL_FARM)	1= yes, 0= no	-	-
Farm's structural characteristics			
Total farm area (F_AREA)	-	SE025	ha
Decoupled payments (DEC_PAY)	$\frac{\text{Decoupled payments}}{\text{UAA}}$	$\frac{\text{SE630}}{\text{SE025}}$	€/ha
Environmental subsidies (ENV_SUB)	$\frac{\text{Environmental subsidies}}{\text{UAA}}$	$\frac{\text{SE621}}{\text{SE025}}$	€/ha
Other CAP 2nd pillar subs. (OTHER_2P)	$\frac{\text{Other CAP 2nd pillar subsidies}}{\text{UAA}}$	$\frac{\text{SE624}-\text{SE621}}{\text{SE025}}$	€/ha
Family Farm (FAM_FARM)	1= yes, 0= no	-	
Owned land (OWN_LAND)	$\frac{\text{UAA} - \text{Rented UAA}}{\text{UAA}}$	$\frac{\text{SE025}-\text{SE030}}{\text{SE025}}$	%
Located in Castilla y León (REG_CYL)	1 = yes, 0 = no	-	-
Located in Castilla-La Mancha (REG_CLM)	1 = yes, 0 = no	-	-
Located in Andalucía (REG_AND)	1 = yes, 0 = no	-	-
Located in other regions (REG_OTH)	1 = yes, 0 = no	-	-
Location in less favored areas (LFA)	1 = yes, 0 = no	-	-
Farm's resources			
Non-land fixed assets (NL_FASSET)	$\frac{\text{Total fixed assets} - \text{Land assets}}{\text{UAA}}$	$\frac{\text{SE441}-\text{SE446}}{\text{SE025}}$	€/ha
Outsourcing (OUTSOURC)	$\frac{\text{Contract work costs}}{\text{UAA}}$	$\frac{\text{SE350}}{\text{SE025}}$	€/ha
Labor input hours (LABOR_H)	$\frac{\text{Total labor input hours}}{\text{UAA}}$	$\frac{\text{SE011}}{\text{SE025}}$	hrs/ha
Debt ratio (DEBT)	$\frac{\text{Total liabilities}}{\text{Total assets}}$	$\frac{\text{SE485}}{\text{SE436}}$	%

Three profiles LPA solution

Indicator	Profile 1 (n=235)	Profile 2 (n=212)	Profile 3 (n=112)	Overall (n=559)
LAND_PROD (€/ha)	519.4	**777.7**	**262.5**	565.6
ROA (%)	9.01	**15.85**	**8.02**	11.41
VIABILITY (dimensionless)	0.876	**1.653**	**0.399**	1.075
SDI (dimensionless)	**0.874**	**0.707**	0.763	0.789
GHG_EM (kg CO2e/ha)	291.6	**304.4**	**196.0**	277.2
NITROG (kg N/ha)	**58.39**	48.72	**13.60**	45.73
Profile size	0.420	0.379	0.201	



Note: The values on the outside of the graph (**green values**) represent the best values for each indicator in the sample, while the values on the inside (**red values**) represent the worst values for each indicator.

Synergies and trade-offs among indicators

	Indicator X / Indicator Y	LAND_PROD	ROA	VIABILITY	SDI	GHG_EM	NITROG
Profile 1	LAND_PROD						
	ROA	0.004					
	VIABILITY	-0.001	**0.067**				
	SDI	-0.000	0.001	**0.051**			
	GHG_EM	**0.230**	-0.481	**-24.5**	**-56.8**		
	NITROG	**0.052**	0.220	**-2.92**	**-8.23**	**0.212**	
Profile 2	LAND_PROD						
	ROA	**0.004**					
	VIABILITY	**0.001**	**0.037**				
	SDI	**-0.000**	**-0.007**	**-0.054**			
	GHG_EM	**0.168**	**-2.48**	5.21	57.8		
	NITROG	**0.027**	**-0.937**	4.58	**23.8**	**0.205**	
Profile 3	LAND_PROD						
	ROA	**0.020**					
	VIABILITY	**0.001**	**0.047**				
	SDI	0.000	**0.011**	**0.288**			
	GHG_EM	**0.683**	-1.26	**-69.0**	-45.8		
	NITROG	**0.036**	0.014	**-4.76**	**-11.9**	**0.046**	

Three-step model

Covariate	Profile 1		Profile 2		Profile 3 (reference)	
	Coef.		Coef.		Coef.	
Intercept	-4.559	*a*	-0.523	*a,b*	.	*b*
TRAIN = 1	0.771	*a,b*	1.998	*b*	.	*a*
FULL_FARM = 1	-0.949	*a,b*	-1.166	*a*	.	*b*
DEC_PAY	0.004	*a*	0.013	*b*	.	*a*
REG_CYL = 1	2.556	*c*	-2.580	*a*	.	*b*
REG_CLM = 1	2.567	*b*	0.983	*a*	.	*a*
REG_AND = 1	-4.399	*a*	-0.800	*b*	.	*b*
LFA = 1	3.211	*b*	-0.806	*a*	.	*a,b*
NL_FASSET	0.003	*b*	0.003	*b*	.	*a*
OUTSOURC	0.008	*a,b*	0.012	*b*	.	*a*

* Differences are shown at the 5% level, with shared letters indicating no statistically significant difference.

Main conclusions

- The case study implemented proves that **the proposed farm typology-building approach could be helpful in supporting policy decision-making.**
- The results obtained could be used to **enhance agricultural policy tailoring** by fine-tuning the design of policy instruments to **differentiate synergies/trade-offs across farm profiles**.
- These results could also **improve agricultural policy targeting** by focusing **differentiated policy instruments** on each farm profile **according to farms' specific structural features and farmers' socio-demographic characteristics**.

Policy implications from empirical results

- **Reducing the higher decoupled payments granted to farms in Profile 2** (economically sustainable) would not jeopardize their economic sustainability but would allow for **increasing the policy support to farms in Profile 3** (environmentally sustainable with poor economic performance)**.**
- **Policy instruments constraining land use choices** (e.g., CAP conditionality based on crop diversification) could be intensified for farms included in **Profiles 1 and 3** without payment increases since these **changes would not involve a worsened economic sustainability**.
- To efficiently **reduce GHG emissions and nitrogen pollution** (i.e., with the least possible impact on economic performance), higher **environmental payments should be focused on less intensive farms (Profiles 1 and 3)**.

Limitations

- Limited suitability of the environmental indicators built, given the **lack of detailed environmental information in the FADN** microdata.
- These data limitations may be solved in the near future with the upgrade of the FADN into the **Farm Sustainability Data Network (FSDN)**.

Further research / Next steps

- Farm classification from a **dynamic perspective**, considering how they evolve across years to face economic, technological, or policy changes.

¡THANK YOU FOR THE ATTENTION!

¿Any comments or suggestions?

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