Cereal farming under pressure: Economic drivers of cereal decline in Tuscany (2017–2024)

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Global agri-food value chains in a changing geopolitical order: towards new equilibria?

Motivation: Agricultural Abandonment in Tuscany

A structural transformation above the national average

- Between 1982 and 2020, cultivated land in Tuscany contracted by more than one third, compared to -21% nationally.
- The number of farms fell by nearly 100,000 units, with only limited farm-size consolidation relative to other Italian regions.
- Unlike most regions, the contraction of utilisable agricultural area has not decelerated.
- Within this broader contraction, cereal production shows an acute and accelerating decline, with no compensating gains over 2017–2024.

UAA change, 1982–2020

-34%

Farms lost, 1982–2020

$-100\mathbf{K}$

Cereal area lost, 2017–2024

$-57\mathbf{K}$ **ha**

Source: ISTAT Agricultural Censuses 1982, 2000, 2010, 2020; PCG-ARTEA 2017–2024, own elaborations.

Crop area in Tuscany

Average annual change in cultivated area by crop category

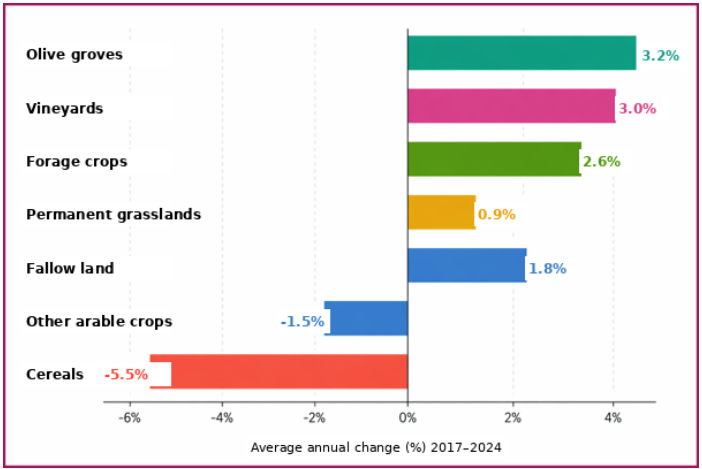


Figure: Evolution of crop areas in Tuscany, 2018-2024

Cereal crops areas in Tuscany

Average annual change in cultivated area by cereal category

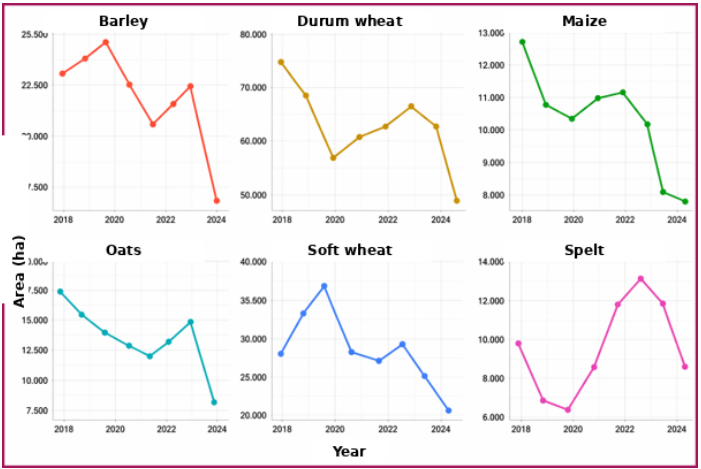


Figure: Evolution of cereal crop areas by category in Tuscany, 2018-2024

Conceptual Framework: Three Forms of Cereal Retreat

1. Structural abandonment

Persistent, irreversible exit from cereal production. The plot is no longer actively cultivated and does not transition to an alternative productive use.

2. De-intensification

The parcel formally remains agricultural but shifts to fallow or very low-input uses. This may be partly concealed in official statistics.

3. Crop substitution

Farmers permanently replace cereals with alternative crops offering higher or more stable returns, such as vineyards, olives or forage.

Measurement challenges: land idling is difficult to detect; farm exit is not equivalent to land abandonment; profitability is unobserved and must be proxied.

Source: Framework draws on Levers et al. (2018), Perpina Castillo et al. (2021), Terres et al. (2015).

Structural profitability gap and data availability

- Structural farm income problem due to low demand elasticity to income and low supply elasticity (Hill, 2018; Gardner, 1992; Cochrane, 1979).
- Most grains are positioned at the rear end of the value chain—which is often very long—and capture only a very limited share of the value added (Turchetti & Ferraresi, 2025)
- Mediterranean cereal profitability is compressed by competition from high-value perennial crops (Salvioni et al., 2014; Henke et al., 2012).
- Price volatility and asymmetric shock transmission (Capitanio et al., 2011)

$\Rightarrow$ **Farm-level profitability data are largely unavailable, limiting direct assessment of the economic performance of cereal farming and any other evaluation of its contribution to abandonment**

Microeconometric studies on farms: challenges and our strategy

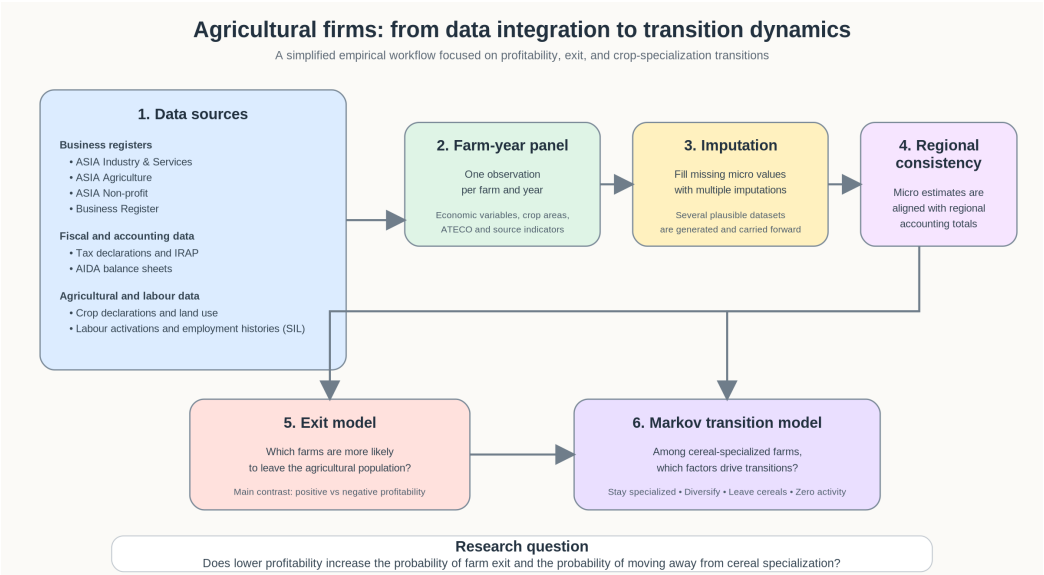
$\Rightarrow$ Main challenges:

- Limited availability of economic information covering the entire population of farms;
- Lack of longitudinal data suitable for survival and transition analyses, even for representative samples.

$\Rightarrow$ Our strategy:

- We integrate multiple administrative and statistical sources to reconstruct a farm-level panel for Tuscany over the period 2017–2022;
- We use multiple imputation techniques to reconstruct a simplified set of balance-sheet variables for the entire population of farms;
- We estimate each model across M imputed datasets and combine the resulting estimates through Monte Carlo averaging, using the variability across imputations to assess statistical significance.

The pipeline of the work



Data sources

Land use and crop specialization	Tuscan *Piani Colturali Grafici* (PCG–ARTEA), 2017–2022: annual parcel-level crop declarations covering the universe of Tuscan farms.
Business registers	ISTAT, Camera di commercio business registers (ASIA Agriculture, ASIA Industry and Services, ASIA Non-profit, Business Register, AIDA): firm identifiers, sector classification, demographic events and structural characteristics.
Fiscal and accounting data	Agenzia delle Entrate fiscal archives (IRAP and tax declarations) and AIDA balance-sheet data: economic and financial information used to reconstruct farm-level accounts; Sistema Informativo Lavoro and tax declarations to reconstruct the labour cost component of value added.
Labour histories	Sistema Informativo Lavoro (SIL): labour activations and employment histories used to reconstruct workforce dynamics.
Regional accounts	National and regional accounting aggregates used as consistency constraints during the multiple-imputation procedure.

Model Specification: Exit and Markov Transition Models

1. Agricultural exit model

Binary logit for structural exit:

$$\Pr(E_{f,t} = 1 \mid X_{f,t}) = \frac{1}{1 + \exp[-(\alpha + \beta^\top X_{f,t})]}$$

- $E_{f,t} = 1$: farm absent from the agricultural population in $t+1, t+2, t+3$
- Key contrast: positive vs negative profitability
- Controls: crop areas, specialization, concentration, year and sector effects; employees; owner age and sex

2. Markov transition model

Multinomial logit for crop-specialization transitions:

$$\Pr(S_{f,t+1} = j \mid S_{f,t} = i, X_{f,t}) = \frac{\exp(\alpha_{ij} + \beta_{ij}^\top X_{f,t})}{\sum_k \exp(\alpha_{ik} + \beta_{ik}^\top X_{f,t})}$$

- Estimated for farms specialized in cereals at t
- Destinations: stay specialized, diversify, leave cereals, zero activity
- Focus: effect of negative profitability on transition probabilities

Both models are estimated across multiple imputations and summarized using Monte Carlo averages. Two types of target populations: more market oriented farms (Asia agricoltura or AIDA or Tax declarations or with employees); sole proprietorship farms

Exit model: the role of profits

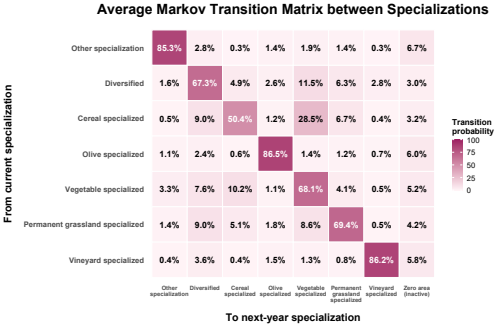
⇒ Observed exit rates over a three-year horizon are slightly below 10% for cereal-specialized farms with positive profitability, but rise to around 15% among sole proprietorships specialized in cereals and exhibiting negative profitability.

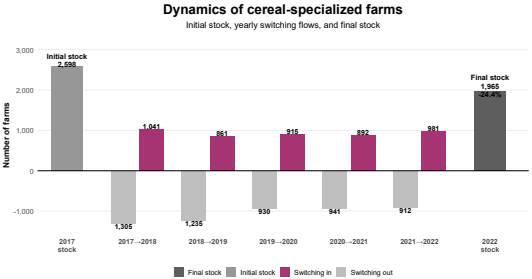
Population	Effect	MC coefficient	MC p-value
Market-oriented firms	Negative profitability	**0.25**	< 0.001
	Negative profitability × cereal specialization	-0.01	0.685
Sole proprietorships	Negative profitability	**0.26**	< 0.001
	Negative profitability × cereal specialization	**0.05**	0.006

Monte Carlo estimates from the agricultural exit model. The first coefficient measures the effect of negative profitability relative to positive profitability. The interaction term captures the additional effect of negative profitability for cereal-specialized farms. Results are averaged across 100 imputations.

⇒ Negative profitability increases the probability of farm exit. Among sole proprietorships, cereal-specialized farms appear particularly vulnerable, facing a higher exit risk than farms specialized in other agricultural activities.

Markov switching model: the observed transitions





- Cereal-specialized farms exhibit the highest probability of transitioning out of their specialization state.
- Transitions away from cereals are partly persistent, as farms switching out of cereal specialization almost always exceed those switching in from other specializations.

Markov switching model: the role of profits

Population	Transition outcome	MC coefficient	MC p-value
Market-oriented firms	To non-specialized cereals	-0.10	< 0.001
	To other specialization state	**0.03**	0.010
	To zero agricultural area	**0.06**	0.009
Sole proprietorships	To non-specialized cereals	-0.02	0.009
	To other specialization state	-0.01	0.449
	To zero agricultural area	**0.13**	< 0.001

Estimated effect of *negative profitability* relative to positive profitability. All transitions are defined for farms specialized in cereals at time t. Coefficients are Monte Carlo averages across 100 imputations.

$\Rightarrow$ Negative profitability appears more likely to push farms away from cereal cultivation—and ultimately towards other specialization state or dismissing.

Next steps

1. Towards a unified hurdle model

- The current approach estimates exit and crop switching as *separate* processes; the next step is to embed both within a **single hurdle specification** that jointly models the zero-outcome (farm exit) and the conditional multinomial transition.
- Better disentangling crop rotation effects from other permanent cereal retreat

2. Extending the analytical framework

- **EU agricultural policy**: assess the role of CAP in mediating exit and crop-transition probabilities, distinguishing decoupled income support from production-linked measures.
- **Geopolitical shocks**: incorporate crop-specific international price indicators and input-cost indices (fertilizers, energy) to identify asymmetric pass-through effects, with particular attention to the post-2022 disruption of Black Sea cereal supply chains.
- **Climate covariates**: integrate biophysical stress indicators derived from Copernicus data to disentangle climate-effects from economic drivers of cereal retreat (and their interactions)