A census-based methodology for classifying agricultural holdings: the case of Italy

Roberto Gismondi[1]

Abstract

The seventh general agricultural census, conducted in 2020, showed a sharp decline in the number of small farms compared with 2010. Modernisation of Italian agriculture is an essential objective to ensure the survival of smaller agricultural holdings and the competitiveness of larger farms. Using census microdata, we propose a methodology to estimate the degree of modernisation of Italian agricultural holdings. The methodology is based on five census indicators that refer to specific strategic farm features rather than to structural characteristics of the farm or the farm manager. The number of modernity indicators possessed by each farm forms the basis of the proposed classification criterion. The results show that in 2020, 4.6% of holdings had at least four modernity indicators, while 57.3% had none or only one. Farms with young farm managers are much more modern than the general average.

Keywords: Classification, innovation, market orientation, modernisation, organic farming, standard output.

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1 Roberto Gismondi (gismondi@istat.it), Italian National Institute of Statistics - Istat.

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1. Introduction

An *agricultural holding*, or *farm*, is a single unit, both technically and economically, operating under a single management and undertaking agricultural economic activities within the economic territory of the European Union, either as its primary or secondary activity. The holding may also provide other supplementary (non-agricultural) products and services.

The national and international debate on the classification criteria for agricultural holdings is extensive and complex and has intensified, above all, due to the progressive transformation of agricultural units from predominantly family-run entities, primarily aimed at self-consumption, to real market enterprises (Rocchi and Stefani 2005).

Although within the EU, statistical institutes have been called upon for years to produce numerous statistical indicators relating to the structure and production of agricultural holdings, their integrated key of reading is not always easy. In other words, the description of the phenomena often prevails over the analysis of the processes of change underway. For example, it is not easy to answer what the level of modernisation of agricultural holdings could be and what differences can be found on a territorial basis.

The literature on the classification criteria for agricultural holdings is vast and heterogeneous.

The simplest classification criteria are essentially based on a single classificatory variable. For example, in Ministry of Agriculture, Food Sovereignty and Forests (MASAF 2009), the main typological classification of agricultural holdings - proposed by the European Union (EU) - is outlined, with adaptations to the Italian context, based on the technical-economic orientation (OTE)[2], which indicates the agronomic specialisation of the farm. Food and Agriculture Organization (FAO 2022) widely uses the concept of family farming, on the basis of which family farms are managed and operated by a family are predominantly reliant on family capital and labour, including both women's and men's. The percentage of the family workforce in the total employed workforce has to be at least 50%. A recent example of such

2 The OTE of an agricultural and livestock farm is determined by the percentage incidence of the standard production (defined in Section 2) of the farm's various production activities (crops and livestock) compared to its total standard production.

classification, based on census results, is provided in National Agriculture Statistical Service (USDA NASS 2021).

Most of the works, known in the literature, which propose multivariate quantitative analyses, are based on essentially descriptive analyses, which stratify agricultural holdings based on surface and/or livestock classes, administrative territorial divisions and other characteristics of the farm or of the farm manager (Lund 2005; López et al. 2008; Glogovetan et al. 2011; Dimitrova 2021).

The proposals suggested by Kostov and Mc Erlean (2006), Etumnu and Gray (2020), Hloušková and Lekešová (2020) are based on approaches oriented towards the use of more sophisticated classification tools, as cluster analysis or mixture of distributions techniques.

In the well-known work by Arzeni and Sotte (2014), which follows the previous work by Sotte (2006), a typological classification criterion is proposed which, based on the results of the sixth agricultural census of 2010, stratifies Italian agricultural holdings based on the joint analysis of different census variables. The indicators examined are: altimetric area, percentage of self-consumed production, days of work, use of passive contracting, age of the farm manager, presence of other gainful activities, share of direct payments from the EU on revenues, educational qualification of the farm manager, presence of quality production, OTE. This is one of the first works that proposes distinct typological and behavioural profiles of farms. It highlighted how the vast majority of Italian agricultural units are not "businesses" in the strict sense but pseudo-family entities of very limited economic size.

According to an approach closer to that proposed in this work, the methodology for classifying agricultural holdings should be more focused on answering a specific question. For instance, Rocchi et al. (2012) propose an empirical analysis aimed at verifying whether Italian farming households are actually poorer than other non-agricultural households. FAO (2019) defines the methodology to be used in order to identify small-scale farmers (see also Section 3.1), with the main goal of calculating the sustainable development goals 2.3.1 and 2.3.2 and of remarking different capabilities of small-scale and not-small-scale farmers in accessing the right quantity of safe food.

In this context, we asked the following question: is the information collected with the seventh general agricultural census (Section 2) able to evaluate the

degree of modernisation of Italian agricultural holdings? Being "modern", or not being so, implies the definition of modernity in the agricultural field, a concept that is obviously very complex and cannot be assessed only on the basis of what the census itself can capture (De Filippis and Henke 2014). The modernisation of the national agricultural system is an unavoidable process, which today can also be sped up on the basis of the National Recovery and Resilience Plan (PNRR), defined in 2021. As regards interventions relating to the world of agriculture, the Ministry of Agriculture, Food Sovereignty and Forests (MASAF)[3] is supporting measures relating to: development of logistics and improvement of energy efficiency for operators in the agri-food chain, innovation and mechanisation in agricultural holdings, improvements in the agro-irrigation system for better management of water resources.

The 2020 census questions were derived from the information needs that emerged at the EU level, connected to multiple aspects of business management that are not always correlated to the concept of modernisation. However, based on the census, it was possible to collect data relating to the five aspects (Section 3), which can determine, even if approximately, the level of modernity of farms. Broadly speaking, being modern means choosing a management model oriented to the principles of sustainable agriculture, integrated with the surrounding territorial and entrepreneurial context, that can guarantee a minimum level of economic well-being for those who manage the farm and offer additional services beyond the basic agricultural production.

The proposed classification methodology aims to address some limitations of pre-existing methodologies (Gismondi et al. 2023), which often overestimate the number of "small" farms. In this framework, the basic idea is to use indicators referable to specific strategic farm choices and features, and not just to the structural characteristics of the farm (production orientation, altitude, location) or of the farm manager (age, gender, educational qualification), which, however, can be used as post-stratification criteria. Even economic results of farms – which are not observed by agriculture censuses – in some way are consequences of modernity features of farms rather than causes.

Based on simple summary indicators (Section 4), Section 5 illustrates

3 https://www.politicheagricole.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/17911.

the main results. Further details are available post-stratifying the analyses according to particular characteristics of the farm or the farm manager (Section 6), or geographical location (Section 7). The comparison with the 2010 census highlights the growth in the degree of modernisation of Italian agricultural holding (Section 8), while in Section 9 a slightly modified methodology is proposed, which uses a greater number of indicators, which however are not available for previous years. Section 10 contains prospective conclusions. In the following, the terms "agricultural holding" and "farm" will be used with the same meaning.

2. The census of agriculture

The seventh general census of agriculture finds its regulatory basis, at the European level, in Regulation (EU) 2018/1091 of the European Parliament and of the Council of 18 July 2018 relating to integrated statistics on agricultural holdings (European Union Commission 2018). Therefore, the 2020 census was mandatory in each European Union country and fully consistent with recommendations from FAO (2017). The census had the main purpose of updating the now-outdated structural data collected with the 2010 census and enriching the available information assets. The most critical feature was the actual state of farm's activity, in a historical context characterised by the progressive concentration of farms and the consequent reduction in the number of very small agricultural units, whose production is often finalised to self-consumption only. The census referred to 1st October 2020 and included questions on the degree of modernisation and integration of farms with respect to the market. Among all we mention: generational turnover (see, for instance, Proctor and Lucchesi 2012), degree of educational training of the farm manager, relevance of non-EU workers, innovation and digitisation introduced on the farm, irrigation tools, the breakdown of farm revenues, and other gainful activities related to agriculture.

Data collection took place between January and July 2021. Approximately 83% of the units in the census list (which included about 1,7 million units) replied to the questionnaire, and approximately 75% declared to be active farms (the remaining 25% includes holdings that have closed down, were temporarily inactive, are off-target or could not be contacted). Istat is now finalising the data dissemination process. Some preliminary analyses related to the evolution process of Italian farms are available in Henke and Sardone (2022).

All data used for elaborations presented in the next Sections are definitive. The main differences with census data already released (Istat 2022a) are due to two reasons: 1) light revisions concerning a few microdata; 2) common lands have been excluded from elaborations, because some relevant census questions – as those concerned with innovation and multifunctionality – could not be addressed to common lands.

Available data include agricultural land and livestock, but do not include revenues. However, based on census data, Istat calculated the standard output for each active farm. The standard output of an agricultural product (crop or livestock), abbreviated as SO, is the average monetary value of the agricultural output at farm-gate price, in euros per hectare or per head of livestock. There is a regional SO coefficient for each product. The sum of all the SO per hectare of crop and per head of livestock in a farm is a measure of its overall economic size, expressed in euros. The standard output can be used to classify agricultural holdings by type of farming and by economic size.

The census counted 1,133,006 agricultural holdings, including common lands. As a matter of fact, the census outlined the sharp decrease in the number of agricultural holdings between 2010 and 2020 (-30.1%). In particular, farms with SO not exceeding 2,000 euros decreased by 52.4%.

3. The five dimensions

The degree of modernisation of agricultural holdings depends on multiple factors. In this context, five factors have been identified, probably not the only ones among all those that can be listed, but all measurable on the basis of the census survey conducted in Italy. The second and fifth factors were not mandatory based on the EU legislation.

Let's note that the indicators selected are focused on particular managerial strategies and do not concern structural features of the farm (as hectares of surface or geographical localisation) or the farm manager (as gender or age). Many works among those mentioned in Section 1 often mix together managerial strategies and structural features, while we prefer to separate them from a conceptual point of view.

3.1 Economic dimension

The economic dimension is a basic indicator for each agricultural holding (Davis et al. 2013). The basic rationale is that each farmer has the right to ensure food security for himself and his household. Even though the census of agriculture did not pick up any economic data (the IFS Regulation does not require any economic information on farms), census data have been used in order to calculate the above-mentioned standard output (SO).

The standard output takes into account land and livestock, but does not consider other sources of income, such as EU subsidies and other gainful activities. The SO (CREA 2023) is a proxy of the true (but unknown) economic revenues of farms.

The economic dimension of farmers is fundamental in the framework of the FAO Sustainable Development Goal 2.3: by 2030, double the agricultural productivity and revenues of small-scale food producers. Even though, according to FAO (2019; 2022), small-scale food producers should be identified according to the combination of the three dimensions given by agricultural land, livestock and net revenues, Gismondi (2023) showed that very similar results could be obtained using the SO in place of the three above-mentioned indicators.

Each modern farm must have a yearly SO larger than a given threshold. Of course, the threshold may be determined in different ways. In this context,

we followed the same approach used in the Farm Accountancy Data Network (FADN) context, better known as RICA in Italy. The yearly FADN survey – managed by CREA – does not represent the entire universe of farms active in a given territory, but only those that, due to their economic size, can be considered professional and market-oriented. In Italy, starting from 2014, the minimum threshold for inclusion in the FADN observation field is 8,000 euros in annual standard production value.

So, the first feature taken into account is expressed through the binary variable, equal to 1 (Yes) if the farm has SO≥8,000 euros and equal to 0 (No) otherwise.

3.2 Market orientation

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Farmers' market participation is a vital part of agricultural transformation aimed at economic growth and poverty reduction. Market-oriented farming can generate welfare gains through comparative advantages, benefits from economies of scale due to the emergence of large-scale production and technological advances (Zhang et al. 2021).

Market-orientation in agriculture can be defined as the degree to which resources (land, labour and capital) are allocated to the production process and the exchange or sale of agricultural products. Results from several analyses (for instance, Dos Santos and Ahmad 2020) indicate there are economies of scale associated with farms that sell through local and regional markets.

The last agriculture census asked farmers to indicate the share of the final production used for self-consumption. The farmer could select one of these answers:

1. all the value of the final production (100%);
2. over 50% of the final production value;
3. 50% or less of the final production value;
4. no self-consumption (0%).

Of course, the farms that have selected 2 or 3 cannot be attributed with certainty to the market or non-market category. However, type 3 farms can be considered predominantly market-oriented.

Therefore, the second feature taken into account is expressed through the binary variable, equal to 1 (Yes) if the farm answered 3 or 4 and equal to 0 (No) otherwise.

The methodological upgrade of the classification methodology proposed in Section 9 is based on additional information – external to the census – concerning the market orientation of farms.

3.3 Organic farming

Organic farming can be defined as a method of production that places the highest emphasis on environmental protection and, with regard to livestock production, on animal welfare considerations. It avoids or largely reduces the use of synthetic chemical inputs such as fertilisers, pesticides, additives and medicinal products. The production of genetically modified organisms and their use in animal feed are forbidden. It is a part of a sustainable farming system and a viable alternative to the more traditional approaches to agriculture.

A sustainable food system is at the heart of the European Green Deal. The European Commission has set a target of at least 25% of the EU's agricultural land under organic farming and a significant increase in organic aquaculture by 2030.

As a matter of fact, the area used for organic agricultural production in the EU continues to increase. It expanded from 14,7 million hectares in 2020 to 15,9 million ha in 2021, equivalent to 9.9% of the total utilised agricultural area (UAA) in the EU. In Italy (SINAB 2023), in 2022, organic agricultural areas were 2,35 million hectares, the 18.9% of the whole UAA. More details on data sources on organic farming in Italy are available in Gismondi (2020).

Even though organic farming is not the only dimension able to measure the attention to the environment on the part of farmers, this is an important variable measured by the 2020 census. It indicates the propensity of farmers to

radically change their production techniques in order to guarantee sustainable agriculture and preserve food safety for consumers.

The third indicator taken into account is expressed through the binary variable, equal to 1 (Yes) if the farm was organic (crops and/or livestock) and equal to 0 (No) otherwise.

3.4 Other gainful activities (OGAs), or differentiation

Gainful activities of the farm comprise all activities other than the basic agriculture production, having an economic impact on the farm. The census questionnaire took into account other gainful activities directly related to the holding, in which either the resources of the holding (area, buildings, machinery, etcetera) or its products are used in the activity. They include: provision of health, social or educational services; tourism (in particular, agro-tourism activities), accommodation and other leisure activities; handicraft; processing of farm products; production of renewable energy; wood processing (e.g. sawing); aquaculture; contractual work using production means of the holding (agricultural or non-agricultural work); forestry.

OGAs constitute a source of additional income compared to basic agricultural production. The diversification of sources of income is important, especially in the presence of economic shocks or other undesired events, such as climate change, natural disasters or wars (Van der Ploeg et al. 2009). Moreover, OGAs respond to new demand needs and allow the characteristics and traditions of the territory to be valorised.

According to the census results, in 2020 65,126 farms had at least one OGA, the 5.7% of the total number of farms. This percentage increased compared with 2010 (4.7%).

In this context, the fourth feature taken into account is expressed through the binary variable, equal to 1 (Yes) if the farm has at least one OGA and equal to 0 (No) otherwise.

The methodological upgrade of the classification methodology proposed in Section 9 is based on a more detailed use of information on OGAs collected by the census.

3.5 Innovation

Innovation in the agricultural and forestry sector is a broad subject, but in general terms, it can be described as a new idea that proves successful in practice. In other words, the introduction of something new (or renewed, a novel change) which turns into an economic, social or environmental benefit for rural practice. Innovation may be technological, non-technological, organisational, or social, and may be based on new or traditional practices. Moreover, the innovations era is often related to agricultural sustainability (Fontana and Fiorillo 2023).

Support for innovation has been a key priority for EU rural development for many years. The trend towards increasing support for innovation was further reinforced within the Common Agriculture Policy (CAP) 2023-2027. Introducing innovation is a cross-cutting objective that must be integrated into all priorities adopted by Member States in their rural development plans.

The latest agricultural census collected two types of innovation-related information. The first one consists of the answers to the question: "In the last three years (2018-2020), has the farm made investments aimed at innovating the technique or production management?"

The second information source derives from AGEA[4] , which collects data on EU subsidies related to innovation supplied to Italian farms. They concern the following rural development measures:

- quality regimes for agricultural and food products;
- investments in tangible assets;
- aid for starting up entrepreneurial activities for non-agricultural activities in rural areas;
- aid for starting up entrepreneurial activities for the development of small agricultural businesses;
- support for investments in the creation and development of non-agricultural activities;

4 Agenzia per le erogazioni in agricoltura. This body manages all payments from the EU to Italian farmers. The Regulation (EU) 2018/1091 asked the national statistical institutes to link the census with the AGEA database at the microdata level.

- agro-climate-environmental payments;
- biological agriculture;
- Natura 2000 payments and payments related to the Water Framework Directive;
- animal welfare.

The fifth feature taken into account is expressed through a binary variable equal to 1 (Yes) if the farm answered "Yes" to the question on innovation and/or if the farm received at least one of the EU subsidies listed above, and to 0 (No) otherwise.

4. Analysis and synthetic indicators

The basic idea consists of classifying agricultural holdings based on the number of dimensions they possess, from 0 to 5. Obviously, in this way, two farms can have the same "score" even if they possess modernisation features that are partially or totally different from each other.

For each reference domain, n is the number of agricultural holdings, while n_i is the number of agricultural holdings which have i modernisation features – or i "Yes", for i=0,1,2,3,4,5. For instance, in 2020, n_1 = 340,744 was the number of farms with one "Yes" only (Table 5.2). Therefore:

$$n = \sum_{i=1}^{5} n_i . \tag{4.1}$$

Moreover, we define:

Number of *high level* agricultural holdings = $n_4 + n_5$ (4.2)

Number of *medium level* agricultural holdings = $n_2 + n_3$ (4.3)

Number of *risk level* agricultural holdings = $n_0 + n_1$. (4.4)

Two important and simple relative indicators are given by:

Share of agricultural holdings at risk = $(n_0 + n_1)/n \cdot 100$ (4.5)

Risk ratio = $(n_0 + n_1)/(n_4 + n_5)$. (4.6)

The risk ratio indicates the number of farms at risk for each "high level" farm. Of course, this indicator should be as low as possible, and it cannot be calculated in case $n_4 + n_5 = 0$. Moreover, we can define:

Number of farms with the particular feature $j = m_j$, $\quad j = 1,2,3,4,5.$ (4.7)

Among the n_1 agricultural holdings which have one modernisation feature only, m_{j*} is the number of farms which have *exclusively* that particular feature *j*. Let's note that while label *i* indicates the number of "Yes", label *j* indicates the *j-th* feature, where *j*=1: economic dimension, *j*=2: market orientation, *j*=3: organic farming, *j*=4: other gainful activities, *j*=5: innovation. For instance, in 2020, m_1=520,425 was the number of farms with SO≥8,000 euros and m_{1*}=66,496 was the number of farms with SO≥8,000 euros and without any other "Yes" (Table 5.3). We have:

$$n_1 = \sum_{j=1}^{5} m_{j*}. \quad (4.8)$$

Therefore, we can also define:

Exclusive effect of the *j-th* feature = $m_{j*}/\, m_j \cdot 100$. (4.9)

For instance, in 2020, the economic dimension exclusive effect was 12.8% (66,496/520,425·100). The larger the exclusive effect *j*, the larger is the relative importance of the *j-th* feature for the overall modernisation framework. In case the five exclusive effects are equal, their standard deviation would be zero. On the other hand, large standard deviations will indicate heterogeneous exclusive effects: the various features do not have the same relative importance as regards the overall modernisation picture of the Italian agriculture.

5. The main results

Using the census data referring to the single farms, Table 5.1 was populated, which counts the number of agricultural holdings that had, in 2020, a certain number of characteristics connected to the degree of modernisation, varying between 0 and 5.

There are 32 different combinations of binary variables equal to one if the farm meets that requirement ("Yes") and equal to zero otherwise ("No"). Given that the final score for each farm is obtained by simply adding the number of "Yes", the procedure implicitly attributes the same weight to each of the five characteristics examined.

The significantly more frequent combinations, which overall concern more than seven out of ten farms, are:

- farms without any modern characteristics (n_0=306,675; 27.1% of the total);
- among farms with only one modern characteristic, the 254,610 market-oriented (22.5%);
- among farms with two modern characteristics, the 247,688 market-oriented and with standard production exceeding 8,000 euros (21.9%).

On the other hand, farms with the three characteristics: organic farming, OGAs and innovation, but with standard production not exceeding 8,000 euros and not (yet) market-oriented, are very rare (only 148).

Table 5.1 - Farms with certain modernisation features (32 combinations). Year 2020

SO > 8,000 euro	Market orientation	Organic farming	With OGAs	Innovation	Number of "Yes"	Number of farms	Number of farms (%)
Yes	Yes	Yes	Yes	Yes	5	6,049	0.5
Yes	Yes	Yes	Yes		4	2,150	0.2
Yes	Yes	Yes		Yes	4	23,880	2.1
Yes	Yes		Yes	Yes	4	17,574	1.6
Yes		Yes	Yes	Yes	4	2,360	0.2
	Yes	Yes	Yes	Yes	4	196	0.0
Yes	Yes	Yes			3	16,778	1.5
Yes	Yes		Yes		3	16,495	1.5
Yes	Yes			Yes	3	86,961	7.7
Yes		Yes	Yes		3	907	0.1
Yes		Yes		Yes	3	6,500	0.6
Yes			Yes	Yes	3	4,333	0.4
	Yes	Yes	Yes		3	243	0.0
	Yes	Yes		Yes	3	1,414	0.1
	Yes		Yes	Yes	3	1,432	0.1
		Yes	Yes	Yes	3	148	0.0
Yes	Yes				2	247,688	21.9
Yes		Yes			2	5,863	0.5
Yes			Yes		2	4,882	0.4
Yes				Yes	2	11,509	1.0
	Yes	Yes			2	5,154	0.5
	Yes		Yes		2	4,499	0.4
	Yes			Yes	2	14,059	1.2
		Yes	Yes		2	182	0.0
		Yes		Yes	2	1,074	0.1
			Yes	Yes	2	764	0.1
Yes					1	66,496	5.9
	Yes				1	254,610	22.5
		Yes			1	6,154	0.5
			Yes		1	2,910	0.3
				Yes	1	10,574	0.9
					0	306,675	27.1

Source: Istat, Census of Agriculture

A more concise key of reading is proposed in Table 5.2, which summarises the n_i frequencies defined in Section 4 and proposes a simple reclassification of farms based on the number of modernity characteristics they possess. This is how we pass from high level farms – which have 5 “Yes” (optimal) or 4 “Yes” (almost optimal) – to those medium level – which have 3 “Yes” (medium-high) or 2 “Yes” (medium-low) – and, finally, to the risk level farms

– with 1 “Yes” (almost critical) or 0 “Yes” (critical). In 2020, compared with the 4.6% of high-level farms, 57.3% were found to be at risk level, with the remaining 38.1% medium level.

Table 5.2 - Farms by number of “Yes” (from 5 to 0). Year 2020

Number of "Yes"	Classification	Number of farms	Number of farms (%)
TOTAL	**Whole population**	**1,130,513**	**100.0**
5	Optimal	6,049	0.5
4	Almost optimal	46,160	4.1
3	Medium-high	135,211	12.0
2	Medium-low	295,674	26.2
1	Almost critical	340,744	30.1
0	Critical	306,675	27.1
4+5	High level	52,209	4.6
2+3	Medium level	430,885	38.1
0+1	Risk level	647,419	57.3

Source: Istat, Census of Agriculture

Table 5.3 summarises the m_j frequencies defined in Section 4, which indicate how many farms have or do not have a certain feature, as well as the frequencies m_{j*}, which indicate how many farms present only that specific feature. As was predictable, m_1=520,425 and m_2=699,182 are the predominant characteristics, but while m_{1*}=66,496, m_{2*}=254,610, therefore the market orientation characteristic is much more exclusive than economic size and other characteristics in general, so much so that the exclusive effect reaches the highest level, equal to 36.4%. Organic farming (m_3=79,052) and differentiation (m_4=65,124) appear not yet to be very widespread, while innovation characterises as many as 16.7% of farms (m_5=188,827).

Table 5.3 - Farms with certain modernisation features.Year 2020 (a) (b) (c)

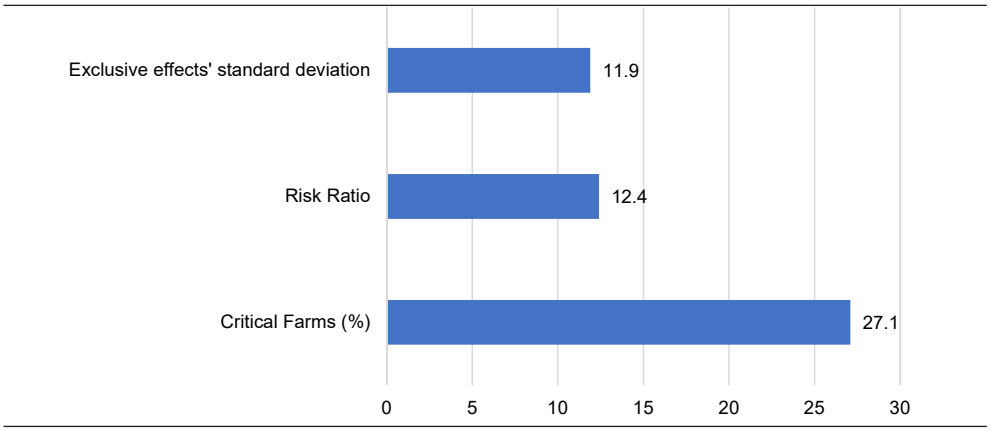
FEATURE	Number of “Yes”	Number of “Yes” (%)	Exclusive “Yes”	Exclusive effect (Ee)
Economic size	520,425	46.0	66,496	12.8
Market orientation	699,182	61.8	254,610	36.4
Organic farming	79,052	7.0	6,154	7.8
Differentiation (OGAs)	65,124	5.8	2,910	4.5
Innovation	188,827	16.7	10,574	5.6

Source: Istat, Census of Agriculture
(a) Number of “Yes”: % ratio between the number of “Yes” and the whole population (1,130,513).
(b) Exclusive “Yes”: number of farms with “Yes” for that particular dimension only.
(c) Exclusive effect: % ratio between exclusive “Yes” and the number of “Yes”.

A very short resume of the main results is provided in Figure 5.1, which shows three main figures:

- the relative share of critical farms (27.1%);
- the risk ratio: for each high-level farm, there are 12.4% farms at risk;
- the standard deviation of exclusive effects: the level 11.9 means that the five modernisation features do not have the same importance, because on average they tend to be exclusive with very different relative frequencies.

Figure 5.1 - Three synthetic indicators. Year 2020 (percentage values)



Source: Istat, Census of Agriculture

The degree of modernity of agricultural holdings is strongly correlated with their dimensional characteristics (Table 5.4). On the one hand, critical farms (with no characteristics of modernity) present on average 1.7 hectares of UAA, 0.1 adult livestock units, 0.17 full-time equivalents, and a relatively low share of non-family workers (8.6%). By contrast, optimal farms have 47.6 hectares, 28 adult livestock units, 3.57 full-time equivalents, and 62.6% of non-family workers.

Table 5.4 - Standard output, utilised agricultural area, adult livestock units and full-time equivalents. Year 2020 (average per farm and percent indicators by number of “Yes” (from 5 to 0))

Number of "Yes"	Standard output (a)	Average per farm: Utilised agricultural area (b)	Average per farm: Adult livestock units (c)	Average per farm: Full-time equivalents	Standard output (% share)	Weight of non-family workers (%)
TOTAL	**49,740**	**10.6**	**8.3**	**0.67**	**100.0**	**30.3**
5	233,385	47.6	28.0	3.57	2.5	62.6
4	208,922	37.8	38.5	2.28	17.2	46.0
3	161,168	28.2	31.3	1.68	38.8	35.7
2	66,266	14.0	9.6	0.87	34.8	26.4
1	8,719	4.4	0.9	0.28	5.3	15.1
0	2,673	1.7	0.1	0.17	1.5	8.6

Source: Istat, Census of Agriculture
(a) Euros.
(b) Hectares.
(c) An indicator that summarises in a single number the different varieties of animal species present on the farm.

6. Post-stratification of results

Based on the data collected with the census, it was possible to verify which exogenous factors most influence the presence of farms positioned in the high-level and risk-level clusters. These are post-stratification factors of agricultural holdings belonging to four types: farm characteristics, manager characteristics, kind of production (crops/livestock) and territory (plains/hills/mountain and disadvantaged of non-disadvantaged municipality). Information on disadvantaged municipalities derives from the same data used by Istat (2022b). Their use was made possible through linkage to the census database at the municipal level.

Since the indicator of greatest interest concerns the percentage of farms at risk, in order to evaluate the effect of each post-stratification factor, the factor ratio can be calculated, given by the ratio between the percentage of farms at risk in the particular sub-population identified by post-stratification and the percentage of farms at risk for Italy as a whole (equal to 57.3%). For instance, in the sub-population of 207,085 new farms, the percentage of farms at risk is 50.7%, so the factor ratio is: 50.7/57.3=0.852. In other words, if the farm is new, the probability that it is at risk is on average 14.8% lower than the general average. All results have been summarised in Table 6.1 and in Figure 6.1.

Table 6.1 - Main results using some post-stratification factors. Year 2020

FACTOR	Number of farms	High level	Medium level	Risk level	Risk ratio	Ee Standard deviation (a)
OVERALL	**1,130,513**	**4.6**	**38.1**	**57.3**	**12.4**	**11.9**
Farm characteristics						
New farm	207,085	6.0	43.3	50.7	8.4	9.4
Not a new farm	923,428	4.0	36.5	59.5	14.7	12.5
Management < 3 years	55,124	5.1	47.4	47.6	9.4	9.7
Management ≥ 3 years	1,075,389	4.4	37.3	58.4	13.3	12.0
Family farm	1,114,117	4.4	37.8	57.8	13.1	11.9
Not a family farm	16,396	19.0	62.6	18.4	1.0	6.8
Manager characteristics						
Young (< 40 years)	94,870	12.1	57.7	30.2	2.5	5.4
Not young	1,035,643	3.9	36.3	59.8	15.2	12.5
Male	774,751	5.2	41.2	53.6	10.4	10.6
Female	355,762	3.4	31.4	65.2	19.1	14.8
Basic education	741,704	2.9	35.5	61.5	20.9	13.1
Diploma/degree	388,809	7.8	43.0	49.2	6.3	9.3
Kind of production						
Crops and livestock	186,313	9.7	57.4	32.8	3.4	4.7
Only cultivations	933,405	3.6	34.3	62.0	17.1	13.6
Only livestock	10,795	1.8	30.6	67.6	37.4	6.7
Territory						
Plains	368,957	3.7	43.1	53.2	14.4	12.6
Hills	566,831	4.6	35.3	60.2	13.2	11.9
Mountain	194,725	6.6	36.9	56.6	8.6	10.7
Disadvantaged	260,408	3.1	29.9	67.0	21.3	14.0
Not disadvantaged	870,105	5.1	40.6	54.4	10.7	11.3

Source: Istat, Census of Agriculture
(a) Ee: Exclusive effect.

It is clear that all the factors examined identify behaviours that are different from the general average, confirming how the world of Italian agricultural holdings is extremely heterogeneous internally. However, it is equally clear that some factors discriminate between different behaviours more than others. In particular, the most significant factors are:

- not family farm: the percentage of farms at risk is only 1.0%;
- young managers: the percentage of farms at risk is 2.5%;

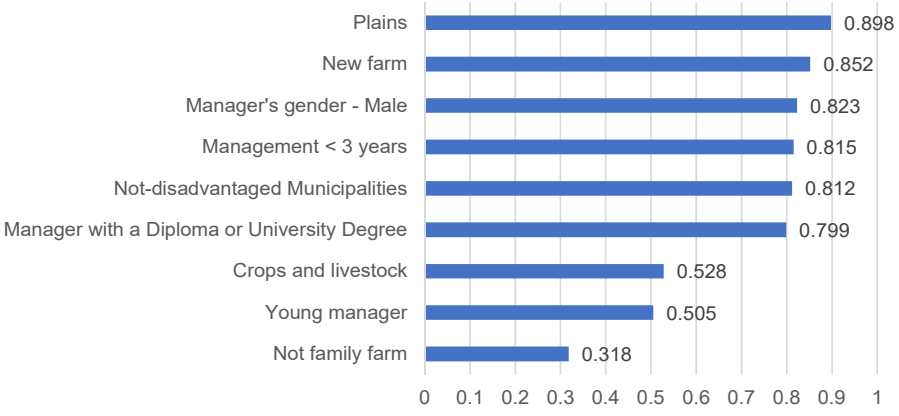
- farms with both crops and livestock: the percentage of farms at risk is 3.4%;
- managers with a diploma or degree: the percentage of farms at risk is 6.3%.

Other factors – although with less intensity than in previous cases – allow us to identify sub-populations of agricultural holdings less at risk than the general average:

- new farms: the percentage of farms at risk is 8.4%;
- farms located in mountain areas: the percentage of farms at risk is 8.6%;
- farms managed by less than 3 years by the farm manager: the percentage of farms at risk is 9.4%.

The lower risk propensity of mountain farms is surprising, at least in part (for those located in flat areas, the share at risk is 14.4%), perhaps due to the fact that the lower accessibility of mountain sites may lead to the need to organise one's own production according to schemes that are basically modern and integrated with the surrounding area. On the other hand, it is undoubtedly comforting to note that the manager's gender does not have much effect on risk propensity, although for female-run holdings this propensity is higher than for male-run ones (19.1% versus 10.4%). Factor ratios in Figure 6.1 summarise what has emerged and are ordered according to an increasing scale, so the first factors are the most discriminating ones.

Figure 6.1 - Factor ratios by post-stratification factor. Year 2020



Source: Istat, Census of Agriculture

7. Geographical details

The geographical breakdown represents one of the most important post-stratification criteria. The persistence of geographical gaps in the degree of evolution of Italian agriculture has already emerged from the first census data released by Istat (2022a). If we focus on the level of modernisation, a somewhat dramatic picture emerges (Table 7.1).

Table 7.1 - Main results by Regions and geographical areas. Year 2020

REGION	Number of farms	High level	Medium level	Risk level	Risk ratio	Ee Standard deviation (a)
Piemonte	50,469	7.2	62.2	30.6	4.3	6.9
Valle d'Aosta/*Vallée d'Aoste*	2,433	6.9	48.1	45.0	6.5	9.9
Lombardia	43,409	7.1	58.2	34.7	4.9	7.0
Liguria	12,416	4.5	41.0	54.5	12.1	6.7
Bolzano/*Bozen*	19,361	20.9	57.2	21.9	1.0	3.7
Trento	13,902	8.6	56.4	35.0	4.1	8.7
Veneto	82,327	4.1	49.9	46.0	11.2	14.7
Friuli-Venezia Giulia	16,217	6.5	45.4	48.1	7.4	14.2
Emilia-Romagna	52,682	10.2	61.1	28.7	2.8	7.2
Toscana	52,3	7.1	36.9	56.1	7.9	8.2
Umbria	27,438	4.9	28.4	66.8	13.7	13.3
Marche	33,669	7.5	33.5	59.0	7.8	14.9
Lazio	62,68	4.6	34.9	60.5	13.0	10.6
Abruzzo	44,293	3.3	31.6	65.1	20.0	11.3
Molise	18,664	1.8	29.6	68.6	38.8	14.3
Campania	79,729	3.1	34.5	62.5	20.2	10.9
Puglia	194,458	2.0	27.3	70.7	35.9	16.1
Basilicata	35,054	2.5	30.8	66.8	26.9	14.1
Calabria	98,278	4.0	21.6	74.4	18.6	14.1
Sicilia	143,72	3.1	36.0	60.9	19.5	14.0
Sardegna	47,014	4.1	51.8	44.1	10.8	6.3
ITALY	**1,130,513**	**4.6**	**38.1**	**57.3**	**12.4**	**11.9**
North-West	108,727	6.8	57.8	35.3	5.5	7.0
North-East	184,489	8.1	54.0	37.9	6.9	10.9
Centre	176,087	5.9	34.2	59.9	10.6	11.1
South	470,476	2.7	28.1	69.2	27.6	14.2
Islands	190,734	3.4	39.9	56.7	17.4	12.1

Source: Istat, Census of Agriculture
(a) Ee: Exclusive effect.

In 2020, in the North-West area, the percentage of farms at risk was only 35.3%, in the South, this share was almost double: 69.2%. The incidence of holdings at risk is much higher than the national average, also in the Centre (59.9%) and in the Islands (56.7%), while in the North-East it is slightly higher than the North-West (37.9%).

Although the North-East area has the highest share of high-level farms, the North-West is the area with the lowest risk ratio (5.5). On the other hand, the risk ratio reaches an extremely high level in the South (27.6), an area in which there is also the lowest relative share of high-level farms (2.7%).

The extreme territorial heterogeneity of the degree of modernisation is further highlighted by regional analyses. In fact, we move from the autonomous province of Bolzano/*Bozen*, with a risk ratio of 1 (only one farm at risk for each high-level farm), to Molise, with a risk ratio of 38.8; the only non-northern regions with a risk ratio lower than the national average are Toscana (7.9), Marche (7.8) and Sardegna (10.8); on the other hand, all the northern regions have a risk ratio lower than the national average.

In the South, modernisation is hindered by the prevalent presence of very small, not very market-oriented agricultural holdings, with few connected and not very innovative activities. In fact (Table 7.2), in the South the percentages of farms, out of the total number of active holdings, with the previous characteristics are respectively equal to 36.2%, 51.1%, 2.4%, and 10.3%, compared to national averages equal to 46.0%, 61.8%, 5.8%, and 16.7%. On the other hand, organic farming is quite widespread in the South, given that the percentage of organic farms is 6.5%, slightly lower than the national average (7.0%) and higher than the share in the North-West (5.2%).

Table 7.2 - Farms with certain modernisation features by geographical areas. Year 2020

AREAS	Number of farms	Of which, with certain modernisation features (% on total number of farms)				
		Economic size	Market orientation	Organic farming	OGAs	Innovation
ITALY	**1,130,513**	**46.0**	**61.8**	**7.0**	**5.8**	**16.7**
North-West	108,727	65.4	78.0	5.2	12.5	26.6
North-East	184,489	61.0	84.8	7.2	10.5	27.6
Centre	176,087	43.7	55.2	9.0	8.7	15.9
South	470,476	36.2	51.1	6.5	2.4	10.3
Islands	190,734	46.9	63.1	7.1	3.0	17.0

Source: Istat, Census of Agriculture

It should also be noted that the average profile of the two largest islands (Sicilia and Sardegna) is quite different from that of the southern regions: although economically small holdings prevail, the agricultural holdings of the Islands are characterised by having market orientation and innovation shares higher than the national average.

The analysis at the municipal scale (Table 7.3) confirms the evidence that emerged at the regional scale. There are 114 municipalities without critical farms (1.4% of municipalities). Overall, 100 municipalities without critical farms are located in the North-West.

In Italy as a whole, 61.0% of the municipalities (4,814 municipalities) have relative shares of risk level farms not exceeding 57.3%, which, as seen in Tables 5.2 and 6.1, is the national average percentage of risk level farms. Consequently, in 3,072 municipalities (39.0%), the relative share of risk level farms exceeds 57.3%. This share reaches 71.5% of the municipalities in the South.

Table 7.3 - Municipalities with certain shares of farms at risk on total farms by geographical areas. Year 2020

AREAS	Number of municipalities	Of which, with a certain share of "Risk level" farms on total farms					
		Percentages on total			Number of critical farms		
		0%	≤57.3%	>57.3%	0%	≤57.3%	>57.3%
ITALY	**7,886**	**1.4**	**61.0**	**39.0**	**114**	**4,814**	**3,072**
North-West	2,982	3.4	79.9	20.1	100	2,382	600
North-East	1,385	0.4	80.8	19.2	6	1,119	266
Centre	971	0.2	39.9	60.1	2	387	584
South	1,781	0.3	28.5	71.5	6	507	1,274
Islands	767	0.0	54.6	45.4	0	419	348

Source: Istat, Census of Agriculture

8. Comparison with 2010

Although agricultural censuses are traditionally aimed at collecting similar and therefore comparable data over time, even if every ten years, each census includes partly or entirely new questions. Therefore, the 2020 census collected data that were not available with the 2010 census. For example, these are the responses provided by agricultural holdings on innovation, which, as described in Section 3.5, represents one of the five dimensions on which the level of modernisation of Italian agricultural holdings in 2020 has been estimated.

Furthermore, the observation fields of the 2020 and 2010 censuses are not exactly the same: while in 2020 fixed minimum size thresholds were used[5], in 2010 these thresholds varied by region. On the other hand, both censuses examined only kitchen gardens managed by farms that also owned other types of crops in addition to kitchen gardens (so both censuses did not include agricultural units that only managed kitchen gardens).

Overall, the 2020 data are substantially comparable with those of 2010. However, given that data on innovation are not available for 2010, in order to be able to measure the changes in the degree of modernisation of Italian farms that occurred over the decade, we opted for the application of a classification methodology slightly different from that described in Sections 3 and 4. In practice, for both 2020 and 2010, the methodology applied differs from that seen so far because the "innovation" dimension has been excluded, starting from the availability of data for each individual farm. The remaining four dimensions (economic size, market orientation, organic farming, and other gainful activities) are measurable for both 2020 and 2010.

The main consequence is that, to allow comparison between 2020 and 2010, the classification of holdings has been as follows:

- high level farms: have 4 "Yes" (optimal) or 3 "Yes" (almost optimal);
- medium level farms: have 2 "Yes";
- risk level farms: have 1 "Yes" (almost critical) or 0 "Yes" (critical).

5 The 2020 census observed agricultural and livestock units with at least: 0.2 hectares of used agricultural surface; or 0.2 hectares planted with vines, greenhouses or mushrooms; or, one adult bovine unit.

Of course, the results for 2020 reported in Table 8.1 and Figure 8.1 are slightly different from those already seen in the previous Sections because they are based on 4 dimensions rather than 5.

With regard to 2020, the exclusion of the innovation dimension led to the growth of the share of both high-level farms and risk-level farms: these shares are equal to 7.7% and 59.7% respectively (Table 8.1), while including innovation in the analysis, the shares were equal to 4.6% and 57.3% (Table 5.2).

These growths derive above all from the fact that in the reduced classification proposed in this Section, the medium level holdings are exclusively those with exactly 2 "Yes", and which therefore decrease compared to the standard classification analysed in Section 5 (in fact, they go from 38.1% to 32.6%).

However, it is worthwhile to remark that the reduced classification has the sole purpose of allowing comparison with 2010. The most important results tell us that, between 2010 and 2020:

- the percentage of high-level farms grows from 5.1% to 7.7%;
- the percentage of risk-level farms drops from 65.9% to 59.7%;
- in particular, the percentage of critical farms (zero "Yes") drops from 34.6% to 28.1%;
- the risk ratio (Figure 8.1) drops from 12.8 to 7.8;
- the exclusive effect standard deviation drops from 14.8 to 12.8; so, over the decade, the degree of relative importance of each of the four dimensions examined tends to become more uniform.

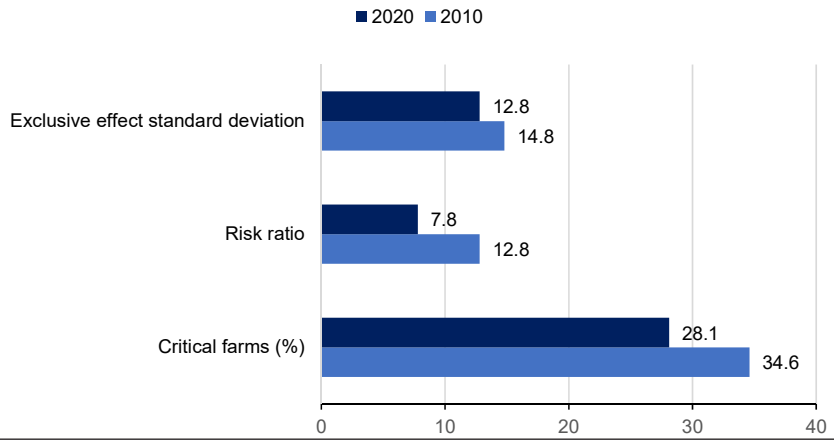
Overall, the results confirm that Italian agriculture is on the path of modernisation, emerging from the essentially rural context that characterised it at least until the 1990s. However, modernisation levels still depend too much on farms' size and location, according to trends that would be useful to monitor at time intervals closer than a decade.

Table 8.1 - Farms by number of "Yes" (from 4 to 0). Years 2010 and 2020

Number of "Yes"	Classification	Number of farms	Number of farms (%)
Census 2020			
TOTAL	**Whole population**	**1,130,513**	**100.0**
4	Optimal	8,199	0.7
3	Almost optimal	78,433	6.9
2	Medium	369,056	32.6
1	Almost critical	357,576	31.6
0	Critical	317,249	28.1
3+4	High level	86,632	7.7
2	Medium level	369,056	32.6
0+1	Risk level	674,825	59.7
Census 2010			
TOTAL	**Whole population**	**1,620,884**	**100.0**
4	Optimal	6,580	0.4
3	Almost optimal	76,783	4.7
2	Medium	470,119	29.0
1	Almost critical	507,201	31.3
0	Critical	560,201	34.6
3+4	High level	83,363	5.1
2	Medium level	470,119	29.0
0+1	Risk level	1,067,402	65.9

Source: Istat, Census of Agriculture

Figure 8.1 - Three synthetic indicators. Comparison between 2020 and 2010



Source: Istat, Census of Agriculture

9. Methodological upgrade

The methodology proposed in Sections 3 and 4 – the standard methodology – can be further upgraded by introducing changes to the calculation criteria for three of the five indicators of modernity. In fact, again, based on data from the 2020 census, it is possible to evaluate the degree of innovativeness of agricultural holdings also based on specific types of other gainful activities carried out by farms. Furthermore, as seen in Section 3.1, the economic dimension was evaluated using the threshold of 8,000 euros of standard production: this threshold is inevitably subjective – even if it coincides with the threshold that determines the field of observation of the FADN survey – and could be determined according to an alternative logic. Finally, the market orientation was based exclusively on the answers provided by the farms regarding the percentage of production intended for self-consumption, even though it is possible to use a source other than the census to measure this propensity. In order to evaluate how much - and in what direction - the aforementioned methodological changes could modify the results described so far, the entire classification procedure was modified according to the criteria described below.

- Innovation. This feature can be based not only on the question of innovation and the type of subsidies received from the EU, but also on some specific OGAs carried out by the farms. Reference is made to the production of energy from renewable sources (wind, biomass, solar, water, other). Therefore, the innovation dimension can be expressed through the binary variable, equal to 1 (Yes) if the farm answered "Yes" to the question on innovation, and/or if the farm received at least one among the EU subsidies listed above, and/or if the farm produces any kind of renewable energy, and to 0 (No) otherwise. As a consequence, the number of innovative farms should be greather than under the standard methodology.
- Economic dimension. This feature can be expressed as a binary variable equal to 1 (Yes) if the farm has $SO \geq T$ euro and 0 (No) otherwise. In the previous Sections, we put T=8,000, while the alternative methodology is founded on the concept of poverty threshold and on the old question about poverty and richness of rural households (Salvioni 2005). This indicator is updated by Istat annually and represents the monetary value, at current prices, of the basket of goods and services considered

essential for each family to avoid serious forms of social exclusion in the reference context (Istat 2023). In this framework, the threshold *T* depended on the territorial division in which the agricultural holding was located and was based on the standard household composition of 3 adults. On average, the poverty threshold was found to be *T*=15,990 euros, almost double compared to *T*=8,000 euros.

- Market orientation. In addition to the census, Istat has another source of information for evaluating the market propensity of Italian agricultural holdings. The ASIA Agriculture Register[6] includes agricultural farms which, based on available administrative sources, are active on the market (Istat 2022c). Therefore, within the alternative methodology, this feature is expressed through the binary variable, equal to 1 if the farm answered 3 or 4 to the census question concerning self-consumption, and/or if the farm is included in the ASIA Agriculture Register, and equal to 0 otherwise.

We note that while the changes introduced regarding innovation and market orientation contribute to increasing the share of farms with modern characteristics, the change relating to the economic dimension works in the opposite direction, as it introduces a higher threshold than that of the standard methodology.

Taking these changes into account, the rest of the methodology remains identical to that described above. The results are summarised in Table 9.1 and in Figure 9.1.

Table 9.1 - Farms by number of "Yes" (from 5 to 0). Year 2020

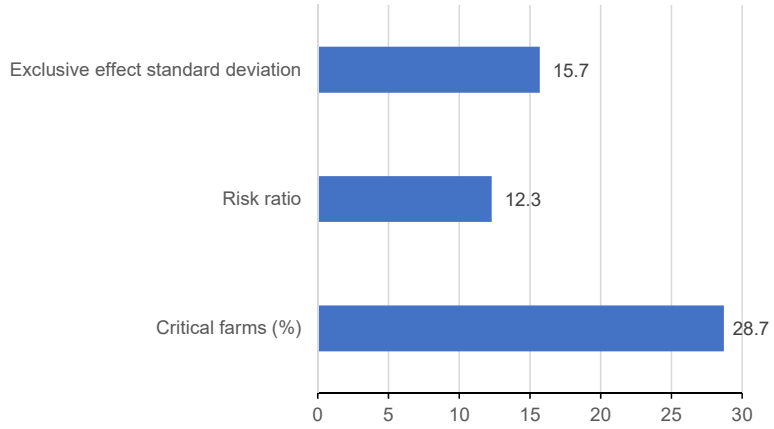
Number of "Yes"	Classification	Number of farms	Number of farms (%)
TOTAL	**Whole population**	**1,130,513**	**100.0**
5	Optimal	11,339	1.0
4	Almost optimal	46,254	4.1
3	Medium-high	124,974	11.1
2	Medium-low	241,612	21.4
1	Almost critical	381,665	33.8
0	Critical	324,669	28.7
4+5	High level	57,593	5.1
2+3	Medium level	366,586	32.4
0+1	Risk level	706,334	62.5

Source: Istat, Census of Agriculture; ASIA Agriculture Register

6 See https://www.istat.it/tavole-di-dati/le-imprese-agricole-in-italia-nel-registro-asia-anno-2020/.

Overall, the alternative methodology leads to results quite similar to those obtained with the standard methodology (Table 5.2). While with the alternative methodology the percentages of high-level, medium-level and risk-level holdings are respectively 5.1%, 32.4%, and 62.5%, these percentages, with the standard procedure, are 4.6%, 38.1%, and 57.3%. While, according to the alternative procedure, the relative weight of farms at risk is higher than in the standard procedure, the risk ratio remains substantially unchanged (12.3% compared with 12.4%).

Figure 9.1 - Three synthetic indicators. Alternative methodology. Year 2020



Source: Istat, Census of Agriculture; ASIA Agriculture Register

In conclusion, it can be stated that the standard methodology defined in Section 3 remains the reference one, even for further applications, and that possible methodological improvements may derive above all from the evaluation of additional dimensions beyond the five examined so far, which cannot be evaluated on the basis of the census data.

10. Conclusions and further steps

The seventh census of agriculture was a huge effort made by all National Statistical Institutes of the European Union. Although most of the data collected through the census were intended to satisfy the requests of the DG-Agri (EU) and Eurostat, the questionnaire used in Italy included additional questions (such as those on self-consumption and innovation).

Using microdata available for each farm, we proposed a methodology to estimate the degree of modernisation of Italian agricultural holdings. The methodology is based on five census indicators concerning specific strategic farm features: economic size, market orientation, recourse to organic farming, other gainful activities beyond the basic agriculture production, and innovation. The number of modernity indicators each farm possesses is the basis for the classification. The main results showed that, in 2020, 4.6% of farms had at least four modernity indicators, while 57.3% had none or only one. Moreover, 1) age of the farm manager, education level and legal form are the most important parameters which determine the degree of modernisation of farms; 2) clear geographical heterogeneities persist in the level of modernisation of holdings, given that all the regions of the South are significantly behind the Centre-North; 3) compared to 2010, the degree of modernisation of agricultural holdings is growing.

One of the limitations of the proposed methodology derives from the fact that each of the five dimensions has the same weight in the synthesis procedure, which allows the classification of agricultural holdings. On the other hand, this aspect is partly only apparent, because based on the analysis of the exclusive effect standard deviations, it follows that market orientation and, to a lesser extent, economic size are much more relevant indicators than the others. That is because often the holdings that present positive performances for these dimensions present positive performances for at least one of the remaining three dimensions.

Furthermore, the use of indicators that are at least in part conceptually interconnected could imply the risk of multicollinearity between the indicators, which, however, is contradicted by the empirical evidence, given that the average linear correlation between the five dimensions was found to be equal to only 0.193.

A further constraint is represented by the impossibility of evaluating other aspects related to the level of modernisation of agricultural holdings, which are not available on the basis of the census. For example, the use of precision agriculture, the level of training of the workforce other than the farm manager, and other environmental protection measures in addition to organic agriculture. For this reason, it is extremely important to increase collaboration among institutions that, in various ways and for different purposes, manage information bases, including administrative ones, relating to agricultural holdings, in order to cross-reference indicators with high informative power at the single-unit level .

An intrinsic limit of the classificatory analysis, as the one proposed, derives, in reality, from the intrinsic structure of Italian agriculture. Some of the dimensions examined, such as organic farming and the presence of other gainful activities, remain infrequent among Italian agricultural holdings, so the relative impact of these indicators on the classification mechanism is limited.

From this perspective, it would be extremely important to replicate the calculations according over time intervals of less than ten years. The convergence process that should reduce the old North-South gap is certainly underway, but it is necessary to monitor its speed and territorial capillarity. We must keep in mind that an agricultural system still so divided into two large blocks, the predominantly modern market holdings and those small and oriented towards self-consumption, is not sustainable anymore (Andreoli and Tellarini 2000; Dos Santos et al. 2020).

No one behind must be the objective to be pursued for Italian agriculture; in the future, it will be extremely important to have data and tools capable of evaluating where we are on the realignment path. From this perspective, the results of the Integrated Farm Statistics 2023 survey, which Istat should disseminate by the end of 2024, will be very useful, because although on a sample and not census basis, they will update the information collected by the 2020 census.

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