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Editorial

With the seventy-seventh volume, the Rivista di Economia Agraria, now REA – Italian Review of Agricultural Economics, begins a new season of its illustrious history. Since its foundation, the idea of an enlightened assembly of fathers of the economics discipline, the REA has been a point of reference for researchers, political decision-makers and for those who care about Italian agriculture and rural life.

In these seventy-seven years, the Journal has created and explored new horizons of knowledge and has proposed itself as an ideal ground for a fruitful and loyal scientific comparison. In this long period, the interests and ambits of reference of agricultural economics have altered significantly: the frontiers of analysis have extended from the farm to the supply chain, up to the modelling of consumer behaviour; new functions and social responsibilities have been assigned to agriculture; we have witnessed market globalization and the commodity standardisation of many types of products; farming families have diversified their occupations and sources of income. In terms of methods, innovative approaches have been introduced that allow increasingly wide and complex information sources to be managed, the principles of the neoclassical paradigm have come under discussion and new viewpoints proposed for the formulation and interpretation of the problems of economics. New social and territorial themes have captured the interests of a growing number of researchers; increasing attention has been paid to silviculture and fish-farming; we have realised the dignity and value of the work of farmers and Italian and foreign manual labour and the role of human capital in agricultural innovation and development; the need has arisen to reinstate in an ethical dimension the positive and regulatory analysis of activities that, like those in the primary sector, satisfy basic needs and operate on natural and biological resources.

In these seventy-seven years, the REA has anticipated and accompanied these dynamics, offering outlooks and interpretations based on rigorous scientific premises. In this new season of crisis of consolidated theoretical and political paradigms, undermined by historically important and universal events such as the health emergency and the insurgence of war, the REA proposes itself more than ever as a place for analysis and discussion, citing its particular vocation for the treatment of subjects of agricultural politics and, more in general, of regulatory economics.

In the meantime, the panorama of scientific communication has also been radically renewed: the entry of multinationals in publishing, the digitalization of the supports to the diffusion of knowledge, the promotion of open access and the introduction of an objective and rigid system of quality certification have concurred to design the current order, based on new sources of competitiveness and value. If, on the one hand, this new context imposes rigour and traceability in the processes of selection of the material to publish, on the other it redefines the equilibrium between supply and demand of research results, in which editorial intermediation acquires new and important responsibilities. In this scenario, the choice of CREA and SIDEA to entrust the publication and diffusion of the REA to an academic publisher – the Florence University Press (FUP) - assumes particular importance.

It is in this scenario that the new Editorial Board of the REA has now been installed. We know that we are starting from a good basis, devised over time by the scientific stance of the Centre of Research for Agricultural Policies and Bioeconomy (CREA) and the Italian Society of Agricultural Economics (SIDEA). These foundations have been consolidated in the recent period due to the work and expertise of the outgoing Editorial Board, from whom we inherit – thanks also to the fruitful partnership with the FUP – an invaluable heritage of successes. Among these, in addition to the accreditation on the Scopus database, the chane to digital support and open access is worth mentioning, as it heralds promising prospects of development. Heartfelt thanks go to SIDEA and CREA for their trust in us, while we express our appreciation to the outgoing Board for their impressive work and the important results achieved in objectively difficult times and circumstances.

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We shoulder the responsibility of a tradition of authoritativeness and rigour, of a role that tries to connect the research community with other interested individuals, the defence and consolidation of a competitive position in the international scientific publishing panorama, the creation of a free and efficient open space for comparison and shared progress in the discipline. We have many ideas, aimed at the strengthening of the results obtained and consolidation of the role of the REA. First of all, the use of the FUP platform for the standardization of a rigorous protocol of submission, revising, editing and publication of the papers: in this procedure, we trust in the contribution of the referees, which we intend to enhance through a strict selection of qualified and competent names, as well as with the accreditation of their contribution on the online platform ReviewerCredits and the attribution of a recognition to the best referee of the year. In addition, we intend to reduce the length of research papers to a maximum of 8,000 words, publishing those that expand the essential advancement of knowledge. We also want to produce monographic special issues, aimed at the deepening of research subjects of importance and originality and giving space to the research groups of the universities, academies and centres, to the work of the SIDEA and CREA research groups, to the notification of books, events and initiatives of common interest, and the publication of brief notes and position papers. It is our intention to invite reputable researchers to produce keynote papers, which represent the state of the art of the discipline to the community and stakeholders in relation to the most interesting and innovative subjects and suggest interesting ideas for the development of research.

We are determined to put our experiences in the field with a spirit of service and the curiosity typical of researchers. We have the ambition to become the first choice as method of diffusion of analysis results, to be the first source for finding novelties, ideas, approaches, tools and original results. In short, to be the home of agricultural economists, Italian and foreign. It is a challenge that we tackle with enthusiasm and the certainty of being able to count on the support of CREA and SIDEA, on the expertise and resources of the FUP, but especially on the participation of the community of agricultural economists, in the conviction that we all have our idea of research to be shared and discussed. Now you know that this idea already has a home and a showcase, it only needs to be developed and made available. The REA will think of everything else.

Editorial board
Altobelli F., Brun F., De Luca A.I., De Rosa M., Povellato A., Pulina P., Zumpano C.

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Editoriale

Con il settantasettesimo volume, la Rivista di Economia Agraria, ora REA – Italian Review of Agricultural Economics, inizia una nuova stagione della sua gloriosa storia. Fin dalla sua fondazione, voluta da un illuminato consesso di padri della disciplina economico-estimativa, la REA è stata un punto di riferimento per i ricercatori, per i decisori politici e per quanti hanno a cuore l'agricoltura e le realtà rurali italiane.

In questi settantasette anni, la Rivista ha creato ed esplorato nuovi orizzonti di conoscenza e si è proposta come terreno ideale per un fruttuoso e leale confronto scientifico. In questo lungo periodo, l'economia agraria ha mutato sensibilmente interessi e ambiti di riferimento: i confini dell'analisi si sono estesi dall'azienda alla filiera, fino alla modellizzazione dei comportamenti del consumatore; all'agricoltura sono state assegnate nuove funzioni e responsabilità sociali; abbiamo assistito alla globalizzazione dei mercati e alla omologazione merceologica di molte tipologie di prodotti; le famiglie agricole hanno diversificato le fonti di reddito e di occupazione. Sul piano metodologico, sono stati introdotti approcci innovativi che consentono di gestire fonti di informazioni sempre più ampie e complesse, sono stati messi in discussione i cardini del paradigma neoclassico e proposte nuove chiavi di formulazione e lettura dei problemi dell'economia. Nuove tematiche sociali e territoriali hanno catturato l'interesse di un numero crescente di ricercatori; si è riservata attenzione crescente alla silvicoltura e al comparto ittico; si è presa coscienza della dignità e del valore del lavoro degli agricoltori/trici e del bracciantato italiano e straniero e del ruolo del capitale umano nell'innovazione e nello sviluppo agricolo; è sorta la necessità di ricollocare in una dimensione etica l'analisi positiva e normativa di attività che, come quelle del settore primario, soddisfano bisogni basilari e operano su risorse naturali e biologiche.

In questi settantasette anni, la REA ha anticipato e accompagnato queste dinamiche, offrendo visioni e interpretazioni fondate su rigorosi presupposti scientifici. In questa nuova stagione di crisi di consolidati paradigmi teorici e politici, minati alla base da eventi di portata storica e universale quali sono l'emergenza sanitaria e l'insorgenza di conflitti, la REA si propone più che mai come il luogo di analisi e discussione, richiamando la sua peculiare vocazione alla trattazione dei temi di politica agraria e, più in generale, di economia normativa.

Nel frattempo, anche il panorama della comunicazione scientifica si è radicalmente rinnovato: l'ingresso delle multinazionali dell'editoria, la digitalizzazione dei supporti alla diffusione del sapere, la promozione dell'accesso aperto e l'introduzione di un sistema obiettivo e rigido di certificazione della qualità hanno concorso a disegnare l'attuale assetto, improntato su nuove fonti di competitività e di valore. Se, da un lato, questo nuovo contesto impone rigore e tracciabilità nei processi di selezione dei contenuti e dei saperi da diffondere, dall'altro ridefinisce gli equilibri tra domanda e offerta di risultati della ricerca, nei quali l'intermediazione editoriale acquisisce nuove e importanti responsabilità. Assume particolare rilievo, in questo scenario, la scelta di CREA e SIDEA di affidare l'edizione e la diffusione della REA a una casa accademica – la Florence University Press (FUP).

In questo quadro si insedia oggi il nuovo Editorial Board della REA – Italian Review of Agricultural Economics. Sappiamo di partire da una buona base, costruita nel tempo dall'indirizzo scientifico dettato dal Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria (CREA) e dalla Società Italiana di Economia Agraria (SIDEA). Tali fondamenta sono state consolidate nel periodo recente per merito del lavoro e delle competenze dell'Editorial Board uscente, dal quale ereditiamo – grazie anche alla fruttuosa partnership con la FUP - un patrimonio prezioso di successi. Tra questi, oltre all'accreditamento sul database Scopus, merita menzione il passaggio al supporto digitale e all'accesso aperto, che lascia presagire promettenti prospettive di sviluppo. Alla SIDEA e al CREA va il più sentito ringraziamento per la fiducia che hanno voluto accordarci, mentre al Board uscente rivolgiamo un pensiero di grato riconoscimento per il brillante lavoro svolto e per i prestigiosi risultati conseguiti in tempi e circostanze oggettivamente difficili.

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Sentiamo sulle spalle la responsabilità di una tradizione di autorevolezza e rigore, di un ruolo che vuole connettere la comunità dei ricercatori con i portatori di interesse, della difesa e del consolidamento di una posizione competitiva nel panorama editoriale scientifico internazionale, della creazione di uno spazio libero ed efficace di confronto e progresso condiviso della disciplina. Abbiamo tante idee, volte al potenziamento dei risultati conseguiti e al consolidamento del ruolo della REA. Innanzitutto, l'uso della piattaforma FUP per la standardizzazione di un protocollo rigoroso di submission, revisione, editing e pubblicazione dei papers: in tale procedura, confidiamo nel contributo dei referees, che intendiamo valorizzare attraverso una selezione severa di nominativi qualificati e competenti, nonché con l'accreditamento del loro apporto presso la piattaforma online ReviewerCredits e l'attribuzione di un riconoscimento al miglior revisore dell'annata. Inoltre, intendiamo ridurre la lunghezza dei research papers a un massimo di 8.000 parole, pubblicando prodotti che vanno dritti al punto per soffermarsi sull'essenziale avanzamento di conoscenza. Vogliamo poi realizzare special issues monografiche, mirate all'approfondimento di tematiche di ricerca di assoluto rilievo e originalità e riservare spazio ai gruppi di ricerca delle università, delle accademie e dei centri, all'operato dei gruppi di lavoro della SIDEA e del CREA, alla segnalazione di libri, eventi e iniziative di interesse comune, alla pubblicazione di brevi note e position papers. È nostra intenzione invitare prestigiosi ricercatori a produrre keynote papers, affinché rappresentino alla comunità e agli stakeholders lo stato dell'arte della disciplina in relazione agli argomenti più interessanti e innovativi e suggeriscano interessanti spunti di riflessione e sviluppo della ricerca.

Siamo determinati a mettere in campo le nostre esperienze con spirito di servizio e con la curiosità tipica dei ricercatori. Abbiamo l'ambizione di diventare la prima scelta come mezzo di diffusione dei risultati delle analisi svolte, di essere la prima fonte presso la quale ricercare novità, idee, approcci, strumenti e risultati originali. Insomma, essere la casa degli economisti agrari, italiani e stranieri. Si tratta di una sfida esaltante, che affrontiamo con entusiasmo e con la certezza di poter contare sul supporto del CREA e della SIDEA, sulle competenze e sulle risorse della FUP, ma soprattutto sulla partecipazione della comunità degli economisti agrari, nella convinzione che abbiamo tutti una nostra idea di ricerca da condividere e su cui discutere. Ora sapete che quell'idea ha già una casa e una vetrina pronta, si tratta solo di svilupparla e renderla fruibile al confronto. Al resto ci penserà la REA.

Comitato di direzione
Altobelli F., Brun F., De Luca A.I., De Rosa M., Povellato A., Pulina P., Zumpano C.

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Keynote Article

Long-term land cover changes and ecosystem services variation: have the anthropogenic transformations degraded human well-being in Italy?

Davide Marino, Margherita Palmieri, Angelo Marucci, Silvia Pili

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Abstract. Landscape composition has a crucial role in determining ecosystem functioning and human well-being. Human activities (e.g. urban expansion or agricultural intensification) have strongly modified the natural environment and ecosystem integrity. This paper presents an exemplary application of the ecosystem service (ES) concept to the whole Italian territory. A GIS-based analysis of the long-term dynamics (1960-2018) between land cover changes and landscapes' capacities to provide ecosystem services was conducted in order to achieve a qualitative and quantitative assessment of the supply and demand of ES. The applied methodology considers a matrix linking spatially explicit biophysical landscape units to ecosystem services supply, which was united in a GIS framework. We set the analysis considering national scales and 3 time periods (1960-1990, 1990-2018, 1960-2018). As main results we found a great impact of intensification and urbanization on the decline of ES supply, while forest expansion and forest permanence determined the most important increases. The analysis detected several variations of ES supply that have direct impact on humans and can provide information about the importance of preserving the environment and the benefits we derive from nature.

Keywords: ecosystem services, land cover changes, national scale assessment, GIS analysis.
JEL codes: Q57.

1. INTRODUCTION

1.1. Background

Ecological systems are relevant in the supply of many goods and services essential for human survival, health and economic well-being (Costanza *et al.*, 1997; Müller and Burkhard, 2007). These benefits are defined as Ecosystem Services (ES) generally classified into support, supply, regulation and cultural services (Millenium Ecosystem Services, 2005; Costanza *et al.*, 2011). The continuous natural capital degradation by anthropogenic activities compromises the ecosystem services flow, determining an impact on the socio-economic well-being of present and future generations (IPBES, 2019). Therefore, the responsibility of researchers is to provide tools to public decision makers for monitoring the conservation status of ecological systems. The need to quantify and assess ES and include them in decision-making policies is also highlighted in the Biodiversity Strategy for 2030 and the "EU Guide on Integrating Ecosystems and Their Services in Decision Making" (SWD (2019) 305 final) (Marino *et al.*, 2021).

The supply of ES is linked to the various land cover (LC) classes (Costanza *et al.*, 1997): for example, wooded areas are essential for air purification, whereas meadows and pastures for forage supply (Marino *et al.*, 2021). LC changes (LCC) modify the functions and structure of ecosystems (Wu *et al.*, 2019; Salvati, Colantoni, 2015) and consequently their ability to produce goods and services (Blumstein, Thompson, 2015). Also, population growth and urbanization affect the ability of ecosystems to provide goods and services (Lawler *et al.*, 2014; Li *et al.*, 2010; Obeng, Aguilar, 2018; Ridding *et al.*, 2018). Rapid development of the economy and urbanization has increased ES demand. This has led to soil conversion to agricultural and urban land and severe habitat loss (Wang *et al.*, 2019). Globally, natural ecosystems conversion into agricultural land, and grasslands into urban areas, have caused a loss of biodiversity and a reduction in the supply of ecosystem goods and services (Balvanera *et al.*, 2006; de Groot *et al.*, 2002; Díaz *et al.*, 2006; Mendoza-González *et al.*, 2016).

1.2. Land Cover Changes and methods to evaluate Ecosystem Services

Over the past 20 years, the number of publications studying future changes in land use and impacts on ES has increased. According to the analysis conducted by Gomes *et al.* (2021), these studies are mainly located in Asia (55.7%) and Europe (17.7%). Recently Schirpke *et al.* (2021) studied the ES response to LCC in Europe in the period between 2000 and 2018. The study highlighted a loss in the value of the provisioning ES due to (i) urban expansion, (ii) the conversion of grasslands into arable land and (iii) an increase in the regulation and cultural ES due to the presence of protected areas. In Italy, the main drivers of LCC are depopulation of remote areas (inland and mountain rural areas) and urbanization processes with effects on the ES supply (Munafò, 2021). In the period between 1960 and 2012, the LCC in Italy affected an area of 13 million hectares, approximately 42 percent of the national surface (Marino *et al.*, 2016). While the abandonment of inland mountain areas (Falcucci *et al.*, 2007) causes a loss in the ES supply, the population increase in urban areas causes an increase in the demand for ES, creating a strong imbalance between supply and demand (Marino *et al.*, 2021). Understanding the impacts of LCC on the ES supply is essential to mitigate the consequences of the interactions between human activities and natural capital and to identify a correct management strategy.

In the international context, there is no common methodology for quantifying ES supply (Wei *et al.,* 2017). Usually based on data availability, biophysical methods are used (Vihervaara *et al.*, 2017). To map ES, remote sensing data (Richard *et al.*, 2015) and GIS (Geographic Information System) software are the tools mainly used, which allow the spatial and temporal distribution of ES to be analyzed (Grêt-Regamey *et al.*, 2012) and understand how their supply varies in relation to territorial dynamics (Rodríguez *et al.*, 2006). Some authors (Talukdar *et al.*, 2020; Sharma *et al.*, 2019; Arowolo *et al.*, 2018) have associated land cover classes with the 16 biomes identified by a model of ESV (Costanza *et al.*, 1997). These studies analyzed the net variation rate of ES values with respect to Land Use and Land Cover (LULC) using the two coefficients of Costanza (Costanza *et al.*, 1997; Costanza *et al.*, 2019). To evaluate the variation of ES supply, Assefa (2012) used the transition matrix model (Gashaw *et al.*, 2017; Berihun *et al.*, 2019) and the coefficient of Kindu *et al.* (2016) for ESV analysis. The transition matrices have also been used by Tang *et al.* (2020), Lin *et al.* (2021) and Chen *et al.* (2020) to study landscape change and ESV. The GIS and the integrated Valuation of Ecosystem Services and Tradeoffs Tool (InVEST) model were used to estimate the economic value of some ES. For example, Rimal *et al.* (2021) used Landsat and InVEST satellite images to estimate ES trade-offs. Other authors used InVEST to estimate the ES response to LCC (Daneshi *et al.*, 2021; Berta Aneseyee *et al.*, 2020; Fadaei *et al.*, 2020; Liang *et al.*, 2017). Furthermore, on the international scene there are also qualitative methods based on ES matrices to estimate the supply and response of ES to LCC dynamics. The ES matrix method is a generally used approach for a synthetic assessment of ES and is based on the LCC. The ES matrices are constructed by associating a single class of land use, habitat or ecosystem with a score related to the ES supply and demand potential. For example (Madrigal-Martínez and Miralles i García, 2020; Madrigal-Martínez and Miralles i García, 2019), developed a matrix to estimate the ability of different land use classes to provide SE. According to Campagne *et al.* (2014), the Burkhard matrix approach (Burkhard *et al.*, 2009) and related updates (Burkhard *et al.*, 2012; Burkhard *et al.*, 2014) is among the methods most used by researchers (Marino *et al.*, 2014) as it can be adapted to map and evaluate ES at a local (Nedkov, Burkhard, 2012), national (Depellegrin *et al.*, 2016) and continental (Stoll *et al.*, 2015) scale. The Burkhard matrix links the units of the physical landscape (ecological integrity) to the supply and demand of ES. Some authors (García-Llamas *et al.*, 2019; Wu *et al.*, 2019; Li *et al.*, 2016) have adapted the Burkhard (Burkhard *et al.*, 2012) matrix scores with expert team judgements to evaluate the ES in their study areas.

1.3. Objective of paper

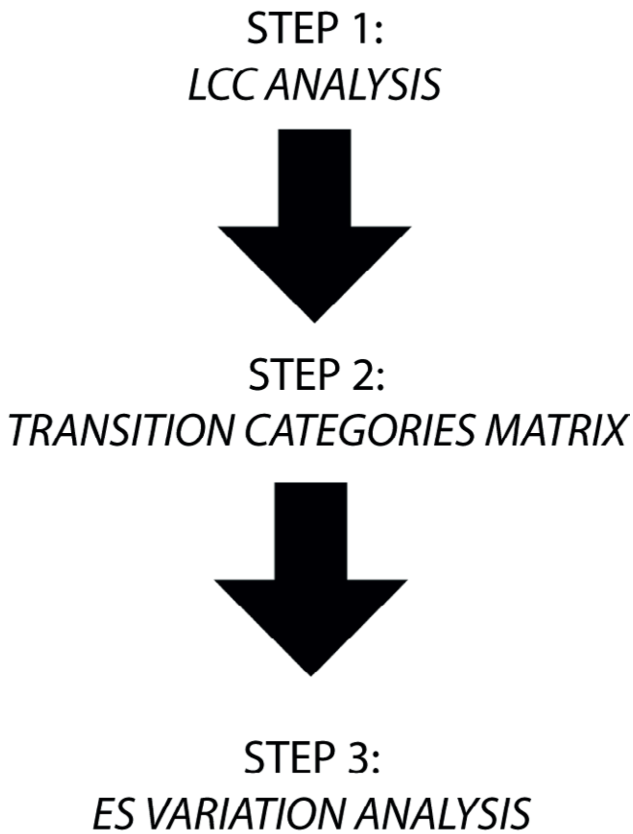
Our research is different from other studies because we used an innovative method to analyze LCC and relative variations to ES supply. This method is based on transition categories and describes LULC permanencies and LCC due to intensification, extensification, urbanization, renaturation process (Tab. 1). According to these categories of transitions we evaluated the ES supply response variation. Through a diachronic analysis (1960-2018), we analyzed the qualitative variation in ES supply in Italy, using the ES matrix approach. We also mapped the total ES variation as a function of transition processes. This allowed us to analyze synergies and trade-offs between different ES at spatial and temporal scales. The transition analysis between different categories and variation in ES supply can support decision making in defining strategies and land planning tools.

2. MATERIALS AND METHODS

2.1. Study area

The national territory is the area we selected to improve current studies on ES variation appling our innovative approach. The spatial extension of this paper consists of 301.670 km^2 and corresponds to the whole Italian territory, which is mainly represented by agricultural areas (51%) and forests (41%). Administratively, Italy comprises 7,904 administrative municipalities in 20 regions. The population has increased from 50.6 million to 59,8 million from 1960 to 2018, with an average population density of 183/km^2. Italy is characterized by a Mediterranean climate with rainy winters and a notable drought during summer months. As Frigerio and De Amicis (2016) report, it is one of the European countries that are most strongly exposed to a wide range of natural hazards. In the context of climate change and increasing frequency of extreme natural events, which represent only some of the current threats along with, for example, increasing air and water pollution, the analysis of the variations of the benefits nature provides to humans over time seems to be a crucial issue to face potential socioeconomic impacts.

Fig. 1. Methodological framework of the ES variation analysis.



2.2. Methodological Framework

Our study was based on a methodological framework divided into three steps (Fig. 1). In the first step we analyzed the land use changes in Italy between 1960 and 2018. In the second step we applied a GIS-based methodology that allows a thematic in-depth analysis of diachronic LCC. Finally, in the third step, we analyzed the qualitative assessment of potential ES supply on the basis of the transition matrix.

2.2.1. Step 1 - Land Cover Change analysis

In our study we studied land use change over the whole period 1960-2018 and also for two sub-periods 1960-1990, 1990-2018 to observe different trends in land use and ES supply fluctuations. We considered these two periods of circa 30 years as they were affected by different socio-economic dynamics that influenced the environmental and spatial context. We considered the interval 1960-2018 to assess the long-term effects of land use on the supply of ecosystem services. We used GIS software to generate LCC maps. The vectorial geographic dataset consists of two data sources: (i) Land Use Map 1960 that was edited by the National Research Council of Italy (CNR) and published by Touring Club Italiano (TCI) and (ii) CORINE Land Cover (CLC) (used for 1990 and 2018). In order to ensure the comparison between CNR and Corine map legends, previous works (Marino *et al.*, 2021; Marino *et al.*, 2016) achieved the equivalence of codes. For more details concerning legend conversion see Tab. A.1. in the Appendix). Since there are no alternative cartographic resources for the time period considered (1960-2018), we performed the analysis with the available data. While equivalence of code methodology presents some limitations due to the differences between the maps used, it represents the first original contribution on long-term analysis of the SE variations linked to changes in uses and land cover occurring in Italy.

2.2.2. Step 2 - Transition categories matrix

The LCC map, at the basis of the Transition Categories approach, has been generated intersecting TCI 1960 vector data with CLC 2018 data. This new approach takes into account the Corine Land Cover legend at the III hierarchical level (artificial areas = 1xx, agricultural lands = 2xx, forests = 3xx, etc.). At each change from one to another use (e.g. wood to urban) a concatenation code was assigned creating the first new column in the attribute table of the shapefile. For instance, in the case of a wood-to-urban conversion, the concatenation code is 3xx1xx (for example 300100). Each code has been linked, in turn, to a "text" qualitative attribute described by a new column in the shapefile (e.g. 300100= "urbanization"). These categories, from here onwards defined as *Transition Categories,* indicate a specific land use process of change or rather transformations (urbanization, agricultural intensification or extensivization, evolution to complex agricultural areas, natural forest expansion) or permanences (Tab. 1).

2.2.3 Step 3 - ES Variation analysis.

The qualitative assessment of potential ES supply was made on the basis of the transition categories. In fact the transition categories approach allows not only land use permanences and transformations but also ES supply variation analysis.

This paper provides continuity to the ES matrix approach (Burkhard *et al.*, 2009; Burkhard *et al.*, 2012, Burkhard *et al.*, 2014) that links land cover types to ES supply capacities. We used a new original matrix, that links ES variation with Transition Categories as defined by Marino *et al.* (2016). As the literature highlighted, each land use correlates with a specific ES potential supply, each LCC has been linked to a specific ES variation. We used the classification developed in the LIFE + MGN project based on 8 provisioning ES (P), 9 regulation ES (R) and 3 cultural ES (C) (Schirpke *et al.*, 2013): crops (P1), forage production (P2), huntable species and fish (P3), raw materials (e.g. wood, fibres) (P4), edible plants and mushrooms (P5), medicinal plants (P6), genetic resources (P7), drinking water (P8); carbon sequestration (R1), local climate regulation and air purification (R2), groundwater recharge (R3), water purification (R4), protection from erosion and geological instability (landslides, slope instability) (R5), protection from hydrological disasters (floods) (R6), pollination (R7), biological control (pests) (R8), habitats for biodiversity (R9), aesthetic value (C1), recreational value

Tab. 1. Transition categories description.

Permanences	All areas in which there is a permanence of land use and cover are included (artificial areas, arable land and pastures, permanent crops,...)
Urbanization	Conversion of agricultural and forest are land cover and use in artificial areas.
Agricultural intensification	The category includes all the transitions that, starting from agrarian or rural land uses, evolve in the sense of an increase in anthropogenic pressure (exept urbanization). This is the case of the evolution of pastures into agricultural land uses, of less intensive into more intensive cultivation, as well as of forest into agricultural cultivation.
Agricultural extensification	The category includes all the transitions that, starting from permanent crops ends in arable and pastures.
Evolution to complex systems	The category represents the transition to heterogeneous agricultural areas starting from arable and pastures and permanent crops
Forest extension	The category includes all the transitions that correspond to secondary ecological succession.

(ecotourism, outdoor activities) (C2), inspiration for culture, arts, educational and spiritual values, sense of identity (C3).

For the qualitative evaluation of ES variation, we have i) assigned to each LULC class a relevance class on a scale from 0 to 3 (3 - very important, 2 moderate importance, 1- low relevance, 0 - no relevance), (ii) assigned a quantitative change score of the ES for each transition category of the intended use change, iii) weighted the ES variation score on the percentage (TCA*100/A) of surface area occupied by each plot of land to reflect the spatial extent of the analysis.

$$\Delta\text{ES} = QV \times \left(\frac{TCA \times 100}{A}\right) \quad (1)$$

Where:
ΔES is the Variation Score of ES;
QV is the qualitative value of ES;
TCA is Transition Category Area (ha);
A is the overall area of the study (ha).

3. RESULTS

3.1. Land Cover Change and transition categories

The first step of our analysis highlighted the quali-quantitative distribution of LCC as shown in the table and map below. The figure (Fig. 2) represents the macro classes of LULC (artificial, agriculture, forests and water bodies) and their distribution in 1960 (left), 1990 (centre) and 2018 (right).

The pivot table shows that the highest level of permanence occurred mainly in the following land use and cover classes: 300 and 211, which arewoodland and non-irrigated arable lands, respectively (Tab. A.2. in Appendix). This observation is valid in all the considered time periods and is corroborated by the matrix below.

At national level, between 1960 and 2018, transition categories analysis finds a consistent permanence of forests (89,345 km^2), arable lands (54,655 km^2), heterogeneous agricultural areas (12,151 km^2) and permanent crops (12,104 km^2) (Fig. 3). Concerning transformation, agricultural intensification represents the most important process of LCC that occurred in Italy in the considered time period: a total of 168,257 km^2 was transformed mainly from (i) natural to agricultural, (ii) heterogene-

Fig. 2. LULC in Italy represented through 4 macroclasses.

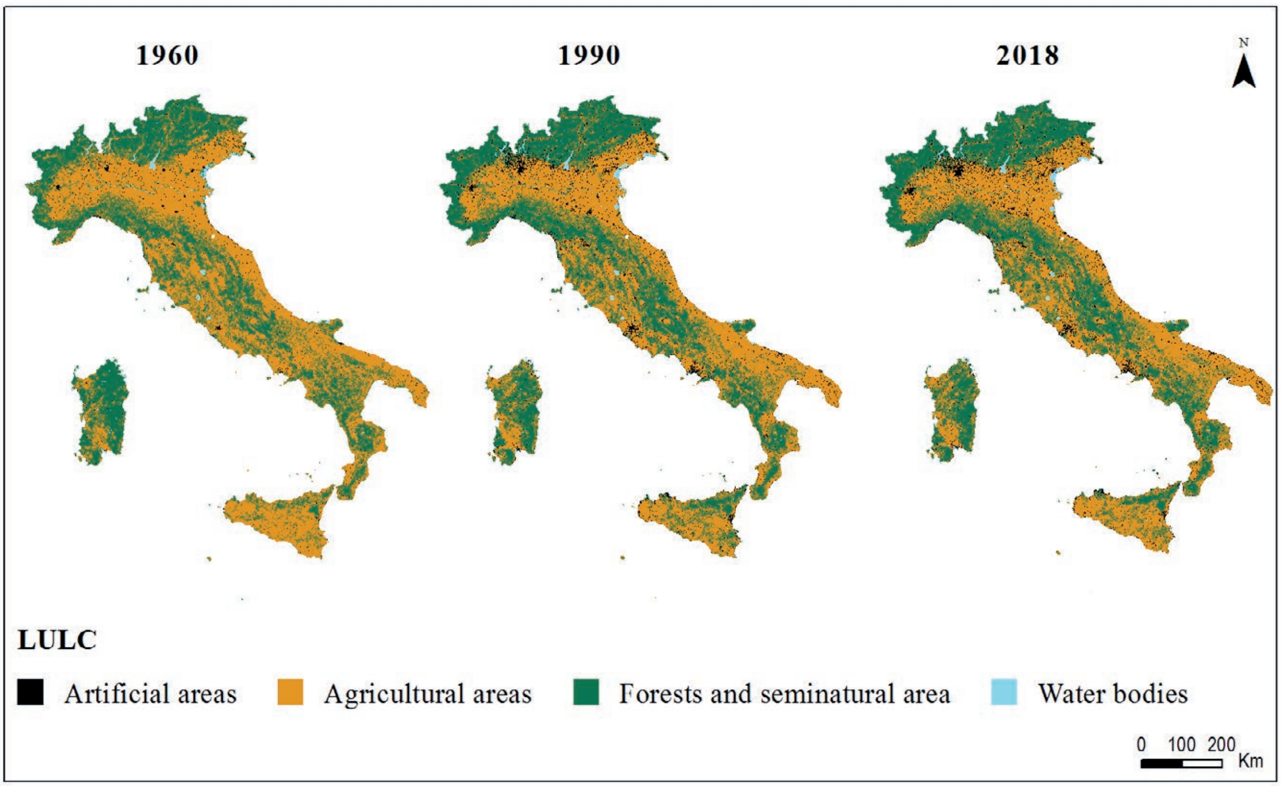
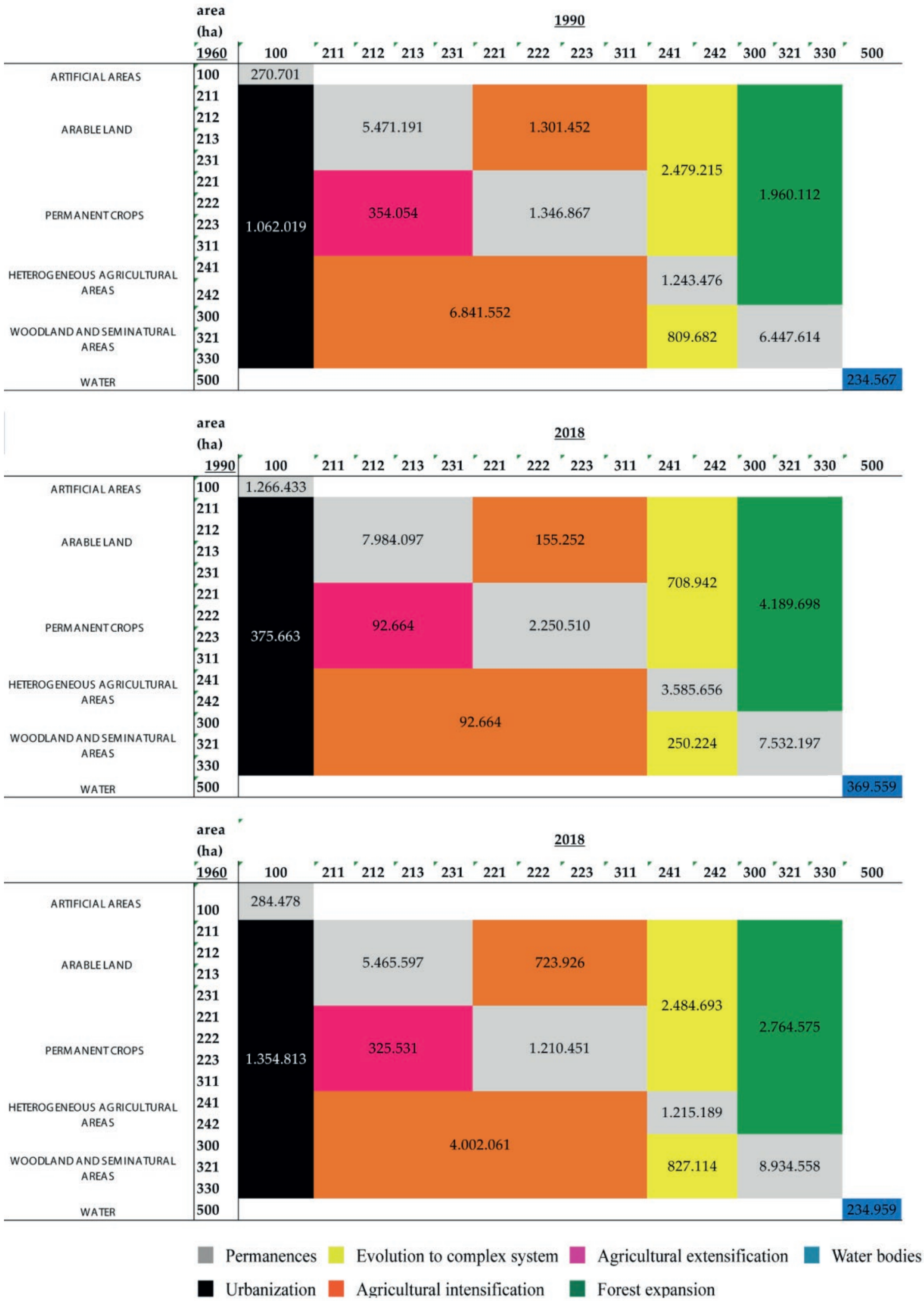


Fig. 3. Transition categories matrix between 1960-1990, 1990-2018, 1960-2018.



ous agricultural areas to arable land and grassland. An area of 27,645 km^2 underwent natural forest expansion, while 33,118 km^2 were converted into complex systems and just 3,255 km^2 agricultural areas were subjected to extensification. Lastly, 13,548 km^2 were converted from agricultural and woodland to urban areas.

Some differences can be observed between the two time periods we studied: forestation was more intense during the second period (1990-2018) while agricultural intensification characterizes a large part of the changes that occurred in the first period (1960-1990). Those processes are reflected in the maps below. Between 1960-1990, furthermore, urbanization was higher than in the second period. Evolution to complex systems and agricultural extensification are other categories that are more represented in the first than in the second period.

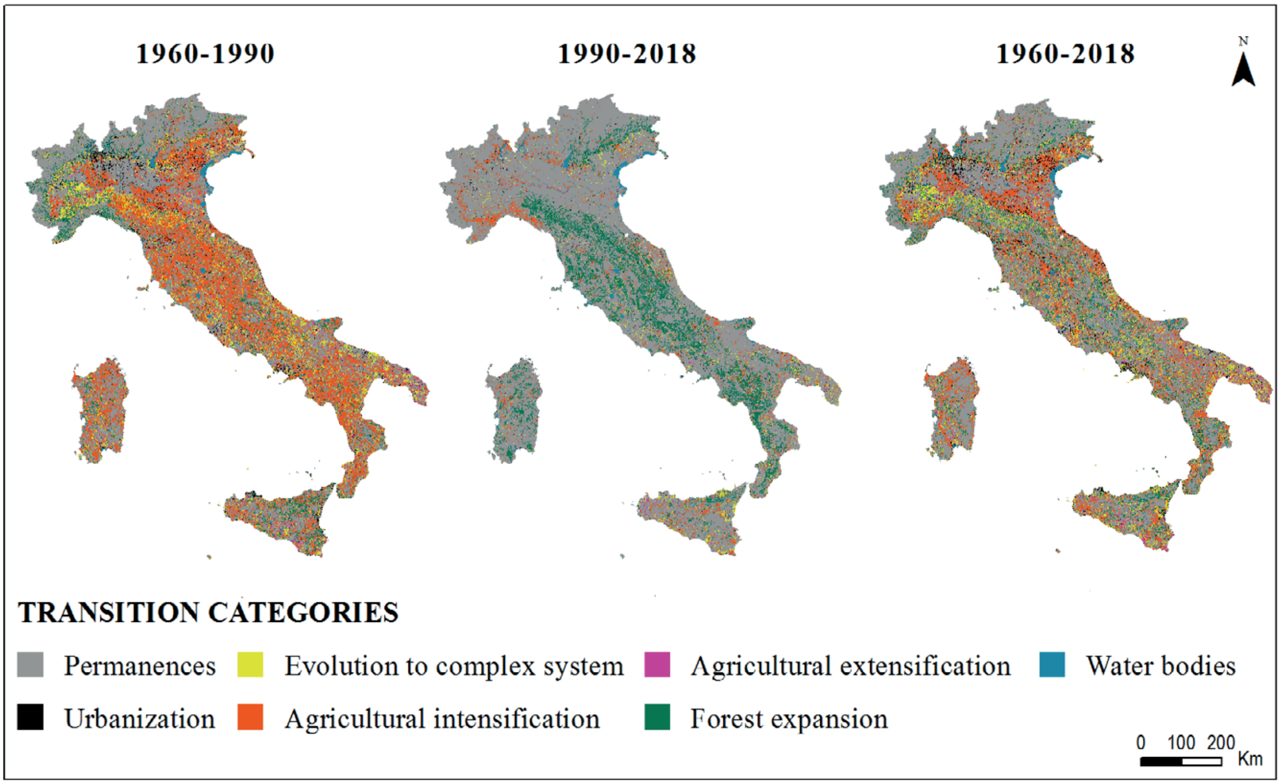
With regard to the transition categories spatial distribution, agricultural intensification is highly representative of the changes that occurred in the NE, especially in the Po Valley area, and in the E-NE, along the Adriatic coasts (Fig. 4). Evolution to heterogeneous agricultural areas invloved large parts of the NW, as in Piedmont region, also on Sicily in the S. Forest expansion is particularly extended and concentrated in the NE area in Liguria and Tuscany. Concerning the urbanization category, this is significant above all in the Milan and Rome areas but, as the other categories, can be found in lesser or greater concentration all over Italy.

3.2. Transition Categories-ES variation analysis

LULC produced different variations in ES supply over the periods studied. These values are distributed differently among Italian regions (Fig. 4). In the periods investigated there was a generalized loss of ES caused by agricultural intensification, urbanization, and, to a lesser extent, the permanence of arable land.

In the 1960-1990 period there was a greater variation in ES supply than in 1990-2018. The processes of agricultural intensification and urbanization caused a decrease in all regulation and cultural ES and some of the ES provision. This decrease has been balanced, with varying intensity, by the permanence and forest expansion. In 1960-1990, the increase in anthropogenic pressure on agriculture triggered the intensification process caused mainly by the transition from extensive to intensive farming and agricultural mechanization, which also affected hilly areas (Tab.3 and Fig. 5).

Fig. 4. Transition categories map of the LCC occurring between 1960-2018.



Tab. 2. ES variation qualitative and transition categories of LCC.

Transition categories and SE variation	1960-1990				1990-2018				1960-2018			
	P	R	C	TOT	P	R	C	TOT	P	R	C	TOT
Agricultural intensification	-18,1	-68,4	-13,8	-100,4	-11,6	-36,0	-6,9	-54,5	-38,9	-130,0	-36,1	-205,0
Urbanization	-19,5	-27,2	-8,0	-54,6	-5,3	-8,5	-2,3	-16,1	-24,5	-34,1	-9,9	-68,5
Arable land permanence	-1,3	-8,6	-1,1	-11,0	-4,6	-2,9	-0,1	-7,6	-3,7	-9,6	-1,1	-14,3
Agricultural extensification	3,6	-2,7	-4,4	-3,5	0,4	-1,9	-1,5	-3,0	3,3	-2,5	-4,0	-3,2
Crop permanence	3,9	7,1	2,6	13,6	0,0	0,2	-0,1	0,2	1,3	1,4	1,4	4,2
Heterogeneous agricultural area permanence	3,6	14,3	0,0	17,9	0,4	1,7	0,0	2,1	3,6	14,3	0,0	17,9
Evolution to complex systems	-2,3	34,2	-4,1	27,7	-1,4	5,6	-4,0	0,3	-1,5	34,9	-4,7	28,8
Forest permanence	2,2	56,9	3,7	62,8	3,1	4,5	2,1	9,7	5,3	80,7	4,8	90,9
Forest expansion	38,1	107,1	38,3	183,5	7,7	17,3	7,3	32,3	56,0	164,1	57,1	277,1
Water bodies	-2,7	-2,1	1,2	-3,7	-0,4	-0,3	0,3	-0,4	-2,9	-2,1	1,4	-3,6
Water body variation	1,0	1,0	-0,5	1,5	0,1	0,1	-0,2	0,1	1,0	1,1	-0,5	1,6
Total	8,5	111,7	13,7	133,9	-11,5	-20,2	-5,3	-37,0	-1,0	118,3	8,4	125,7

Legend: P= Provisioning ES; R = Regulation ES; C= Cultural ES.

Regions with high coverage of intensive agricultural areas (i.e., permanent crops, arable land and fertilized grasslands) have lower ES values than regions with higher forest area. The process of forest expansion is critical to the provision of regulating ES such as carbon sequestration (R1), local climate regulation (R2), biological control (R8), and protection from hydrological disaster (R6) in addition to the provision of wood and fFibre (F4) and the values of recreation (C2) and inspiration for art and culture (C3). Increased forest expansion has only partially offset the loss of ES due to agricultural intensification (Tab. 2 and Fig. 5).

Each transition category influences with a different weight the supply of individual ES compared also to the investigated periods (Fig. 4 and Fig. 5). As the results show, the conversion from forests and pastures to agricultural land (agricultural intensification) has led, on the one hand, to an increase in the ES of food production and, on the other, to a reduction in the capacity of soils to provide mainly regulatory ES. In fact, intensive agricultural practices, especially in lowland and hilly areas, reduce the capacity to absorb carbon, increase vulnerability to surface erosion and cause the loss of natural habitats.

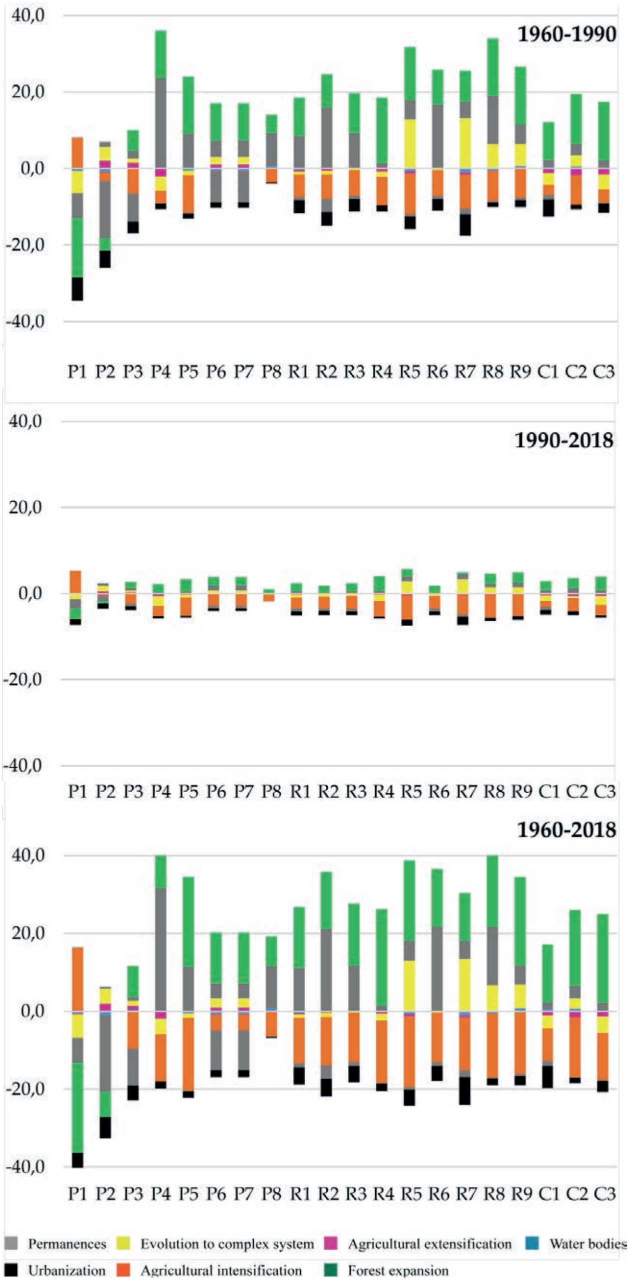
Agricultural intensification is more concentrated in the Po Valley, NE, and the mid-Adriatic coast than in the rest of Italy (Fig. 4). Areas where there was no transition between different land use and cover categories (Fig. 4) maintained medium-high values in ES supply (Fig. 6). Medium-high values were also recorded along the Alps and Apennines where forest expansion occurred. In these areas, forest expansion resulted in an increase in the supply of all ES with the exception of ES P1 (crops) and P2 (forage production). The transition towards the evolution into complex systems has affected in a widespread way the internal areas from north to south, contributing to the protection of biodiversity. In fact, this transformation, between 1960-2018, led to an increase in the ES supply linked to biodiversity such as R5 (protection from erosion and geological instability), R7 (pollination), R8 (biological control), R9 (habitats for biodiversity).

4. DISCUSSION

The results of the paper showed how changes in LULC affect ES supply and this is consistent with studies conducted in other areas in Europe (García-Llamas *et al.*, 2019; Schirpke *et al.*, 2021). Most of the LULC changes that have occurred in the Mediterranean are due to human activities and mainly involve agriculture and urban expansion (Vogiatzakis *et al.*, 2020; Parcerisas *et al.*, 2012). These changes can negatively affect natural capital and lead to a decline in biodiversity and ecosystem services (Ioannidou *et al.*, 2021). This has led to the need to monitor such changes at spatial and temporal scales and link them to the provision of ES. In Europe these changes differently affect the provision of different ES because they depend on some factors such as latitude, altitude zone and specific spatial characteristics of the investigated areas (Ioannidou *et al.*, 2021; Sil *et al.*, 2016).

The results of the study highlight the trade-offs between different land uses. In fact, the intensification of agricultural activity has led to a contraction in the sup-

Fig. 5. ES Variation at national level between 1960 and 2018.



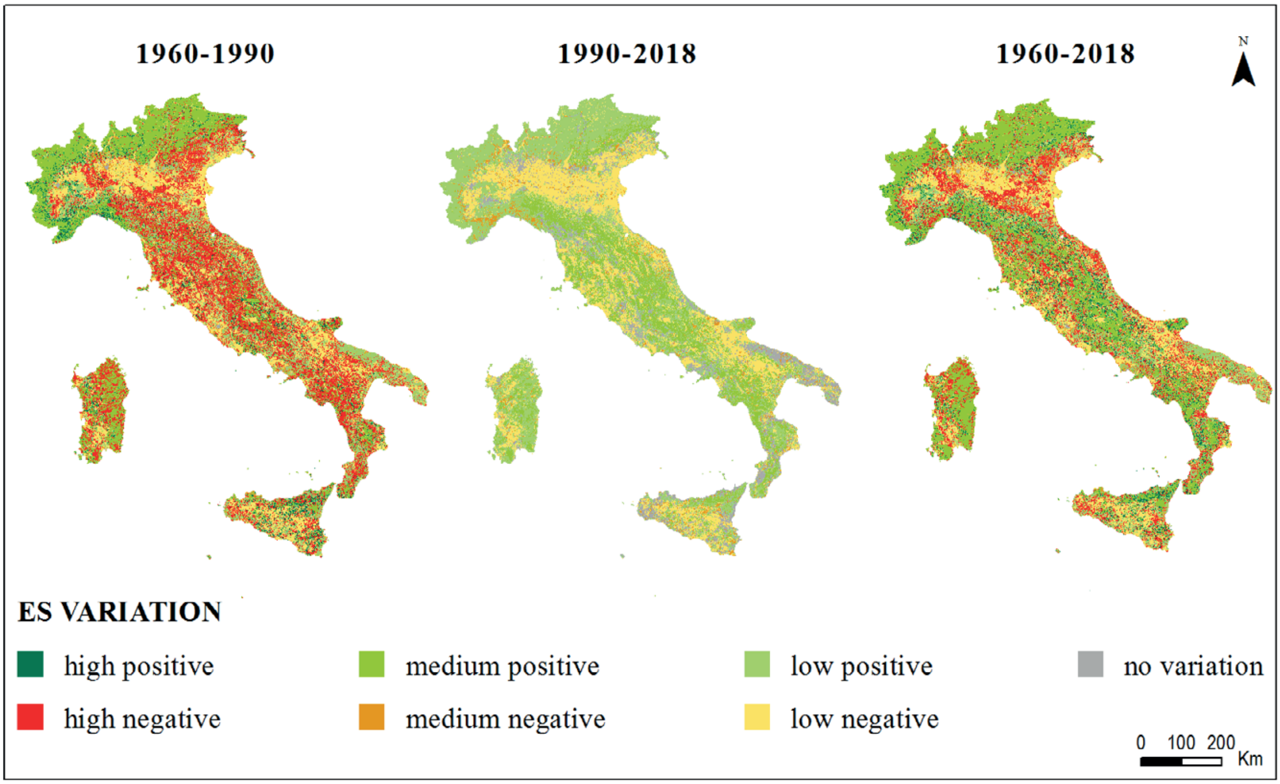
ply of ES, especially ES regulation. Urbanization has also caused a decrease in ES supply. This has led to the expansion of urban areas and the building over of soil previously occupied by agricultural land, natural and semi-natural areas. In these areas land consumption has permanently changed the ecosystem function of protecting the territory from hydrogeological instability, of mitigating climate change (absorption of carbon dioxide, removal of pollutants) and habitats for biodiversity. Over the period analyzed, the difference between gain and loss of ES was 125.7 points. The loss in ES provision associated with agricultural intensification (-205 points) and urbanization (-68.5 points) was offset by an increase in ES provision due to forest expansion, (+277.1 points), and forest permanence (+90.9 points). Agricultural intensification in Italy is in line with what is happening in Europe. In particular, the use of new technologies foreseen by the Green Revolution, and the Common Agricultural Policy (CAP) in the last 50 years have driven the intensification of agriculture, promoting the simplification and specialization of agroecosystems through the decline of landscape heterogeneity, the increase in the use of chemicals per unit area and the abandonment of less fertile areas (Emmerson *et al.*, 2016). These processes have eroded the quantity and quality of habitat for many plants and animals, and thus reduced natural capital and biodiversity across Europe (Rolando *et al.*, 2017). The increased forest expansion occurred mainly as a result of abandonment in rural hill and mountain areas. These processes took place mainly in the post 1990 period with the establishment of several protected natural areas and N2000 sites along the Apennines. The Management Plans of the Parks and N2000 sites have regulated human activities in these territories and contributed, through interventions, to ensure the ecological integrity of ecosystems. Agricultural land over the years has been transformed as a result of the evolution of ecological conditions and social and economic dynamics of rural areas into natural and semi-natural environments. In the 2014-2020 period, the mountain territories of the Alps and Apennines have benefited from funding from the National Strategy for Internal Areas under the EU's Cohesion Policy (CP). The objective of this strategy was to counteract the abandonment of internal areas, promote economic development and improve the maintenance of the territory.

These processes often lead to a trade-off between ES supply. The loss of some ES can adversely affect the provision of others. For example, soil sealing can compromise natural groundwater recharge function, hydrogeological protection function, water cycle regulation, etc. The ES regulation is the category that has registered a substantial increase followed by cultural SE. The supply ES, instead, is the category in which this increase is lowest. In fact, forest expansion has counteracted the loss of ES due to the intensification of agricultural areas and urbanization.

5. CONCLUSIONS

The matrix method simplifies landscape functionality by producing uncertainties about the quantification

Fig. 6. ES variation between 1960-2018.



of ES. For example, the delivery of many ES depends not only on the presence of certain land use and land cover types but also on the spatial configuration and management of each land use (Santana-Cordero *et al.*, 2016; Schirpke *et al.*, 2017). The approximate spatial resolution and thematic generalizations of CORINE data may limit the results presented here. With local or regional scale levels of analysis, additional data must be integrated in order to obtain a better representation of landscape and LULC characteristics (Madrigal-Martínez *et al.*, 2019). Involving the expert panel in the development of the matrix can improve many aspects, such as the determination of LULC classes and relevant ES types.

The results of this paper can provide important knowledge to support land use planning (Kandziora *et al.*, 2013). In fact, through historical analysis it is possible to understand how the impacts of human activities affect changes in LULC and the causes that determine the variation in ES supply (Bürgi *et al.*, 2015). In this context, GIS analysis has allowed us to map ES at different spatial and temporal scales and to analyze trade-offs between different ES in relation to LULC changes. The analysis GIS coupled with qualitative ES provision matrices assumes high potential for land management analysis. Maps of landscape capacity to deliver ES provide information on the potential to deliver goods and services, socioeconomic conflicts, and in environmental management. Supplementing the analysis with additional data such as biotic and abiotic information could improve the data analysis (Burkhard *et al.*, 2009). Finally, ES variation maps (Fig. 5) if analysed in synergy with maps representing the territory (e.g. geological maps, hydrogeological risk maps, urban maps, ecoregions, etc.) could provide useful information to evaluate trade-offs between ES supply and improve land management. These further investigations could be the basis for future research developments.

Furthermore this study could be deepened by analyzing the ES variation also in function of the ES demand. In fact, the relationship between ES supply and demand can contribute to improving ES governance (Marino *et al.*, 2021). In our study we highlighted that LULC changes happen at a different speed depending on the period analyzed. The influencing factors of LULC change are anthropogenic activities such as urbanization, the intensification of agriculture and the socio-economic processes that determine a migration of the population from rural areas to urban and peri-urban areas. To these factors are added the climatic changes that affect the choices of economic and social investment in the territory. Predicting trends in ES supply is complex and depends on how quickly the LULC changes in relation to ES demand. In addition, to respond to environmental policy recommendations, research could be improved by also considering the change in economic value of ES in relation to LULC changes. Economic valuations are an essential part of human-environment systems research. They support awareness of the dependence of human societies on nature and help design instruments for the conservation of important natural systems (Schirpke *et al.*, 2108; Heal *et al.*, 2000; Marino *et al.*, 2016).

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APPENDIX

Tab. A.1. Legend conversion from TCI and CLC to the classes used for transition categories analysis.

TCI classes	CLC Classes	Classes (for transition categories analysis)	New code
01 Arable land (dry)	2.1.1 Non-irrigated arable land (2.1.1.1. Intensive crops; 2.1.1.2. Extensive crops)	Non-watering plants	211
02 Arable land (dry); 04 Arborated irrigated arable land	2.4.1. Annual crops associated with permanent crops	Tree crops in association	241
03 Irrigated arable land	2.1.2. Arable land in irrigated areas	Irrigated arable land	212
05 Paddy field	2.1.3. Paddies	Paddy field	213
06 Vegetable garden; 09 Vineyard - Olive grove	2.4.2. Complex crop and particle systems; 2.4.3. Areas mainly occupied by agricultural crops with the presence of natural spaces	horticultural crops and complex systems	242
07 Vineyard	2.2.1. Vineyards	Vineyard	221
08 Olive grove	2.2.3. Olive groves	Olive grove	223
10 Citrus grove 11 Fruit trees (pulpy fruit) 12 Fruit trees (hard nuts or pods)	2.2.2. Fruit trees and minor fruits	Fruit trees	222
13 Coppice; 14 Tall forest; 15 Promiscuous forest	3.1.1. Broad-leaved woods; 3.1.2. Coniferous forests; 3.1.3. Mixed woods; 2.4.4 Agroforestry areas; 3.3.3. Areas with sparse vegetation; 3.3.4. Areas affected by fires 3.2.2. Moors and bushes; 3.2.3. Areas with sclerophyllous vegetation; 3.2.4. Areas with evolving woodland and shrub vegetation)	Forest	300
16 Chestnut grove (for fruit)	3.1.1.4; Woods with a prevalence of chestnut	Chestnut	311
17 Lawn and wooded meadow (dry) 18 Lawn and wooded lawn (irrigated)	2.3.1. Stable lawns	Lawn and wooded	231
19 Pasture and uncultivated production even if partially or temporarily used for arable land	3.2.1. Natural pasture areas and high altitude grasslands	Pasture	321
20 Open spaces with little or no vegetation	3.3.1. Beaches, dunes, sands; 3.3.2 Bare rocks, cliffs, outcrops; 3.3.5. Glaciers and perennial snows	Open spaces with little or no vegetation	330
21 Settlements and other forms of use; 22 Other uses	1.1.1. Continuous urban fabric; 1.1.2. Discontinuous urban fabric; 1.2.1. Industrial or commercial areas; 1.2.2. Road and railway networks and ancillary spaces; 1.2.3. Port areas; 1.2.4. Airports; 1.3.2. Landfills; 1.3.3. Construction sites; 1.4.1. Urban green areas; 1.4.2. Sports and recreational areas; 1.3.1. Mining areas	Settlements	100
23 Water bodies	5.1.1. Waterways, canals and waterways; 5.1.2. Water basins; 5.2.1. Lagoons; 5.2.2. Estuaries; 4.1.1. Inner marshes; 4.1.2. Peat bogs; 4.2.1. Brackish marshes; 4.2.3. Intertidal zones; 4.2.2. Saline	Water bodies	500

Tab. A.2. Pivot table represents changes from one to another LULC between 1960-1990, 1990-2018, 1960-2018. Percentage permanences can be read along the diagonal.

Area%								1990							
1960	**100**	**211**	**212**	**213**	**221**	**222**	**223**	**231**	**241**	**242**	**300**	**311**	**321**	**330**	**500**	**Tot**
100	*0.9*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.4*
211	*0.8*	*13.0*	*0.1*	*0.0*	*0.6*	*0.4*	*0.7*	*0.5*	*0.5*	*4.5*	*2.1*	*2.1*	*0.9*	*0.1*	*0.1*	*26.3*
212	*0.3*	*2.6*	*0.0*	*0.5*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.3*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*4.0*
213	*0.0*	*0.0*		*0.3*		*0.0*	*0.0*	*0.0*		*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.4*
221	*0.2*	*0.5*	*0.0*	*0.0*	*0.5*	*0.1*	*0.3*	*0.0*	*0.1*	*1.0*	*0.3*	*0.1*	*0.0*	*0.0*	*0.0*	*3.3*
222	*0.2*	*0.3*	*0.0*	*0.0*	*0.1*	*0.4*	*0.3*	*0.0*	*0.0*	*0.4*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*1.8*
223	*0.1*	*0.3*	*0.0*	*0.0*	*0.1*	*0.1*	*1.4*	*0.0*	*0.1*	*0.6*	*0.3*	*0.2*	*0.0*	*0.0*	*0.0*	*3.3*
231	*0.2*	*0.8*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.3*	*0.0*	*0.6*	*1.0*	*0.3*	*0.2*	*0.0*	*0.0*	*3.5*
241	*1.0*	*5.9*	*0.0*	*0.0*	*0.2*	*0.2*	*0.7*	*0.1*	*0.3*	*3.6*	*0.6*	*0.9*	*0.1*	*0.0*	*0.0*	*13.8*
242	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*	*0.0*	*0.0*	*0.2*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.8*
300	*0.2*	*0.8*	*0.0*	*0.0*	*0.1*	*0.0*	*0.2*	*0.2*	*0.1*	*1.1*	*7.8*	*6.9*	*0.5*	*0.1*	*0.1*	*17.9*
311	*0.0*	*0.0*		*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.5*	*0.8*	*0.0*	*0.0*	*0.0*	*1.5*
321	*0.2*	*2.2*	*0.0*	*0.0*	*0.1*	*0.1*	*0.2*	*0.3*	*0.1*	*1.3*	*7.6*	*3.0*	*2.9*	*0.6*	*0.2*	*18.8*
330	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.6*	*0.0*	*0.2*	*1.2*	*0.0*	*2.2*
500	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.8*	*1.0*
Tot	*4.4*	*26.8*	*0.1*	*0.9*	*1.8*	*1.3*	*4.2*	*1.5*	*1.3*	*13.9*	*21.2*	*14.5*	*4.8*	*2.0*	*1.3*	*100.0*

Area%								2018							
1990	**100**	**211**	**212**	**213**	**221**	**222**	**223**	**231**	**241**	**242**	**300**	**311**	**321**	**330**	**500**	**tot**
100	*4.2*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*4.4*
211	*0.6*	*24.1*	*0.1*	*0.1*	*0.2*	*0.1*	*0.1*	*0.1*	*0.1*	*1.0*	*0.1*	*0.0*	*0.1*	*0.0*	*0.0*	*26.8*
212	*0.0*	*0.0*	*0.1*			*0.0*	*0.0*	*0.0*		*0.0*	*0.0*				*0.0*	*0.1*
213	*0.0*	*0.0*	*0.0*	*0.9*		*0.0*		*0.0*		*0.0*	*0.0*	*0.0*		*0.0*	*0.0*	*0.9*
221	*0.0*	*0.1*	*0.0*		*1.5*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.8*
222	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.9*	*0.0*	*0.0*	*0.0*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.3*
223	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.1*	*3.3*	*0.0*	*0.1*	*0.4*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*4.2*
231	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.0*	*0.0*	*0.1*	*0.1*	*0.0*	*0.1*	*0.0*	*0.0*	*1.5*
241	*0.0*	*0.2*	*0.0*		*0.0*	*0.0*	*0.1*	*0.0*	*0.4*	*0.5*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.3*
242	*0.4*	*1.2*	*0.0*	*0.0*	*0.3*	*0.1*	*0.2*	*0.1*	*0.1*	*10.9*	*0.5*	*0.0*	*0.1*	*0.0*	*0.0*	*13.9*
300	*0.1*	*0.2*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.0*	*0.0*	*0.5*	*18.1*	*1.3*	*0.8*	*0.1*	*0.0*	*21.2*
311	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*	*12.6*	*1.5*	*0.0*	*0.0*	*0.0*	*14.5*
321	*0.0*	*0.3*	*0.0*		*0.0*	*0.0*	*0.0*	*0.2*	*0.0*	*0.2*	*0.6*	*0.0*	*3.4*	*0.0*	*0.0*	*4.8*
330	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*	*0.0*	*0.1*	*1.7*	*0.0*	*2.0*
500	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*1.2*	*1.3*
tot	*5.5*	*26.4*	*0.2*	*1.0*	*2.1*	*1.3*	*3.9*	*1.4*	*0.8*	*14.4*	*32.5*	*2.9*	*4.6*	*1.8*	*1.3*	*100.0*

Area%								2018							
1960	**100**	**211**	**212**	**213**	**221**	**222**	**223**	**231**	**241**	**242**	**300**	**311**	**321**	**330**	**500**	**tot**
100	*0.9*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*1.4*
211	*1.1*	*13.1*	*0.1*	*0.0*	*0.7*	*0.4*	*0.7*	*0.4*	*0.3*	*4.5*	*3.9*	*0.2*	*0.7*	*0.1*	*0.1*	*26.3*
212	*0.4*	*2.5*	*0.0*	*0.5*	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.3*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*4.0*
213	*0.0*	*0.0*		*0.3*		*0.0*	*0.0*	*0.0*		*0.0*	*0.0*	*0.0*		*0.0*	*0.0*	*0.4*
221	*0.3*	*0.5*	*0.0*	*0.0*	*0.6*	*0.1*	*0.3*	*0.0*	*0.0*	*1.1*	*0.4*	*0.0*	*0.0*	*0.0*	*0.0*	*3.3*
222	*0.2*	*0.3*	*0.0*	*0.0*	*0.1*	*0.3*	*0.3*	*0.0*	*0.1*	*0.5*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*1.8*
223	*0.2*	*0.2*	*0.0*	*0.0*	*0.1*	*0.1*	*1.4*	*0.0*	*0.1*	*0.6*	*0.4*	*0.0*	*0.0*	*0.0*	*0.0*	*3.3*
231	*0.3*	*0.7*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.3*	*0.0*	*0.6*	*1.1*	*0.2*	*0.1*	*0.0*	*0.0*	*3.5*
241	*1.3*	*5.8*	*0.0*	*0.0*	*0.3*	*0.2*	*0.6*	*0.1*	*0.2*	*3.6*	*1.4*	*0.1*	*0.1*	*0.0*	*0.0*	*13.8*
242	*0.1*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.2*	*0.0*	*0.0*	*0.2*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.8*
300	*0.2*	*0.8*	*0.0*	*0.0*	*0.1*	*0.0*	*0.1*	*0.2*	*0.0*	*1.2*	*13.4*	*1.3*	*0.5*	*0.1*	*0.1*	*17.9*

311	*0.0*	*0.0*		*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.1*	*0.6*	*0.7*	*0.0*	*0.0*	*0.0*	*1.5*
321	*0.3*	*2.2*	*0.0*	*0.0*	*0.1*	*0.1*	*0.2*	*0.3*	*0.1*	*1.4*	*10.3*	*0.2*	*3.0*	*0.5*	*0.2*	*18.8*
330	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.7*	*0.0*	*0.2*	*1.1*	*0.0*	*2.2*
500	*0.0*	*0.1*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.0*	*0.8*	*1.0*
tot	*5.5*	*26.4*	*0.2*	*1.0*	*2.1*	*1.3*	*3.9*	*1.4*	*0.8*	*14.4*	*32.5*	*2.9*	*4.6*	*1.8*	*1.3*	*100.0*

Tab. A.3. LULC and qualitative potencial ES values matrix.

Cod	F1	F2	F3	F4	F5	F6	F7	F8	R1	R2	R3	R4	R5	R6	R7	R8	R9	C1	C2	C3
111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
122	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
123	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
124	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
141	0	0	0	0	0	0	0	0	1	2	2	1	1	0	1	1	1	1	2	0
142	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
211	3	2	1	0	0	1	1	0	1	1	1	0	0	1	1	0	0	1	0	0
212	3	1	0	0	0	1	1	0	1	2	1	0	0	1	1	0	0	1	0	0
213	3	0	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	1	0	1
221	3	0	0	1	0	0	0	0	1	1	1	0	0	1	1	0	0	2	1	1
222	3	0	0	2	0	0	0	0	2	2	1	1	1	1	3	0	0	2	1	1
223	3	1	0	2	0	0	0	0	1	1	1	1	1	1	1	0	0	2	3	2
231	1	3	3	0	1	0	0	0	1	1	1	0	2	1	3	1	2	2	2	1
241	3	2	1	0	0	0	0	0	1	1	1	0	1	1	2	0	0	1	1	0
242	2	2	1	0	0	1	1	0	1	1	1	0	2	1	3	1	1	1	1	0
243	2	2	2	2	2	1	1	0	2	2	1	1	2	1	2	2	2	2	1	1
244	2	2	1	2	1	0	0	0	1	2	1	1	2	1	2	1	1	1	1	0
311	0	1	2	3	3	2	2	1	3	3	3	3	3	3	3	3	3	3	3	3
312	0	1	2	3	3	2	2	1	3	3	3	3	3	2	3	3	3	3	3	3
313	0	1	3	3	3	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3
321	0	3	3	0	2	3	3	0	2	1	2	3	3	1	3	2	3	3	3	3
322	0	1	3	1	1	1	1	0	2	2	2	3	2	2	2	1	3	2	3	1
323	0	1	1	1	1	2	2	0	1	1	1	1	2	1	2	2	3	2	1	1
324	0	1	2	1	1	2	2	0	1	1	1	1	2	2	2	2	3	2	1	2
331	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	1	3	3	2
332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
333	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0
334	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
335	0	0	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	3	3	2
411	0	1	1	1	0	0	0	0	1	1	3	3	0	1	1	1	2	2	1	1
412	0	0	0	0	0	1	1	0	3	3	3	3	0	2	1	1	2	1	1	1
421	0	0	1	0	0	0	0	0	1	2	0	1	0	1	0	0	2	1	1	1
422	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
423	0	0	1	0	0	0	0	0	1	1	0	0	0	0	0	0	1	2	2	1
511	0	0	2	0	0	0	0	3	0	1	3	2	0	1	0	0	3	3	3	2
512	0	0	2	0	0	0	0	3	1	1	3	1	0	2	0	0	3	3	3	3
521	0	0	3	0	0	0	0	0	1	1	0	0	0	1	0	0	3	3	3	3
522	0	0	3	0	0	0	0	0	1	0	0	1	0	2	0	0	2	3	2	2
523	0	0	3	0	0	0	0	0	2	2	0	0	0	0	0	0	2	3	3	2

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Research Article

The role of diversification in the revenue composition of Italian farms

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Abstract. The main aim of this paper is to analyse the evolution, patterns and models of revenue diversification in Italian agriculture in different contexts and for different typologies of farms. The analysis is based on the calculation of the inverse of Herfindahl index, by using different variables available in the Italian FADN database (years 2008, 2013 and 2018), followed by a multiple regression model to analyse the relationship between the diversification index and other variables, in order to highlight both the internal and external factors affecting on-farm diversification processes. The article shows that Italian farms have increasingly adopted non-agricultural revenue diversification strategies to reduce risk and maximize factors' productivity. Among these, agritourism is by far the most relevant; however, in the last few years the production of renewable energy has been growing relatively rapidly. Overall, the study shows that on-farm diversification activities can be either an opportunity for a new entrepreneurship in agriculture or a survival strategy for small and marginal farms that are not sufficiently integrated in the national agri-food system.

Keywords: farm revenues, on-farm diversification, FADN, Herfindahl index.
JEL codes: Q12.

1. INTRODUCTION

The literature on entrepreneurship generally agrees on the economic and social value of a certain degree of revenue diversification (Frumkin and Keating, 2011). Scholars consider multiple sources of business funds, and even a sound combination of earned income and public support, as a rational way to reduce the risk of financial exposure, heavy dependence on one specific activity and income decline. This is particularly relevant in agriculture, where farms are small in both economic and physical terms and revenues depend on many natural and external factors, reducing the possibility of control by farmers (Bowler *at al.*, 1996; Mishra *et al.*, 2004; Salvioni *et al.*, 2020). The Agenda 2000 reform of the Common Agricultural Policy (CAP) was the first EU document to set the bar for the recognition of multifunctional agriculture and the policy tools aimed at enhancing the co-joint production of public and private goods (Commission of the EC, 2000). As a consequence of the abandonment of the productivism paradigm in agriculture and the boost to the multifunctional potential of farms, diversification has become a key strategy adopted by an increasing number of farmers in both developed and developing countries to strengthen farm resilience (Darnhofer, 2010; Wan *et al.*, 2016), increase income and improve market access (Barnes *et al.*, 2015; Barret *et al.*, 2001; Fischer *et al.*, 2012; Markelova *et al.*, 2009). Within the large body of literature on the topic, different definitions of diversification can be identified. Processes leading to diversification are investigated as new challenges and opportunities for farmers, and a diversified enterprise has included, amongst others, the introduction of innovative farming practices, but also non-agricultural activities such as direct marketing, recreational activities and tourism, subcontracting and machinery rental, and so on (Barbieri, Mahoney, 2009).

In this study, the concept of diversification is investigated in a two-step process. The first step looks generically at the diversification of the revenue sources (as opposed to farm and income specialisation). The concepts of specialisation and diversification of revenue sources - which include livestock revenue, crop revenue, insurance revenue, public support and other gainful activities - is a key aspect to increase the understanding of farm business and related risk management strategies, also for its policy implications (Hadrich, 2013). This concept should not be confused with pluriactivity, which includes off-farm work as "diversified sources of income"; on the contrary, the concept of diversification of revenues focuses on multiple income generated within a single business (Hansson *et al.*, 2010).

The second step, in line with the majority of recent studies, limits the concept of diversification to gainful activities outside the range of conventional crop and livestock production. On-Farm Diversification (OFD) in non-agricultural activities has been increasingly recognised as a successful business strategy in which a farmer produces non-agricultural goods and services by employing farm resources (capital, labour and land), with the aim of selling them on the market (Dries *et al.*, 2012; Ilbery, 1991; Boncinelli *et al.*, 2017).

The main objective of this paper is to analyse the evolution, patterns and models of diversification in Italian agriculture in different contexts and for different typologies of farms, building on the two different diversification steps described above (e.g., diversification of revenues and OFD activities). The two steps of analysis are reflected in two different methodological tools: calculation of the inverse of Herfindahl index, followed by an Ordinary Least Squares (OLS) regression model.

In particular, the paper proposes an innovative use of the inverse of Herfindahl index, which was used to identify the different sources of farm revenues in Italy over a decade (2008, 2013 and 2018). To our knowledge this is the first attempt to use this index to calculate revenue diversification at farm level. In a subsequent step, the regression model allowed farm revenues to be decomposed into their individual components (product sales, policy support, self-consumption, agritourism, machinery hire, contract labour, active rent, renewable energies), in order to better understand the role played by the single OFD activities in the revenue composition.

Results show that Italian farms have increasingly adopted revenue diversification strategies to reduce risk and maximize factors' productivity. OFD activities have become an important component of revenues and could also be one of the main reasons why small farms resist dismantling and abandonment of activities, thanks especially to the public financial support targeted to OFD. These farms found a new *reason d'être* in the multifunctional paradigm and the realization of goals that pursue different dimensions of sustainability: economic (income generation), social (labour allocation) and environmental (resource management).

The rest of the paper is organised as follows. The next section provides the background of the study, including relevant definitions and a short review of the literature highlighting the scientific and policy relevance of income diversification patterns in EU agriculture. The third section describes the data and the two-step method used for the analysis of farm revenues and OFD activities, followed by a section showing the main results. The final section discusses conclusions and policy implications.

2. BACKGROUND

Farm diversification can be defined as the generation of an income portfolio from activities with different degrees of risk, expected returns, liquidity and seasonality, thanks to which farmers accordingly adjust their input allocation and output mix (Delgado, Siamwalla, 1997). The main effect of diversification would be the allocation of household productive assets among different gainful activities. The attention and development of farm diversification is a consequence of the crisis of the main productivist paradigm dominating up to the 1980s. That crisis related to an unsustainable model of standardised and overspecialised production that led to a structural crisis of the whole agri-food system, including the mechanisms of EU support and dominant models of consumption (Ortiz-Miranda *et al.*, 2013; Wilson, 2007). The constant decline of agricultural process and revenues pushed towards new internal strategies to differentiate products and collocation of the available inputs in the productive processes of farms. Building on the traditional multi-product family farm model, farm diversification became the new goal of agricultural entrepreneurs and the model explicitly supported by the EU with the reformed CAP. The underlying idea is that there are relevant benefits from the distribution of risk among different processes and products, exactly like in small and medium non-agricultural businesses, based on scope economies (Lin, 1974; Chavas, 2001; Pilati, Boatto, 1999; Fernandez-Cornejo *et al.*, 1992; Henke, Salvioni, 2011).

Building from this body of literature, in the following years the concept of diversification has been extended to other activities developed alongside agricultural products or the allocation of inputs in other gainful non-agricultural activities. On this issue, a systematic classification work had been carried on by van der Ploeg and Roep (2003), which became a key reference in future analysis of on-farm diversification in non-agricultural activities (OFD). Following them, OFD may be grouped in *deepening* and *broadening*: while *deepening* includes activities related to vertical integration of processing and marketing along the food chain, *broadening* covers diversification activities not directly connected to physical agricultural production but to agricultural resources, such as subcontracting, renewable energy production, tourism, educational and recreational activities.

Both *deepening* and *broadening* activities can be adopted for different reasons: while in many cases diversification is the consequence of a new skilled generation of entrepreneurs who look at on-farm business opportunities (Weltin *et al.*, 2017; Forleo *et al.*, 2021), in other cases OFD can be considered a survival strategy for small farms that are seeking to escape from stagnation and decline (Meert *et al.*, 2005; Balázs *et al.*, 2009; Khanal, Mishra, 2014).

Looking at the role of policies, in the European Union the 1992 MacSharry reform of the CAP constituted a major step in shifting the support of farm incomes from products (through prices) towards producers (through direct payments). However, it was especially with Agenda 2000 that reforms increasingly coupled support to specific objectives and functions, opening the way to the multidimensional concept of sustainability, which deals contemporarily with economic, social and environmental issues connected to the process of development and growth (Giovannoni, Fabietti, 2013). In this regard, it may be argued that OFD is also the result of policies that support patterns of new on-farm development, enhancing both internal and external factors that drive, directly and indirectly, the diversification process (Boncinelli *et al.*, 2017; Morris *et al.,* 2017; De Rosa *et al.*, 2019). Indeed, diversification is one of the expected outcomes of public policies that are adopted to foster structural change, as well as to improve the contribution of the farming sector to the growth of the entire economic system (Syrquin, 1988; Timmer, 1997).

Since diversification processes are highly dependent on the effective implementation of public support and, above all, on investments in innovative technologies, the result of the diversification process is heavily affected by a country's specific macroeconomic and institutional conditions. Consequently, analysing diversification is also a way to test the effectiveness of a good part of the policy tools of the most recent CAP programming periods.

In Europe, OFD is also becoming a central point in the body of literature on agricultural and rural economics, for many reasons. Firstly, it helps to explain the heterogeneity of farm structures and the persistence of small farms that were supposed to disappear with the ongoing development process (Meert *et al.,* 2005). Secondly, OFD has been one of the key elements that has contributed to the shift from a sectoral to a regional and rural development perspective on farming (Marsden, Sonnino, 2008). Thirdly, there has recently been increasing attention on the entrepreneurial skills required by diversified farming, which in many cases could be different from those required in conventional farming (De Rosa *et al.*, 2019; Dias *et al.,* 2019), and this may also result in tensions between maintaining a focus towards on-farm activity or pursuing entrepreneurial diversification (Morris *et al.*, 2017). All these factors, together with the development of policies targeted to OFD, have contributed to the theory of transition in terms of multifunctional agriculture and the shift towards a post-productivism paradigm, in which diversification is opposed to specialisation and "monofunctionality" (Wilson, 2007).

As mentioned above, OFD can be considered the result of a switch in the main paradigm driving change in agriculture and rural areas, with the rising post-productivist paradigm focusing on the concept of multifunctionality of agriculture and being based on a spectrum of activities in which farmers get involved to different extents. Indeed, OFD becomes the most evident realization of the multifunctional model of agriculture within a post-productivist paradigm, generating a new role for the primary sector in society and new productive functions that support and stabilise farmers' income (Henke, 2004; Bianchin, Galletto, 2009; Salvioni *et al.*, 2020).

However, what we referred to as the entrepreneurial model as well as the survival model do not compete but rather coexist in European contexts, as well as in other developed environments (Wilson, 2007). These are not alternative and opposing diversification models but rather coexist and make the phenomenon of diversification even more complex.

Italy is a particularly suitable case to represent the coexistence of these different models, since its farming sector is characterized by very different agricultural structures, often associated to different economic, social and environmental functions (Henke, Salvioni, 2008). According to the official statistics and recent analyses, in Italy OFD activities represent a still small but rapidly growing share of total farm income, and often offer job opportunities to the family members of the entrepreneur and also to other skilled non-agricultural workers. Over the period 2010-2019, diversification activities represented about a fifth of the total economic value of agriculture in Italy, playing an important role in stabilising the relative weight of the agricultural sector on the national economic system (CREA, 2020). Among the large body of literature on diversification in Italy, only a few studies have investigated the economic and financial effects of diversification at the national scale (Salvioni *et al.*, 2013 and 2020).

3. DATA AND METHODS

The analysis of revenue diversification of Italian farms is based on set of variables from the Italian Farm Accountancy Data Network (FADN), concerning the 2008, 2013 and 2018 accounting years. The selected years allow the evolution of the different factors to be explored over a decade and cover different socio-economic and policy conditions (e.g., the decade 2008-2018 involved two EU Common Agricultural Policy (CAP) programming periods, 2007-2014 and 2014-2020).

The FADN is a European system of sample surveys that take place each year to collect structural and accountancy data of farms. Its main role is to provide monitoring of farm income and commercial activities and assess the impacts of the CAP, through farm-level analyses based on harmonized microeconomic data. The field of observation of FADN are commercial farms, namely those that are large enough to provide a main activity for the farmers and a level of income sufficient to support their families. In practical terms, in order to be classified as commercial, a farm must exceed a minimum economic size, that for Italy corresponds to 8.000 euros of Standard Production. In accordance with EU guidelines, the stratification adopted in the sample design is carried out according to three main dimensions: geographical region, economic size and type of farming.

The final dataset includes 32,960 farms (11,293 in 2008, 11,379 in 2013 and 10,288 in 2018). We selected all FADN farms located in the Italian national territory. Although panel analyses work particularly well with multiple-topic, multiple-year data, since the FADN farms sample has an annual rotation of around 20-25%, in this study it was not possible to use a panel for the examined time and we opted for a multiple linear regression on cross-section data.

With regards to the geographical distribution of the sample, farms are mainly located in the north of Italy (45%), followed by the south (35.9%) and the centre of the country (19.1%). The average farm size is 34 hectares of Utilised Agricultural Area (UAA), and average farm economic outputs are: 149,582 euros of total outputs and 57,750 euros of net income. As regards the socio-economic profile of farmers, the average age is 55 years, and they are mostly male (81.7%).

The evolution, patterns and models of diversification were analysed through a two-step method: calculation of the inverse of Herfindahl index (D_{ft}), followed by an Ordinary Least Squares (OLS) regression model.

In the first step, the inverse of the Herfindahl index (HI) was used to measure the diversification of farm revenues, in order to evaluate the contribution of each activity to total farm revenues (Dimova and Sen, 2010). This can be considered as a rather innovative use of the HI, since in agricultural studies HI (or its inverse) has traditionally been used to analyse products concentration in the market (Garcìa-Cornejo *et al.*, 2020; Yoshida *et al.*, 2019) or for the diversification of crops and activities at the farm level (Pope and Prescott, 1980; Li *et al.*, 2016).

HI is calculated for each farm as an index of revenue specialisation:

$$R_{it} = \frac{A_{it}}{\sum A_{it}} \quad (1)$$

$$H_{ft} = \sum R_{it}^2 \quad (2)$$

In equation (1) A_i is the revenue of activity I and $\sum A_i$ is the sum of farm revenues. Thus, R_{it} is the share of revenue i in total farm revenues in time t. In equation (2), H_{ft} is the Herfindahl index for farm f in time t, calculated as the sum of farm revenues share squared. The types of farm revenues included in the index are product sales, policy incentives, subcontracting, agritourism, energy production, other *broadening* and *deepening* activities. Because this study examines revenue diversification, the Herfindahl concentration/specialisation index is inverted to formulate a diversification index:

$$D_{ft} = 1 - H_{ft} \quad (3)$$

Where D_{ft} is the level of revenue diversification of farm *f* in time *t* and ranges from 0 to 1: larger values denote higher degree of revenue diversification; lower values indicate greater concentration of revenues.

As for the second step, we aimed at detecting and measuring in a more sound and detailed way the structural and economic factors that have pushed farms towards the diversification of revenues, in order to better capture the role played by the single OFD activities in the revenue composition. For this objective, an ordinary least squares regression model was implemented by carrying out a multiple correlation for the calculation of the parameters.

The regression model utilised may be appropriately represented mathematically using the straight-line equation, in order to obtain the operational formulas for estimating the parameters. The relationship between the explanatory variables and the dependent variable can be written as:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_n X_n + \varepsilon_i$$

in which the parameters β_i will have to be estimated. For this purpose, it is necessary to observe the explanatory variables and dependent variable on a sample of *n* observations.

The coefficient for each independent variable reflects both the strength and type of relationship with the dependent variable, including the concordance of signs.

In our study the multiple regression model was used to analyse the relationship between the inverse of the Herfindahl index and the other variables, with the overall objective of identifying and measuring the key factors affecting the farm diversification of revenues over time.

For this purpose, the level of revenue diversification (D_{ft}, i.e. the inverse of the Herfindahl Index) was used as dependent variable (assessed at farm level for all types of farms), while covariates (independent variables[1]) include variables related to the socio-economic profile of farmers (education, age and sex), structural features of farms (type of farming, economic and physical size, location, labour use, etc.), and policy support (direct payments, RDP payments). To fully understand the role of OFD activities, as well as the role of both internal and external drivers on the dependent variable, in the regression model farm revenue was decomposed into its individual components, used as covariates: product sales, policy support (direct payments), self-consumption, agritourism, machinery hire (contract services), active rents, renewable energies'.

[1] See the Annex (Tab. A.1.) for a full description of the variables used in the regression models.

To address the potential for heteroskedasticity, multicollinearity and endogeneity of the estimated regression models, the results were subjected to validation and verification tests. In particular, the White and Breuch-Pagan tests were used for heteroskedasticity. To consider multicollinearity, the variance inflation factor (VIF) was calculated for each of the independent variables. Finally, to address potential endogeneity, we used the RESET-Ramsey test, which is a general specification test for the linear regression model. With regard to distribution of the residues, the appropriate tests were performed (Testuhat–- residual normality). The results of the multi-collinearity assumption test (VIF value of the coefficients) on the model show that there is no correlation between the coefficients in the different estimated regression models (multi-collinearity does not occur). Furthermore, the assumption tests on heteroskedasticity (White test and Breuch-Pagan test) show that the models are free from heteroskedasticity. The results of the assumption test on the residual model (Testuhat– residual normality) shows that the residuals are not normally distributed[2].

4. RESULTS

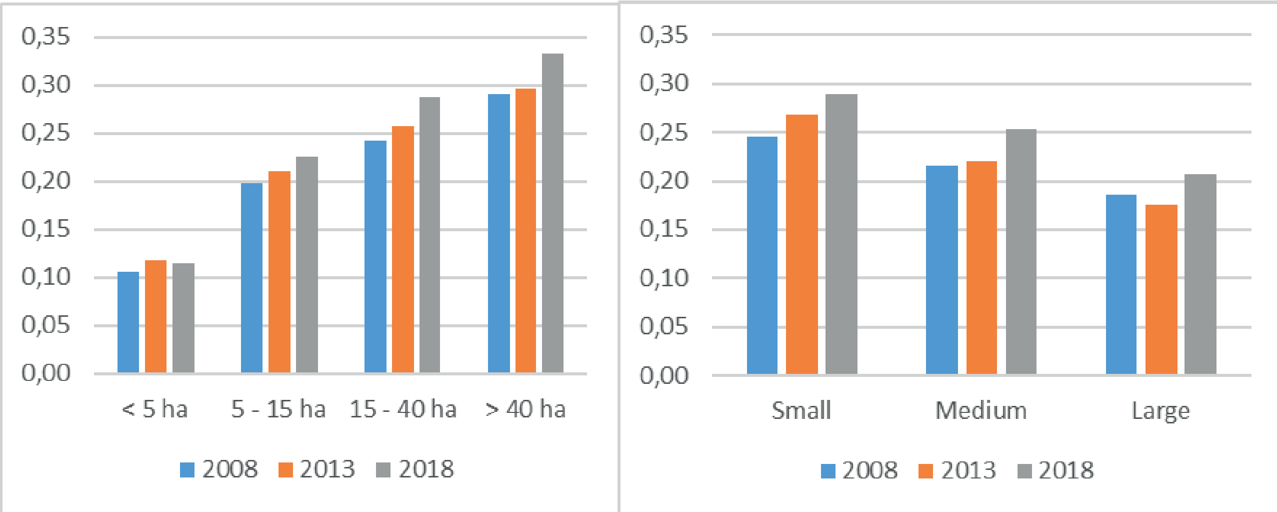
The descriptive analysis of the trend of the diversification index (D_{ft}) over the study period provides interesting insights into the level of revenue diversification on Italian farms. First of all, at national level the average value of the index shows a slight increase from 2008 (0.21) to 2013 (0.22) and a more consistent one in 2018 (0.25). This trend shows that Italian farms have increasingly adopted revenue diversification strategies to reduce risk and maximize factors' productivity.

Secondly, a more careful analysis of the index according to the different structural features of farms and their location provides an interesting overview of both the internal and external drivers that may have affected revenues diversification processes.

Regarding internal drivers, a relevant result is related to the observed values and trends of the diversification index according to both the physical and economic size of farms (Fig. 1). When looking at the relations with agricul-

[2] In particular, the results of this test indicate that the errors tend to be distributed according to a frequency curve with a flattened distribution (or a little pointed - platykurtic distribution) where the kurtosis is very low (negative means that we have light-tails) while the asymmetry takes on a positive value. However, this is acceptable given that the FADN data are representative (the farms are randomly selected from the field of observation), they do not include the micro farms (below 8 ESU) and the sample design is carried out with the rotating panel technique which, however, could lead to a certain discontinuity in the observations.

Fig. 1. Diversification index according to physical and economic size* of farms.



*Small: Standard Output (SO) < € 25K; Medium € 25-100K; Large > € 100K .

tural area, D_{ft} is consistently higher for larger farms compared to smaller ones, while an opposite trend is observed in relation to the economic size, indicating that the diversification of revenues characterises mainly farms with larger agricultural area and with smaller economic size.

To some extent this evidence can be better explained when looking at the diversification index in relation to farm specialisation (Fig. 2): lower values of the index are observed for farm specialised in horticulture, permanent crops and granivores. Traditionally these sectors are characterised by rather specialised practices with smaller areas but larger economic size and, compared to other sectors, direct payments play only a limited role in sustaining their income (EC, 2021). The lower support from direct payments may have affected the diversification index, which includes policy support. On the contrary, Italian farms with mixed production systems and arable crops are traditionally characterised by lower income and higher policy support (CREA, 2021): both factors may have played a role in determining a higher diversification index for these sectors, which are also characterised by farms with larger agricultural areas.

With regards to other farm features observed in the analysis, it is worth mentioning that the diversification index does not show relevant differences according to the age groups of farmers. On the contrary, significant differences are observed between conventional farms (0.20 in 2008; 0.21 in 2013 and 0.23 in 2018), and organic farms (0.32 in 2008; 0.28 in 2013 and 0.30 in 2018), confirming that households with organic production are most likely to diversify activities and revenues (Weltin *et al.*, 2017; Weltin *et al.*, 2021).

When looking at the external drivers potentially affecting the diversification of revenues, it may be observed that the average values of the index vary to a large extent according to the Italian macro-regions and to area typologies (Fig. 3). The higher values observed in central and southern regions of Italy, as well as for intermediate and less favoured areas, confirm that revenue diversification strategies are adopted more in extensive and less specialised farming systems. The significant increase of D_{ft} experienced by farms located in such areas in 2018 is also worth observing. This highlights that revenue diversification could be increasingly adopted as a resilience strategy against income stagnation, especially for farms that are not sufficiently integrated in the national agri-food system and/or located in the most marginal and remote areas.

As shown in section 3, a multiple regression model was adopted in order to better identify the key factors that, to a varying degree and in different ways, manifest their influence on the formation of the diversification index.

The coefficients estimated for the three regression models show a slight difference over time and also that the models obtained are satisfying (see the Annex for additional details on the results and validation and verification tests of the regression models).

The key results of the models are included in Table 1, which shows only the variables that have a maximum level of statistical significance equal to 5%. Other covariates, however, were statistically significant but at a level higher than 5% (e.g., type of farming, presence of machinery, presence of livestock) and were excluded from the analysis.

Fig. 2. Diversification index and farm specialisation.

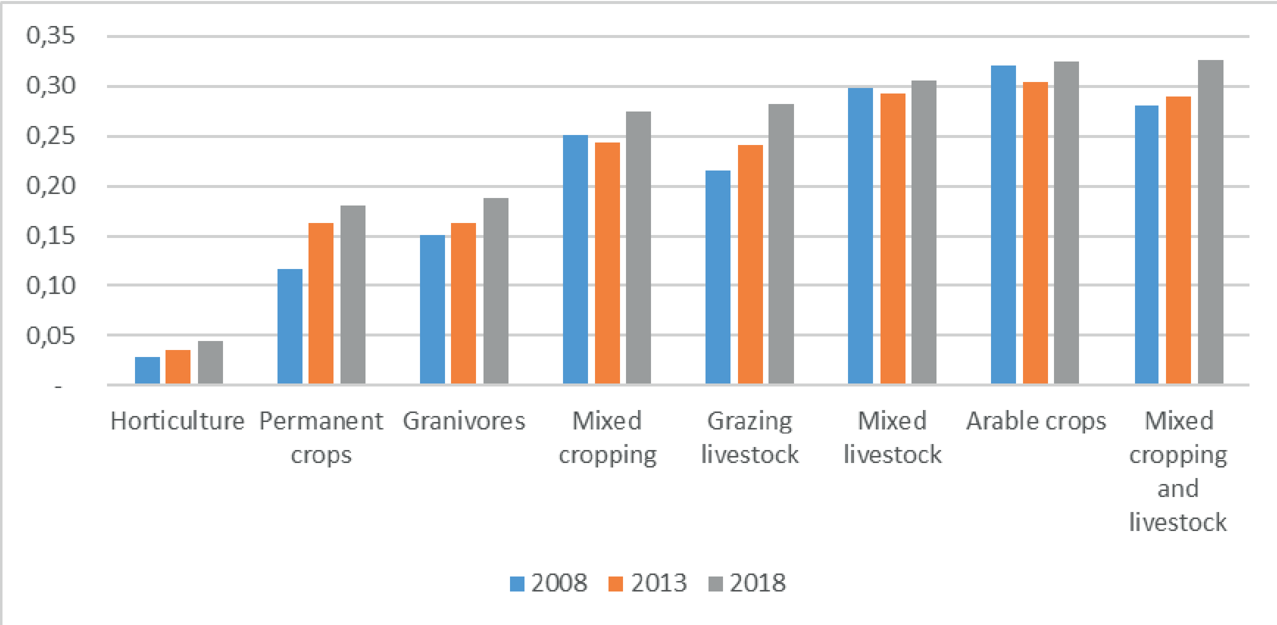
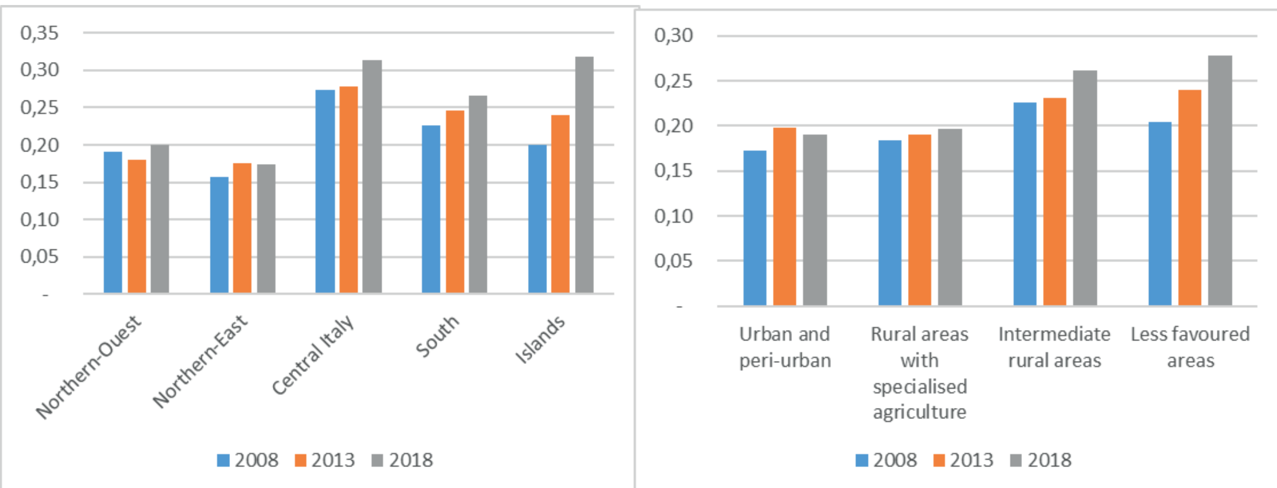


Fig. 3. Diversification index according to Italian macro-regions and area typologies.



Looking at the significant covariates, all the signs of the estimated coefficients are highly significant and consistent with expected results. The only exception is the labour employed, which shows a negative sign in relation to the diversification index. This could be explained by the higher availability of labour for large farms that, as highlighted in the descriptive analysis above, generally diversify their revenues less. To some extent, this value is also in line with the results of Giaccio *et al.* (2018a), who analysed the income sources of Italian agritourism and showed that related income decreases significantly as the number of family members employed on the farm increases.

The regression model confirmed that the structural and economic features of farms played an important role in the farmer's revenue diversification process. Among these variables, the UAA and economic size are significant, even if with an opposite sign, confirming that the diversification of farm revenues increases with the availability of agricultural areas, but decreases as

Tab. 1. The OLS regression results[1].

Coefficients	2008	2013	2018
Const	0,240	0,173	0,206
Geographical area	0,0145	0,017	0,0259
Altimetry	-	0,016	0,0062
Utilised Agricultural Area	0,0006	0,00062	0,00083
Economic size group	- 0,0262	- 0,031	- 0,031
Farm management	- 0,0267	- 0,0183	- 0,0202
Legal Form	-	-	- 0,0047
Type of farming (TOF)	- 0,0030	-	-
Farmer's age	0,00037	0,00054	0,00035
Farmer's gender	0,007*	-	-
Farmer's education level	0,0043	0,0057	0,0035
Level of farmer's engagement	0,0032**	-	-
Farmer's professional conditions	-	-	0,00262
Family work units	- 0,0167	- 0,0062	- 0,0144
Products sales	-	- 1,0936	- 6,2657
Policy support (Direct payments)	1,0381	1,2443	1,1976
Self-consumption	1,2366	2,2012	2,7338
Agritourism	9,0035	1,9581	8,9519
Hire of machinery (contract labour)	2,6674	5,2147	2,4155
Active rent	4,7220	4,9022	-
Renewable energies	-	-	1,0828
Obs.	11.293	11.379	10.288
R^2	0,182698	0,279362	0,276064
F stat	168,056	314,6681	244,7947

Significance: * = 10%; ** = 1-5%; Others = 1%.
[1] A detailed description of variables and additional details on the regression models results are included in the Annex.

the economic size of farms grows. Among the economic variables, the study shows the positive influence of policy support (direct payments), which is one of the key determinants of revenue diversification in all three years under study.

Regarding the single OFD activities, results show that their influence on farms' revenues is significant and relevant, especially for the traditional diversification activities such as agritourism, hiring of machinery (contract labour) and active rent. Particularly high values were observed for agritourism (especially in 2008 and 2018), confirming that it is one of the most important OFD strategies in Italy. Indeed, agritourism plays a central role for the economic development and wellbeing of rural areas in Italy (Lupi *et al.*, 2017; Santucci, 2013), also as the result of a generous policy support (second pillar of the CAP) that has mainly been provided to small and medium-sized farms with tourism activities and located in disadvantaged areas (Giaccio *et al.*, 2018b).

Amongst the other OFD activities, it is worth mentioning that in the last year under review (2018) renewable energy also become statistically significant. Unlike agritourism, the focus on renewable energy as a form of farm diversification has seen little research: additional evidence would be necessary to explore its role in sustaining farming incomes, as well as on the role of policy support in the adoption of income diversification strategies based on renewable energy production (Morris and Bowen, 2020). Results also reveal that some farmer characteristics (i.e., age, gender, education level, major occupation, engagement level, professional conditions) had positive coefficient and were statistically significant but with a very low margin value, suggesting that they are almost completely negligible in influencing the farmer's revenue diversification process.

Overall, the main results of this study showed that both internal and external factors are driving the level and intensity of revenue diversification in Italy, and that their importance and predominance depend on structural features of farms as well as on their geographical location. Supporting policies were identified as a factor that always appeared important, regardless of the size, specialisation, and location of farms, highlighting the key role played by the CAP in supporting farming diversification processes over the last decade.

5. CONCLUSIONS

In this study we adopted a two-step method to describe the evolution, patterns and models of revenue diversification in Italy and to analyse, amongst others, the role played by OFD activities. To accomplish the above objective, we used a nation-wide sample of agricultural holdings based on FADN data.

Overall, the key results confirm the trend identified by official statistics on agriculture (CREA, 2020): OFD activities have become an important component of revenue sources for Italian farms, which have increasingly adopted revenue diversification strategies to reduce risk and maximize factors' productivity.

The analysis of revenue diversification through the Inverse of Herfindal Index showed a widespread and growing share of revenues generated by non-agricultural activities on Italian farms. Such activities are relevant in all farm typologies, probably fulfilling different needs and goals, although higher and increasing values are mainly observed in the most extensive farming systems (mixed farming) located in the central and southern regions of the country and in less favoured areas, confirming that diversification could also be a relevant strategy to avoid dismantling and abandonment of farming.

The descriptive analysis based on the Inverse of Herfindal Index was complemented with a regression model that enabled us to provide additional evidence on the drivers that may affect revenue diversification – and in particular OFD activities – including *internal drivers* (structural aspects and key features of the entrepreneurs such as farm size, economic outputs, age and gender of farmers) and *external drivers* (socio-economic and territorial aspects such as regions, typologies of rural area, altimetry). Results confirm that OFD represent a significant (and growing) share of farm revenues, although with consistent differences amongst farms with different structural features. Data show that diversification strategies are mainly adopted by farms with large agricultural areas and small economic size and that amongst the different OFD activities agritourism – and more recently the production of renewable energy – are giving a substantial contribution to the revenue diversification strategies of Italian farmers.

To some extent the study also confirms the increasing heterogeneity and complexity of different farm structures, which should be better analysed through methods and tools for measuring income but also for evaluating policies (Finger, El Benni, 2021). In relation to the diversification patterns, it is increasingly evident that the coexistence of different agricultural models, with different functions, priorities and organisational structures, call for more effective and targeted policies: a new generation of tools able to address the specific issues and guide the sustained growth of OFD. The call for more targeted and selective policies has been more evident from Agenda 2000 onwards, with the two pillars and institutionalisation of the multifunctional role of agriculture. More recently, both the renewed role of Member States in the CAP implementation and the "new delivery model" have largely opened the way to specific tools in the policy box that enhance OFD activities and set new priorities in the overall support for agriculture and rural areas (Erjavec, Erjavec, 2021; Rac *et al.*, 2020).

The process of OFD could also play a significant role in helping the small-scale agricultural sector to meet the ambitious goals set in the Farm to Fork strategy and, to some extent, the new Green Deal. There is, in fact, a *fil rouge* connecting the diversification of activities in agriculture and rural areas with the overall sustainability of the primary sector, including an enhanced provision of public goods and a reduced and more efficient consumption of natural resources. On this matter, Italy is a very relevant example of differentiated agricultural activity where different models coexist and where farms provide a large set of services, both private and public, meeting the growing demand from citizens for a new role of agriculture and rural areas in contemporary society (Gargano *et al.*, 2021; Mazzocchi *et al.*, 2020).

Further studies could provide additional evidence and more details on trends and patterns of farms revenue diversification in Italy and in other countries, also by addressing some limitations of this study, including the lack of continuity of data over time, and the use of a single database for the analysis. Indeed, while the use of FADN data allowed the internal drivers affecting diversification processes to be explored in detail, an integration with external datasets would be very useful to better capture the external drivers, such as the socio-geographical environment as well as the role played by national and regional institutions and policies in influencing the composition and evolution of farms' revenues. In this regard, the current initiative of converting the FADN into FSDN (Farm Sustainability Data Network) represents a very good opportunity not only to expand the scope of the current network with additional data on the environmental and social practices, but also to improve our understanding on features and development of diversification processes. This new data collection process could also improve the comparability of sustainability performance of different farming systems (including economic performance and income-related issues), as well as better support evidence-based policy making and monitoring, in line with the Farm to Fork strategy objective as well as for future revisions of the CAP.

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APPENDIX

Tab. A.1. Description of the variables used in the regression models.

Variable	Description
Diversification	Inverse of Herfindahl index. Degree of diversification of farms
Geographical area	Localization of farms: North-east, North-west, Centre, South, Islands
Altimetry	Breakdown of farms according to altitude: mountains, hills, plains
Utilised Agricultural Area	Area used for farming in hectares
Economic size group	Economic size of farms, measured in terms of Standard Output
Management	Type of farm management
Legal Form	Type of legal form of the farms (e.g. individual, cooperative)
Type of farming (TOF)	Production specialization of farms
Age	Farmer's age, in years
Gender	Farmer's gender (male, female)
Education level	Farmer's education level
Engagement	Level of farmer's engagement in the farm activity
Professional conditions	Farmer's professional conditions
Family work units	Family workers employed on the farms
Products sales	Gross saleable crop/livestock production
Policy support (Direct payments)	Public support received by farms, in euros
Self-consumption	Value strictly related to the production self-consumption (euros)
Agritourism	Revenues strictly related to the agritourism activity (euros)
Hire of machinery (contract labour)	Revenues strictly related to machinery hire activity (euros)
Active Rent	Revenues strictly related to the active rent activity (euros)
Renewable energies	Revenues strictly related to the renewable energies activity (euros)

Source: Own definitions based on FADN data.

Tab. A.2. Descriptive statistics for dependent variable.

	Diversification		
	2008	2013	2018
Mean	0.21	0.22	0.25
Maximum	0.77	0.76	0.78
Minimum	0.00	0.00	0.00
Std. Dev.	0.18	0.18	0.18
N. Obs.	11,388	11,379	10,288

Source: Own calculation based on FADN data

Tab. A.3. The OLS regression results; year 2008.

	Coefficient	Std. Error	t-statistic	p-value	
const	0.239675	0.012	19.34	<0.0001	***
Geographical area	0.0145160	0.001	11.36	<0.0001	***
Economic size group	−0.0262408	0.002	−17.07	<0.0001	***
Management	−0.0266357	0.002	−14.11	<0.0001	***
Age	0.000370704	0.000	3.00	0.0027	***
Gender	0.00695094	0.004	1.65	0.0986	*
Education level	0.00431206	0.001	3.46	0.0005	***
Engagement	0.00316507	0.001	2.19	0.0284	**
Utilised Agricultural Area	0.000591496	0.000	19.67	<0.0001	***
Family work units	−0.0166712	0.002	−7.83	<0.0001	***
Policy support (Direct payments)	1.03805e-06	0.000	20.97	<0.0001	***
Self-consumption	1.23661e-05	0.000	15.64	<0.0001	***
Agritourism	9.00353e-07	0.000	10.86	<0.0001	***
Hire of machinery (contract labour)	2.66740e-06	0.000	9.62	<0.0001	***
Active Rent	4.72203e-06	0.000	6.71	<0.0001	***
Type of farming	−0.00303143	0.001	−3.71	0.0002	***
Dependent variable mean	0.21		Std. dev. dep. var.	0.18	
Square sum residues	294.77		Std. error regression	0.16	
R^2	0,18		R^2 adjusted	0.18	
F(15, 11277)	168.06		P-value(F)	0.00	
Log-likelihood	4561.68		N. Obs.	11,293	

*, **, ***: significant at 10%, 5%, 1%, respectively.
Source: Own calculation based on FADN data.

Tab. A.4. The OLS regression results; year 2013.

	Coefficient	Std. Error	t-statistic	p-value	
const	0.173163	0.011	15.80	<0.0001	***
Geographical area	0.0169781	0.001	15.32	<0.0001	***
Altimetry	0.0159210	0.002	7.88	<0.0001	***
Economic size group	−0.0308529	0.001	−22.12	<0.0001	***
Management	−0.0182764	0.002	−10.66	<0.0001	***
Age	0.000542593	0.000	4.74	<0.0001	***
Education level	0.00567173	0.001	4.83	<0.0001	***
Utilised Agricultural Area	0.000619377	0.000	20.78	<0.0001	***
Family work units	−0.00617733	0.002	−2.98	0.0029	***
Products sales	−1.09364e-07	0.000	−25.99	<0.0001	***
Policy support (Direct payments)	1.24428e-06	0.000	25.05	<0.0001	***
Self-consumption	2.20123e-05	0.000	18.10	<0.0001	***
Agritourism	1.95806e-06	0.000	15.50	<0.0001	***
Hire of machinery (contract labour)	5.21466e-06	0.000	17.66	<0.0001	***
Active Rent	4.90219e-06	0.000	7.53	<0.0001	***
Dependent variable mean	0,22		Std. dev. dep. var.	0,18	
Square sum residues	256,80		Std. error regression	0,15	
R^2	0,28		R^2 adjusted	0,28	
F(14, 11364)	314,67		P-value(F)	0,00	
Log-likelihood	5424,03		N. Obs.	11,379	

*, **, ***: significant at 10%, 5%, 1%, respectively.
Source: Own calculation based on FADN data.

Tab. A.5. The OLS regression results; year 2018.

	Coefficient	Std. Error	t-statistic	p-value	
const	0.206356	0.013	16.26	<0.0001	***
Geographical area	0.0259509	0.001	20.66	<0.0001	***
Altimetry	0.00621388	0.002	2.81	0.0050	***
Economic size group	−0.0312589	0.002	−20.06	<0.0001	***
Management	−0.0202367	0.002	−11.13	<0.0001	***
Legal Form	−0.00470425	0.002	−2.81	0.0049	***
Age	0.000350416	0.000	2.79	0.0053	***
Education level	0.00371287	0.001	2.93	0.0034	***
Professional conditions	0.00261575	0.001	4.50	<0.0001	***
Utilised Agricultural Area	0.000827093	0.000	19.00	<0.0001	***
Family work units	−0.0144318	0.002	−5.88	<0.0001	***
Products sales	−6.26566e-08	0.000	−17.44	<0.0001	***
Policy support (Direct payments)	1.19760e-06	0.000	12.28	<0.0001	***
Self-consumption	2.73387e-05	0.000	20.40	<0.0001	***
Agritourism	8.95187e-07	0.000	13.31	<0.0001	***
Hire of machinery (contract labour)	2.41550e-06	0.000	11.97	<0.0001	***
Renewable energies	1.08287e-07	0.000	3.83	0.0001	***
Dependent variable mean	0.25		Std. dev. dep. var.	0.18	
Square sum residues	245.53		Std. error regression	0.15	
R^2	0.28		R^2 adjusted	0.27	
F(16, 10271)	244.79		P-value(F)	0.00	
Log-likelihood	4616.37		N. Obs.	10,288	

*, **, ***: significant at 10%, 5%, 1%, respectively.
Source: Own calculation based on FADN data.

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Research Article

Una definizione di agricoltura sociale attraverso il metodo Delphi e l'analisi automatica dei testi

A definition of social farming using the DELPHI method and automatic text analysis

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Abstract. There are different meanings of Social Farming (SF) both in the scientific, operational and administrative world, often linked to the different contexts in which the experiences have matured. The aim of the work, carried out with the *Delphi* method, is to reach a definition of SF as shared as possible, through an organized discussion between selected experts, allowing the use of common languages in explaining the activities related to the SF.

Keywords: Social Farming, *Delphi* method, automatic text analysis.
JEL codes: C83, O35, Q18.

1. INTRODUZIONE

L'agricoltura sociale (AS) negli ultimi anni ha assunto una sempre maggiore rilevanza sia in Italia che in Europa, con diverse sfaccettature, legate alle realtà locali ed ai diversi sistemi di governance. In molte regioni italiane sono presenti, da decenni, realtà consolidate di aziende agricole e cooperative sociali che hanno realizzato progetti di agricoltura sociale, finalizzati all'inclusione di fasce deboli della popolazione, ma anche allo sviluppo delle comunità locali, verso un nuovo "modello" di agricoltura multifunzionale, generalmente a basso impatto ambientale, con una forte connotazione etica e sociale, che ha contribuito anche a definire nuovi scenari di welfare locale/rurale, con la creazione ed il consolidamento di relazioni significative tra gli attori del territorio (Giarè *et al.,* 2018; Moretti, 2020).

Diverse regioni italiane hanno normato in materia di AS e con la l. 141/2015 è stato colmato un vuoto normativo, con la presa d'atto di una realtà esistente, sistematizzando la materia. La legge ha avuto anche il merito di definire l'agricoltura sociale e di individuare i quattro ambiti nei quali tali attività si esplicano, ponendo attenzione alla tutela della persona e della sua dignità, creando quindi una sinergia virtuosa tra obiettivi economici e responsabilità sociale. L'impianto normativo regionale e nazionale, così come le politiche di supporto (Finuola, Pascale, 2008; Giarè *et al.*, 2020) costituisce sicuramente un supporto per lo sviluppo e il consolidamento di tali pratiche su tutto il territorio nazionale. Nonostante ciò, non esiste una definizione condivisa di AS, ma diverse accezioni sia nel mondo scientifico, sia tra i soggetti che praticano l'AS, spesso legate ai differenti contesti nei quali le esperienze sono maturate. Obiettivo del lavoro, realizzato mediante il metodo *Delphi* e l'ausilio di tecniche statistiche per il trattamento automatico del linguaggio naturale, è pervenire ad una definizione di AS quanto più condivisa mediante un confronto tra esperti, una sorta di dibattito "virtuale", intorno all'oggetto della ricerca. Tale metodo permette, infatti, di creare un processo di comunicazione tra i partecipanti, consentendo a ciascuno di esprimere il proprio sapere, il punto di vista, l'opinione su una certa problematica e rivederla, dopo aver conosciuto, in forma aggregata e anonima (*feedback*), il giudizio espresso dagli altri.

2. DEFINIZIONI E APPROCCI ALL'AGRICOLTURA SOCIALE IN ITALIA

Le riflessioni sulle funzioni sociali dell'agricoltura in Italia hanno iniziato a prendere consistenza nei primi anni 2000, con gli studi sui servizi sociali nelle aree rurali realizzati dall'Università di Pisa a supporto delle attività promosse dalla Regione Toscana (Noferi, 2007; Di Iacovo, 2003 e 2004). Nello stesso periodo, l'Università della Tuscia avviava una riflessione nella stessa direzione, mettendo in evidenza come l'agricoltura sia in grado di fornire servizi che tendono a migliorare la qualità della vita dei membri della società, attraverso attività terapeutiche, riabilitative e di integrazione sociale[1]. In questo primo periodo non viene ancora utilizzata la locuzione *agricoltura sociale*, anche se potremmo dire che si avvia un percorso che porterà successivamente a questa scelta: «In primo luogo è utile esplicitare in che senso utilizzeremo il termine "sociale" in riferimento a una delle funzioni svolte dalle attività agricole. Con tale aggettivazione intendiamo riferirci alle capacità del mondo agricolo, in particolare delle unità famiglia-azienda, di generare benefici (servizi) nei confronti di gruppi vulnerabili della popolazione a rischio di esclusione sociale. Tali benefici possono essere erogati sia in forma implicita, che come risultato di un'azione esplicita.» (Senni, 2005).

Dalla collaborazione tra le due Università sopra nominate, è nato nel primo decennio di questo secolo anche il primo Master in Agricoltura Etico-Sociale[2], a seguito del quale sono sorte diverse iniziative di informazione e animazione, come il blog *Lombrico sociale*, l'associazione *Aicare*, il progetto *Buoni frutti*.

È solo nel 2007, tuttavia, che si trovano le prime definizioni di AS. Carbone *et al.* (2007) mettono in evidenza come le attività agricole o connesse – nell'impiegare manodopera a vario tipo svantaggiata – si propongano *esplicitamente* l'obiettivo di generare benefici di tipo sociale: «Attività agricole portate avanti da aziende, di tipo privato o cooperativo, che impiegano manodopera a vario tipo svantaggiata, con l'obiettivo di migliorarne le condizioni di vita e di promuoverne l'inclusione sociale e lavorativa. (…) con riferimento ai percorsi e alle pratiche che attraverso lo sviluppo di attività agricole o a queste connesse si propongono esplicitamente di generare benefici per fasce vulnerabili della popolazione».

Di Iacovo (2007) esplicita il legame *intimo* tra l'attività agricola e il soddisfacimento dei bisogni sociali delle persone a bassa contrattualità: «Quelle pratiche di agricoltura che sono intimamente legate al soddisfacimento di bisogni sociali di quella parte di popolazione a più bassa contrattualità – in modo temporaneo o meno – e al trasferimento/diffusione di conoscenze non codificate che caratterizzano il mondo rurale in generale e la componente agricola in particolare. (…) una pratica nella quale il contatto con le risorse dell'agricoltura e con i processi agricoli (spazio, tempo, cicli biologici, stili di vita) offre elemento di capacitazione e di inclusione di soggetti a più bassa contrattualità».

Dopo queste prime definizioni, negli anni successivi aumentano le occasioni di analisi e studio sul tema, che portano anche a una maggiore attenzione terminologica, nonostante le produzioni scientifiche fossero ancora limitate ai lavori delle Università di Pisa e della Tuscia. Di Iacovo (2008), si focalizza sull'impiego delle risorse dell'agricoltura e della zootecnia e su «la presenza di piccoli gruppi, famigliari e non, che operano nelle aziende agricole, per promuovere azioni terapeutiche, di riabilitazione, di inclusione sociale e lavorativa, di ricreazione, di servizi utili per la vita quotidiana e di educazione», precisando anche che l'AS è una delle pratiche della multifunzionalità e della diversificazione agricola e «una forma specifica di co-produzione dei servizi alla persona, dove le risorse non specialistiche dell'agricoltura sono usate per organizzare servizi innovativi alla persona» (2013).

Senni (2010), invece, si sofferma ulteriormente sul carattere intenzionale delle pratiche di AS: «Quelle atti-

[1] Relazione "AgriAbili. Una funzione sociale per l'agricoltura", di Silvio Franco e Saverio Senni, al seminario organizzato dal Dipartimento di Economia Agroforestale e dell'Ambiente Rurale Università della Tuscia, 2004.

[2] Il Master, lanciato nel 2004 con una serie di iniziative informative e di sensibilizzazione, è stato realizzato nel periodo 2005-2006 dall'Università Tuscia in collaborazione con l'Università di Pisa.

vità nelle quali una finalità sociale è intenzionalmente perseguita e assunta come esito di una pratica agricola».

Più recentemente, a seguito di un ampliamento della platea di studiosi che hanno approfondito il tema, anche da punti di vista disciplinari differenti, sono aumentati gli sforzi definitori, ai quali si sono accompagnate le definizioni "ufficiali" presenti in documenti comunitari e nazionali. Nel Parere del Comitato Economico e Sociale Europeo (2013) sul tema «Agricoltura sociale: terapie verdi e politiche sociali e sanitarie», ad esempio, l'AS viene definita come «un approccio innovativo fondato sull'abbinamento di due concetti distinti: l'agricoltura multifunzionale e i servizi sociali/terapeutico-assistenziali a livello locale». Il Parere, inoltre, precisa come lo scopo dell'agricoltura sociale sia anche quello «di creare le condizioni all'interno di un'azienda agricola che consentano a persone con specifiche esigenze di prendere parte alle attività quotidiane di una fattoria, al fine di assicurarne lo sviluppo e la realizzazione individuale, contribuendo a migliorare il loro benessere».

Una definizione *vincolante* di AS è contenuta nella l. 141/2015: «Per agricoltura sociale si intendono le attività esercitate dagli imprenditori agricoli di cui all'articolo 2135 del Codice civile, in forma singola o associata, e dalle cooperative sociali di cui alla l. 381/1991, nei limiti fissati dal comma 4 del presente articolo, dirette a realizzare: a) inserimento socio-lavorativo di lavoratori con disabilità e di lavoratori svantaggiati (…) e di minori in età lavorativa inseriti in progetti di riabilitazione e sostegno sociale; b) prestazioni e attività sociali e di servizio per le comunità locali mediante l'utilizzazione delle risorse materiali e immateriali dell'agricoltura per promuovere, accompagnare e realizzare azioni volte allo sviluppo di abilità e di capacità, di inclusione sociale e lavorativa, di ricreazione e di servizi utili per la vita quotidiana; c) prestazioni e servizi che affiancano e supportano le terapie mediche, psicologiche e riabilitative finalizzate a migliorare le condizioni di salute e le funzioni sociali, emotive e cognitive dei soggetti interessati anche attraverso l'ausilio di animali allevati e la coltivazione delle piante; d) progetti finalizzati all'educazione ambientale e alimentare, alla salvaguardia della biodiversità nonché alla diffusione della conoscenza del territorio attraverso l'organizzazione di fattorie sociali e didattiche riconosciute a livello regionale, quali iniziative di accoglienza e soggiorno di bambini in età prescolare e di persone in difficoltà sociale, fisica e psichica».

Diverse leggi regionali approvate prima e dopo la l. 141/2015 presentano definizioni differenti, anche in misura consistente, rispetto a quella sopra riportata.

L'analisi del contenuto delle definizioni presenti nella letteratura e nelle norme analizzate mette in evidenza alcuni elementi ricorrenti ed alcune differenze significative, che appaiono – alla luce delle più recenti ricerche sul tema dell'AS, particolarmente interessanti (Tab. 1).

Una prima differenza importante risiede nell'uso alternativo, per quanto riguarda l'oggetto specifico, della locuzione *attività agricola* e di quella *risorse dell'agricoltura*, che risulta determinante perché rimanda a interventi e politiche differenti. Per attività agricola si fa infatti riferimento alla produzione, all'allevamento o alla coltivazione di prodotti agricoli, attività supportate dalla Politica Agricola Comunitaria (PAC), mentre le risorse dell'agricoltura (strutture, attrezzature, superfici, personale, ecc.) possono essere utilizzate anche con altre finalità (ad esempio sociali, terapeutiche, educati-

Tab. 1. Aspetti rilevanti presenti nelle definizioni.

Oggetto	Attività agricola (e zootecnica, e connessa) Risorse dell'agricoltura
Contesto	Mondo agricolo Unità famiglia-azienda Aziende, di tipo privato o cooperativo I processi agricoli (spazio, tempo, cicli biologici, stili di vita) Piccoli gruppi, famigliari e non, che operano nelle aziende agricole
Valore	Attività intimamente legata (al sociale) Attività esplicitamente orientata (al sociale)
Mission	Soddisfacimento di bisogni sociali Migliorarne le condizioni di vita e di promuovere l'inclusione sociale e lavorativa Trasferimento/diffusione di conoscenze non codificate che caratterizzano il mondo rurale in generale e la componente agricola in particolare Capacitazione e inclusione di soggetti a più bassa contrattualità Promuovere azioni terapeutiche, di riabilitazione, di inclusione sociale e lavorativa, di ricreazione, di servizi utili per la vita quotidiana e di educazione co-produzione dei servizi alla persona
Destinatari	Gruppi vulnerabili della popolazione a rischio di esclusione sociale Popolazione a più bassa contrattualità

ve, ecc.) sostenute da altre politiche di settore. Anche il riferimento ai luoghi e al contesto più generale in cui tali pratiche vengono realizzate, lascia spazio ad ambiguità importanti; alcuni autori (Senni 2005, Di Iacovo 2008) si concentrano infatti sull'importanza dei piccoli gruppi e delle aziende agricole familiari (che peraltro costituiscono la quasi totalità delle aziende agricole in Italia), mentre altre definizioni fanno riferimento a un più generico contesto agricolo aziendale.

Per quanto riguarda la *mission*, occorre evidenziare come in alcuni casi si faccia rifermento a un generico soddisfacimento di bisogni sociali o all'inclusione sociale e lavorativa, mentre in altri si utilizzino locuzioni che rimandano ad approcci più attuali di *welfare*, come la capacitazione delle persone coinvolte e la co-produzione dei servizi (ad es. Senni, 2010; Venturi, Zandonai, 2016).

I destinatari, infine, sono denominati nelle forme più varie, anche se ci si riferisce comunque all'insieme delle persone vulnerabili che rientrano tra i soggetti cui sono indirizzate le politiche sociali e socio-sanitarie.

3. METODOLOGIA E RILEVAZIONE DATI

3.1. Metodo Delphi

Il metodo *Delphi* è una ben conosciuta (Avella, 2016; Okoli, Pawlowski, 2004) procedura metodologica di natura mista, qualitativa e quantitativa, utile a far raggiungere a un gruppo di esperti opinioni condivise su problematiche complesse; gli esperti vengono coinvolti in un processo iterativo composto da più sessioni, o *round*, conservando l'anonimato e senza conoscere gli altri componenti.

Il gruppo viene scrupolosamente selezionato tra coloro che sono ritenuti esperti della materia in grado di rispondere a questioni inerenti al fenomeno oggetto di studio. Questo gruppo costituirà il cosiddetto *panel* per tutta la durata dell'indagine. Nella prima sessione, *round*, verrà fornito al *panel* un questionario strutturato con domande sulla tematica in oggetto al quale ciascun esperto risponderà, fornendo la propria valutazione. Una volta raccolte le risposte, queste verranno analizzate statisticamente per iniziare a valutarne un possibile consenso e successivamente mostrate in un secondo *round* tenendo conto di quanto gli esperti hanno espresso in maniera anonima al primo round, secondo un processo di retroazione controllata o *feedback* (Marbach, 1991, p. 47). Lo stesso processo viene ripetuto ad un terzo, o eventuale quarto *round*[3], fin quando non si arrivi ad un buon livello di consenso da parte del *panel* di esperti. In tal modo, il metodo *Delphi* consente ad un gruppo di trattare un fenomeno complesso come se i suoi componenti lavorassero insieme, ma senza i possibili effetti di distorsione generati dal contatto reciproco; un processo di "comunicazione strutturata" che convoglia più pensieri competenti su una questione trattata verso conclusioni il più possibile condivise basate sulla stabilità delle stesse (Marbach, 1991, p. 46).

3.2. Selezione degli esperti

La selezione degli esperti, come precedentemente evidenziato, è una fase delicata dell'indagine, che va condotta con molta attenzione seguendo il criterio dell'*expertise* per quanto riguarda sia i singoli esperti sia la numerosità dei soggetti nel complesso.

L'agricoltura sociale è un fenomeno che negli ultimi due decenni ha incontrato l'interesse di ricercatori, di amministratori, del mondo operativo. È stato all'interno di questi tre universi che si è concentrata l'attenzione e la scelta degli esperti. In particolare, al fine di individuare il panel, sono state svolte le seguenti attività:

- analisi della letteratura per individuare gli autori italiani che hanno pubblicato articoli sul tema dell'AS;
- individuazione attraverso ricerca sul *web* di altri esperti coinvolti in iniziative di dibattito pubblico e/o di formazione sull'AS;
- acquisizione dell'elenco dei membri dell'Osservatorio nazionale Agricoltura sociale istituito presso il Mipaaf ai sensi della l. 141/2015;
- acquisizione di elenchi di partecipanti alle iniziative della Rete rurale nazionale[4] dedicate al tema, con particolare attenzione agli operatori e ai rappresentanti delle amministrazioni regionali (ad esempio, responsabili delle misure del PSR[5] che finanziano l'AS).

Sono stati quindi individuati nel mondo dell'università e della ricerca gli esperti che hanno ampia conoscenza della tematica, che hanno prodotto pubblicazioni e hanno svolto docenze in corsi di laurea, di dottorato o master o in attività formative professionalizzanti. Nell'ambito della pubblica amministrazione sono stati selezionati i funzionari che seguono il tema dell'agricoltura sociale, che sono parte attiva di gruppi di lavoro anche a livello nazionale di elaborazione di norme e linee guida. Gli esperti del mondo operativo sono soggetti che da diversi anni gestiscono attività di agricoltura sociale,

[3] Il numero di round dipende da quanto le posizioni iniziali degli esperti divergono, ma in letteratura il numero dei round non è mai stato inferiore a 3 e né superiore a 6 (Marbach, 1991).

[4] Programma nazionale finanziato nell'ambito delle politiche di sviluppo rurale.

[5] Programmi di Sviluppo Rurale.

Tab. 2. Tipologia di esperti interpellati e tasso di risposta.

Tipologia di esperti	Questionari inviati nr. (a)	Questionari restituiti nr. (b)	b/a
Ricercatori	29	10	*34,5%*
Operatori	34	5	*14,7%*
Amministratori regionali	21	5	*23,8%*

fanno parte di reti nazionali di AS o curano la tematica all'interno di organizzazioni professionali agricole.

L'elenco è stato successivamente organizzato tenendo conto della provenienza geografica, dell'ambito specifico di competenza (sociale, educativo o agricolo) e dell'esperienza maturata (da quanti anni un esperto di occupa del tema).

Tenendo conto che la letteratura raccomanda in genere un numero di esperti almeno pari a 18-20 unità per condurre significativamente un'indagine con il metodo *Delphi* (Okoli, Pawlowski, 2004), sono stati individuati 84 potenziali esperti, invitati a partecipare al primo *round*, 20 dei quali hanno risposto; di questi 10 fanno parte del mondo della ricerca (il 34,5% degli interpellati), 5 di quello operativo (il 14,7%) e 5 sono amministratori regionali (il 23,8%) (Tab. 2); si può quindi evidenziare una maggiore attenzione del mondo della ricerca al tipo di indagine proposto.

Il *panel* si è mantenuto costante nei successivi due *round*, a conferma dell'interesse per la tematica tracciata.

3.3. Descrizione dei round e rilevazione dei dati

L'indagine è stata organizzata in tre *round*. Nel corso del primo è stato costruito un questionario *ad hoc* con risposte aperte[6], inviato tramite *e-mail* a tutti gli esperti selezionati accompagnato da una lettera introduttiva con tenente le modalità dell'indagine e la garanzia dell'anonimato nelle risposte. Sono stati opportunamente evitati invii multipli e quindi la possibilità che gli esperti leggessero l'indirizzo degli altri al fine di garantire il completo anonimato tra i partecipanti. È stata fissata la tempistica di 30 giorni per rispondere al questionario. Alla fine del primo *round* sono state collezionate tutte le risposte testuali e su di esse sono state applicate delle tecniche di analisi automatica del linguaggio naturale attraverso il software *IRaMuTeQ* (Ratinaud, 2014). Questa fase di analisi ha avuto lo scopo di verificare un primo orientativo consenso tra gli esperti e quindi costruire un secondo questionario *ad hoc* con scale di valutazione di tipo *Likert* da sottoporre al panel nel corso del secondo e terzo *round*. Per questi due *round* il questionario è stato implementato via *web*, tramite, rispettivamente, il modulo di *google* e il *limesurvey* di *Polaris*, con modalità di risposta automatica e con la stessa modalità di invito a rispondere del primo *round*, ossia inviando una *e-mail* ad ogni singolo esperto contenente il *link* del questionario. Il tempo di risposta a questi due ulteriori *round* è stato di 15 giorni ciascuno. Nel complesso l'indagine è durata circa cinque mesi, da fine gennaio a metà giugno 2020.

4. RISULTATI

4.1. Primo round

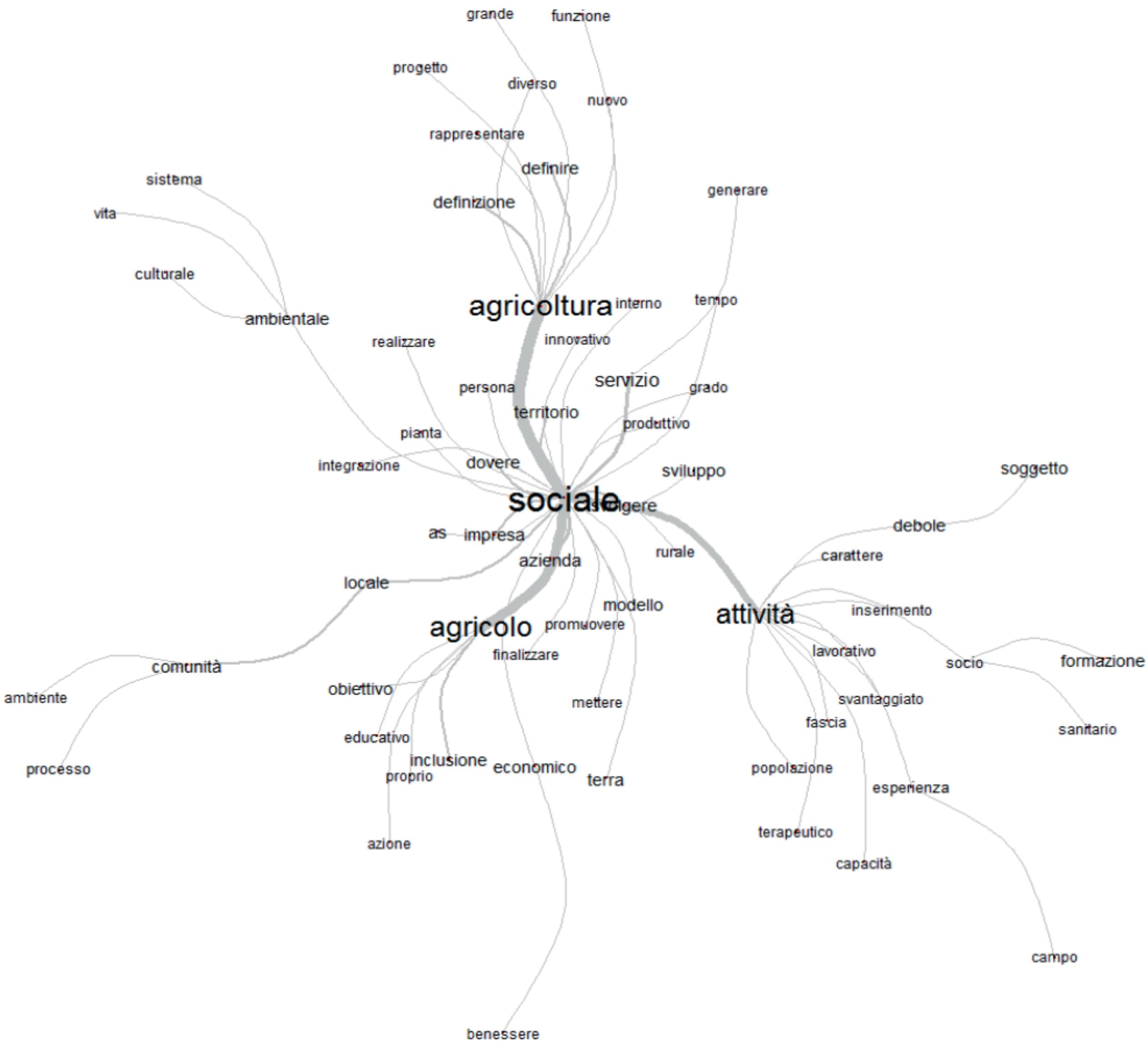
Nel primo *round* 20 esperti sugli 85 contattati hanno restituito compilato il questionario inviato, costruito con domande a risposta aperta, con una limitazione di 10.000 caratteri.

In questa sede prenderemo in esame soltanto le risposte alla domanda: "Che definizione darebbe di agricoltura sociale?" Collezionando tutte le risposte in un unico *corpus* di testo sono state applicate delle tecniche di analisi automatica del linguaggio per individuare inizialmente le potenziali direzioni verso le quali una definizione di agricoltura sociale potesse orientarsi e successivamente le classi di segmenti di testo comuni per cercare come fossero composte le potenziali definizioni di AS.

Il grafo delle co-occorrenze (Fig. 1) sintetizza l'analisi della similarità del testo per segmenti separati da punteggiatura e rappresenta il modo in cui le parole si collegano tra di loro (i.e., co-occorrono) all'interno dei segmenti del testo. Il grafo rappresenta una sorta di albero il cui spessore nei rami riassume il numero di segmenti di testo nel quale quella parola è contenuta (fissato ad una frequenza minima di 5). Dal grafo è già possibile individuare come una possibile definizione di AS possa dipanarsi. Partendo dall'alto, un progetto di definizione sembra possa passare da un sistema di inte-

[6] Il questionario si compone di 9 domande: 1: Che definizione darebbe di Agricoltura Sociale?; 2: Quali sono, secondo la sua opinione, le caratteristiche principali dell'agricoltura sociale?; 3: Quali attività dell'agricoltura sociale ritiene più proprie?; 4: Quali fattori possono influenzare positivamente la riuscita delle azioni di agricoltura sociale?; 5: Quali sono le principali difficoltà che si incontrano nella realizzazione delle attività di AS, sia a livello aziendale che territoriale?; 6: La l. 141/2015 interviene in un vuoto normativo solo in parte coperto in precedenza da alcune regioni con leggi proprie. Quale pensa sia il contributo della legge nazionale alla diffusione e alla valorizzazione dell'agricoltura sociale?; 7: Come pensa si svilupperà in futuro l'agricoltura sociale (attività, caratteristiche, destinatari, ecc.)?; 8: L'agricoltura sociale si rivolge a diverse tipologie di destinatari; a quali, secondo la sua opinione, va preferibilmente indirizzata?; 9: Ci sono altre questioni che riguardano la AS che non sono state considerate in queste domande e che invece lei considera rilevanti? Nell'articolo si riportano soltanto i risultati relativi alla prima domanda.

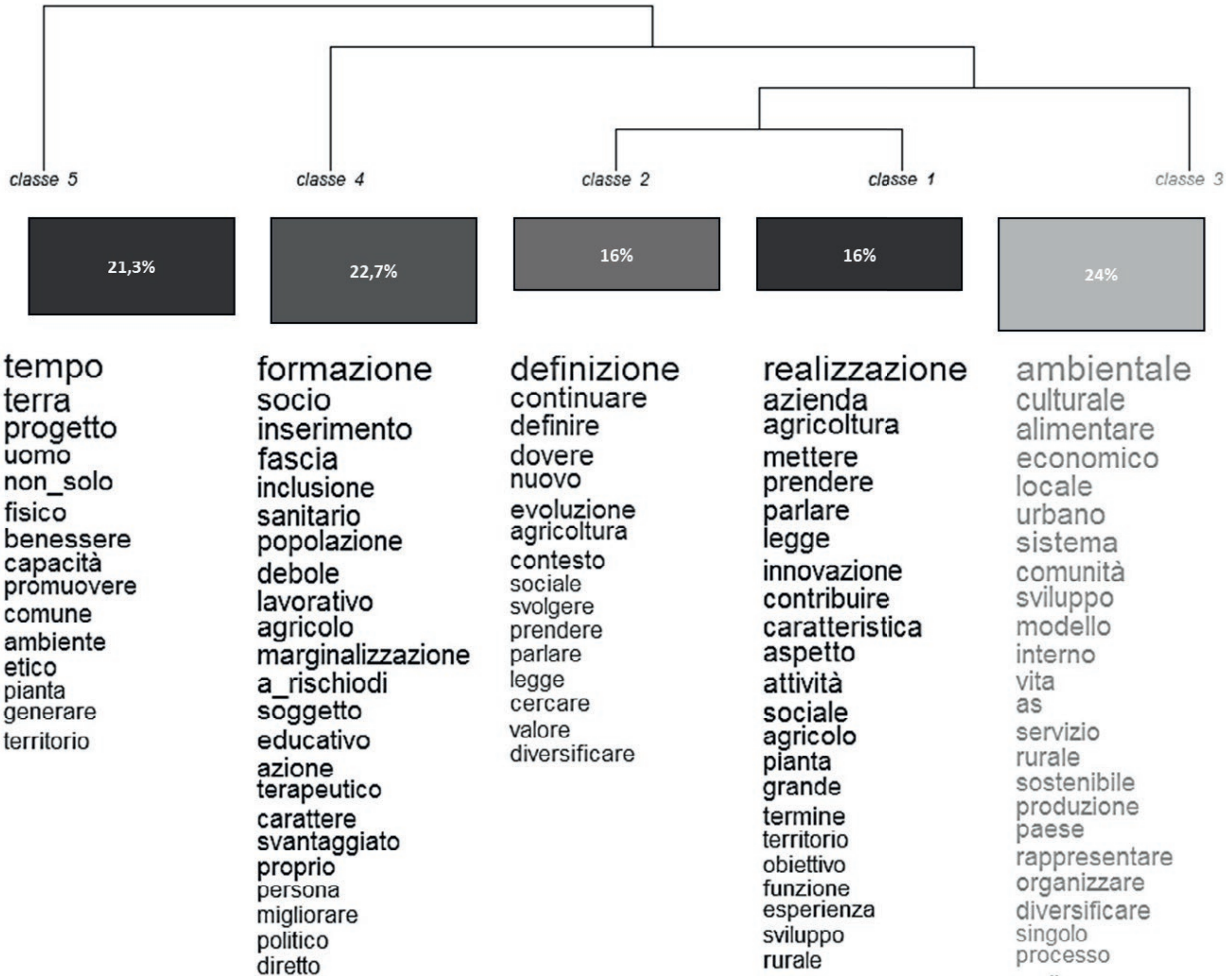
Fig. 1. Grado delle similarità o co-occorrenze.



grazione ambientale e culturale (vedi rami a sinistra) allo sviluppo e valorizzazione del territorio rurale (rami centrali), per divenire un'attività di formazione ed inserimento sociale di tipo terapeutico per persone svantaggiate (rami di destra) e finire con lo sviluppo locale di un modello di azienda agricola orientata al benessere e all'inclusione sociale ed economica (rami in basso).

Nella successiva Figura 2 viene invece riportato il *dendrogramma* dell'analisi cluster che individua 5 classi di segmenti di testo (i.e., 75 segmenti correttamente classificati su 103, il 72,82%; soluzione completa non mostrata per motivi di spazio, ma può essere richiesta agli autori) che riflettono punti di vista comuni da parte degli esperti riguardo le definizioni di AS. All'interno di ciascun cluster vengono rappresentate in ordine decrescente di significatività (i.e., la grandezza della parola è sinonimo sia di alta frequenza che di concatenazione con altre parole all'interno del cluster) le parole distintive di ciascun gruppo. Le classi 1 e 2 contengono entrambe il 16% dei segmenti, sono molto vicini tra di loro e riflettono delle definizioni incentrate sull'AS vista come una componente innovativa delle azioni di sviluppo rurale, capace di coinvolgere il territorio con attività di tipo sociale. La classe 3 non lontana della prime due, con il 24% dei segmenti vede l'AS basata su modello ambientale sostenibile. Ed infine le classi 4 e 5, con rispettivamente il 22,7% e il

Fig. 2. Dendrogramma dell'analisi cluster.



21,3% dei segmenti, più lontane dalle prime tre, tendono ad omologarsi su una definizione orientata all'inclusione sociale di tipo terapeutico, che contempla attività indirizzate alle fasce deboli della popolazione ed è in grado di promuove un ambiente etico di benessere per l'uomo.

Analizzando più nel dettaglio i segmenti tipici di ciascuna classe in termini di significatività statistica (i.e., valore assoluto del chi-quadrato ottenuto come somma dei termini significativi nei segmenti[7]) nel contribuire alla formazione della classe stessa e tenendo conto anche delle informazioni di tipo direzionale ottenute dal grafo delle similarità in Figura 1, sono state estrapolate e riformulate una serie di potenziali definizioni di AS riportate in Tabella 3.

Le quattro definizioni di AS riportate nella successiva Tabella 4 sono state proposte come risultato di sintesi e di potenziale consenso tra gli esperti di questo primo *round*. Queste quattro definizioni hanno quindi costituito l'oggetto dei successivi *round* del *Delphi* per la ricerca di un definitivo consenso.

4.2. Secondo e terzo round

Come detto, nel secondo round del *Delphi* sono state presentate ai 20 esperti le quattro definizioni in Tabella 4, per le quali veniva chiesto loro di esprimere un grado di accordo o disaccordo secondo una scala di tipo *Likert* a 5 categorie di risposta (Tab. 5), con l'aggiunta di un punto centrale di indifferenza (i.e., né d'accordo, né in disaccordo). Nel caso di espressione di un grado di disaccordo (i.e., sia abbastanza che molto) l'esperto ha avuto la possibilità di scrivere la motivazione della propria scelta.

[7] Valori non riportati, ma possono essere richiesti agli autori.

Tab. 3. Riformulazioni da segmenti significativi.

L'agricoltura sociale è costituita da qualsiasi attività connessa all'agricoltura svolta da imprenditori agricoli di cui all'art. 2135 del codice civile finalizzata a dare una risposta ad un problema sociale di persona disabile.
L'agricoltura sociale è la gestione sostenibile di tutti i fattori produttivi di un'azienda agricola, dove le persone – senza distinzioni di abilità, salute, condizione sociale e lavorativa – prendono parte alle attività al fine di garantire la produttività dell'azienda e assicurare lo sviluppo e la realizzazione di ogni singolo individuo.
L'agricoltura sociale è un contenitore di pratiche sociali ed educative sperimentali che utilizzano il potenziale dell'agricoltura per raggiungere obiettivi di inclusione sociale.
L'agricoltura sociale è un insieme di teorie e pratiche, solidali e responsabili, che possono contribuire in modo determinante al conseguimento di uno sviluppo locale sostenibile, alla realizzazione di azioni di welfare di comunità e alla produzione di cibo sano.
L'agricoltura sociale è l'insieme delle attività svolte nell'azienda agricola al fine di promuovere l'inclusione sociale, la riduzione della povertà e lo sviluppo economico secondo una logica di integrazione tra la politica di coesione e quella di sviluppo rurale e di integrazione tra le aree urbane e quelle rurali.
L'agricoltura sociale è nell'ambito della multifunzionalità dell'agricoltura, un'attività che opera sulla base di esperienze e progetti in cui le attività agricole e quelle connesse sono condotte con il proposito di generare benefici inclusivi per coloro che hanno dei bisogni speciali e svolge azioni di collegamento tra politiche agricole e politiche sociali, formative-educative, sanitarie, e della giustizia.
L'agricoltura sociale è un tipo di attività agricola che tende all'inclusione di persone appartenenti a fasce "deboli" quali ex detenuti, persone con disabilita mentali e fisiche non particolarmente gravi o appartenenti ad altre fasce "deboli", che vengono formate in aziende agricole appositamente strutturate per il reinserimento sociale e lavorativo.
L'agricoltura sociale è un'attività della multifunzionalità, attenta all'ambiente, che coniuga l'offerta di servizi con una gestione d'impresa e fornisce servizi per le categorie svantaggiate, che diventano parte attiva e non più soggetti assistiti.
L'agricoltura sociale è l'insieme di pratiche innovative finalizzate a rivitalizzare le comunità locali mediante l'utilizzo delle risorse agricole, materiali e immateriali, e – contestualemente – la creazione di ambienti di vita capaci di promuovere e far crescere le persone e le popolazioni.

Tab. 4. Definizioni di AS dopo il primo round.

A. L'Agricoltura sociale è caratterizzata dall'uso sostenibile delle risorse dell'agricoltura finalizzato a generare esplicitamente benefici per fasce vulnerabili della popolazione, secondo una logica di integrazione tra le politiche.
B. L'agricoltura sociale è un modello di produzione innovativo che contribuisce allo sviluppo sostenibile dei territori, a fornire nuovi servizi e a generare benefici per le fasce vulnerabili della popolazione, che diventano parte attiva del processo produttivo.
C. L'agricoltura sociale è un insieme di pratiche solidali e responsabili, che possono contribuire in modo determinante al conseguimento di uno sviluppo locale sostenibile, alla realizzazione di azioni di welfare di comunità e alla produzione di cibo sano.
D. L'agricoltura sociale è l'insieme di pratiche innovative realizzate in aziende agricole appositamente strutturate finalizzate a rivitalizzare le comunità locali e a creare ambienti di vita capaci di promuovere e far crescere le persone e le popolazioni.

In Tabella 5 sono riportate le frequenze assolute di risposta per ogni tipo di definizione insieme alla percentuale del grado di accordo e a delle statistiche di centralità[8]. Dalle percentuali di accordo si nota che le prime tre definizioni raggiungono già il 90% del consenso (la letteratura raccomanda una percentuale del 70-80% di accordo su scale *Likert*; Hsu e Standford, 2007), con le definizioni B e C migliori della A in termini di percentuale di molto accordo (i.e., 65% e 60%). Sempre le definizioni B e C hanno ottenuto una mediana (massima; per valutazioni su scale *Likert* la mediana è ritenuto un indicatore statistico migliore rispetto alla media; Hsu e Standford, 2007) e una media migliore e rappresentativa (coefficiente di variazione, CV, ben al di sotto del 50%), anche se la C presenta una variabilità leggermente più alta. Inoltre, queste due definizioni non hanno ricevuto commenti significativamente negativi. La definizione A, ma soprattutto la D (che non raggiunge il 70% del totale giudizio di accordo mostrando una variabilità intervallare più ampia) hanno riscontrato invece alcune criticità sia nei punteggi che in commenti di disaccordo rispetto alla B e alla C. Per la definizione A un esperto che ha assegnato "abbastanza in disaccordo" ha espresso questa motivazione «Definizione troppo articolata; semplificherei un po': l'AS è caratterizzata dall'uso delle risorse agricole finalizzato a generare esplicitamente benefici per fasce vulnerabili della popolazione». Mentre per la definizione D, due esperti che hanno assegnato la valu-

[8] Le categorie da molto d'accordo a molto in disaccordo sono state rispettivamente codificate con valori numerici da 5 a 1 per permettere il calcolo delle statistiche.

tazione di "molto" e "abbastanza" in disaccordo hanno poi motivato la loro scelta rispettivamente con «Definizione troppo "aulica": per es.: non è detto che l'AS sia finalizzata a rivitalizzare alcunché. Anche la limitazione ad aspetti "innovativi" mi pare un po' limitante e "verificare la possibilità data alle imprese sociali, dalla riforma del terzo settore, di fare agricoltura sociale».

In definitiva le definizioni B e C hanno raggiunto un soddisfacente consenso tra gli esperti già in questo secondo round; alla stessa stregua può essere considerata anche la definizione A, seppur in maniera leggermente minore rispetto alle altre due. La D, invece, è quella che si è dimostrata essere più dibattuta. Purtuttavia, sia la A che la D sono state sottoposte a piccole revisioni basate sul *feedback* controllato, formato dai suddetti commenti e dai punteggi delle statistiche, e ripresentate al terzo *round,* riformulate in A* e D* come segue:

A*: L'Agricoltura sociale è caratterizzata dall'uso delle risorse dell'agricoltura finalizzato a generare esplicitamente benefici per fasce vulnerabili della popolazione.

D*: L'agricoltura sociale è un insieme di pratiche innovative realizzate in aziende agricole finalizzate a rivitalizzare le comunità locali e a creare ambienti di vita capaci di promuovere e far crescere le persone e le popolazioni.

Nel *round* 3 si è avuto un leggerissimo calo della partecipazione degli esperti (hanno risposto 19 esperti su 20), che però non ha influito sulla validazione del metodo. In letteratura, infatti, si può trovare una diminuzione del tasso di partecipazione ai round successivi al primo pari al 25-40% (Marbach, 1991).

Sempre nel *round* 3 È stato chiesto agli esperti di valutare di nuovo solo queste definizioni A* e D* (valori riportati in Tabella 6) esprimendo sempre un giudizio su una scala di tipo *Likert* a 5 categorie di risposta come nel secondo *round*. Dopodiché è stato richiesto di ordinare tutte e quattro le definizioni per ordine decrescente di preferenza dalla migliore alla peggiore. Solo in questo secondo *step* sono state quindi ripresentate anche le definizioni B e C del secondo round che, come detto, avevano già ricevuto un soddisfacente consenso.

In Tabella 5 sono stati affiancati al *round* 2 i risultati del grado di accordo e disaccordo per le nuove definizioni A* e D*. Da notare il netto miglioramento sia dei giudizi sia delle statistiche per la definizione A* rispetto alla A ed un congruo miglioramento anche nella D* rispetto alla D. Purtuttavia, sia la definizione A* che la D* risultano in secondo piano rispetto alla B e C nell'esercizio di ordinamento di preferenza riportato nella Tabella 6 sia in termini di frequenze assolute di preferenza sia di statistiche. La definizione C è alla fine risultata essere la migliore in quanto, oltre ad aver ottenuto già un consenso al *round* 2, ottiene un'alta mediana e un'unica moda rispetto alle altre. A rafforzare il consenso ottenuto in questo terzo *round* per l'ordinamento ottenuto viene riportato il coefficiente di correlazione intra-classe (i.e., ICC) che viene comunemente usato per valutare l'affidabilità tra gli esperti su giudizi di tipo ordinale (Hallgren, 2012). Questo valore è stato di 0,89 (con intervallo di confidenza al 95% di 0,64-0,99) ed indica un ottimo livello di accordo (Hallgren, 2012) tra gli esperti nell'assegnare l'ordinamento alle definizioni.

Alla luce di questi risultati non si è ritenuto necessario fare un ulteriore *round*.

Tab. 5. Frequenze assolute dei giudizi e statistiche di centralità nei round 2 e 3.

Definizioni		Round 2				Round 3	
		A	B	C	D	A*	D*
Giudizi	Molto d'accordo	7	13	12	4	11	6
	Abbastanza d'accordo	11	5	6	9	6	9
	Nè … nè	1	1	1	4	2	2
	Abbastanza in disaccordo	1	1	1	2	0	2
	Molto in disaccordo	0	0	0	1	0	0
Percentuale di accordo	Molto	*35*	*65*	*60*	*20*	*58*	*32*
	Abbastanza	*55*	*25*	*30*	*45*	*32*	*47*
	Totale	*90*	*90*	*90*	*65*	*90*	*79*
Statistiche	Mediana	4	5	5	4	5	4
	Intervallo	2-5	2-5	2-5	1-5	3-5	2-5
	Media	4,2	4,5	4,4	3,6	4,5	4
	Dev. Standard	0,77	0,83	0,99	1,09	0,70	0,94
	CV (%)	*18,3*	*18,4*	*22,5*	*30,3*	*15,5*	*23,5*

Tab. 6. Frequenze assolute di preferenza e statistiche nel round 3.

Definizioni		Round 3			
		A*	B	C	D*
Ordine	1°	3	6	8	2
	2°	6	4	3	6
	3°	4	6	3	6
	4°	6	3	5	5
Statistiche	Mediana	3	2	2	3
	Moda	2 e 4	1 e 3	1	2 e 3

5. CONCLUSIONI

Il metodo *Delphi* ha permesso di mettere a confronto le opinioni di alcuni esperti sulla definizione di agricoltura sociale, evitando eventuali distorsioni dovute all'interazione diretta. Nonostante la riflessione e la ricerca sul tema sia ormai consolidata, soprattutto nell'ambito della sociologia rurale e dell'economia agraria, non esiste ancora una definizione condivisa di AS. L'esercizio proposto con il *Delphi* ha consentito di determinare un alto grado di accordo su una delle 4 definizioni proposte, secondo la quale:

l'agricoltura sociale […] *è un insieme di pratiche solidali e responsabili, che possono contribuire in modo determinante al conseguimento di uno sviluppo locale sostenibile, alla realizzazione di azioni di welfare di comunità e alla produzione di cibo sano*.

La definizione focalizza l'attenzione sia sulle pratiche sia sugli effetti dell'agricoltura sociale, evidenziando la presenza di esperienze e modalità differenti e la loro omogeneità in termini valoriali, con il riferimento alla sfera della solidarietà e della responsabilità. Inoltre, per quanto riguarda i risultati e gli effetti delle pratiche di AS, si fa evidente riferimento allo sviluppo locale, al *welfare* di comunità e alla produzione di cibo. Gli esperti sembrano, quindi, aver trovato una definizione equilibrata tra gli aspetti economici agricoli (l'accento sulla produzione e sullo sviluppo locale) e quelli sociali (solidarietà, sostenibilità, comunità).

Limitazioni dello studio possono essere ricondotte a quelle tipiche del metodo Delphi, ossia se, in questo caso, la definizione ottenuta sia quella più accurata rispetto ad un'altra estrapolata con tecniche di intervista diretta oppure con una differente composizione degli esperti (Marbach, 1991, p. 97). Per rispondere a queste limitazioni gli autori suggeriscono futuri indirizzi di ricerca verso un utilizzo della definizione trovata sia in ambito applicativo di tipo progettuale che teorico di tipo semantico. Questo utilizzo risulta necessario poiché, ad opinione degli autori, qualsiasi definizione è sempre soggetta ad una mutabilità direttamente legata all'evoluzione delle società e, quindi, anche la definizione di AS proposta in questo lavoro dovrà ricercare la sua validità nei tempi presenti e futuri.

Si tratta di un risultato importante che potrà costituire la base per ulteriori ricerche sul tema che coinvolgano altri attori dell'AS, anche alla luce dei continui sviluppi nelle pratiche di AS e dell'aggiornamento della normativa.

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Research Article

Do Agricultural Imports and Exports Cointegrate? Evidence from 13 OECD Countries

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Abstract. Previous studies have investigated the behaviour of trade flows at the aggregate level, thus they suffer from aggregation bias. In this paper, we use the sectoral data on agricultural exports and imports to examine whether they cointegrate. The likelihood-based panel cointegration technique is applied to investigate the long-run convergence between the variables for 13 industrialized countries. The results indicate that a long-run steady-state relationship exists between the variables for most countries in the sample. The policy implications of our findings are that agricultural trade does not lead to the violation of international budget constraints and, more importantly, there is no productivity gap in the agriculture sector between the domestic economy and the rest of the world, implying a lack of permanent technological shocks to the domestic economy. The results also provide support for intra-industry trade in the agriculture sector.

Keywords: agriculture, imports, exports, cointegration.
JEL codes: E60, F31, F14.

1. INTRODUCTION

A major indicator of a country's economic performance is the external account because significant external imbalances might predict future changes in a managed foreign exchange system. Empirical studies attempt to identify the sources of external imbalances by relating the external accounts to key macroeconomic variables such as government spending, private consumption, income, the net financial balance of the household sector, non-financial and financial corporations, etc. (Sachs, 1981; Ahmed, 1987; Razin, 1995; Elliott, Fatas, 1996; Chen *et al.*, 2013; Allen, 2019).

Some authors argue that fiscal, monetary, and commercial policies (tariff, subsidy and exchange-rate policies) have aimed to reduce the size of external imbalances in several countries (e.g., Artis, Bayoumi, 1989; Ariza, Bahmani-Oskooee, 2018). In most cases, fiscal and monetary policies are used to alleviate domestic problems such as recession or inflation rather than external accounts problems. On the other hand, commercial policies such as currency devaluations or depreciations are used to deal with external problems such as reducing trade deficits.

It is not easy to separate the effectiveness of one policy in solving a problem over other policies. As far as the external accounts is concerned, one way to examine the effectiveness of all policies is to determine whether or not a country's exports and imports cointegrate in the long run (Husted, 1992). If they do, then we can believe that the combined effects of all macro policies are effective. Other studies state that there is evidence of external imbalance being the outcome of "bad policy" (Summers, 1988; Husted, 1992; Irandoust, Sjöö, 2000; Irandoust, Ericsson, 2004). They conclude that outflows and inflows in the current account cointegrate unless there are policy distortions or permanent productivity shocks to the domestic economy. Thus, in a well-functioning economy, external accounts deficits are temporary phenomena that will be balanced by future surpluses. In a country with distorted markets there is no tendency towards a balance of payments equilibrium and thus sustained external imbalances reflect "bad policy".

An external imbalance is regarded as sustainable when it does not violate the nation's solvency constraint; and a nation is said to be solvent if the present-value budget constraint, i.e., its intertemporal budget constraint holds. One way to analyze external imbalances applies the intertemporal approach to the current account (Sachs, 1981; Obstfeld, Rogoff, 1995; Razin, 1995; Irandoust, Sjöö, 2000; Raybaudi *et al.*, 2004; Chen, 2011, 2014; Afonso *et al.*, 2020). According to this approach, the current account equals the difference between savings and investment, and, because savings and investment decisions are based on intertemporal factors (such as life-cycle features, the expected returns of investment projects, and the like) the current account is necessarily an intertemporal phenomenon. Thus, a trade balance or current account balance would be sustainable if the series for exports and imports are found to be cointegrated (Trehan, Walsh, 1991; Hakkio, Rush, 1991; Wickens, Uctum, 1993; Wu *et al.*, 1996; Apergis *et al.*, 2000; Irandoust, Sjöö, 2000; Afonso *et al.*, 2020).

In this study, we focus on the agriculture sector and cointegration between agricultural imports and exports since anticipated growth in the demand for food and agricultural raw materials due to increasing world population and incomes will place significant demands upon the scarce natural resources, particularly land and water, used in the sector. Although agriculture is not expected to add significantly to job creation in the OECD countries due to the relatively small contribution that the sector makes to total employment, its use of purchased inputs and the supply of food and raw materials to other sectors are significant for employment and total economic activity. Thus, our research questions are: Are agricultural exports and agricultural imports cointegrated? What are the implications of agricultural imports and exports being cointegrated?

The cointegration between agricultural exports and imports also indicates intra-industry trade (IIT) within the agriculture sector. The creation and expansion of the European Union has contributed to an increase in IIT between European countries. Despite the importance of the topic, most literature examines IIT of industrial products and the agricultural sector is usually neglected in empirical works, possibly because agricultural markets are assumed to be competitive. However, recent studies support the view that agricultural markets can be characterized by imperfect competition and economies of scale (Sexton, 2013) and IIT plays an increasing role in agricultural trade (e.g., Leitao, 2011; Ferto, 2015a, b).

Examples of studies that have found evidence of cointegration between aggregate exports and aggregate imports include Bahmani-Oskooee (1994), who tested the hypothesis for Australia, Bahmani-Oskooee and Rhee (1997), for Korea, Arize and Bahmani Oskooee (2018), for 100 countries that supported nonlinear cointegration in most cases of bilateral trade, Irandoust and Ericsson (2004), for industrial countries. Previous studies suffer from aggregation bias since they use aggregate exports and imports to investigate trade flows and external accounts position. Thus, the purpose of this paper is to examine the behaviour of the agricultural trade flows in 13 OECD countries (France, Germany, Italy, Sweden, Switzerland, Austria, Denmark, Norway, Spain, Portugal, Finland, the Netherlands and the UK). We focus on these countries because of the fact that they are major exporters and importers of agricultural products in Western Europe. The total value of imports and exports of agricultural products between the EU and the rest of the world was EUR 275 billion in 2017 (Eurostat, 2018).

The departures from earlier studies are in disaggregate agricultural trade flows and the asymptotic theory of likelihood-based panel cointegration allowing for multiple cointegrating vectors. The main contribution of this study stems from the methodology used which is a likelihood-based panel cointegration under assumptions of cross-sectional dependence and slope homogeneity restrictions. This is an extension of the Johansen (1995) multivariate maximum likelihood developed by Larsson and Lyhagen (1999) and Larsson *et al.* (2001). They developed a likelihood-based panel test of the cointegrating rank and a general likelihood-based framework for inference in panel-VAR models with cointegration restriction, allowing for multiple cointegrating vectors. By using this method, the assumption of a unique cointegrating vector and the problem of normalization is relaxed. This is not the case with the usual residual-based tests of cointegration (e.g., Kao, 1999; Pedroni, 1999a, b). However, to the best of the author's knowledge, this study is the first attempt to test the cointegration between agricultural exports and imports using panel cointegration techniques based on likelihood inference of cointegrating vectors.

Our results indicate that agricultural trade flows are cointegrated for all countries in the sample except for Italy, Sweden and the Netherlands. The cointegration between agricultural exports and imports reveals that these countries are not in violation of their international budget constraints. Furthermore, macroeconomic policies have been effective in bringing agricultural imports and exports into equilibrium in the long run. More importantly, there is no productivity gap between the domestic economy and the rest of the world, implying a lack of permanent technological shocks to the domestic economy. The findings also provide support for ITT in most of the countries under review.

The paper is organized as follows. Section 2 outlines a simple model and we discuss the data and methodology used. In section 3, we present and interpret the results from the cointegration tests. In section 4 we discuss some policy implications. Conclusions are given in section 5.

2. MODEL, DATA AND METHODOLOGY

The international budget constraint for analyzing the dynamics of the exports and imports follows Husted (1992), Irandoust and Sjöö (2000) and Irandoust and Ericsson (2004). These studies show that the international budget constraint for a given country can be written as

$$EXP_t = a+bIMP_t+e_t \tag{1}$$

where EXP_t and IMP_t denote agricultural exports and imports respectively. The null hypothesis states that the economy satisfies its international budget constraint. Thus, it is expected that $b = 1$, and e_t is a stationary process that includes all short-term dynamics. In other words, if EXP_t and IMP_t are nonstationary and trending, then under the null hypothesis they are co-trending (cointegrating) with cointegrating vector $b = (1, -1)$.

An important question here pertains to the policy implications of cointegration or lack of cointegration and convergence between agricultural imports and exports. The theory suggests that cointegration is to be expected under the maintained hypothesis that the economy is working properly and that breaking international budget constraints leads to a lack of cointegration.

An important reason why the time series paths of agricultural imports and exports might diverge, and not cointegrate, is technological shocks or the productivity gap hypothesis. Thus, finding cointegration for the variables rejects the assumption of a permanent technological or productivity gap between the economy and the rest of the world (Irandoust, Sjöö, 2000; Irandoust, Erisson, 2004). In other words, if agricultural trade flows are not cointegrating, this could be regarded as the outcome of permanent technological shocks to the domestic economy.

The data used in this study are agricultural (raw materials) exports and imports as a percentage of merchandise imports and exports, respectively. The sample consists of 13 European industrialized countries (France, Germany, Italy, Sweden, Switzerland, Austria, Denmark, Norway, Spain, Portugal, Finland, the Netherlands and the UK) and covers the period 1963-2020. The choice of the time period and sample countries are dictated by data availability. The variables are extracted from the World Bank database. Figures 1-13, Appendix A, illustrate the variables. Descriptive statistics for the variables under analysis is also reported in Table A.1., Appendix A.

The process is estimated by implementing a likelihood-based panel framework developed by Larsson and Lyhagen (1999) and Larsson *et al.* (2001). By using this method, the assumption of a unique cointegrating vector and the problem of normalization is relaxed which is not the case with the usual residual-based tests of the cointegration approach. Let LR denote the cross-section-specific likelihood-ratio (trace) statistic of the hypothesis that there are at most r cointegrating vectors in the system. The standardized LR-bar statistic is given by:

$$Y_{\bar{LR}} = \frac{\sqrt{N\left(\bar{LR} - \mu\right)}}{\sqrt{V}} \tag{2}$$

where $\bar{LR}$ is the average of the N cross-section LR statistics, μ is the mean and v is the variance of the asymptotic trace statistic. Asymptotic values of μ and v (with and without constant and trend) can be obtained from stochastic simulations as described in Johansen (1995).[1]

Two steps should be followed before using any cointegration tests: testing the panel for cross-sectional dependence and testing for cross-country heterogeneity. The first issue means the transmission of shocks from

[1] This methodology is also used in Irandoust and Ericsson (2005).

one variable to another. In other words, all countries in the sample are affected by globalization and have common economic characteristics. The second issue shows that a significant economic connection in one country is not necessarily replicated by the others. A set of three tests is constructed to check the cross-sectional dependence assumption: the Breusch and Pagan (1980) cross-sectional dependence (CD_{BP}) test, the Pesaran (2004) cross-sectional dependence (CD_P) test, and the Pesaran *et al.* (2008) bias-adjusted LM test (LM_{adj}). Regarding the country-specific heterogeneity assumption, the slope homogeneity tests ($\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$) of Pesaran and Yamagata (2008) are used (Appendix B provides more information about these tests).

The traditional panel unit root tests do not consider cross-sectional dependence of the contemporaneous error terms. Failing to take into account cross-sectional dependence may lead to misleading results. Thus, to eliminate this problem, we use the cross-sectionally augmented panel unit root test (CIPS) that allows for parameter heterogeneity and serial correlation between the cross-sections (Pesaran, 2007).[2] Finally, we check diagnostic tests, i.e., if the residuals are normally distributed and there is no autocorrelation. The normality test stems from a multivariate extension of the Bowman-Shenton test developed by Doornik and Hansen (1994) and the test for autocorrelation is the Ljung-Box test statistics.

3. ESTIMATION RESULTS

As a pre-test for the cointegration analysis, we first examine cross-sectional dependence and slope homogeneity assumptions. Table 1 indicates the results of cross-sectional dependence tests (CD_{BP}, CD_p, and LM_{adj}) and slope homogeneity tests ($\tilde{\Delta}$ and $\tilde{\Delta}_{adj}$). The first set of tests, for cross-sectional dependence, clearly shows that the null hypothesis of no cross-sectional dependence is rejected for all significance levels. This implies that there is a cross-sectional dependence in the case of our sample countries. Any shock in one country is transmitted to others. The second part of the table shows that the null hypothesis of slope homogeneity is rejected for both tests and all significance levels. This means that the economic relationship in one country is not replicated by the others. As there are both cross-sectional dependence and slope heterogeneity, the cointegration tests can be used.

Tab. 1. Cross-sectional dependence and slope homogeneity tests.

Method	Test statistic
Cross-sectional dependence test	
CD_{BP}	377.126*** (0.000)
CD_P	54.392*** (0.000)
LMadj	65.287*** (0.000)
Slope homogeneity test	
$\tilde{\Delta}$ test	19.205*** (0.000)
$\tilde{\Delta}_{adj}$ test	16.211*** (0.000)

*** indicate significance for 0.01 levels. The numbers within parentheses show *p*-values.
CD_{BP} test, CD_P test and LM_{adj} test show the cross-sectional dependence tests of Breusch and Pagan (1980), Pesaran (2004), and Pesaran *et al.* (2008), respectively.
The slope homogeneity tests are proposed by Pesaran and Yamagata (2008).

Tab. 2. Panel unit root test.

Variable	CIPS statistic
EXP	-1.926
IMP	-1.823

Critical values for the CIPS test are -2.15 (1%), -2.07 (5%), and -2.02 (10%), Pesaran (2007).

We test for panel non-stationarity among the variables before applying the cointegration test. The results of the cross-sectionally augmented IPS test are reported in Table 2. After inspection of the data, we only include a constant term (mainly due to measurement errors). When applying the Schwartz criterion to decide the optimal lag length, the common lag length was set to four. The table shows that all variables support the null hypothesis of panel non-stationarity. Furthermore, note that our approach does not exclude the possibility of including stationary variables.[3]

The likelihood ratio tests are reported in Table 3. The Bartlett corrected critical values are obtained by using the estimated model as data generating process when calculating the sample mean. Using the Bartlett corrected critical values, the test rejects the null of 0 cointegrating ranks but accepts the null of 1 cointegrating vector. Since the panel cointegration tests show that

[2] The CIPS panel unit root test is based on the Im, Pesaran and Shin (2001) test (IPS), which controls for cross-sectional heterogeneity in the estimated coefficients. The CIPS is the average of the individual country's cross-sectionally augmented ADF (CADF) statistics.

[3] The effect of one stationary variable in the system is that the rank order increases with one.

Tab. 3. Test for the cointegrating rank.

H_o	*ACV* [a]	*BCV* [b]	$-2logQ_T$
R = 0	536.11	647.22	605.49
R ≤ 1	270.19	471.20	393.52
R ≤ 2	103.35	275.18	167.38

Notes:
a. The asymptotic critical values at 5% significance level.
b. Bartlett corrected critical values at 5% significance level.

Tab. 5. Diagnostic tests[a].

Normality[b]	Autocorrelation[c]
0.038	0.507

Notes:
a. The table reports the p-values.
b. The test is a multivariate extension of the Bowman-Shenton test developed by Doornik and Hansen (1994).
c. This is the Ljung-Box test statistics for autocorrelation.

the common cointegrating rank is one, it is thus interesting to estimate the cointegrated vectors. The estimated cointegrating vectors, normalized for *IMP,* are presented in Table 4.

According to Table 4, we can assert that *EXP* is positively associated with *IMP* for almost all countries in the sample. Exceptions are Sweden, Italy and the Netherlands. In these countries, the coefficients have a very low value and are not significant. This implies that there is no long-run relationship between agricultural imports and exports in these countries. The lack of cointegration is probably a result of policy distortions or technological shocks. However, the magnitude of parameters varies from country to country.

The results from the diagnostic tests are given in Table 5. It seems that there is no problem with autocorrelation since the p-value is very high but the null hypothesis of normality is rejected and this problem could not be solved by using more lags.

4. POLICY IMPLICATIONS AND DISCUSSIONS

All theories of the trade balance assert that sustained deficits or surpluses might signal underlying policy problems. The elasticity approach suggests the real exchange rate and its effect on the demand and supply of traded goods as the key factor, while the absorption approach proposes that total expenditure is the most critical factor for understanding and correcting external account imbalances. The dynamics of the external accounts are explained by agents' responses to transitory and permanent shocks, in particular shocks in productivity. In the case of favourable productivity or technological shocks, investment booms tend to boost output growth but worsen the external accounts (Glick, Rogoff, 1995).

What does cointegration or lack of cointegration between agricultural imports and exports in the trade balance tell us about the state of the economy? The theory states that cointegration is to be expected under the maintained hypothesis that the economy is working properly and that breaking international budget constraints causes a lack of cointegration. (e.g., Trehan, Walsh, 1991; Hakkio, Rush, 1991; Husted, 1992; Bahmani-Oskooee, 1997; Irandoust, Sjöö, 2000; Herzer, Nowak-Lehman, 2006; Ariza, Bahmani-Oskooee, 2018; Afonso *et al*., 2020). This means that sustained external imbalances are the outcome of distorted markets or "bad policy". For understanding the cointegration results based on the international budget constraints, the conclusion is that lack of cointegration reveals fundamental policy problems unless there are permanent productivity shocks that lead to a non-stationary agricultural import-export relationship. In a well-functioning economy without permanent one-sided productivity shocks, cointegration is to be expected.

What are the policy implications of our findings? First, our findings of cointegration indicate that ten OECD countries, out of 13 under review, are not in violation of their international budget constraint as far as

Tab. 4. Cointegrating vectors normalized on *IMP.*

	Finland	Spain	Portugal	Italy	Austria	Denmark	Norway	Sweden
IMP	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000	-1.000
EXP	0.727	0.833	0.945	0.066	0.857	0.565	0.632	0.078

	Germany	France	UK	Switzerland	Netherlands
IMP	-1.000	-1.000	-1.000	-1.000	-1.000
EXP	0.510	1.052	1.116	0.912	0.059

agricultural trade is concerned. Second, macroeconomic policies (such as fiscal and monetary policies) have been effective in bringing agricultural imports and exports to converge towards equilibrium in the long run. In the case of Sweden, Italy and the Netherlands, the lack of cointegration is a sign of bad policy or the existence of permanent technological shocks to the domestic economy. In other words, fundamental policy problems and the permanent productivity gap hypothesis lead to long-run agricultural trade imbalances. Third, the cointegration between agricultural imports and exports also provide support for intra-industry trade in the agriculture sector for almost all countries under review.

However, countries that suffer from longer-term "structural" external imbalances have to strongly concentrate their policy attention on a recovery of the tradable sector such as agriculture. This is not simply subject to real exchange rate adjustments or fiscal and monetary policies, as the expansion of export capacities requires strong investment in the tradable sector. This can be achieved by foreign direct investment (FDI), but since FDI flows have become smaller in the post-crisis period (Hunya, 2015), other domestic and policy instruments have to be applied. The focus here is on other industrial policy instruments that have to be adjusted to the specific requirements of OECD's peripheral economies (e.g., Landesmann, 2015). Combined with the use of innovative industrial policy instruments, there has to be an emphasis on institutional upgrading so that industrial policy intervention might show positive rather than negative results (Stöllinger, Holzner, 2013).

Although concern about real exchange rate developments is still valid, this has to be directed towards a joint sustained move towards supply-side improvements (i.e., targeting structural change and productivity improvements) as well as a consideration of balanced wage-productivity and human capital developments (Hanzl-Weiss, Landesmann, 2016). Growth and incomes policies combined with education, training and labour market policies should be included in a targeted policy that aims at competitive real exchange rate developments and not simply wage setting. Finally, capital markets policies or policies oriented towards attracting FDI should allocate capital towards the tradable sector rather than non-tradable activities (Hanzl-Weiss, Landesmann, 2016).

Generally speaking, if deficit countries are looking to improve their external balances permanently, they should assure that the capital flows stemming from abroad are allocated to tradable industries with high added value, avoiding the concentration of resources in non-tradable sectors in which the potential for increasing productivity is restricted. In other words, such countries should develop non-price competitive industries (Carrasco, Hernandez-del-Valle, 2017). This implies that a European industrial policy would create benefits by targeting resources towards the development of these industries. On the other hand, surplus countries should implement an expansive economic policy so as to boost domestic demand. An increase of domestic demand and a deterioration of the external balance in surplus countries could relieve the burden of deficit countries when trying to address external imbalances. Thus, addressing the persistent external European imbalances requires asymmetric responses from deficit and surplus countries, and the collaboration and coordination of economic policy between both groups of countries (Carrasco, Hernandez-del-Valle, 2017).

5. CONCLUSIONS

The purpose of this paper was to examine the long-run convergence of agricultural exports and imports in 13 industrialized OECD countries (France, Germany, Italy, Sweden, the UK, Switzerland, Denmark, Spain, Portugal, Finland, Austria, Norway and the Netherlands) over the period 1963-2020. Economic theory suggests that non-stationary agricultural trade flows in the trade balance will cointegrate in the long run. This is not the case if policy distortions exist or permanent technological shocks to the domestic economy. Thus, a natural tendency towards cointegration and convergence between agricultural exports and imports are expected in a well-functioning economy where there are neither permanent productivity shocks nor policy distortions.

The departures from earlier studies are in disaggregate agricultural trade flows and the asymptotic theory of likelihood-based panel cointegration allowing for multiple cointegrating vectors. The main contribution of this study stems from its methodology, which is a likelihood-based panel cointegration under assumptions of cross-sectional dependence and slope homogeneity restrictions. By using this method, the assumption of a unique cointegrating vector and the problem of normalization is relaxed, which is not the case with the usual residual-based tests of the cointegration approach. To the best of our knowledge, this is the first attempt to study cointegration between agricultural imports and exports.

Based on the likelihood-based panel cointegration technique, we found cointegration and convergence between agricultural exports and imports for almost all countries in the sample, but it was rejected for Sweden, Italy and the Netherlands. Our findings support the view that there is a stable underlying trend towards convergence between agricultural exports and imports in 10 OECD countries out of 13. The results also provide support for intra-industry trade in the agriculture sector for most of the countries under review.

It is worth to mentioning that other studies focus on the cointegration between the aggregate variables. Examples are Wickens and Uctum (1993), Bahmani-Oskooee (1994), Wu *et al*., (1996), Bahmani-Oskooee and Rhee (1997), Apergis *et al*., (2000); Irandoust and Sjöö, (2000); Holmes (2006), Konya and Singh, 2008; Chen (2011, 2014), Camarero *et al*. (2013), and Afonso *et al*., (2020).

This study has a few limitations. These stem from the fact that we used a linear, bivariate model without considering structural breaks since the likelihood panel cointegration model does not allow for structural shifts. Future studies should consider nonlinear and multivariate estimation methodology to account for structural breaks and regime shifts.

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APPENDIX A

Tab. A.1. Descriptive statistics of the variables, 1963-2020, n = 58 for each individual country.

Country	Mean	S.D.	Skewness	Kurtosis
Austria				
EXP	4.7765	3.2231	0.7910	2.4961
IMP	3.4139	1.3596	1.0229	3.2689
Switzerland				
EXP	0.7742	0.4479	0.1956	1.8689
IMP	2.2761	1.4511	0.8457	3.0635
Germany				
EXP	1.1335	0.3171	0.6510	2.3388
IMP	3.5216	2.3830	1.2061	3.5550
Denmark				
EXP	3.9372	1.2582	0.2954	1.4938
IMP	3.5420	1.1707	0.8616	2.8535
Spain				
EXP	1.7775	0.8603	2.2008	8.6913
IMP	3.9147	2.7023	0.6241	1.9390
Finland				
EXP	13.1630	8.9774	1.3772	4.0694
IMP	3.2135	1.0239	1.2382	3.9876
France				
EXP	1.9881	1.0933	0.7657	2.6097
IMP	3.5428	2.8339	1.5753	4.8509
Italy				
EXP	1.0619	0.5482	1.4370	4.4943
IMP	5.9746	3.6801	0.9097	3.0388
Netherlands				
EXP	3.7425	0.9809	1.0680	3.5263
IMP	2.7472	1.4851	1.5524	4.5914
Norway				
EXP	2.8134	2.8470	1.3975	3.8755
IMP	2.3061	0.9567	1.1063	3.3454
Portugal				
EXP	5.8596	3.1595	0.2035	1.4046
IMP	5.1661	3.7925	1.0891	3.4066
Sweden				
EXP	8.2365	4.8663	0.8971	2.7031
IMP	2.0890	0.7636	1.3368	4.9992
UK				
EXP	1.1938	0.7218	0.7107	2.2111
IMP	4.0373	3.6073	1.4568	4.2595

Fig. 1.-13. Agricultural exports and imports in the sample countries (1963-2020).

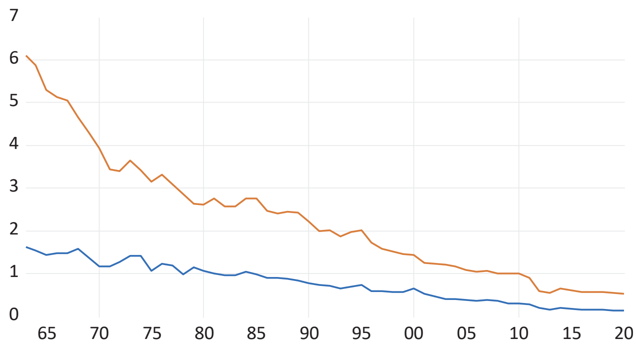

Fig. 1: Agricultural EXP and IMP in Switzerland (1963-2020).

CHEEXP CHEIMP

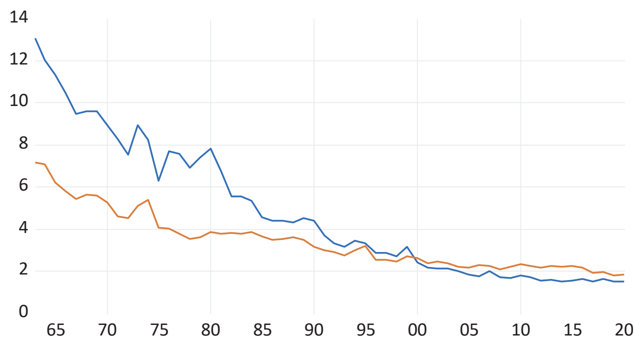

Fig. 2: Agricultural EXP and IMP in Austria (1963-2020).

AUTEXP AUTIMP

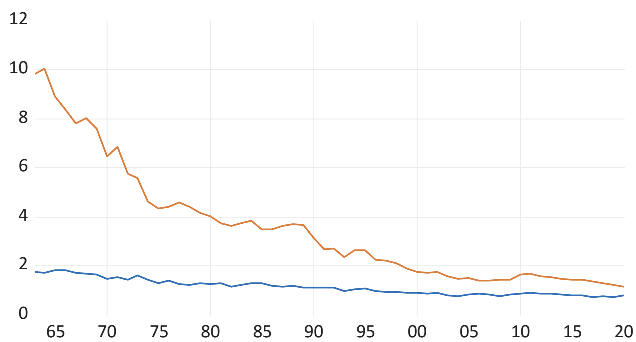

Fig. 3: Agricultural EXP and IMP in Germany (1963-2020).

DEUEXP DEUIMP

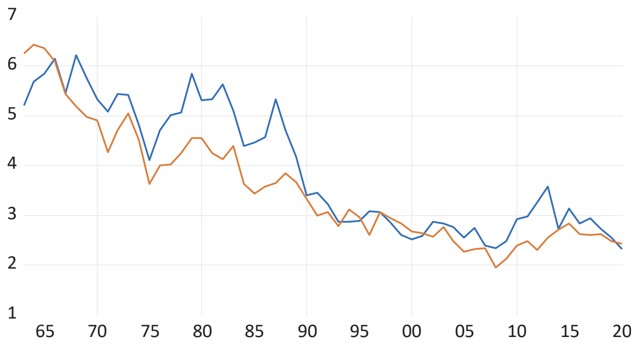

Fig. 4: Agricultural EXP and IMP in Denmark (1963-2020).

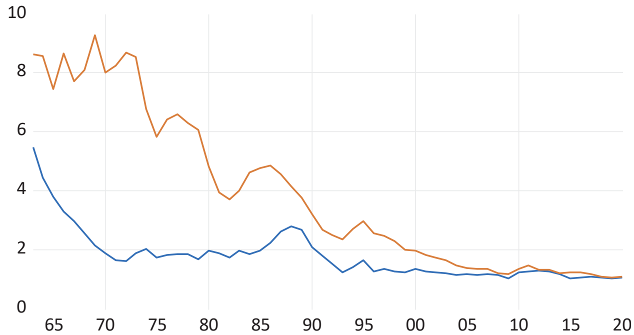

Fig. 5: Agricultural EXP and IMP in Spain (1963-2020).

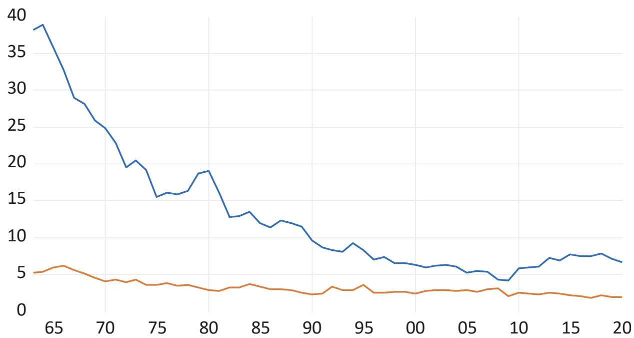

Fig. 6: Agricultural EXP and IMP in Finland (1963-2020).

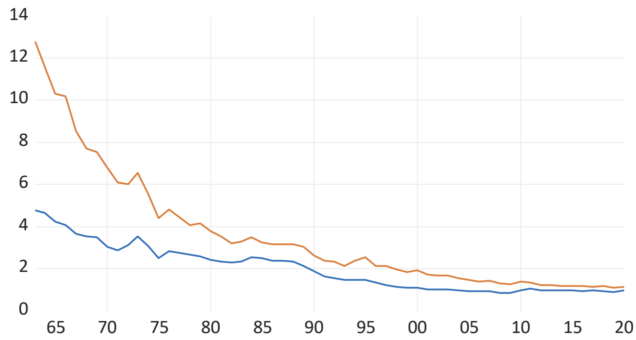

Fig. 7: Agricultural EXP and IMP in France (1963-2020).

Fig. 8: Agricultural EXP and IMP in Italy (1963-2020).

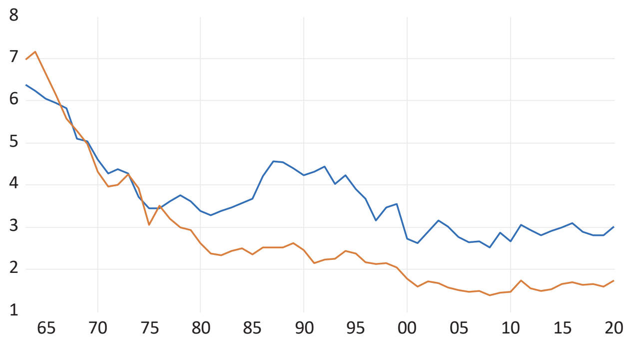

Fig. 9: Agricultural EXP and IMP in the Netherlands (1963-2020).


Fig. 10: Agricultural EXP and IMP in Portugal (1963-2020).

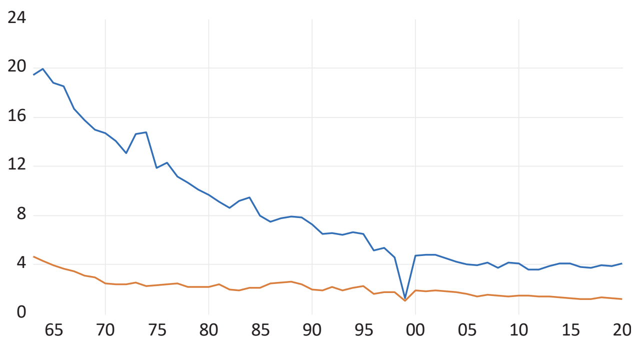
Fig. 11: Agricultural EXP and IMP in Sweden (1963-2020).

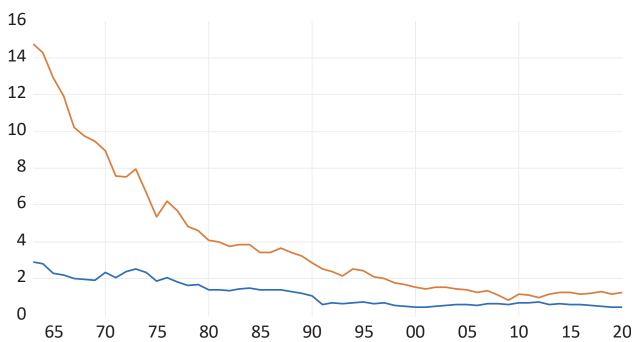
Fig. 12: Agricultural EXP and IMP in the UK (1963-2020).

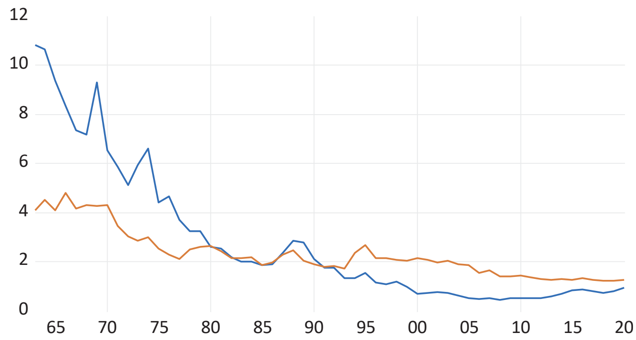
Fig. 13: Agricultural EXP and IMP in Norway (1963-2020).

APPENDIX B

Cross-sectional dependence tests

Breusch and Pagan's (1980) LM test has been used in many empirical studies to test cross-sectional dependency. LM statistics can be calculated using the following panel model:

$$y_{it}=\alpha_i+\beta^{\circ}_{it}\, x_{it}+\mu_{it}, \quad i=1,2,\ldots, N \quad t=1,2,\ldots, T, \qquad \text{1A}$$

where i is the cross-section dimension, t is the time dimension, x_{it} is $k \times 1$ vector of explanatory variables. while α_i and β_i are the individual intercepts and slope coefficients, respectively, that are allowed to differ across states. In the LM test, the null hypothesis of no cross-sectional dependence $H_0 : Cov(\mu_{it},\mu_{jt}) = 0$ for all t and $i \neq j$ is tested against the alternative hypothesis of cross-sectional dependence $H_1 : Cov(\mu_{it},\mu_{jt}) \neq 0$ for at least one pair of $i \neq j$. For testing the null hypothesis, Breusch and Pagan (1980) developed the following test:

$$CD_{BP}=T\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}^{2}_{ij}, \qquad \text{2A}$$

where $\hat{\rho}^{2}_{ij}$ is the estimated correlation coefficient among the residuals obtained from individual OLS estimation of Eq. (1A). Under the null hypothesis, the LM statistic has an asymptotic chi-square distribution with $N(N-1)/2$ degrees of freedom. Pesaran (2004) proposes that the LM test is only valid when N is relatively small and T is sufficiently large. To overcome this problem, Pesaran (2004) introduces the following LM statistic for the cross-section dependency test:

$$CD_P=\sqrt{\frac{1}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\left(T\hat{\rho}_{ij}^{2}-1\right) \quad \text{3A}$$

However, Pesaran *et al.* (2008) state that while the population average pair-wise correlations are zero, the CD test will have less power. Therefore, they proposed a bias-adjusted test that is a modified version of the LM test by using the exact mean and variance of the LM statistic. The bias-adjusted LM statistic is calculated as follows:

$$LM_{adj}=\sqrt{\frac{2T}{N(N-1)}}\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}^{2}\frac{(T-k)\hat{\rho}_{ij}^{2}-u_{Tij}}{\sqrt{v_{Tij}^{2}}}, \quad \text{4A}$$

where u_{Tij} and $v^2{}_{Tij}$ are the exact mean and variance of $(T\text{-}k)\hat{\rho}_{ij}^{2}$, which are provided in Pesaran *et al.* (2008). Under the null hypothesis of no cross-sectional dependence with $T \to \infty$ first followed by $N \to \infty$, the results of this test follow an asymptotic standard normal distribution.

Slope homogeneity tests

In order to relax the assumption of homoscedasticity in the F-test, Swamy (1970) developed the slope homogeneity test that examines the dispersion of individual slope estimates from a suitable pooled estimator. Pesaran and Yamagata (2008) state that both the F-test and Swamy's test require panel data models where N is relatively small compared to *T*. To overcome this problem, they proposed a standardized version of Swamy's test (the so-called $\tilde{\Delta}$ test) for testing slope homogeneity in large panels. The $\tilde{\Delta}$ test is valid when $(N, T) \to \infty$ without any restrictions on the relative expansion rates of *N* and *T* when the error terms are normally distributed. Pesaran and Yamagata (2008) then develop the following standardized dispersion statistic:

$$\bar{\Delta}=\sqrt{N}\left(\frac{N^{-1}S^{\approx}-k}{\sqrt{2k}}\right), \quad \text{5A}$$

where $S^{\approx}$ is Swamy's statistic. Under the null hypothesis with the condition of $(N, T) \to \infty$ and when the error terms are normally distributed, the $\tilde{\Delta}$ test has an asymptotic standard normal distribution. The small sample properties of the $\tilde{\Delta}$ test can be improved when there are normally distributed errors by using the following mean and variance bias adjusted version:

$$\bar{\Delta}_{adj}=\sqrt{N}\left(\frac{N^{-1}S^{\approx}-E(z_{it}^{\approx})}{\sqrt{\mathrm{var}(z_{it}^{\approx})}}\right) \quad \text{6A}$$

where $E(z_{it}^{\approx})=k, var(z_{it}^{\approx})=2k(T-k-1))/(T+1)$.

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Data Availability Statement: All relevant data are within the paper and its Supporting Information files.

Competing Interests: The Author(s) declare(s) no conflict of interest.

Research Article

An inquiry on north-eastern Italian farmers' perception of climate change and related risks to agriculture

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Abstract. Even though agricultural activities have always had to face systemic risk, increasing uncertainty linked to market conditions, policy revision and climate change require the adoption of extensive, functional and informed risk management strategies. Our study aims to investigate north-eastern Italian farmers' perception of climate change-related risks and attitudes towards adaptation strategies, in order to promote the adoption of effective communication strategies and the development of more attractive insurance schemes to widen famers' interests. Cross-sectional survey data were analysed using structural equation modelling to explore concerns over the impact of climate change on agricultural activities and identify the factors that promote the adoption of coping strategies. According to the results, the actual experience of negative consequences linked to specific extreme meteorological events is the main driver for the adoption of mitigation strategies. Further efforts on awareness of climate change and its consequences, coupled with the provision of simpler and more tailored insurance schemes, are required to support a widespread diffusion of adaptation strategies among farmers.

Keywords: risk mitigation, insurance, adaptation, structural equation modeling, Italian farmers.
JEL codes: Q10, Q14, Q18, Q54.

1. INTRODUCTION

In recent years, risk management has become an increasingly important issue in agriculture. Farmers have limited or no control over shocks and events related to external factors, as in the case of negative climate conditions or market and policy changes, even though such events directly impact agricultural outputs and outcomes such as yields, revenues and incomes (Komarke *et al*., 2020). Growing uncertainty and instability due to high price volatility in commodity markets, the reduction of traditional market regulation instruments in the European Union (EU) and the increase in extreme climatic events are pushing farmers to adopt instruments and strategies to manage the different sources of risk in agriculture (Iyer *et al*., 2020). Indeed, compared to other industries and economic activities, the spectrum of risks affecting agricultural outcomes is quite broad, and directly impacts the stability of food production and supply, hence food security, and the cost efficiency of agricultural activities (Calicioglu *et al.*, 2019).

The primary source of risk in agriculture is linked to nature: unfavourable weather conditions, plant or livestock disease outbreaks, pests and other natural factors may reduce yields. Weather phenomena and climatic events in particular are hard to predict and even harder to mitigate, at least at the beginning of the growing season. Other types of weather risks to consider as unforeseeable are sudden events like hail, heavy rain, windstorms or frost. In light of the complexities that characterize global climate and related evolution trends, the effects of weather are also difficult to generalize; at the same time, the impact of such events may vary considerably according to local and context-specific conditions of production systems such as crop characteristics, soil composition and structure or hydrogeological profile (Tarolli, Straffelini, 2020). In addition to this, other factors such as drainage and irrigation systems and the quality of farm management interact with weather conditions and are likely to enhance and magnify their effects (OECD, 2020; Porrini *et al.*, 2019). Under this perspective and taking into account the fact that weather conditions often affect large areas, the vulnerability and susceptibility of the agricultural sector determine the existence of systemic risks, which is one of the main limits for insurability.

Another source of risk in agriculture is related to changes in the market and the institutional context. Changes in agricultural policies and connected legal frameworks, such as trade liberalization, the introduction of new standards or environmental protection laws, funding and subsidizing, all contribute to rapidly modify the institutional environment in which agricultural entrepreneurs operate and require rapid adaptation to avoid facing operational and financial difficulties (El Benni *et al.*, 2012; Koundouri, 2009). Moreover, the global supply chain crisis, related to the consequences of the COVID-19 pandemic, and increasing political instability worldwide are determining increasing intersectoral systemic risk (Zhu *et al.*, 2021).

Various classification criteria have been used to categorize risk in agriculture (Komarek *et al.*, 2020; Marin, 2019). According to its nature, agricultural risk may be defined as natural–climatic, agrobiological or technogenic. Moreover, risks can be classified with respect to their intensity and extent (minor/acceptable, critical or catastrophic) or following the response of the policyholder (controllable, partially controlled or uncontrollable). Further classifications take into account other factors and characteristics, for example the degree of typicality of the risk phenomenon to the given area, its frequency and intensity of occurrence, degree of predictability and its impact on specific stages of crop development.

Insurance schemes and policies aimed at stabilizing agricultural income, reducing outcome uncertainty and increasing resilience to macroeconomic shocks (Heiman and Hildebrandt, 2018) are the most effective risk mitigation tools available in the agricultural industry (Wang *et al.*, 2020). Since the early 2000s, the development and adoption of agricultural insurance tools have been increasingly promoted at EU level (Capitanio, De Pin, 2018; Meuwissen *et al.*, 2018). In recent years, the 2014-2020 Common Agricultural Policy (CAP) explicitly provided specific funds and programmes for the ex-ante subsidization of agricultural insurance contracts, and similar measures have been extended to the transition period before the enforcement of the upcoming 2021-2027 CAP (Pieralli *et al.*, 2020).

Our research focuses on the natural-climatic risk and farmers' related responsiveness in north-eastern Italy. As demonstrated by the 2022 drought (Toreti *et al.*, 2022), the Po River valley, Italy's most important agricultural area, is already witnessing the impact of climate change. The vulnerability of the local agricultural industry (Monteleone *et al.*, 2022; Nickayin *et al.*, 2022) calls for the development of better risk management strategies and further involvement of farmers. To this end, this study proposes a theoretical model that imposes the relationships between latent constructs related to climate change beliefs and concerns among north-eastern Italian farmers. While the literature on Italian famers' risk perception and adaptation mainly focuses on case studies and specific crops/production (Perrone *et al.*, 2020; Rosa *et al.*, 2019; Sarvia *et al.*, 2019; Vitali *et al.*, 2019), the aim of our research is to generalize the analysis of farmers' perceptions of climate change and their intentions to take action to mitigate its negative consequences. Based on a cross-sectional survey, our analysis sheds light on farmers' perceptions of environmental risk in agriculture and their attitude towards adaptation and mitigation strategies; structural equation modelling was used to study the influence of climate change beliefs on the adoption of risk mitigation strategies, climate change concerns and barriers to adaption. The results highlight the limits of current approaches and support the identification of optimal strategies to maximize farmers' involvement in agricultural risk management.

Section 2 provides the theoretical background of the study. The research methods are detailed in Section 3, while we discuss the results in Section 4. Concluding remarks are then presented in the final section.

2. BACKGROUND AND RESEARCH HYPOTHESES

In order to measure farmers' concerns over climate change and intention to adopt mitigation strategies, we developed a theoretical model based on four constructs: Climate Change Beliefs, Perceived Barriers to Adaptation, Climate Change Concerns and Likelihood to Adopt Strategies. Validated scales to describe the constructs were taken from the literature and adapted to the specific research design.

Climate Change Beliefs (CCB): the CCB construct aims at observing farmers' perceptions and opinions on general climate change trends. More specifically, the construct was designed to identify whether farmers believe climate change is real and, if so, how human activities influence it. While there is a broad expert consensus on anthropogenic climate change (Oreskes, 2018), public opinion on these topics is still polarized (Benegal, 2018). Social and economic factors such as age, education and income, influence the perception of climate change (Benegal, 2018; Bromley-Trujillo, Poe, 2018; El Barachi *et al.*, 2021), and similar attitudes have been recorded among farmers (Ricart *et al.*, 2018, Woods *et al.*, 2017), including in Italy (Milone, Ventura, 2019). The literature confirms that farmers' personal beliefs on climate change and its extent are the primary factors that drive the necessity (or not) for reaction and adaptation strategies (Adger *et al.*, 2009; Arbuckle *et al.*, 2015).

Perceived Barriers to Adaptation (PBA): the adoption of risk management strategies is not straightforward, and there is widespread consensus among farmers on the existence of barriers to adaptation (Le Dang *et al.*, 2014; Woods *et al.*, 2017). The PBA construct deals with the complex of structural, contextual and individual obstacles to the selection of mitigation strategies and their integration in farming management activities (Chenani *et al.*, 2021; Eakin *et al.*, 2016). In the context of our analysis, the construct encompasses the perception of the negative consequences of non-adaptation and its costs for the farm in the long term (Pickson, He, 2021; Woods *et al.*, 2017; Wu, Mweemba, 2010).

Climate Change Concerns (CCC): linked to the first construct, CCC examines farmers' judgement on the consequences and potential events linked to climate change and the extent to which their activities are threatened by each of them. The construct items refer to the main negative events commonly associated with climate change, such as floods, drought, plant diseases, extreme weather events, soil erosion and water eutrophication (McBean, Ajibade, 2009). Several studies confirm that risk perception acts as an antecedent of adaptive behaviour (Azadi *et al.*, 2019; Tran, Chen, 2021), and its effect is amplified by risk aversion (He *et al.*, 2020). Besides the abovementioned individual beliefs on climate change, farmers' perceptions of negative events and the associated risks for agricultural activities may also be influenced by the specific type of farm and its pedoclimatic context, as well as individual and personal factors such as education, income and social networks (Mirzaei *et al.*, 2022; Yin *et al.*, 2020). Under this perspective, the actual experience of extreme weather events and other negative circumstances related to climate change is not equal among all farmers. Therefore, the perception of the need for adaptation and, eventually, the selection of optimal mitigation strategies may vary.

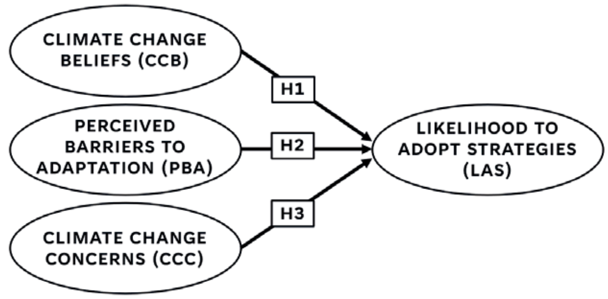
Likelihood to Adopt Strategies (LAS): the actual probability to adopt mitigation strategies is described by the LAS construct. The items that describe this construct include the main risk management actions, either linked to production and primary activities (production optimization, income diversification, adoption of new technologies, switch to conservative agriculture), financial management (insurance policies, sale or renting of part of the farm, management of cash flows and debt) or individual choices (side business or second job, exit from the farming sector) (Pagliacci *et al.*, 2020; Woods *et al.*, 2017).

This study proposes a theoretical model to analyse the relationships between the four latent constructs. Based on the existing literature, three hypotheses were developed to assess these factors and empirically test their impact on the adoption of mitigation measures. Figure 1 graphically represents the theoretical framework, with the proposed causal relationships among climate change beliefs, perceived barriers to adaptation, climate change concerns and likelihood to adopt strategies. Specifically, the hypotheses to be tested are as follows:

Hypothesis 1 (H1): climate change beliefs affect the likelihood to adopt mitigation strategies.

Hypothesis 2 (H2): perceived barriers to adaptation have a significant impact on the likelihood to adopt mitigation strategies.

Fig. 1. The proposed model.



Hypothesis 3 (H3): climate change concerns have a significant impact on the likelihood to adopt mitigation strategies.

3. MATERIALS AND METHODS

In order to collect data for hypothesis testing, a computer-assisted web interview (CAWI) was forwarded to 3,000 north-eastern Italian farmers in the Condifesa Friuli-Venezia Giulia (an Italian farmers' consortium involved in atmospheric risk management) mailing list. A total of 105 farmers took part in the survey. The first section of the questionnaire included questions on farm structure, size, activities and characteristics. The second section was organized into four subsections, one for each construct. Each subsection included a set of seven-point Likert-like psychometric scales to measure participants' knowledge of climate change, perception of related risks for farms, attitude towards potential adaptive strategies and intention to undertake mitigation actions, respectively. As detailed in the previous section, the items used to describe the constructs were based on validated scales taken from the literature. Descriptive statistics were used to describe the sample, and a structural equation model was developed to test the importance of the cognitive factors underpinning farmers' likelihood to adapt.

Data analysis was conducted by first assessing the measurement models via confirmatory factor analysis (CFA), which determines whether the latent variables were correctly measured. Thereafter, the proposed hypotheses were tested via a structural equation model (SEM) because this method is more suitable for making the structure of the causal relationships among latent variables explicit (Cohen *et al.*, 1990). The CFA for each measurement model was estimated using maximum likelihood to identify the four latent constructs. The specification of the SEM was composed of three equations:

$$y=A^y\eta+\varepsilon \tag{1}$$

$$x=A^x\xi+\delta \tag{2}$$

$$\eta=B\eta+\Gamma\xi+\xi \tag{3}$$

Equations 1) and 2) are measurement models, which tie the constructs to observable indicators. The p x 1 vector y contains the measures of the endogenous constructs, and the q x 1 vector x consists of the measures of the exogenous indicators. The coefficient matrices and A^y and A^x show how y relates to η and x relates to ξ, respectively. The vectors of disturbances e and d represent errors in variables (or measurement error). Equation 1) is called the structural model and expresses the hypothesized relationships among the constructs in the conceptual framework. The m x 1 vector η contains the latent endogenous constructs, and the n x 1 vector ξ consists of the latent exogenous constructs. The coefficient matrix B shows the effects of the endogenous constructs on each other, and the coefficient matrix Γ signifies the effects of exogenous on endogenous constructs. The vector of disturbances ς represents errors in equations. Generally (but not always) the measurement model possesses simple structure such that each observed variable is related to a single latent variable.

4. RESULTS AND DISCUSSIONS

Descriptive statistics are presented in Table 1 as a summary of the social and demographic characteristics of the sample. Most respondents (88.58%) were agricultural entrepreneurs, farm owners and/or shareholders, and about half of them had completed high school. Farms greatly varied in size, ranging from 1.5 ha to 201 ha, with the mean equal to 36.73 ha. While distant from the national average of 7.9 ha (Caffaro, Cavallo, 2019), these figures confirm that land ownership in Italy is generally fragmented, and most farms fall into the small to medium size category. Respondents' farms represented all the main specializations (arable crops, grapevine, woody fruit, pasture, livestock) that characterize the national agricultural industry structure.

Tab. 1. Main characteristics of the sample.

Characteristics	Classes	N	%
Role of respondent	Owner	93	*88.58*
	Collaborator	6	*5.71*
	n.a.	6	*5.71*
Education	Elementary	3	*2.86*
	Middle school	23	*21.90*
	High school	54	*51.43*
	Vocational training	8	*7.62*
	University	23	*16.19*
Farm size	Min	1.5 ha	
	Max	201 ha	
	Mean	36.73 ha	
Workers (excl. seasonal)	1-5	83	*79.05*
	6-10	4	*3.81*
	More than 15	1	*0.95*
	n.a.	17	16.19

The hypotheses were tested via a SEM by using the LISREL 10.2 software. This method is best suited to explicit causal relationships in a latent structure. The purpose of this work is to test the relationships among the four latent dimensions proposed in the model in Figure 1.

First, the factor analysis with varimax oblique rotation approach is used to identify the four latent dimensions of the survey. This is useful to obtain four latent factors as a linear combination with minimum loss of information. The reliability of each latent factor is positively analysed by the Cronbach's α coefficients and the average variance explained (AVE), as summarized in Table 2.

Furthermore, the analysis conducted with LISREL 9.1 allowed us to test the hypotheses made in the proposed model. The fit indexes of the model (Tab. 3) are produced in order to verify how well the hypothesized model reproduces the observed covariance matrix (Nassivera, Sillani, 2017; Sillani, Nassivera, 2015; Cheah *et al.*, 2018). Specifically, the selected indexes are: the goodness of fit index (GFI) and adjusted goodness of fit index (AGFI), both proposed by Schumacker and Lomax (2004); the incremental fit indexes or normed fit index (NFI), proposed by Bentler and Bonnett (1980); the non-normed fit index (NNFI), as proposed by Bollen and Liang (1988); the comparative fit index (CFI), proposed by Bentler (1990); and the root mean square error of approximation (RMSEA), proposed by Browne and Cudeck (1992). The results indicated a good fit between the model and observed data and allowed for the analysis of the assumptions of the hypotheses.

Of the hypotheses, one of the three is well supported (Tab. 4). The correlation between CCC and LAS is statistically significant (y = 0.60, t = 2.75), supporting H3. The relationship between PBA and LAS is not statistically significant (y = -0.05, t = -0.30); hence, H2 is not supported. Lastly, CCB statistically influenced LAS (y = 0.22, t = 1.70). Supporting these hypotheses, the model depicts a particular reactivity of farmers to adopt strategies.

Tab. 2. Reliability and AVE of latent constructs.

Construct and items	Label	λ	α	AVE
CLIMATE CHANGE BELIEFS	CCB		0.64	0.45
Climate change is natural	CCB1	0.40		
Climate change is not happening	CCB2	0.79		
Climate change not confirmed	CCB3	0.69		
PERCEIVED BARRIERS TO ADAPTATION	PBA		0.81	0.5
My long-term success requires climate variability adaptation strategies	PBA1	0.46		
Farmers' long-term success requires climate variability adaptation strategies	PBA2	0.47		
Climate change is damaging me	PBA3	0.80		
Five years perceived increase in climatic instability	PBA4	0.81		
Climate change will likely damage me in the future	PBA5	0.68		
Long-term goals influenced by past extreme weather	PBA6	0.72		
CLIMATE CHANGE CONCERNS	CCC		0.81	0.5
Floods	CCC1	0.59		
Drought	CCC2	0.70		
Phytopathies	CCC3	0.57		
Heavy rain	CCC4	0.70		
Strong wind	CCC5	0.63		
Hailstorm	CCC6	0.79		
Frost	CCC7	0.69		
Plant heat stress	CCC8	0.69		
Water eutrophication	CCC9	0.78		
Soil erosion	CCC10	0.70		
LIKELIHOOD TO ADOPT STRATEGIES	LAS		0.75	0.58
Adapt/optimize production	LAS1	0.58		
Income diversification	LAS2	0.70		
Technological improvement	LAS3	0.57		
Conservative agriculture	LAS4	0.70		
Financing and debt management	LAS5	0.63		

Tab. 3. Main indexes of model fitting.

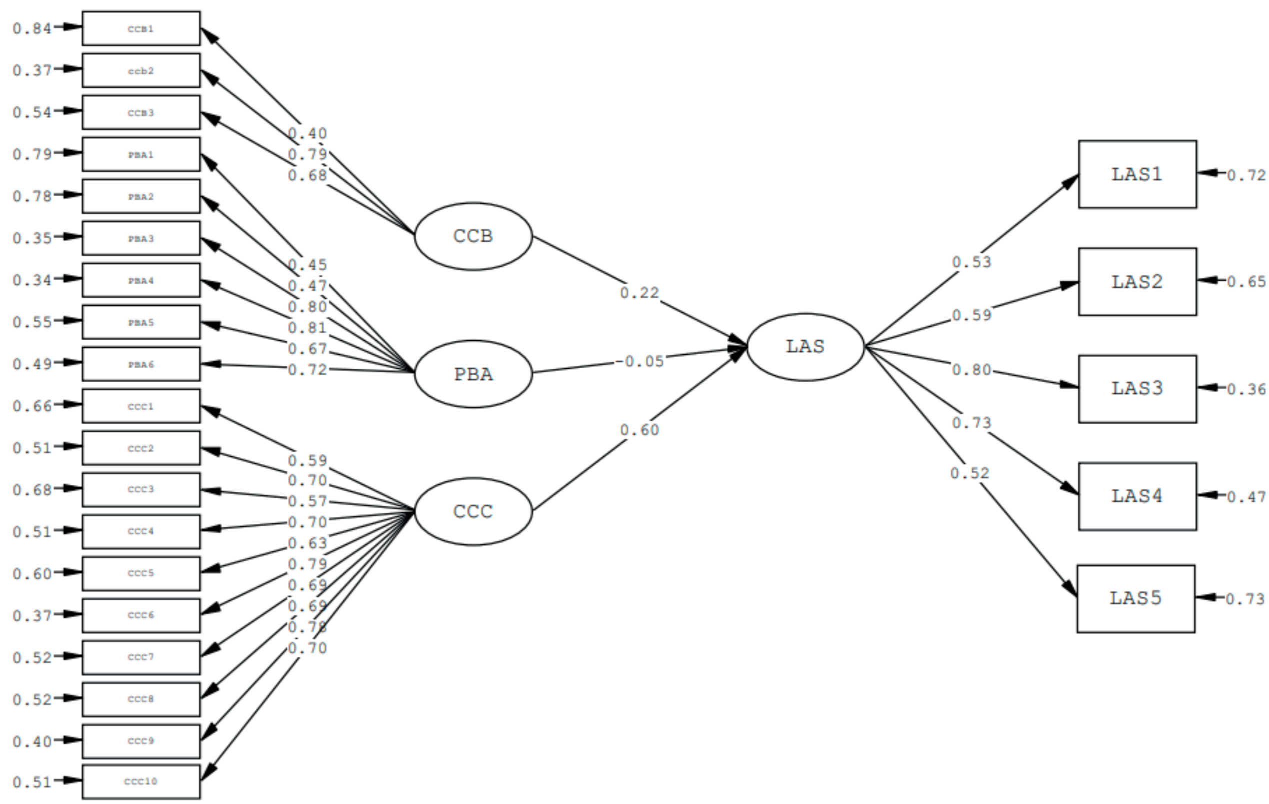
Global fit indexes	Value	gdl
GFI	0.74	
AGFI	0.68	
NFI	0.85	
NNFI	0.91	
CFI	0.91	
RMSEA (Test of Close Fit)	0.096	
$\chi 2$	492.53	246

Tab. 4. Direct effects among constructs.

Hypothesis	Estimate (*Standardized*)	s.e.	t
(H1) CCB→LAS	0.22	0.13	1.70
(H2) PBA→LAS	-0.05	0.17	-0.30
(H3) CCC→LAS	**0.60**	**0.15**	**2.75**

The opinions on climate change of Italian farmers who reside in the north-eastern regions are mixed. While most of them do not believe that climate change is not happening (mean response equal to 2.6), no clear consensus emerges over its natural or anthropogenic origin. This duality in perceptions, already reported in the literature (Niles *et al.*, 2013; Ricart *et al.*, 2018), likely drives respondents' limited concern over climate change *per se*, which is in line with the existing literature (Woods *et al.*, 2017). In fact, climate change appears to be classified as a future, rather than current, problem: this biased temporal perspective, coupled with the feeling of limited control over it, may explain the small effect of CCB on LAS. On the contrary, with respect to PBA, the existence of barriers, though acknowledged, is not a deal breaker: similar to Eakin *et al.* (2014), agricultural entrepreneurs are confident in their adaptive capacity. Finally, the strong positive correlation between CCC and LAS indicates the likelihood to undertake adaptive action in the future and identify potential opportunities from climate change impacts. In this perspective, the more a farmer has experienced or is afraid to experience negative consequences linked to specific extreme meteorological events, the more likely he is to adopt mitigation strategies. In fact, risk-coping strategies are generally based on adequate perception of risks

Fig. 2. Path analysis of the proposed model.



(Sulewski, Kłoczko-Gajewska, 2013); therefore, if the impact of climate change or the vulnerability of their own businesses are perceived as purely hypothetical or a far future matter, adaptation would definitely not be considered a priority (Hitayezu *et al*., 2017; Waldman *et al*., 2019). In line with existing knowledge on the topic (Pagliacci *et al*., 2020; Woods *et al*., 2017), farmers apparently prefer incremental and flexible adaptations in the face of uncertain future climate change impacts.

5. CONCLUSION

Our research contributes to the literature on agricultural risk perception by providing localized insights on the opinions and attitudes of north-eastern Italian farmers. The results of our inquiry call for the necessity to promote sensibilization and spread awareness over the issues related to global climate change trends and their growing impact on agricultural activities and productivity. The analysis confirms that the primary element pushing farmers' intention to adopt risk-coping strategies is the perception of risk and consequent vulnerability (Weber, 2010). Under this perspective, in order to maximize farmers' engagement in mitigation strategies, more effective communication strategies by institutions, policymakers and insurance scheme providers should increase understanding of climate change mechanisms and impacts, and stress that it is already altering the basic conditions for agriculture at our latitudes (Asmi *et al*., 2019; Azadi *et al*., 2019; Whitmarsh, Capstick, 2018). Moreover, the results confirm that pluri- and multi-risk insurance schemes are expensive and barely understood by agricultural entrepreneurs (Georgievich, 2021); more flexible insurance schemes, able to cope with effective risk management and, at the same time, in line with farmers' sentiments and perceptions, would likely be more attractive (Ceballo and Robles, 2020; Doherty *et al*., 2021; Santeramo, 2018). Replication of the study in other regions and nations is desirable to overcome weaknesses and limitations, in particular with respect to geographical representativeness and generalization of the results (Coletta *et al*., 2018, Capitanio *et al*., 2014; Miglietta *et al*., 2021; Pontrandolfi *et al*., 2016).

While the results of our analysis might hardly be generalized outside the specific, though extensive, study area, the model can easily be adapted for replication in other contexts. Further investigations on barriers to adaption might promote policymakers and practitioners' commitment to their removal, hence enhancing farmers' engagement and the adoption of mitigation measures.

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