ISSN 2280-6180
www.fupress.net




BAE

VOL. 10, NO. 2, 2021

Bio-based and Applied Economics



FIRENZE UNIVERSITY PRESS

Bio-based and Applied Economics is the official journal of the Italian Association of Agricultural and Applied Economics – AIEAA (www.aieaa.org; E-mail: info@aieaa.org).

Journal Contact: Meri Raggi, via Belle Arti 41, Dept. of Statistics, 40124 Bologna; Email: meri.raggi@unibo.it

Available online at: http://www.fupress.com/bae

Università degli Studi di Firenze
Firenze University Press
via Cittadella, 7 - 50144 Firenze, Italy
www.fupress.com/
E-mail: journals@fupress.com

ISSN 2280-6180 (print)
ISSN 2280-6172 (online)
Direttore Responsabile: Corrado Giacomini
Registrata al n. 5873 in data 10 maggio 2012
del Tribunale di Firenze

BAE

Bio-based and Applied Economics

Volume 10, Issue 2 - 2021

Firenze University Press

Bio-based and Applied Economics
Published by
Firenze University Press – University of Florence, Italy
Via Cittadella, 7 - 50144 Florence - Italy
http://www.fupress.com/bae

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

Citation: F. Arfini (2021). Mediterranean agriculture facing climate change: Challenges and policies. *Bio-based and Applied Economics* 10(2): 87-88. doi: 10.36253/bae-12230

Received: October 9, 2021
Accepted: October 11, 2021
Published: October 28, 2021

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.

Editor: Fabio Gaetano Santeramo.

ORCID
FA: 0000-0002-5179-2541

Mediterranean agriculture facing climate change: Challenges and policies

Filippo Arfini

Dipartimento di Scienze Economiche e Aziendali, Università di Parma, Italy
E-mail: filippo.arfini@unipr.it

1. BACKGROUND AND OBJECTIVES

This special issue of Bio-based and Applied Economics (BAE) features a selection of four papers previously presented at the 9th Conference of the Italian Association of Agricultural and Applied Economics (AIEAA) (10-12 June 2020, Valenzano-Bari, Italy), titled "Mediterranean agriculture facing climate change: Challenges and policies".

Changes in climate conditions consistently point to increasing risks to societies all over the world in uneven and multiple ways. The increasing average temperatures, frequency and intensity of extreme weather events are expected to severely affect agri-food systems in the next decades. According to figures, climate change is responsible for around 80-90% of projected changes in water availability and soil loss due to desertification processes and erosion. In many areas agricultural land and crop suitability is affected by the climate change that modifies the production patterns. The expected fall in the food production will have important consequences in the gross domestic product in the worst affected regions. All these phenomena will have important consequences for the global social stability.

The harmful effects of global climate change on agriculture are unequally distributed across regions and countries, both in relation to the physical and environmental conditions, and depending on the sensitivity, exposure and adaptive capacity of local natural and social systems. The Mediterranean area is one of the most vulnerable regions in the world to the impacts of global warming, according to international reports and projection scenarios. The European Environmental Agency (2019) states that in the coming decades, the entire Mediterranean region is expected to experience severe climate events with diversified consequences on agriculture, depending on the adaptation capacities of different areas.

The debate on impacts and consequences of climate change on Mediterranean agricultural and food systems is particularly sensitive and controversial, considering historical, socio-economic and political diversities. The Mediterranean region turns out to be a crucial crossroads for people movements induced by climate change. Relocation and movement of people will cause an increased pressure on certain areas in terms of production and consumption,

Firenze University Press | www.fupress.com/bae

while other geographic regions will suffer further erosion and desertification, due to land abandonment and reduced level of land protection. Such migrations put increasing pressure on the geopolitical role of the region as well as its internal relations and domestic politics. Mediterranean countries, due to their geographical location, play a central role in the EU international relations. Programs within Euro-Mediterranean Partnerships often promote initiatives for climate change mitigation and adaptation. Current and future policies for agricultural and sustainable development of Mediterranean countries need to prioritize climate risks considering agriculture multiple objectives such as providing adequate food for growing populations, protecting the environment and ensuring resilience to future climatic change.

Against the above scenarios, the 2018 evaluation report of the EU Adaptation Strategy invites enhancing the knowledge base and encourages new research and development, as well as innovation, in the field of climate change adaptation and mitigation policies.

The purpose of this special issue is to address some of the challenges that agri-food systems in the Mediterranean area are facing due to climate change.

2. THE PAPERS IN THIS ISSUE

The four papers in this issue are very different in scope and methods and provide examples of different and complementary issues in addressing the topic of climate change in the Mediterranean agri-food system.

Vaquero Piñeiro (2021) focuses on GIs and their impact on the economic development of Mediterranean rural areas. Especially the paper aims at identifying whether territorial features drive the success of GIs, thus affecting their capacity to stimulate the local development. The findings demonstrate that PDO-food localized in less-developed regions struggle to achieve the highest GIs market shares. The unique presence of food quality designation does not guarantee the development of the rural area where such food is produced. The study thus invites European, national and local policymakers to intervene in the areas with weaker socio-economic conditions, by applying more flexible production regulations and creating synergies between producers, associations and regional authorities prior the designation.

Raina, Zavalloni, Targetti, D'Alberto, Raggi and Viaggi (2021) focus the attention on the farmers' decision to participate and their willingness to accept (WTA) a particular agri-environmental scheme (AES). According to literature the design of the contracts proposed to farmers influences their choice. The paper thus investigates which are the most successful attributes of the contracts, as highlighted by the scientific literature that uses choice experiments to test farmers' preferences. Results show that monetary attributes, in terms of compensation measures are highly preferred by the farmers and can increase their participation in AES, along with general contract attributes, such as the possibility to include smaller area or a shorter duration, and flexibility attributes, such as higher flexibility of participation, or different kinds of management. The study thus has the ambition to serve as a repository of possible attributes to be used in other choice experiments at disposition of other researchers and policymakers.

The paper by Lamonaca, Santeramo, and Seccia (2021) highlights the connection between climate change and wine productivity in different regions in the world. In particular, the paper aims at analyzing the effect of climate change parameters, such as increasing temperature and precipitation on production patterns in different producing regions such as Old-World Producers and New World Producers. Results seems to suggest that the effect may be different between them: while New World Producers may suffer from precipitation patterns, Old World Producers may suffer from increasing temperature. The paper thus invites other future research to examine how the entry of new world producers in the global markets may affect the global trade of wine and to understand how importers and exporters could react to new trade dynamics, due to climate change, in terms of trade regulations.

Zucaro, Manganiello, Lorenzetti, and Ferrigno (2021) in their article aims at presenting the feasibility and usefulness of Multi Criteria Analysis (MCA) in identifying the most effective project proposals in the field of water management. The issue is relevant considering the increasing effort of European and national institutions to adequately tackle the environmental effects of climate change by means of funds that follow public calls. The paper thus demonstrates that MCA can be useful tool for choosing between different investment alternatives, since it allows for the inclusion of different quantitative and qualitative criteria that can be measured in a single evaluation process. Nevertheless, the methodology is highly complex and there is the high risk of influencing the results of the method, by introducing subjective choices. For this reason, proper methods should also be applied to make MCA a useful informative support for policy decisions.

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: C. Vaquero-Piñeiro (2021). The long-term fortunes of territories as a route for agri-food policies: evidence from Geographical Indications. *Bio-based and Applied Economics* 10(2): 89-108. doi: 10.36253/bae-9429

Received: July, 15, 2020
Accepted: January 5, 2021
Published: October 28, 2021

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.

Editor: Meri Raggi, Davide Menozzi.

ORCID
CVP: 0000-0002-1378-3361

The long-term fortunes of territories as a route for agri-food policies: evidence from Geographical Indications

Cristina Vaquero-Piñeiro

Department of Economics, Università degli Studi Roma Tre, Italy
E-mail: cristina.vaqueropineiro@uniroma3.it

Abstract. Once the EU has perceived the strategic importance of local peculiarities to support rural development and high-quality productions, it has emphasized the need for more place-sensitive agri-food policies. The importance of socio-economic, historical and cultural factors as transfers of intangible value-added is particularly evident in the agri-food sector. Place-blind and sectorial-oriented approaches have indeed not succeeded in dealing with the territorial heterogeneity of agri-food systems. By delving into the longstanding debate on the conceptualizations of territory and focusing on the territories of origin of the most economically performant Italian Protected Designation of Origins (PDOs), this paper empirically investigates what are the contextual conditions that have mainly contributed in the economic success of local productions. Drawing on an original geo-referenced database, the analysis is conducted on a panel of Italian municipalities and exploits non-linear dynamic panel models. Findings point out the heterogeneity of affecting territorial factors. Imbalances come from both socio-economic conditions (food PDOs) and socio-cultural knowledge (wine PDOs). This paper informs the evidence-based debate on the relevance of territorially-sensitive interventions for the future of EU agri-food and rural development policies. In the case of GIs, it should consider being more place-sensitive as well as more integrated with other agricultural and regional policies to meet the EU's socio-economic objectives.

Keywords: local development, geographical indications, rural development policy, agri-food policy, Italy, panel data.
JEL Codes: O130, P250, Q180, C230, O200

INTRODUCTION

In the conventional framework of economic competitiveness, the importance of territorial factors for socio-economic development and policy effectiveness has been subject to competing claims in academic debates. Two main different approaches can be identified (Crescenzi and Rodriguez-Pose, 2011): a territorially-blind and a territorially-sensitive standpoint. The former approach considers economic activities, at least in principle, reproducible everywhere as devoid of any territorial dimension and the maximization of

Firenze University Press | www.fupress.com/bae

factor endowments as a fundamental condition for economic growth. The latter advocates for the active role of territories for economic activities (Pike et al., 2017): contextual specificities help in understanding local production systems, economic growth and development performances and opportunities (Markus et al., 2018; Farole et al., 2011; Scott and Storper, 2003).

The importance of socio-economic, historical and cultural factors as transfers of intangible value-added is particularly evident in the agri-food sector, where productions are deeply rooted in their place-of-origin. To preserve high-quality and traditional products, as well as to support rural development, in 1992 the EU established the Quality scheme for Geographical Indications (GIs) (EEC No 1992/2081). [1] GIs are often framed as levers of economic value-added. However, the economic returns differ radically among GIs. Most of the economic power, in terms of revenues, competitiveness, internationalization and so on, tends to remain spatial and sectorial concentrated. The GIs market is led by products that were well-know also before they got the designation (Qualivita, 2019). As a result, while GIs may stimulate the local economy, they may also cause market inefficiencies and rent-seeking. Among territories, impacts on local development depend on the extent to which local actors succeed in appropriating the rent with respect to actors located outside the region of origin. Within the region of origin, the positive effects of GIs on local development are instead dependent on an inclusive organization that ensures the participation of local actors and equitable distribution of such rent. The main risk is potentially exclusionary effects: the largest agribusiness capture GIs rents without any benefits flowing to smaller (Bramley et al., 2009).

This paper investigates what are the contextual conditions that have mainly contributed in the economic success of local agri-food productions by delving into the longstanding debate on the conceptualizations of territory and focusing on the territories of origin of the most economically performant (in terms of production value) Italian Protected Designation of Origins (PDOs). We start from the hypothesis that the economic benefits of adopting the GIs scheme are biased by contextual conditions. In this way, more developed and productive areas should be likely to persist as leaders in the monopolistic competition.

We develop a novel geo-referenced dataset, use nonlinear spatial dynamic panel models, and the analysis is conducted for food and wine PDOs separately.

Findings show that food-PDOs localized in less-developed regions struggle to achieve the highest GIs market shares. Local instability, defined as socio-economic vulnerability in municipalities and their neighbouring areas, has a negative effect on the success of PDO local market. However, the economic returns of PDO wines seem not to be affected by socio-economic development pre-conditions, but presumably by social and historical factors, such as cultural heritage. This discrepancy suggests that to avoid counterfactual effects the territorial dimension of GIs should not be overlooked. Although we cannot exclude that small producers and less known products have benefited from this scheme, evidence suggests that it might not succeed in dealing with growing market competition (EC, 2020). Better policy results could have been achieved, if the GIs European legal framework taped into both territorial and sectorial heterogeneity of agri-food systems.

The results contribute to better understanding why some territories fail while others thrive in converting local food systems in levers of local economy.

Economic literature has highlighted as place-blind approaches are ill-adapted to address the heterogeneity of agri-food production systems and regional inequalities and advocated in favour of more place and community-sensitive interventions (e.g., De Schutter et al., 2020; OECD, 2016). In the case of the Common Agricultural Policy (CAP), changes in the socio-economic context have shed light on the inadequacy of place-neutral sectorial quantity-oriented interventions to deal with the structural weaknesses of agricultural and rural areas. With the Rural Development Policy introduced by the Agenda2000 reform, context-specific interventions became crucial to promote rural endogenous development (Henke et al., 2018; Dax and Fisher, 2018; Corsinovi and Gaeta, 2019). Not surprisingly, the public buzz for territorial brands, like GIs, increases in parallel with the shift in the paradigms of EU policies towards a more place-based and bottom-up approach (Iammarino et al., 2019).[2] While there is scepticism about promoting innovation and productivity-oriented place-based strategies at the local level (Rodriguez-Pose and Wilkie, 2019), recently agricultural economists have recalled the importance of territorial factors as transfers of intangible value-added

[1] Legal documents available at: https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/quality-schemes-explained/regulations-food-and-agricultural-products_en; https://ec.europa.eu/info/food-farming-fisheries/food-safety-and-quality/certification/quality-labels/quality-schemes-explained/regulations-wine_en

[2] Spatially-targeted and bottom-up are not synonymous. The term spatially-targeted refers to the fact that policies are targeted at specific regions/cities/areas. Conversely, the term refers to the fact that the design of interventions is based on the involvement of local actors and the identification of their needs.

in the light of the European efforts towards more inclusive and sustainable agri-food policies (e.g., Farm to Fork strategy) (EC, 2019). there is a growing concern about the effectiveness of investing in a series of coordinated and wide-ranging interventions targeting local productions to meet those goals. Notwithstanding this progress, interventions have mainly remained locked into territorial-blind approaches without synergies.

This paper proceeds with the introduction of the analytical and theoretical framework underpinning this study (section 1 and 2). The empirical analysis is discussed in section 3, while section 4 presents the results and the composition analysis. Lastly, concluding remarks are provided.

1. UNDERSTANDING TERRITORY: REGIONAL AND AGRICULTURAL ECONOMICS PERSPECTIVES

To what extents territory matters for socio-economic activities has long been disputed among economists, who have examined the different factors in search of answers (Friedman, 2005).

The territory concept has been neglected by neoclassical (Solow, 1957) and endogenous growth theories (e.g., Romer, 1986 and 1994) as well as by the New Economic Geography literature (Ottaviano and Puga, 1998; Krugman, 1991). Understanding how territorial features mediate policy effects and what are the main affecting factors is, however, essential to building coherent and efficient policies (Capello, 2009). Since the early 2000s, the socially constructed nature of regions has been highlighted. Territorial factors have been considered as endogenous resources to blame for socio-economic development (Pike et al., 2017). The concept of space has been progressively replaced by the multidimensional (i.e. diversified-relational) notion of territory. Space and territory are, in fact, not interchangeable terms; territory is not a fixed entity; its evolves and changes in time and space. Territory can be assumed as the combination of coexisting exogenous and endogenous context-specific factors (Paasi, 2010; OECD, 2009; Camagni, 2009). Besides conventional spatial elements like administrative units and geographical boundaries, territory compasses of several human and environmental dimensions influencing each other, e.g., altitude, natural habitats, citizenship, networks, capabilities, ethnicity, and culture (Storper, 2013; Paasi, 2011). Nowadays, the predominant declination of territory refers to a territorial identity: the feelings of belonging to a group not only rooted in common socio-cultural and political values but also in the socio-economic advantages that a system of common competencies and local relationships generate (Zimmerbauer, 2011; Savage et al., 2005). In this perspective, development depends on endogenous factors and amenities; local factors are recognized as drivers of the local long-term development and territorial competitiveness. Path-dependence frictions can arise in socio-economic systems leaving behind less-development regions.

A consensus on what are the structural, physical and socio-cultural characteristics of territories that have a significant impact on local development and firms' choices is, however, still lacking (ESPON, 2017; Barca et al., 2012). Over the years, literature has pointed out the key role of education (Harrison and Turok, 2017), institutions (Rodriguez-Pose, 2020), the quality of governments (Ezcurra and Rios, 2019; Rodriguez-Pose and Garcilazo, 2015; Charron et al., 2014) as well as foreign investments (Crescenzi et al., 2016). Spatial contiguity and accessibility (World Bank, 2009; Boschma, 2005), innovation (Crescenzi and Jaax, 2017; Rodriguez-Pose, 1999), and historical traditions (Cortinovis et al., 2017; Scott, 2004) have also been considered key issues in defining territories.

Albeit with lower emphasis, the importance of territorial peculiarities has been stated also by agricultural economists.

From the supply-chains perspective (Carbone, 2017), territory acquires a distributional-positional meaning, and the geography of agri-food productions is set up in response to market challenges and obstacles, such as land availability, expiry dates and market access.

In marketing and food-label studies, territorial features are strategical assets with the evocative power of creating a perception of exclusiveness and uniqueness (Pike, 2011). Territory works as a catalysator of value-added inferred from reputation and diversification strategies (Newton et al. 2015; San Eugenio-Vela and Barniol-Carcasona, 2015; Shapiro, 1993).

A conceptualization of territory linked to social collectively is emphasised by the last group of economists concerned with how territories instil their peculiarities to agri-food productions (e.g, Rivera et al., 2019; Cross et al., 2011). In their perspective, territorial peculiarities become conditioning factors for the agri-food systems (Sforzi and Mancini, 2012). They represent "an inherent quality system located in a place" (Muchnik, 2009, p. 9) that evokes a special link between the unique quality of agri-food productions and the inimitable peculiarities endowed with local history and culture, tacit knowledge, institutional and social connections, like in the French notion of terroir (Cross et al., 2011; Josling, 2006).[3] These

[3] We can define terroir as a territory endowed with a strong identity characterized by a set of physical-environmental (e.g. soil and climate), social and cultural constructed local resources.

territories are anchored into their socio-economic structures. Among regions specialised in agri-food productions, they are a minority.

Territories specialised in agri-food productions can be classified in areas devoted to standardized and local productions. While standardized systems are reproducible everywhere as unrelated to the contextual features, local systems are linked with their place of origin. Among local agri-food systems characterised by alternative localized distribution schemes (e.g., Km0 farmers' markets), drawing a direct link between producers and consumers (Pretty et al., 2005) must be distinguished from local embedded ones (Bowen and Mutersbaugh, 2014). The latter refers to local production systems entirely connected, and affected, by socio-economic, historical, institutional, natural, and cultural environments. GIs belong to this group.

Dealing with the heterogeneous, unmeasurable and sometimes unobservable dimensions of territory is a very demanding task. To date, a wide set of complementary rather than substitute, methodologies has been used. Qualitative approaches, such as surveys, focus groups, ethnography experiences or thematic analysis, are the most exploited (Lourenco-Gomes et al., 2015; Dedeurwaerdere et al., 2015; Tregear et al., 2007). For instance, Haeck et al. (2019) has recently conducted a qualitative analysis to reconstruct the evolution of four of the most famous European wine terroirs, namely Port, Chianti, Champagne and Burgundy from historical documents.

Econometric and quantitative investigations are scanter, also due to methodological-statistical complexity (Kelly, 2020). Recently, OECD (2019) has formalised quasi-experimental (i.e. counterfactual) analyses as efficient methodologies to evaluate how effects of agricultural and rural policies interventions may vary across space, confirming the validity of what a great number of empirical studies have done (e.g., Dinkelman, 2011). These techniques capture territorial elements by estimating the difference between treated and non-treated observations given that only one group of observations is treated (Bondonio and Greenbauman, 2018; Daunfeldt et al., 2017). In utility and agent-based models, it is conceived as an element beyond the actors' making processes (Kremmydas et al., 2018; Altomonte et al., 2016; Brady et al., 2012). Spatial analyses are the most used as they are able to consider where the phenomenon takes place and capture the presence of spatial spillover effects and the potential geographical endogeneity (e.g., Wicht et al., 2019; Crescenzi and Giua, 2016; Henderson et al., 2012).

This paper leverages on the latter approach and uses the Italian PDOs in order to identify which are the territorial features that mainly support the economic performant of local agri-food systems.

2. GEOGRAPHICAL INDICATIONS: A CONFLICTING TERRITORIALLY-BASED APPROACH

Over the last decades in Europe, agri-food products deeply-rooted in their place-of-origin are marked by Geographical Indications. This sign identifies the product as legally tied to a specific production area where micro-climatic conditions, informal traditions, entrepreneurial practices and channels of collaboration were consolidated over time.

GIs comprise of Protected Designation of Origin (PDO) and Protected Geographical Indications (PGI).[4] The differences between PDO and PGI are linked primarily to how much of the product's raw materials must come from the area or how much of the production process has to take place within the specific region. In the case of PDOs, every part of the production, processing and preparation process must take place in the specific region. For wines, grapes have to come exclusively from the geographical area where the wine is made. PGIs requires that at least one of the stages of production, processing or preparation takes place in the region. At least 85% of the grapes used have to come exclusively from the geographical area where the wine is actually made.

GIs offer worldwide recognition and protection through the specific property right scheme, which identifies and endorses local forms of production on a global scale (Reg. EU No.2012/1151; Reg. EU No.2013/1308). At the world level, more than 200 bilateral and multilateral WIPO and WTO agreements exist defining GIs regulations.[5]

However, GI regime goes father becoming the institutional formalization of localized agri-food systems (Liu et al., 2016; Menapace et al., 2012). Indeed, for GIs, tacit knowledge, informal institutions, historical traditions and cultural habits are important as much as environmental factors, or even more (e.g., Van Leeuwen and

[4] The European quality scheme for agri-food products preserves also Traditional speciality guaranteed (TSG). TSG highlights the way the product is made or its composition, without being related to a specific geographical area. The name of a product being registered as a TSG protects it against falsification and misuse.

[5] The WTO TRIPS Agreements (1994), the WIPO Madrid Protocol, the WIPO Lisbon Agreement on Appellations of Origin and their international registration (1958), the WIPO Geneva Act of the Lisbon Agreement on Appellations of Origin and Geographical Indications (2015). In addition, the enforcement of GIs is carried out thanks to bilateral agreements between EU and trading partners, such as South-Korea, Japan and CETA. More information available at https://www.wipo.int/geo_indications/en/.

Seguin, 2006).[6] The quality expressed by the GIs is a fundamental territorial asset (Ditter and Brouard, 2014), expression of the cross-fertilization of specific contextual conditions.

The literature on GIs is quite vast, due to the great EU efforts on supporting this scheme. A bourgeoning group of studies has attempted to evaluate the ex-post impacts of GIs on premium pricing and economic value (Costanigro et al., 2019; Cacchiarelli et al., 2014), market access (Prescot et al., 2020; Altomonte et al., 2016), exports (Agostino and Trivieri, 2014), value distribution (Belletti and Marescotti, 2011) or local development (FAO, 2018). The chain of causality might be, however, ambiguous as GIs and socio-economic developed conditions strengthen each other.

A second group of contributions have investigated what factors encourage producers to obtain institutional acknowledgement. Favourable institutional context, local actors' engagement and co-operation have been highlighted among others (Meloni and Swinnen, 2018; Charters and Spielmann, 2014). Despite the common regulatory framework, GIs located in regions with similar environmental and natural elements, differ in the capacity of creating economic value due to other territorial conditions (e.g., socio-economic and cultural) (Haeck et al., 2019).

GIs are increasingly valued for their endogenous development potential (Gangjee, 2017). It aims to support long-run development by strengthening the endogenous local assets (Marsden, 2003). The establishment of a GI system can stimulate rural development, but previous structural bottlenecks of the region of origins are likely to impact on the whole local economy, and, in turn, GIs can also be negatively affected.

Although there is not enough empirical evidence of this link to date, the uneven spatial distribution of GIs across countries and regions may be a first wake-up call. If we look at the most important (in terms of revenues) PDOs in Italy, they are spatially concentrated in the North-Central Italy (Fig. 1),[7] which are the most developed ones (Fig. A1, A2 and A3).[8] According to the 2019 Qualivita report, Emilia Romagna is the first region in terms of the territorial economic impact of GIs food, around 3 million euros. In the same way, PDO wines predominate in the North, while the South has the large majority of generic wines. The Northern regions account for the largest share of vineyard area for PDO wines and the highest number of farms producing PDO vines (ISTAT, 2010). The hypothesis that less developed regions struggle to convert GIs in levers of development, cannot be thus excluded a-priori. It is not just about identifying traditional products; the success of GIs lies also on the socio-economic and institutional context. Several studies have confirmed the relevance of institutional context (Giovannucci et al., 2009), cooperation along the supply-chain and local actors engagement (Bowen, 2010) as well as the fact that lagging areas are beset by problems of institutional sclerosis (Farole et al., 2014).

Figure 1. Most important PDOs in Italy (production value) (Source: Author's elaboration on data collected from PDO codes of practice).

Even if the success of these GIs is likely to be determined by the territorial-specific factors of the region of origin, the European regulation on GIs seems to not concerned explicitly the interaction between a single unitary EU framework and the heterogeneity diversified territorial conditions of the regions of origin. Moreover, there is a lack of a sort of policy package within existing EU policies (i.e. CAP and Cohesion Policy) supporting quality schemes and the synergies with other agricultural and regional policy mix used by the EU is weak.

[6] According to the European regulation, the decision of designating an agri-food product as GIs is based on three main points: (1) the specific nature of local resources used in the production process, (2) the application of traditional production techniques and (3) the presence of local identity.

[7] Parmigiano Reggiano PDO, Grana Padano PDO, Prosciutto di Parma PDO, Prosecco PDO, Mozzarella di Bufala Campana PDO, Gorgonzola PDO, Prosciutto di San Daniele PDO, Conegliano Valdobbiadene – Prosecco PDO, Pecorino Romano PDO and Asti PDO (Qualivita, 2018).

[8] A vibrant literature employs population, employment and income data as a measure of economic development.

This scenario may pave the way to path-dependence frictions in the economic returns of local agri-food of less-developed regions and less-renewed products. Understanding which, and to what extent, territorial conditions have been more relevant is challenging, but there is a need to investigate it. Otherwise, practical caveats on how to operationalise these tools to the benefit of agri-food systems cannot be drawn. The next sections provide robust evidence in this direction.

3. METHODOLOGY AND EMPIRICAL APPLICATION

The aim of the analysis is to assess the importance of territorial features by using the most economically performant (in terms of revenues) PDOs in Italy as a case study. We use the official national ranking provided by the 2018 annual report of ISMEA-Qualivita. They account for just over a third of the Italian GIs market production value by themselves (36 per cent).[9] Among them, Parmigiano Reggiano PDO shows the highest value (€1,343 m), followed by Grana Padano PDO (€1,293 m) and Prosciutto di Parma PDO (€850 m). The leader of PDO wines is the Prosecco-system: Prosecco PDO (€631 m - bulk) and Conegliano Valdobbiadene Prosecco PDO (€184 m - bulk).

The analysis is conducted at the municipality level on a panel of 7,755 Italian municipalities observed from 1991 to 2011.[10] Since the 1992 European Regulation, the number of municipalities included in PDO areas increases over time. In 2011, 60 per cent of sample municipalities are included within the production area of one of the PDOs under analysis. In the case of wine, first GIs was assigned in 1962, and therefore already existed in 1991: in 1991, 2.5 per cent of sample municipalities were producing the most performant PDO wines, and they reached 11 per cent in 2011. PDOs came to be recognized during the sample period justifing the use of a panel.

Municipalities are the most appropriate observation to conduct the analysis due to the fact that the GIs regulation (especially for the wine sector) is established at that level. We know that the designated areas are not always defined on administrative boundaries and that for some PDOs the spatial scale can exceed the municipality level. However if we had conducted the analysis at a more aggregate level, for the majority of PDOs the result would have co-mingled PDO and non-PDO municipalities, resulting in a lower level of precision and constant contextual factors (Ashley and Maxwell, 2001). Considering the exact production areas would improve the explanatory power of the analysis, but contextual indicators do not exist. Conversely, if we consider more aggregated administrative units (i.e. provinces or regions), we will include areas where the product is not produced and contextual factors will become constant for all products. As a result, the municipality level is the most appropriate one for this study.

We rely on an original geo-referenced database arranged by digitalizing all the GIs product specifications and collecting data from national censuses and remote sensing sources. Existing literature, indeed, have extensively applied panel data models and spatial econometrics to control for omitted variable bias, measurements errors and endogeneity issues (Hsiao, 2007). The validity of adopting a spatial specification has been properly tested (Elhorst, 2014). The Moran's test has been performed to check for spatial autocorrelation, which has been also ruled out by the spatially lagged variable.

We adopt a binary choice model to estimate the probability that a municipality is included in the production area of PDOs under analysis.[11] We exploit the following spatial dynamic logit-panel models with fixed effects, according to Hausman's test:[12]

$$Y_{i,t}= \alpha + \beta_1 LocalAgriculture_{i,t} + \beta_2 LocalContext_{i.,t} + - \beta_3 LocalEconomy_{i,t} + \beta_4 m(LocalEconomy, s)_{i,t} + + \beta_5 m(z,s)_{i,t} + \beta_6 RegAg_{i,t} + \delta i + \delta t + \varepsilon_{it} \quad (1)$$

[9] PDO-food: Parmigiano Reggiano PDO, Grana Padano PDO, Prosciutto di Parma PDO, Mozzarella di Bufala Campana PDO, Gorgonzola PDO, Prosciutto di San Daniele PDO, Pecorino Romano PDO, Asiago PDO, Mela della Val di Non PDO. PDO-wine: Prosecco PDO, Conegliano-Valdobbiadene Prosecco PDO, Asti PDO, Amarone della Valpolicella PDO, Alto Adige PDO, Chianti Classico PDO, Barolo PDO, Valpolicella Ripasso PDO, Chianti PDO.

[10] We restrict our sample to those municipalities whose administrative borders have been never changed since 1951. Although several high-performing PDO-wines existed already long before 1991, the analysis starts in 1991 due to the fact that the first PDO-foods were registered in 1996 by the EU. The analysis stops in 2011 due to census data availability.

[11] Although territories "do not take decisions" and using agents' micro-data are more adequate for choice models, they can be used also to estimate the probability of a certain class or event existing, regardless of the fact that the outcome depends on agents' choices. In this perspective, we consider the probability that a municipality is included in the production area, which can be at least partially assumed due to the choices of agents working in this context.

[12] The choice of a fixed-effects approach is justified on both conceptual and empirical grounds. From the conceptual point of view, the municipalities included in the dataset cannot be considered as a 'random sample' of the Italian municipalities. Moreover, fixed-effects make it possible to control for all the geographical variables fixed over time (e.g., altitude, remoteness and soil texture) and partially for unobserved time-invariant factors. Since regional characteristics accounted for the unobserved specific components are likely to be correlated with other geographical aspects, fixed effects are preferable (Rodriguez-Pose and Fratesi, 2004). From the empirical standpoint, we the Hausman's test confirms that fixed-effects estimation has to be preferred over random effects.

where $Y_{i,t}$ is a binary variable taking value 1 if the municipality *i* is within the PDO area at the census year *t* (0 otherwise). We estimate the model twice: (i) $Y_{i,t}$ refers to the production areas of the most relevant food PDOs and (ii) $Y_{i,t}$ refers to the production areas of the most relevant PDO wines. The wine sector is very different in international reach, history and organization, and thereby needs to be investigate separately.

Being a PDO area is regressed on independent variables referring to the agricultural sector (*LocalAgriculture)* and the socio-economic context of municipalities (*LocalContext)*. The economic prosperity and the well-being conditions are captured by an economic and social vulnerability index provided by the Italian Statistic Institute (ISTAT) (*LocalEconomy*). This index summarises the socio-economic condition of each municipality related to some principal components, such as education, income, employment and housing. The spatial lagged value of this index is also included, *m(LocalEconomy)*, as well as other spatially lagged territorial characteristics *m(z,s)*.[13] In all specifications, we control for the regional output of the agricultural sector (*RegAg*), municipality (δi) and time (δt) fixed-effects. $\varepsilon_{i,t}$ is the idiosyncratic error. Variables are described in details in Table A1 of the Appendix, while Table A2 shows their descriptive statistics.

Potential concerns can regard the outcome selection, as the choice of PDOs could seem to be almost tautological.

First of all, as sometimes PGIs outweigh the production value of PDOs. However, PDOs are the only ones that allow us to properly capture the product-territory nexus given the rules of GIs assignment. They have the strongest links to the place where they are produced as every part of the production, processing and preparation processes must take place in the same region. Conversely, in the case of PGIs only one of the stages of production, processing or preparation has to take place in the area. In this sense, we have however to highlight the fact that the products specifications of some of these PDOs are "unconventional", as they allow raw materials to come from areas not included in the designed production area. Prosciutto di Parma is one of them.[14] Although the non-coincidence could have some endogeneity implications for the study, we minimise it by considering only the municipalities where the production process takes place (areas from where raw materials can come from have been excluded). In this way, we are more confident that the model estimates the effect on the delimited areas whose traditional production techniques have been recognized and codified. The geographical, historical and cultural origin added-value regard, in fact, the production areas, and not the other regions outside of this space-bounded context.

Secondly, because of the threshold in the number of PDOs. If we had considered all the PDOs, in fact, the majority of Italian municipalities would have become treated, and there would have not been enough spatial heterogeneity for the analysis. Lastly, we consider the status of being a PDO area without differentiation (e.g., an ascending ranking classification) as it allows us to compare the status – being a PDO area – regardless of the structural differences between productions.

Reverse causality may affect the estimates yet. The main concern regards the possibility that some explanatory variables might be affected by the achievement of PDOs certification. In this direction, the use of long term variables, which are territorial factors that cannot be influenced in the short-run by the achievement of PDOs, such as population density or education level, reduce the probability of this reverse causality. The fact that PDOs follow a common European acknowledgement and scheme rules potential endogeneity bias out. Endogeneity is also minimized by controlling for long-term territorial characteristics.

4. RESULTS

Regression analysis provides an in-depth insight into the relevance and the nature of territorial features. Agri-food sector characteristics are entered as the first block of explanatory variables (column 1), followed by demographic and contextual predictors (column 2), employment controls (column 3) and economic vulnerability index (column 4). Conscious that estimations do not represent causal mechanism, in the interpretation, we focus on the comprehensive significance of both signs and coefficients. [15]

Estimations in Table 1 suggest that the Italian food PDOs with highest revenues come from municipali-

[13] Spatial lags have been measured through the nearest neighbour approach.

[14] According to the product specification, the raw materials originate from a larger geographical area than the production area [Province of Parma] that corresponds to the following regions: Emilia-Romagna, Veneto, Lombardy, Piedmont, Molise, Umbria, Tuscany, Marche, Abruzzi, Lazio. This exception has been justified from the producers' perspective to ensure consistent and adequate supplies of raw materials.

[15] As a robustness check, we investigate what will happen if we consider the presence of one of these PDOs as a driver of local development, rather than the result. In practice, we use the dummy accounting for the presence of PDOs no longer as the outcome variable, but as an explanatory one (i.e. 1 for those municipalities included in PDO areas, 0 otherwise). The outcome variable refers to local development in terms of population growth and employment rate. The test is conducted over the same 1991-2011. Results are available upon request.

ties with better socio-economic conditions, a diversified economy and a competitive agri-food sector. This is particularly relevant given that a handful of large-scale actors still access and monopolise these markets and some scepticism persists about the viability and rigidity of this regime (Meloni and Swinnen, 2013; EU, 2010). This is the case of some Italian Central and Northern regions, such as Emilia Romagna region, where the geographical concentration of farming activities and local know-how have promoted the shift towards an outstanding agri-food sector (INEA, 2012).

Economically performant PDOs are positively correlated with the share of commercial farms and the productivity rate of agricultural areas, but negatively with the absolute amount of UAA. GIs economic returns are indeed unrelated not only with the agricultural sector, for which can become even counterproductive in terms of productivity and land exploitation but also with the whole economic system of the place-of-origin.

A positive correlation emerges in the case of lower illiteracy rates, lower vulnerability index and the presence of diversified and interconnected economies. The vulnerability index of neighbourhood municipalities is also negatively correlated suggesting that indirect spatial effects exist. In the case of the most economic performant Italian PDOs, the establishment of a successful GIs would seem to be brought forward from the presence of thriving socio-economic preconditions and higher value-added economies, which have been considered an expression of economic growth for years. The regional output of the agricultural sector has been positive and statistically significant since the first specification. However, it does not reduce or undo, the significance of the territorial variables.

However, results are not univocal and there is not a one-size-fits-all solution to territorial dynamics. Estimations point out a different story when we performed the same set of analysis on the PDO wines with the highest revenues (Table 2): the socio-economic predictors are no longer statistically significant. The only exceptions are agricultural intensity and illiteracy rate, but they are not enough to conclude that there is an overall effect of ex-ante development condition on leading PDO wine market. Other contextual factors hidden behind would seem to be responsible for the success of the high segment of PDO wines market (e.g., relational and social assets).

Vitivinicultural activity has contributed for the success of the European agri-food sector and the maintaining of adequate socio-economic conditions in some lagging regions for decades. In Italy, local winegrowers have continued their activity over the decades preserving an outstanding capillary spatial distribution and different varietals (Corsi et al., 2019). Vine-growing shifts from the popular viticulture that characterized the Roman Empire, to the viticulture managed by churches and monasteries during the Middle Ages to the low-quality wines of local farmers during the XVI and XVII centuries. The unification of Italy in 1861 paved the way to some specific policy interventions with high-quality orientation. After the Second World War, when Italy had to decide if importing French grapes or recovering the Italian historical ones, the latter strategy was followed. As a result, most of the current PDO-wines are rooted in their historical presence and family businesses. This does not mean that they have been well-known wines since the beginning, but that their grapes have a century-old history that cut across time hiding the presence of common habits, informal institutions and cultural proximity. The history of *Brunello di Montalcino* is an evocative example.[16] A productive and high-quality vineyard is a long-time investment strongly hard to replicate either elsewhere or in a short time (Carbone et al., 2019).[17] During that time, vineyards are certainly affected by the geographical and pedological factors of the region, such as minerals, organic matters and micronutrients, but they are also embedded in cultural habits, tacit knowledge and historical traditions of local communities (i.e. terroir). Cultural traditions, community-based expertise and local identity seem to be thus decisive. From a theoretical perspective, these results are consistent with the integrated territorial approach literature that advocates for the relevance of considering the heterogeneity of all exogenous and endogenous features.

In sum, findings suggest that not only economic returns but also affecting territorial factors are highly heterogeneous across PDOs. While in the food sector the higher production value of the most relevant Italian PDOs seems to be explained by an ex-ante socio-economic development and a vibrant agri-food system, in the case of PDO wines it depends on other contextual factors.

These adverse socio-economic influences should be taken into account when projecting the future returns and effectiveness of agri-food policies targeting local

[16] The product specification tells the history of the *Brunello di Montalcino* and reveals that it has achieved its fame thanks to a few local farmers who had been continuing the production over the two World Wars. After the Second World War, when historical grapes were reintroduced to restart to produce typical wines, the *Brunello di Montalcino* was selected and became one of the most renewed Italian wine worldwide. It was one of the first Italian wines to receive the DOC certification, in 1966, and to be recognized as DOCG, in 1980.

[17] Vineyards are permanent crops that occupy the yielding for centuries, do not grow in rotation and their effective production starts years after vines have been planted.

Table 1. Effects of contextual factors on PDO-food.

	(1)	(2)	(3)	(4)
Utilized Agricultural Area (UAA)	-0.003***	-0.003***	-0.002***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural intensity	5.633***	5.921***	4.321***	5.177***
	(0.380)	(0.504)	(0.878)	(1.317)
Big farms	37.581***	35.543***	19.581***	21.961***
	(1.760)	(1.891)	(2.595)	(3.891)
Family farms	1.712***	1.137*	0.602	-0.588
	(0.454)	(0.654)	(1.366)	(2.509)
Livestock	-4.438***	-3.757***	-2.919***	-4.085***
	(0.225)	(0.284)	(0.602)	(0.901)
Population density		0.003**	-0.001	-0.000
		(0.001)	(0.003)	(0.004)
Illiteracy rate		-2.769***	-1.567***	-1.438***
		(0.128)	(0.190)	(0.243)
Employment rate			0.046	-0.079***
			(0.055)	(0.850)
Employed people in agriculture, forestry and fishing			-0.335***	-0.394***
			(0.037)	(0.0622)
Employed people in tradable sectors			0.357***	0.342***
			(0.030)	(0.045)
Employed people in services sectors			0.153***	0.216***
			(0.039)	(0.057)
Economic vulnerability index				-0.865***
				(0.152)
Economic vulnerability index – Spatial lag				-1.765***
				(0.239)
Territorial characteristics – spatial lags		✓	✓	✓
Regional output agricultural sector	✓	✓	✓	✓
Municipalities and year FE	✓	✓	✓	✓
Observations	9,166	9,166	9,166	9,166
Municipalities	4,583	4,583	4,583	4,583
Hausman FE/RE (p>χ2)				
χ2	713.80	872.74	305.03	193.71
p-value	0.000	0.000	0.000	0.000

Notes: observations are at the municipality-year level; fixed effects estimations; standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Test for multicollinearity has been performed; estimations for the odd-ratio are coherent. We only report the preferred fixed effects results.
Source: Author's elaboration.

development, like GIs, otherwise the evaluation may be biased.[18]

[18] According to the Italian Regulation (DM 14/10/2013, art.6), a sort of preventive diagnosis is already needed by Italian National Authority in the socio-economic report (i.e. one of the documents required for the application). However, the socio-economic report requires a very limited number of data: the amount of production (i.e. quantity produced over the last three years) and the number of local actors engaged (i.e. people working along the supply chain). Information on the socio-economic conditions of the area and on the other EU policies in force (e.g., Cohesion and CAP policy) is conversely not requested.

4.1 Composition analysis

After providing evidence of the long-run effect of the socio-economic contextual features in the case of PDO-food, we turn to an analysis of the potential mechanisms they operate through.

Table 2. Effects of contextual factors on PDO-wine.

	(1)	(2)	(3)	(4)
Utilized Agricultural Area (UAA)	-0.001***	-0.000	0.001	0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Agricultural intensity	10.525***	8.304***	6.788*	11.091*
	(3.10)	(2.295)	(3.652)	(6.272)
Big farms	-305.76***	-54.301*	-54.772	-13.318
	(48.493)	(28.663)	(20.337)	(23.582)
Family farms	-15.470***	-13.515***	-10.044	-9.106
	(2.03)	(3.325)	(6.602)	(6.442)
Vineyards	-9.990***	-4.666	-7.169	-6.994
	(2.322)	(5.039)	(8.845)	(7.953)
Population density		0.006	-0.002	0.001
		(0.006)	(0.011)	(0.011)
Illiteracy rate		-2.765**	2.448*	4.373**
		(1.084)	(1.751)	(1.912)
Employment rate			-0.308	-0.405
			(0.340)	(0.366)
Employed people in agriculture, forestry and fishing			-0.619	-0.804
			(0.477)	(0.614)
Employed people in tradable sectors			0.319*	0.238
			(0.184)	(0.173)
Employed people in services sectors			-0.119	-0.422
			(0.261)	(0.325)
Economic vulnerability index				-1.161
				(0.978)
Economic vulnerability index – Spatial lag				0.678
				(0.802)
Territorial characteristics – spatial lags		✓	✓	✓
Regional output agricultural sector	✓	✓	✓	✓
Municipalities and year FE	✓	✓	✓	✓
Observations	1,586	1,586	1,586	1,586
Municipalities	532	532	532	532
Hausman FE/RE (p>χ2)				
χ2	33.27	28.85	28.26	48.14
p-value	0.000	0.000	0.013	0.000

Notes: observations are at the municipality-year level; fixed effects estimations; standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Test for multicollinearity has been performed; estimations for the odd-ratio are coherent. We only report the preferred fixed effects results. The sample is restricted to municipalities with positive vineyards UAA.
Source: Author's elaboration.

The European Commission has included among its top priorities the revitalization of rural areas (EC, 2016) and GIs are often presented as a potential strategic tool, but how do the negative effects of socio-economic vulnerability differ by level of rurality?

Table 3 considers the level of rurality of municipalities.[19] We use the National Rural Network classification that groups municipalities in urban poles, rural areas with specialised intensive agriculture, intermediate rural areas, rural areas with comprehensive developed problems.[20] In comparison with conventional rural classifications based on population density, this one allows us to capture the complementary effect generated not only by being classified as a rural municipality but also by being

[19] Even if the baseline estimations have highlighted the no relevance of socio-economic conditions for PDO wines, we conduct the analysis also for PDO wines, but, as we can expect, the test is not significant. Both the socio-economic index and the interaction terms are not significant.

[20] More information available at https://www.reterurale.it/areerurali.

Table 3. PDOs, rurality and economic vulnerability.

	PDO food
Economic vulnerability index (EVI)	-3.067*** (0.954)
Economic vulnerability index*Rurality	
EVI* rural areas with specialised intensive agriculture	1.602* (1.001)
EVI* intermediate rural areas	2.422*** (0.971)
EVI* rural areas with comprehensive developed problems	2.234*** (0.957)
Rurality dummy	✓
Agricultural controls	✓
Socio-economic contextual conditions	✓
Economic vulnerability index – Spatial lag	✓
Territorial characteristics – spatial lags	✓
Regional output agricultural sector	✓
Municipalities and year FE	✓
Observations	9,144
Municipalities	4,572

Notes: observations are at the municipality-year level; fixed effects estimations; standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1.
Test for multicollinearity has been performed; estimations for the odd-ratio are coherent.
Model (1) has been augmented with the interaction term between the level of vulnerability index and the level of rurality; all the other explanatory variables are the same.
Evi*non rural as the control level.
Source: Author's elaboration.

Table 4. Effects of contextual factors on PDO-food by product categories.

	PDO-cheese	PDO-cured ham
Utilized Agricultural Area (UAA)	-0.001*** (0.000)	0.000** (0.000)
Agricultural intensity	0.161 (0.199)	2.916** (1.487)
Family farms	0.997*** (0.245)	10.176*** (1.935)
Population density	0.000 (0.000)	0.002 (0.002)
Illiteracy rate	-0.551*** (0.057)	-2.511*** (0.731)
Employment rate	-0.016 (0.046)	0.071 (0.075)
Employed people in agriculture, forestry and fishing	0.031*** (0.007)	0.009 (0.044)
Employed people in tradable sectors	0.015*** (0.007)	-0.087* (0.047)
Employed people in services sectors	-0.029*** (0.008)	-0.191*** (0.071)
Economic vulnerability index	-0.074** (0.035)	-0.671*** (0.309)
Economic vulnerability index – Spatial lag	✓	✓
Territorial characteristics – spatial lags	✓	✓
Regional output agricultural sector	✓	✓
Observations	5,715	550
R^2adj	0.23	0.38

Notes: observations are at the municipality level (Yi); cross-section estimations; standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Test for multicollinearity has been performed.
PDO-cheese: Parmigiano Reggiano PDO, Grana Padano PDO, Mozzarella di Bufala Campana PDO, Gorgonzola PDO, Pecorino Romano PDO, Asiago PDO.
PDO-cured ham: Prosciutto di Parma PDO and Prosciutto San Daniele PDO.
Source: Author's elaboration.

more devoted to intensive agriculture activities or suffering from structural bottlenecks.

The results confirm the overall negative impact, in line with the baseline estimations, which however diminishes in the case of intermediate rural areas. The socio-economic vulnerability in these areas does not particularly hind the economic returns of GIs.

How are the territorial effects distributed across PDOs category? In terms of economic returns, cheese and cured-ham PDOs are the most repressed, in line with the national trend.[21] The model is estimated for each category separately (in order to compute product-specific effects) and focused on those regions where the production area is located. In the case of cured-ham, successful PDOs would seem to be particularly brought forward from the presence of higher productivity rates and the presence of family farms. In the case of cheese, the presence of thriving socio-economic preconditions and higher-value-added economies would be more relevant. In terms of socio-economic vulnerability, municipalities with cured-ham PDOs are the most affected.

These results need to be framed in the exception to the origin requirement for raw materials (e.g., meat and milk), which may come from another geographical area, of some of these PDOs. The external sourcing makes local expertise and specificities more important in shaping the economic success of GIs as related to product production and transformation. Only a few restricted areas have developed as production areas for hams with a designation thanks to the unique, inimitable condi-

[21] In Italy, the dairy sector accounts for the 57 per cent of the GIs' market in terms of production value.

tions and specific human skills.[22] The evidence of the positive effects of family farms goes in this direction; it is valid only for product-specific nature, with no insights for Italian PDOs as a whole.

CONCLUSIONS

Territorial features play a fundamental role in agri-food production systems. They generate a sort of entry barrier deriving from the strong linkage with the place of production, its inimitable resources, and specific competences. In this perspective, the quality system of the designations of origin has assumed a crucial role, as it represents the first step to deal with rural development by distinguishing local products from standardized ones.

Local production systems are very promising in terms of reducing environmental impacts, safeguarding local expertise and avoiding those high-quality local products will be crushed by industrialized and quantity-oriented competitors, like the New World Wines countries (Mariani et al., 2012). Conversely, several studies have provided insights on the responsibility of one-fits-all and place-blind approaches for the growing decline in the returns of a public intervention targeting local needs (Rodriguez-Pose, 2020). They could risk triggering communities towards homogenous economic systems and standardized productions.

On their part, agri-food policies have slowly proven to adapt to this paradigm (EC, 2016). There is a great deal of interest harnessing rural and regional territorially-sensitive development tools in the service of building local agri-food systems.

This paper has contributed to this debate by empirically demonstrating that territorial factors are fundamental to understand local dynamics, and the socio-economic benefits of local production systems, like GIs. We identify that a product-territory nexus exists, but that the affecting territorial factors differ across regions and sectors. Imbalances come from both socio-economic conditions (food PDOs) and socio-cultural knowledge (wine PDOs).

GIs require a full-ranging adaptation of local economies. Producers must follow product specification, new administration offices (i.e., *Consortia*) must be established to collectively manage the appellation and intersectoral productive and services mechanisms activated. The presence of a fertile socio-economic context could support this process. However, these peculiarities are not evenly distributed across all municipalities.

This territorial imbalance of GIs requires above all addressing the territorial distress felt by the areas that have been left behind by a preventive territorial analysis of the production area, more severe than the socio-economic report required for the application. The territorial diagnosis should be conducted to collect information on the socio-economic conditions of the area, the other EU policies in force and local potential strengths and weakness with the ultimate aim to find territorial features contributing to the success of different types of territories. Even if EU institutions have highlighted the importance of supporting GIs products by a common regulation to achieve rural development, these results show that the GIs scheme, as it is now, is yet far away from ensuring the benefit of such regime to all products, and places-of-origin. A possible adaptation of GIs scheme to the socio-economic condition of production areas may be introducing to guarantee far-reaching general provisions for less-developed areas or niche products. For instance, from the offer side, the lack of a florid socio-economic context should entail an effort by EU and national institutions to create synergies between producers, associations and regional authorities prior to the designation.

Ideally, only by creating a sort of policy package within the existing EU policy mix, the GIs regime could operate as a flexible strategic tool to support the local development and well-being of all the regions-of-origin. Being aware of the key role of territories should be a necessary condition for policymakers and practitioners to understand why agri-food systems located in similar regions sometimes react so differently to the same policies.

ACKNOWLEDGEMENTS

The author would like to thank participants at the 2020 AIEAA Conference, the editor and two anonymous referees, for their helpful and constructive comments that greatly contributed to improving the final version of the paper. The author would like to thank Fabrizio De Filippis, Riccardo Crescenzi and Mara Giua for their very helpful contribution to the first version of the paper.

REFERENCES

Agostino, M. and Trivieri, F. (2014). Geographical indication and wine exports. An empirical investigation considering the major European producers. Food Policy 46:22-36.

[22] Dossier No. IT/PDO/0117/0067. It can be accessed at http://ec.europa.eu/agriculture/quality/door/list.html (Accessed on 10 Apr 2014).

Altomonte, C., Colantone, I., and Pennings, E. (2016). Heterogeneous Firms and Asymmetric Product Differentiation. Journal Industrial Economics 64:835-874.

Ashley, C. and Maxwell, S., (2001). Rethinking rural development. Development Policy Review 19(4):395-425.

Barca, F. (2009). An agenda for a reformed cohesion policy. A place-based approach to meeting European Union challenges and expectations. Independent Report prepared at the request of Danuta Hübner, Commissioner for Regional Policy.

Barca, F., McCann, P., and Rodriguez-Pose, A. (2012). The case for regional development intervention: places-based versus place-natural approaches. Journal of Regional Science 52:134-152.

Belletti, G. and Marescotti, A. (2011). Origin Products, Geographical Indications and Rural Development, pp.75-91 in: Barham E., Sylvander B. (Eds.). Labels of origin for food. Local development, global recognition, Cambridge (Usa), Cabi International.

Bondonio, D. and Greenbaum, R.T. (2018). Natural disasters and relief assistance: Empirical evidence on the resilience of U.S. counties using dynamic propensity score matching. Journal of Regional Science 58:659-680.

Boschma, R. (2005). Proximity and Innovation: A Critical Assessment. Regional Studies 39(1):61-74.

Bowen, S. (2010). Embedding local places in global spaces: Geographical indications as a territorial development strategy. Rural Sociology 75(2):209-243.

Bowen, S. and Mutersbaugh, T. (2014). Local or localized? Exploring the contributions of Franco-Mediterranean agri-food theory to alternative food research. Agriculture and Human Values 31:201-213.

Brady, M., Sahrbacher C., Kellermann, K., and Happe, K. (2012). An agent-based approach to modelling impacts of agricultural policy on land use, biodiversity and ecosystem services. Landscape Ecology 27.

Bramkley, C., Bienabe, E. and Kirsten, J. (2009). The economics of geographical indications: towards a conceptual framework for geographical indication research in developing countries. The economics of intellectual property right - WIPO.

Cacchiarelli, L., Carbone, A., Laureti, T., and Sorrentino, A. (2016). The value of the certifications of origin: a comparison between the Italian olive oil and wine markets. British Food Journal 118(4):824-839.

Camagni, R. (2009). Territorial capital and regional development. Handbook of Regional Dynamics and Growth: Advances in Regional Economics 118-132.

Capello, R. (2009). Regional growth and local development theories: conceptual evolution over fifty years of regional science. Lavoisier - Géographie, économie, société 11:9-21.

Capello, R. (2018). Cohesion Policies and the Creation of a European Identity: The Role of Territorial Identity. Journal of Common Market Studies 56:489-503.

Carbone, A. (2017). Food supply chains: coordination governance and other shaping forces. Agricultural Economics 5(3).

Carbone, A., Quici, L., and Pica, G. (2019). The age dynamics of vineyards: Past trends affecting the future. Wine Economics and Policy 8(1):38-48.

Charron, N., Dijkstra, L., and Lapuente, V. (2014). Regional Governance Matters: Quality of Government within European Union Member States. Regional Studies 48(1):68-90.

Corsi, A., Mazzarino, S., and Pomarici, E. (2019). The Italian Wine Industry. In: Alonso Ugaglia A., Cardebat JM., Corsi A. (eds) The Palgrave Handbook of Wine Industry Economics. Palgrave Macmillan, Cham.

Corsinovi, P. and Gaeta, D. (2019). The European Wine Policies: Regulations and Strategies. In: Alonso Ugaglia A., Cardebat JM., Corsi A. (eds) The Palgrave Handbook of Wine Industry Economics. Palgrave Macmillan, Cham.

Cortinovis, N., Xiao, J., Boschma, R., and Van Oort, F.G. (2017). Quality of government and social capital as drivers of regional diversification in Europe. Journal of Economic Geography 17(6):1179-1208.

Costanigro, M., Scozzafava, G., and Casini, L. (2019). Vertical differentiation via multi-tier geographical indications and the consumer perception of quality: The case of Chianti wines. Food Policy 83:246-259.

Crescenzi, R. and Giua, M. (2016). The EU cohesion policy in context: does a bottom up approach work in all regions?. Environment and Planning A: Economy and Space 48(11):2340-2357.

Crescenzi, R., and Rodriguez-Pose, A. (2011). Commentary. Environment and Planning A: Economy and Space 43(4):773–780.

Crescenzi, R. and Rodriguez-Pose, A. (2012). An integrated framework for the comparative analysis of the territorial innovation dynamics of developed and emerging countries. Journal of Economic Surveys 26(3):517–533.

Crescenzi, R. and Jaax, A. (2017). Innovation in Russia: the territorial dimension. Economic Geography 93(1):66-88.

Crescenzi, R., De Filippis, F., and Pierangeli, F. (2015). In Tandem for Cohesion? Synergies and Conflicts between Regional and Agricultural Policies of the European Union. Regional Studies 49:681-704.

Crescenzi, R., Gagliardi, L., and Percoco, M. (2013). Social Capital and the Innovative Performance of

Italian Provinces. Environment and Planning A: Economy and Space 45(4):908-929.
Crescenzi, R., Pietrobelli, C., and Rabellotti, R. (2016). Regional strategic assets and the location strategies of emerging countries multinationals in Europe. European Planning Studies 24(4):645-66.
Cross, R., Plantinga, A., and Stavins, R. (2011). What Is the Value of Terroir?. The American Economic Review 101(3):152-156.
Dax, T. and Fischer, M. (2018). An alternative policy approach to rural development in regions facing population decline. European Planning Studies 26(2):297-315.
Daunfeldt, S., Mihaescu, O., Nilsson, H., and Rudholm, N. (2017). What happens when IKEA comes to town?. Regional Studies 51(2):313-323.
De Schutter, O., Jacobs, N., and Clement, C. (2020). A Common Food Policy for Europe: How governance reforms can spark a shift to healthy diets and sustainable food systems. Food Policy 101849.
Dedeurwaerdere, T., Polard, A., and Melindi-Ghidi P. (2015). The role of network bridging organisations in compensation payments for agri-environmental services under the EU Common Agricultural Policy. Ecological Economics 119:24-38.
Dinkelman, T. (2011). The Effects of Rural Electrification on Employment: New Evidence from South Africa. American Economic Review 101(7):3078-3108.
Ditter, J. G. and Brouard, J. (2014). The competitiveness of French protected designation of origin wines: a theoretical analysis of the role of proximity. Journal of Wine Research 25(1):5-18.
EC (2010). Proposal for a Regulation of the European Parliament and of the Council on agricultural product quality schemes, COM(2010) 733 final, 2010/0353 (COD).
EC (2016). Sustainable Development: EU sets out its priorities, European Commission Press Release, Strasbourg, 22 November 2016.
EC (2019). Towards a Common Food Policy for the European Union. International Panel of Experts on Sustainable Food Systems (IPES-Food).
EC (2020). Study on economic value of EU quality schemes, geographical indications (GIs) and traditional specialities guaranteed (TSGs)- Final report, European Commission Press Release.
ESPON (2017). Shrinking rural regions in Europe. Towards smart and innovative approaches to regional development challenges in depopulating rural regions. ESPON.
Ezcurra, R. and Rios, V. (2019). Quality of government and regional resilience in the European Union. Evidence from the Great Recession. Papers in Regional Science 98:1267-1290.
FAO (2018). Strengthening sustainable food systems through geographical indications. Food and Agriculture Organization of the United Nations FAO.
Farole, T., Rodriguez-Pose, A., and Storper, M. (2011). Cohesion Policy in the European Union: Growth, Geography, Institutions. Journal of Common Market Studies 49:1089-1111.
Friedman, T. L. (2005). The World is Flat: A Brief History of the Twenty-First Century. Farrar, Straus, and Giroux, New York.
Gangjee, D.S. (2017). Proving Provenance? Geographical Indications Certification and its Ambiguities Century. World Development 98:12-24.
Giovannucci, D., Josling, T.E., Kerr, W.A., OConnor, B. and Yeung, M.T. (2009). Guide to Geographical Indications: Linking Products and Their Origins. International Trade Center.
Haeck, C., Meloni, G., and Swinnen, J. (2019). The Value of Terroir: A Historical Analysis of the Bordeaux and Champagne Geographical Indications. Applied Economic Perspectives and Policy 41(4):598-619.
Harrison, J. and Turok, I. (2017). Universities, knowledge and regional development. Regional Studies 51(7):977-981.
Henderson, J. Vernon, A., Storeygard, D., and Weil, N. (2012). Measuring Economic Growth from Outer Space. American Economic Review 102(2):994-1028.
Henke, R., Benos, T., De Filippis, F., Giua, M., Pierangeli, F., and Pupo D'Andrea, M.R. (2018). The New Common Agricultural Policy: How do Member States Respond to Flexibility?. Journal of Common Market Studies 56:403-419.
Hsiao, C. (2007). Panel Data Analysis—Advantages and Challenges. TEST 16(1):1-22.
Iammarino, S., Rodriguez-Pose, A., and Storper, M. (2019). Regional inequality in Europe: Evidence, theory and policy implications. Journal of Economic Geography 19(2):273-298.
INEA (2012). La cooperazione sociale Agricola in Italia. Una panoramica dei dati camerali. Quaderni INEA 2012.
ISTAT (2010). 6º Censimento Generale dell'Agricoltura, data warehouse.
Josling, T. (2006). The War on Terroir: Geographical Indications as a Transatlantic Trade Conflict. Journal of Agricultural Economics 57:337-363.
Kelly, M. (2020). Understanding persistence. CEPR Discussion Paper Series, DP15246, London
Kremmydas, D., Athanasiadis, I., and Rozakis, S. (2018). A review of Agent Based Modelling for agricultural policy evaluation. Agricultural Systems.

Krugman, P. (1991). Geography and trade. MIT Press Cambridge Massachusetts, London, England.

Liu, G., Zhang, Q., Yin, G., and Zipporah, M. (2016). Spatial distribution of geographical indications for agricultural products and their drivers in China. Environmental Earth Science 75(612).

Lourenco-Gomes, L., Pinto, L.M.C., and Rebelo, J. (2015). Wine and cultural heritage. The experience of the Alto Douro Wine Region. Wine Economics and Policy 4(2):78-87.

Mariani, A., Pomarici, E., and Boatto, V. (2012). The international wine trade: recent trends and critical issues. Wine Economics and Policy 1:24-40.

Markus, G., Asheim, B., and Trippl M. (2018). Unrelated Knowledge Combinations: The Unexplored Potential for Regional Industrial Path Development. Cambridge Journal of Regions, Economy and Society 11(2):257-274.

Marsden, T., Banks, J., and Bristow, G. (2000). Food Supply Chain Approaches: Exploring their Role in Rural Development. Sociologia Ruralis 40:424-438

Meloni, G. and Swinnen, J. (2013). The political economy of European wine regulations. Journal of Wine Economics 8(3):244-284.

Menapace, L. and Moschini, G.C. (2012). Quality certification by geographical indications, trademarks and firm reputation. European Review of Agricultural Economics 39(4):539-566.

Newton, S.K., Gilinsky, A., and Jordan, D. (2015). Differentiation strategies and winery financial performance: an empirical investigation. Wine Economics Policy 4(2):88-97.

OECD (2009). How Regions Grow: Trends and Analysis. OECD Publishing, Paris

OECD (2016). A New Rural Development Paradigm for the 21st Century, OECD Publishing, Paris.

OECD (2019). Agricultural Policy Monitoring and Evaluation 2019. OECD Publishing, Paris.

Ottaviano, G. I. and Puga, D. (1998). Agglomeration in the Global Economy: A Survey of the New Economic Geography. World Economy 21:707-731.

Paasi, A. (2011). Geography, space and the re-emergence of topological thinking. Dialogues in Human Geography 1(3):299-303.

Paasi, A. (2010). Regions are social constructs, but who or what constructs them?. Environmental Planning A 42:2296-2301.

Pike, A. (2011). Introduction: brands and branding geographies. In: Pike, A. (Ed.), Brands and Branding Geographies. Edward Elgar, Cheltenham.

Pike, A., Rodriguez-Pose, A., and Tomaney, J. (2017). Local and regional development, Second edition. London: Routledge, Taylor & Francis Group.

Prescott, C., Pilato, M., and Bellia, C. (2020). Geographical indications in the UK after Brexit: An uncertain future?. Food Policy 90(101808).

Pretty, J. N., Lang, T., Morison J., and Ball, A. S. (2005). Food miles and farm costs: The full cost of the British food basket. Food Policy 30(1):1-20.

Qualivita (2018). Rapporto 2018, ISMEA-Qualivita, Fondazione Qualivita.

Qualivita (2019). Rapporto 2019, ISMEA-Qualivita, Fondazione Qualivita.

Rivera, M., Knickel, K., Maria Diaz-Puente, J., and Afonso, A. (2019). The Role of Social Capital in Agricultural and Rural Development: Lessons Learnt from Case Studies in Seven Countries. Sociologia Ruralis 59:66-91.

Rodriguez-Pose, A. and Fratesi, U. (2004). Between Development and Social Policies: The Impact of European Structural Funds in Objective 1 Regions. Regional Studies 3(1):97-113.

Rodriguez-Pose, A. and Garcilazo, E. (2015). Quality of Government and the Returns of Investment: Examining the Impact of Cohesion Expenditure in European Regions. Regional Studies 49(8):1274-1290.

Rodriguez-Pose, A. (1999). Innovation Prone and Innovation Averse Societies: Economic Performance in Europe. Growth and Change 30(1):75-105.

Rodriguez-Pose, A. (2013). Do Institutions Matter for Regional Development?. Regional Studies 47(7):1034-1047.

Rodriguez-Pose, A. (2020). Institutions and fortune of territories. Regional Science Policy Practice 1-16.

Rodriguez-Pose, A. and Crescenzi, R. (2008). Mountains in a flat world: why proximity still matters for the location of economic activity. Cambridge Journal of Regions, Economy and Society 1(3):371-388.

Rodriguez-Pose, A. and Wilkie, C. (2019). Strategies of gain and strategies of waste: what determines the success of development intervention?, Progress in Planning 133.

Rodrik, D. (2010). Diagnostics before Prescription. Journal of Economic Perspectives 24(3):33-44.

Romer, P. (1986). Increasing Returns and Long-Run Growth. Journal of Political Economy 94(5):1002-1037.

Romer, P. (1994). The Origins of Endogenous Growth. The Journal of Economic Perspectives 8(1):3-22.

San Eugenio-Vela, J. and Barniol-Carcasona, M. (2015). The relationship between rural branding and local development. A case study in the Catalonias countryside: Territoris Serens (El Lluçanès). Journal of Rural Studies 37:108-119.

Savage, M., Bagnall, G., and Longhurst, B. (2005). Globalization and Belonging. London, SAGE.

Scott, A. J. and Storper, M. (2003). Regions, Globalization, Development. Regional Studies 37(6-7):579-593.
Scott, A. J. (2004). A Perspective of Economic Geography. Journal of Economic Geography 4(5):479-499.
Sforzi, F. and Mancini, M. (2012). The Reinterpretation of the Agri-Food System and Its Spatial Dynamics through the Industrial District. Agricultural Economics 58(11):510-519.
Shapiro, C. (1993). Premiums for High Quality Products as Returns to Reputations. The Quarterly Journal of Economics 98(4):659-679.
Solow, R. (1957). Technical Change and the Aggregate Production Function. The Review of Economics and Statistics 39(3):312-320.
Storper, M. (2013). Keys to the city: How economics, institutions, social interaction, and politics shape development. Princeton: Princeton University Press.
Tregear, A., Arfini, F., Belletti, G., and Marescotti, A. (2007). Regional foods and rural development: the role of product qualification. Journal of Rural Studies 23:12-22.
Van Leeuwen, C. and Seguin, G. (2006). The Concept of Terroir in Viticulture. Journal of Wine Research 17(1):1-10.
Wicht, A., Kropp, P., and Schwengler, B. (2019). Are functional regions more homogeneous than administrative regions? A test using hierarchical linear models. Papers in Regional Science 1(30).
World Bank (2009). World Development Report 2009: Reshaping Economic Geography. World Bank.
Zimmerbauer, K. (2011). From Image to Identity: Building Regions by Place Promotion. European Planning Studies 19(2):243-260.

APPENDIX

Table A1. Description and sources of variables.

Variable	Definition	Source
PDO	Dummy variable equal to 1 if the municipality is included in one of the PDO production areas	Author's elaboration
Local Context		
Population density	Logarithmic transformation of population density - Inhabitants per km^2	Population and Housing Census, ISTAT
Illiteracy rate	Share of illiterate residents	Population and Housing Census, ISTAT
Employment rate	Share of residents working-aged 15 years or over	Population and Housing Census, ISTAT
Employed people in agriculture, forestry and fishing	Share of economically active population working in agriculture, forestry and fishing sectors	Population and Housing Census, ISTAT
Employed people in non-tradable sectors	Share of economically active population working in non-tradable sectors	Population and Housing Census, ISTAT
Employed people in tradable sectors	Share of economically active population in tradable sectors	Population and Housing Census, ISTAT
Population density – Spatial lag	Logarithmic transformation of population density in neighbouring municipalities - Inhabitants per km^2. Nearest neighbour approach.	Author's elaboration – Geographical Information System
Employment rate – Spatial lag	Share of residents working-aged 15 years or over. in neighbouring municipalities. Nearest neighbour approach	Author's elaboration – Geographical Information System
Local Agriculture		
UAA	Utilised Agricultural Area	Agricultural Census, ISTAT
Agricultural intensity	Utilized Agricultural Area/Total Agricultural Land	Agricultural Census, ISTAT
Big farms	Share of farms with more than 100 ha	Agricultural Census, ISTAT
Family farms	Share of family employees	Agricultural Census, ISTAT
Livestock farms[1]	Share of farms with livestock	Agricultural Census, ISTAT
Vineyards[2]	Share of wine grape UAA	Agricultural Census, ISTAT
Regional output agricultural sector	Output of the agricultural industry - basic and producer prices	EUROSTAT
Local Economy		
Economic vulnerability index	Socio-economic condition of each municipality related to some principal components: education, income, employment and housing	8mila Census, ISTAT
Economic vulnerability index	Socio-economic condition in neighbouring municipalities. Nearest neighbour approach.	Author's elaboration – Geographical Information System

Notes: (1) The variable livestock is included only in the model related to the presence of food PDOs. (2) The variable vineyard is included only in the model related to the presence of PDO wines.
Source: Author's elaboration.

Table A2. Descriptive statistics.

Variable	Obs.	Mean	Std. Dev.	Min	Max
Local Agriculture					
Utilised Agricultural Area (UAA)	23,265	1729.34	2,860.02	0	64246.74
Agricultural intensity	23,265	0.70	0.23	0	1
Big farms	23,265	0.029	0.07	0	1
Family farms	23,265	0.86	0.15	0	1
Livestock	15,479	0.43	0.28	0	4
Vineyards	23,265	92.87	355.43	0	13512.79
Regional output agricultural sector	23,265	3,274.705	1,868.87	56.9	6,485.86
Local Context					
Population density	23,265	280.35	630.08	0.9	15164.90
Illiteracy rate	23,265	1.81	2.42	0	30.1
Employment rate	23,265	43.02	8.73	11.7	74
Employed people in agriculture, forestry and fishing	23,265	11.18	10.31	0	80
Employed people in tradable sectors	23,265	35.38	10.45	0	88.9
Employed people in services sectors	23,265	17.76	5.46	0	71.6
Population density – Spatial lag	23,265	282.93	529.24	1.35	10547.55
Employment rate – Spatial lag	23,265	43.03	7.98	20.7	66.55
Local Economy					
Economic vulnerability index	23,265	99.03	2.49	92.4	120.9
Economic vulnerability index – Spatial lag	23,265	97.49	0.92	95.1	102.9

Source: Author's elaboration on data collected from PDO codes of practice and ISTAT.

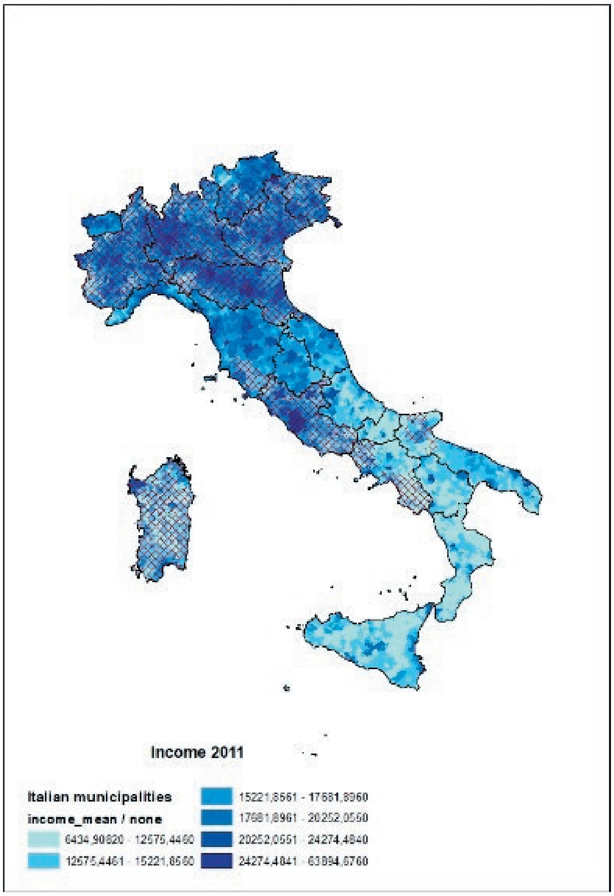

Figure A1. PDOs and income spatial distribution. Source: Author's elaboration on data collected from PDO codes of practice and ISTAT.

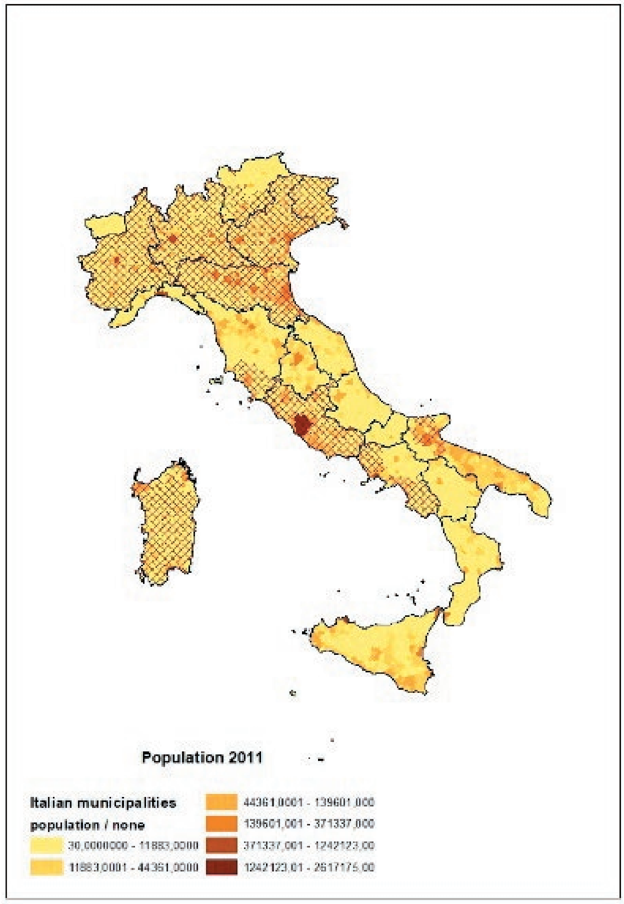

Figure A2. PDOs and population spatial distribution. Source: Author's elaboration on data collected from PDO codes of practice and ISTAT.

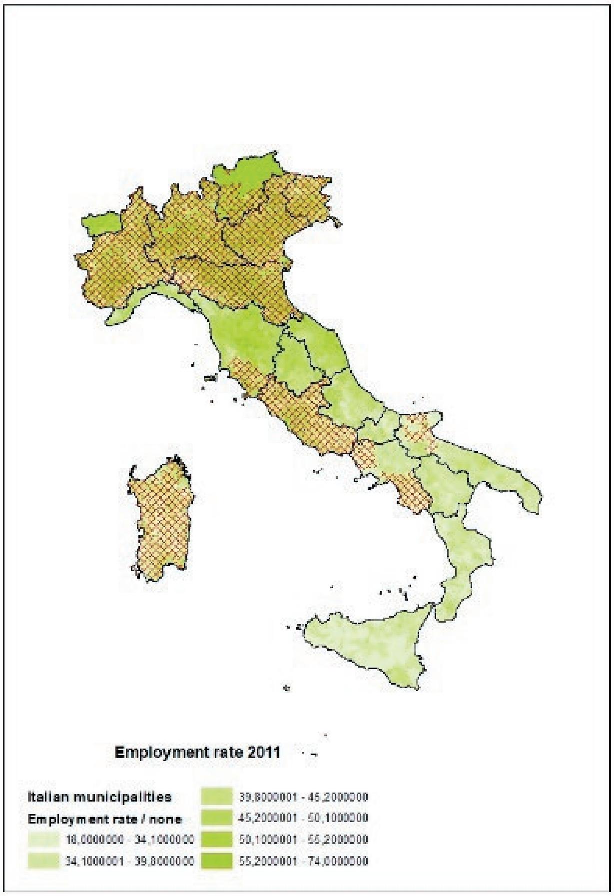

Figure A3. PDOs and employment spatial distribution. Source: Author's elaboration on data collected from PDO codes of practice and ISTAT.

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: R. Zucaro, V. Manganiello, R. Lorenzetti, M. Ferrigno (2021). Application of Multi-Criteria Analysis selecting the most effective Climate change adaptation measures and investments in the Italian context. *Bio-based and Applied Economics* 10(2): 109-122. doi: 10.36253/bae-9545

Received: July 30, 2020
Accepted: June 23, 2021
Published: October 28, 2021

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.

Editor: Meri Raggi, Fabio Bartolini.

ORCID
RZ: 0000-0001-9386-7612
VM: 0000-0003-0348-6600
RL: 0000-0003-3346-0874
MF: 0000-0002-5347-0984

Application of Multi-Criteria Analysis selecting the most effective Climate change adaptation measures and investments in the Italian context

Raffaella Zucaro, Veronica Manganiello, Romina Lorenzetti*, Marianna Ferrigno

Council for Agricultural Research and Economics - Research Centre for Agricultural Policies and Bioeconomy (CREA-PB), Via Po 14, 00198 Roma, RM, Italy.
E-mail: raffaella.zucaro@crea.gov.it, veronica.manganiello@crea.gov.it, romina.lorenzetti@crea.gov.it, marianna.ferrigno@crea.gov.it.
*Corresponding Author: romina.lorenzetti@crea.gov.it

Abstract. In the context of climate change, one of the EU's major political efforts focus on water management. Public investment is carried out considering several drivers, from economic development to demographics, climate, and pollutants. Meanwhile, the need for evaluation methods is also increasing, so their development has grown in recent years. Among these, Multi-Criteria Analysis methodologies (MCA) have taken on great importance. This work aims to demonstrate the usefulness of MCA in addressing crucial environmental issues, such as the use of water resources for agricultural and food production. The document presents an application of MCA for the ranking and selection of projects to be financed under the Italian National Plan on Water Resources. The Plan is part of the national initiatives planned for the adaptation of the agricultural sector to climate change. The selection criteria have been identified following a participatory approach, and to respond to both the challenge of climate change and the limited availability of funds. MCA is used to select the best projects to be financed with the available amount. The Italian experience confirms the effectiveness of MCA and highlights how the involvement of both decision makers and stakeholders is necessary for a successful application of MCA to environmental issues.

Keywords: drought risk, water management, investment database, reservoirs, climate change.

1. INTRODUCTION

In recent decades, climate change has caused worrying drought events across Europe, even in Countries where past meteorological drought had been rare. This situation has led EU Member States to monitor the availability of and need for water, to provide timely alerts in the event of drought and identify possible actions to undertake in the event of a crisis. Recent studies carried out on the Italian territory have shown a growing climate heterogeneity due to climate change (Zucaro, 2017; ISPRA, 2018). In the past, drought events

Firenze University Press | www.fupress.com/bae

were mainly concentrated in the Southern Regions and Islands, while, in the last 20 years, Central and Northern Italy have also suffered from recurrent droughts.

The agricultural sector is the most exposed to the effects of climate change (Mahato, 2014), there is therefore a need for targeted investments increasing the preparedness to face extreme events. As floods and droughts affect both the quantity and quality of water, they contribute to environmental degradation and loss of ecosystem services. Thus, all Member States (MSs), including Italy, are implementing adaptation and mitigation measures. International institutions, and in particular the European Union (EU) are steering their policies and economies towards long-term sustainability. In recent years, there has been a crescendo in the political narrative aimed at promoting climate change adaptation and mitigation. Several actions have been proposed to implement these policies, namely: enhancing knowledge in the field of climate change adaptation and mitigation policies (EU Adaptation Strategy, European Commission, 2013); managing water risks and disasters; ensuring good water governance and sustainable investment for water services (OECD, 2015, ODEC 2016); encouraging the sustainable use of water for agriculture and the introduction of priority actions for the adaptation of agriculture to climate change (FAO – WASAG Global Framework for Action to Cope with Water Scarcity in Agriculture); taking account of climate adaptation in public and private investments (European Green Deal, European Commission, 2019).

Several measures, singly or in combination, can be taken to cope with drought risk in agriculture, climate change adaptation, and sustainable water management. These include regulatory measures, risk management measures, water governance, research and innovation, and structural measures. There is no single decisive action, but the most effective one or a combination of them should be taken. Public investment in water distribution infrastructure allows for greater and more constant availability of water for irrigation and greater efficiency in water use, by reducing water abstractions, introducing instruments for water metering, and increasing the use of non-conventional water. These investments can also contribute to achieving the objectives of the Water Framework Directive (WFD, 2000/60/EC) of ensuring the availability of quality water for the needs of people and the environment. This is possible through the improvement of the ecological quality of water bodies and the conservation and restoration of areas of naturalistic interest (e.g. Nature 2000 sites).

At the European level, specific funds have been allocated to finance irrigation investments as a response to the water crises of 2003 and 2007. These investments aimed to increase water storage and irrigation efficiency, through the modernization of existing assets, the building of new reservoirs, and the recovery and improvement of existing ones. To decrease the dependency on conventional sources and reduce withdrawals from natural water bodies, the promotion of the reuse of treated wastewater for irrigation purpose is also pursued.

In Italy, with the aim of ensuring the integrated management of water resources, a steering committee has been set up to coordinate the various administrations responsible for water: the Steering Committee addressing investments in cross-sectoral investments, responding to the recommendations of the European Commission communication "Addressing the challenge of water scarcity and drought in the European Union" (COM, 2007) 414 final).

Following this strategy, in 2017 the Italian Government financed the "National Plan of interventions in the Water Sector" (Budget Law 2018, December 27, 2017, No. 205). The National Plan was finalized to modernize and complete the national water distribution network (including the irrigation network) and to build new reservoirs. The National Plan also foresaw the adoption of an *Extraordinary Plan*, consisting in the implementation of urgent interventions against drought, with a focus on multipurpose reservoirs.

At the River Basin scale, reservoirs are considered as effective climate change adaptation measures, especially where natural water availability is highly variable throughout the year. In fact, they retain water to be released during periods of scarcity, thus sustaining irrigated agriculture and increasing the availability of water for irrigation (Biemans, 2011). In addition, reservoirs have ecological and recreational functions, ranging from the conservation of protected migratory species (Mascara, 2010) and biodiversity (Deacon, 2018, Croce, 2015), to cultural and recreational purposes. That is why some of them are now defined as natural conservation areas.

The case study shows the procedure followed by the Council for Agricultural Research and Economics (CREA), on behalf of the Italian Ministry of Agriculture (Mipaaf), in selecting interventions to help the agricultural sector adapt to climate change. The interventions were selected according to the objectives of the *Extraordinary Plan* applying a Multi-Criteria Analysis (MCA). MCA is a non-monetary method of ranking and prioritizing the characteristics of the projects submitted for funding.

The paper aims to present the feasibility and usefulness of MCA in identifying the most effective project proposals in the field of water, stating that this method can allow the inclusion of different disciplines in a single evaluation frame. In addition, MSs need appropriate methods to assess *ex ante* effectiveness of investment projects, including their potential impacts on natural resource protection. The Italian experience can therefore be extended to other countries.

2. DATA AND RESEARCH METHODOLOGY

2.1 Multi-Criteria Analysis

Multi-Criteria Analysis (MCA) was selected as a method for classifying and selecting projects, as it allowed consideration of the different priority elements according to the requirements by the funder, and the needs in term of adaptation to climate. MCA was considered the appropriate method as it allowed several specific agricultural and environmental conditions to be applied (Figueira et al., 2005). This facilitates the achievement of increased efficiency and sustainability in the use of natural resources in line with the EU guidelines.

Several papers have been published over the last 30 years on the empirical applications of MCA to a range of nature conservation topics, including: conservation priority and planning; management and zoning of protected areas; forest management and restoration; mapping of biodiversity, naturalness, and wilderness. Many references can be found in several reviews, such as: Mendoza et al. (1986); Romero and Rehman (1987); Tarp and Helles (1995); Hayashi (2000); Kangas et al. (2001); Steiguer et al. (2003); Mendoza and Martins (2006).

A recent and extensive review of the applications of Multi-Criteria Decision Analysis was carried out by Adem Esmail and Geneletti, (2017), based on 86 papers and dealing with empirical applications in nature and biodiversity conservation. Decision-making in environmental management requires more and more comparison alternatives to achieve multiple and competing goals. Indeed, many of the following objectives must often be considered: ensuring a sufficient quantity of water for both people's needs and the environment (Water Framework Directive – implementation of the Water Framework Directive), economic development, addressing the challenges posed by demographic change, climate change, and emerging pollutants. The public administrations responsible for determining and evaluating strategic choices need systems and/or selection criteria that are as objective as possible and not influenced by endogenous factors. This problem is particularly acute when it comes to public funding.

In this context, Multi-Criteria Methodologies have become important because they provide valuable help in choosing between alternatives, especially since the classic economic and monetary surveys do not represent the plurality of aspects that these problems present (Skonieczny et al, 2005). Compared to monetary methods based on welfare economy principles (Cost- Benefit Analysis, CBA), non-monetary methods that also consider natural resources and are based on decision theory are an alternative when assessing the effectiveness of the interventions. While CBA is mainly applied to project evaluation to improve a specific environmental service, non-monetary methods such as MCA are used for issues related to territorial and environmental assessment and planning, as they can also evaluate qualitative information. Currently, several books deal with Multi-Criteria methodologies as applied to natural resources management (e.g. Zeleny, 1984; Yoon and Hwang, 1995; Malczewski, 1999; Belton and Stewart, 2002).

Basically, MCA is applied with the following typical steps:

1. Structuring of the problem and the decision-making network.
2. Data acquisition and processing.
3. Normalization (linear normalizations or Value and Utility functions).
4. Criteria and weight allocation.
5. Calculation and sorting of alternatives (e.g. with outranking methods; graphic methods; scoring methods).
6. Results.
7. Sensitivity analysis (optional).

The next paragraph describes how these steps were applied to the case study.

2.2. Applied methodology

In this study, the listed steps of the Multi-Criteria Analysis were slightly reformulated, as follows.

1. Structuring of the problem and the decision-making network. There are many MCA approaches that differ in terms of computational complexity, level of stakeholder engagement and time and data requirements.

To protect the agricultural sector against drought events, policymakers identified structural measures, concerning infrastructure interventions on multipurpose reservoirs for water collection during rain periods and water saving interventions. A specific fund has been set up to these objectives, governed by specific rules.

Water management operates within an interdisciplinary framework that seeks to ensure the protection of resources (Cugusi and Plaisant, 2019; Dir. 2000/60/EC; Dlgs 152/1999; Autonomous Region of Sardinia, 2005), and requires the integration of ecological, economic, and socio-political elements of different territorial scales. Therefore, all the institutions responsible for water management (Ministries of Agriculture, Environment, Infrastructure, Regions and River Basin District Authorities (RBDAs)), Local Agencies for irrigation Water Management (LAWMs), and stakeholders were involved in the decision-making network of this case study. The involvement of the stakeholders was a selling point in the methodology adopted by the CREA.

2. Data acquisition and processing. For the collection of data useful for the analysis, the CREA, Mipaaf, and Regions with the support of the LAWMs, identified the infrastructure priorities to be financed through national and EU resources. All information was stored and managed by DANIA, the National Database of Investments for Irrigation and the Environment (http://dania.crea.gov.it/). It was implemented by the CREA for Mipaaf, for the collection of structural and financial information on financed and programmed projects. Information about investments were provided by Regions and by SIGRIAN, the National Information System for Water Resources Management in Agriculture (https://sigrian.crea.gov.it) managed by the CREA (Mipaaf, 2015). SIGRIAN contains data from the Italian national irrigation system and is the national reference database for the collection of data on water used for irrigation on a national scale. In this work, SIGRIAN was used to collect information on the use of water resources and the extent of the irrigated area affected by the projects for the estimation of the catchment area. Starting from DANIA information, MCA was applied to identify a series of projects to be financed up to the amount of 80 million euros, allocated by the *Extraordinary Plan*.

3 - 4. Criteria and weight allocation and normalization. The criteria and their weights, as well as related attributes and scores were defined in compliance with the requirements and objectives of the financing instrument, by a technical committee of experts through focus group discussions. The focus group involved representatives of the aforementioned institutions, in the application of a participatory approach. Through debates between the actors of the technical committee, shared choices were developed. The participatory approach minimized decision makers' subjectivity in weight and score allocation, which is a very important and delicate step. Indeed, it can influence the final order of alternatives and, therefore, significant involvement is appropriate. Within the Technical Committee, the criteria were defined in accordance with the objective and priority of the Fund. Once the criteria were decided, several possible attributes for each criterion were defined. At first, the normalization step was bypassed in this case study. Since the main aim of normalization in MCA is to make quantities comparable, this was achieved by using nominal attribute quantities, to which scores must then be assigned.

The different attributes of the criteria were sorted according to their compliance with the selection aims. The weight of the criteria and the score of the attributes were assigned at the same time. Applying a monotonically linear utility function, a discrete scoring scale was adopted, with a step of 1, in all the criteria. In a descending way, a maximum score was assigned to its best attribute and a lower score was assigned to the other attributes, according to the preferences of the technical committee, and with reference to the selection goals. In this way, the weight of a given criterion coincides with the highest score assumed by its best attribute. Attribute scores ranged from 0-1 to 0-4, while the weights assigned to the criteria ranged from 1 to 4. With this operative choice, the discretions and uncertainties implied in weights were shifted to the definition of scores. For this reason, the technical committee verified that the highest score of each attribute truly represented the weight that the individual criterion should have had compared to the others.

5. - 6. Calculation and sorting of alternatives and examination of results. The ranking of alternatives, namely the projects, was achieved by applying a scoring method as a type of aggregation. The scoring method classified the alternatives by assigning a numerical evaluation for each of the attributes considered; the scores obtained for each criterion were summarized in a "summary indicator" which aimed to represent the effectiveness of the proposal in achieving the objectives of the Fund. The number of projects financed was the maximum obtainable on the basis of the defined budget allocated by the Budget law. The direct assignation of a value to the attribute and the use of a linear aggregation method with scores simply added together, have made the method used for the evaluation of the proposal clearer to the potential beneficiary. Consequently, even the self-assessment required in the submission phase of the projects was more feasible. Self-assessment was introduced because the RBDA was called upon to prioritise proposals, mainly based on the declared information.

7. Sensitivity analysis. The shared approach gave a certain degree of robustness, as the steps of criteria and weight allocation were based on the expert judgment of the technical committee. The order of importance of criteria and attributes was considered clear and objective, as it was shared among all the stakeholders. Nevertheless, in this study sensitivity analysis was carried out to verify the stability of the results, testing some changes in the weight of criteria (Skonieczny G. et al. 2005). New weights were allocated to the criteria in compliance with the aims and rules of the Fund and without upsetting the priorities established by the technical committee.

To perform sensitivity analysis, as first step, the attribute scores were normalized to the maximum value that each attribute could assume (maximum row normalization), so that all the attribute scores are between 1 and 0. Then, Weighted Linear Combination (WLC) was used (Malczewski and Rinner, 2015) for the aggregation. Following equation 1, the normalized value of attribute score (x_i) was multiplied for the tested weights (w_i), and the new summary indicators (S) were returned for each alternative.

$$S = \sum w_i x_i \qquad (1)$$

The new rankings of the alternatives, given from the different tested weight assignments, were compared with the original ranking by means of the Spearman's rank correlation coefficient, that is a non-parametric measure of rank correlation, following equation 2 (Clef, 2013):

$$\text{rho} = \sum_i (\mathrm{x_i} - \bar{\mathrm{x}})\,(\mathrm{y_i} - \bar{y}) \,/\, \sqrt{\sum_i (\mathrm{x_i} - \bar{\mathrm{x}})^2 \sum_i (\mathrm{y_i} - \bar{y})^2} \qquad (2)$$

where i = paired score, x and y are the ranks, and x-bar and y-bar are the mean ranks. The analysis of the results was carried out taking into account that the Spearman correlation between two variables is high when observations have a similar rank, up to a correlation of 1 for identical ranks.

3. RESULTS AND DISCUSSION

This section describes the detailed application and results of each step described above.

3.1 Structuring of the problem and of the decision-making network

The case study concerned the application of MCA when selecting infrastructure interventions to facilitate adaptation of the agricultural sector to climate change.

The financial instrument identified was the *Extraordinary Plan* as part of *National Plan of interventions in the water sector*. It was introduced by the Budget Law 2018 to finance urgent interventions concerning: preferentially executive projects (the final phase of the project was also accepted); multipurpose reservoirs; water saving in agricultural and household use.

The decision-making network identified included the competent Ministries of Infrastructure (MIT), Environment (MATTM) and Agriculture (Mipaaf), the 7 RBDAs, the 21 Regions and Autonomous Provinces, and the LAWMs.

According to Italian legislation, the Regions are responsible for irrigation water management and reclamation, while the LAWMs, reclamation and irrigation consortia, and land improvement consortia are territorial authorities and actuators of the interventions.

3.2 Data acquisition and processing - the Database

At the time of the study, DANIA included 894 irrigation infrastructure projects, representing almost 6 billion euros. Information was collected in the database for each project for their evaluation, in accordance with the established criteria. The stored data were acquired in collaboration with Regions and processed with identification data (title, actuators, etc.), technical features of projects (project objective and type, project stage, etc.), intervention cost, vulnerability of the intervention area to drought and hydrogeological risk, regional priority of intervention (1-high, 2-medium, and 3-low).

Starting with the stored projects, a first selection was made before applying the MCA according to the following eligibility criteria, in line with the Budget Law objectives and in the framework of financing fund rules:

- project stage = executive (because quickly implementable);
- type of intervention = interventions on multipurpose reservoirs and water saving interventions in agriculture;
- regional priority of intervention = level 1 (urgent interventions).

A dataset of 55 projects was identified on the entire national territory, representing a total amount of almost 360 million euros. The RBDAs were asked to give priority to projects in this dataset, to which MCA was applied.

3.3 Criteria and their attributes

Some of the adopted criteria related to technical elements and aims of projects, while others referred to effectiveness, in compliance with the aim and priority of the Fund, as established in Law 205/2017.

As mentioned, the *Extraordinary Plan* dealt with multipurpose reservoir (irrigation and household) and the priority water saving objectives. More in detail, the Plan includes a) completion of interventions concerning large existing dams or unfinished dams; b) recovery and expansion of the reservoir capacity, waterproofing of large dams and safety of the main water derivations for significant river basins in seismic areas classified in zones 1 and 2 and at high hydrogeological risk. As a result, the following project criteria were identified:

- *Water resource use*. Multiple uses were favoured over exclusive ones.
- *Site sensitivity in terms of seismicity and hydrogeological instability*. Great importance was given to the presence of these hazards. One of the priority objectives was identified as safety in seismic areas (classified in zones 1 and 2) and in areas of high hydrogeological risk. The technical committee decided to assign more importance to areas at seismic risk than to the landslide. Therefore, the same value was associated with the presence of hydrogeological risk and the presence of the lower class of seismic risk (fourth class). Increasing importance was given to other seismic classes, because of the growing risk.
- *Catchment area in Equivalent Inhabitants* – EI (given 40 Equivalent Inhabitants –per irrigated hectare). This criterion intended to indicate the impact of the project on the territory in term of users of financing (population or agricultural areas). Three classes were created for this continuous variable (EI > 500,000; 300,000 ≤ EI ≤ 500,000; EI < 300,000), both based on expert assessment, and on assessments based on the DANIA dataset. In addition, it was necessary to provide a unique criterion for household, irrigation, and multiple interventions. Thus, the irrigated area was returned to the EI, with a conversion criterion of 40 EI per hectare of irrigated surface.
- *Project stage.* The attributes represented the possible status of the project. The *Extraordinary Plan* focused on the final and executive level.
- *Project objectives*. This criterion aimed to select projects compliant with fund objectives. So, completion of existing dams and the recovery or extension of the reservoir capacity were among the priority objectives. In addition to these, a third class was created for projects aimed at the improvement of the derivation efficiency.
- *Project type*. This criterion integrated the technical information agreed in the previous one, detailing the specific type of intervention. The following attributes were identified: Securing; Extraordinary maintenance; Completion; New intervention.
- *Co-financing*. This was considered a reward element by the Technical Committee to promote Public-Private partnership.
- *Possibility of subdivision into lots*. This was considered a reward element by the Technical Committee, since it made it possible to assess the multiple financing of a project, even with different funding sources at different times.

In addition, three effectiveness criteria were identified, as follows.

- *Project effectiveness* (ratio of the intervention cost to the number of equivalent inhabitants corresponding to the irrigated area covered by the project: project cost (€)/EI). The criterion was described in 3 classes, namely < 25€/EI, >=25 €/EI <50 €/EI, >=50€/EI. They were created according to the evaluation by experts, also through the DANIA.
- *Territorial effectiveness*. This reflected a classification of the Italian Regions in relation to the percentage of their regional territory under risk of desertification; according to the scientific reference available for the national scale (Ceccarelli et al., 2006), 3 classes were adopted, namely: >40% very sensitive danger (Basilicata, Marche, Molise, Puglia, Sicily and Sardinia); > 40% moderately sensitive danger (Abruzzo, Campania, Emilia-Romagna, Lazio, Piedmont, Tuscany, Umbria and Veneto); little sensitive (other Regions).
- *District priority*. This was the assessment provided by the RBDA on the effectiveness of the project, in the context of the specific River Basin Management Plans. This criterion was considered by the Technical Committee to be the most important of the effectiveness criteria, as it was evaluated through expert assessment by each RBDA and summarised several environmental aspects. In particular, each RBDA established their priority based on the information listed above and considering the objectives of the Water Framework Directive (2000/60/EC) and the main issues in the National Plan. For the estimation of District priority, the factors considered were:
    - consistency with another District Plans;
    - criticality of the intervention area, such as the hydraulic risk level; hydro-morphological aspects; environmental pressures;
    - expected benefits in terms of pressure reduction on water bodies;
    - expected benefits in terms of improving the water balance at river basin level.

The level of effectiveness dealing with the strategic environmental feature, was described with four attributes: Strategic, Relevant, Important, Required.

3.4 Weight and score allocation

The weights assigned to the criteria are shown in Table 1. The criteria with the highest weight were: district priority, seismicity degree, project type, and project stage (weight 4). They were of equal importance and were followed by water resource use, project objective,

Table 1. Criteria and their assigned weights .

	Criterion		Weight
	ID	Name	
Project criteria	1	Water resource use	3
	2.1	Site sensitivity - seismicity	4
	2.2	Site sensitivity - hydrogeological instability	1
	3	Project objectives	3
	4	Catchment area	3
	5	Co-financing	1
	6	Project type	4
	7	Possibility subdivision in lots	1
	8	Project stage	4
Effectiveness criteria	9	Project effectiveness (ratio cost/ equivalent inhabitants)	3
	10	Territorial effectiveness	2
	11	District priority	4
TOTAL	12		33

catchment area, and project effectiveness, each with a weight of 3. For an easier understanding of the order of the criteria, a matrix was developed (Table 2).

The attributes assigned to each criterion and their scores are shown in Table 3. The normalization of the score is also reported because it was used to perform sensitivity analysis.

Although the Project stage was used to enter the selection, it was included in the MCA criteria. The criterion cannot affect the MCA result in any way since each alternative evaluated had the same score. However, it was decided to keep it in the process because the same method was adopted by the MIT, on another group of projects to be financed with the same Fund. Unlike Mipaaf, the MIT did not choose to focus only on executive projects. Therefore, it was necessary to maintain the criterion in order to make the results of the two selection processes comparable.

3.5 Calculation and sorting of alternatives and selection of the projects

The summary indicator returned from the sum of the scores obtained from each project. It represented the effectiveness of the intervention proposal to meet the objective of the Fund. Based on the defined budget allocated by the Budget law, 10 projects were financed in the amount of almost 80 million euros (fig. 1 and table 4), all with a summary indicator of 22 to 26.

The 10 projects financed were in 7 Regions (Veneto, Lombardy, Emilia-Romagna, Tuscany, Abruzzo, Sicily, and Sardinia) and were implemented by 8 LAWMs. Figure 1 shows the location of the LAWM which received funding.

Table 2. Criteria order: Score matrix.

Criteria	Site sensitivity - hydrogeological instability	Co-financing	Possibility subdivision in lots	Territorial effectiveness	Project effectiveness	Water resource use	Project objectives	Basin users	District priority	Site sensitivity - seismicity	Project type	Project stage
Site sensitivity - hydrogeological instability	1	1	1	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Co-financing	1	1	1	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Possibility subdivision in lots	1	1	1	0.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Territorial effectiveness	2	2	2	1	0.7	0.7	0.7	0.7	0.5	0.5	0.5	0.5
Project effectiveness	3	3	3	2	1	1	1	1	0.8	0.8	0.8	0.8
Water resource use	3	3	3	3	1	1	1	1	0.8	0.8	0.8	0.8
Project objectives	3	3	3	4	1	1	1	1	0.8	0.8	0.8	0.8
Basin users	3	3	3	5	1	1	1	1	0.8	0.8	0.8	0.8
District priority	4	4	4	6	1.3	1.3	1.3	1.3	1	1	1	1
Site sensitivity - seismicity	4	4	4	7	1.3	1.3	1.3	1.3	1	1	1	1
Project type	4	4	4	8	1.3	1.3	1.3	1.3	1	1	1	1
Project stage	4	4	4	9	1.3	1.3	1.3	1.3	1	1	1	1

Table 3. Attributes and their scores. Row max normalization refers to normalization carried out before sensitivity analysis.

Criterion		Attribute		Row max normalization
ID	Name	Name	Score	
1	Water resource use	Irrigation and household	3	1.00
		Household	2	0.67
		Irrigation	1	0.33
2.1	Site sensitivity - seismicity	Seismic zone 1	4	1.00
		Seismic zone 2	3	0.75
		Seismic zone 3	2	0.50
		Seismic zone 4	1	0.25
2.2	Site sensitivity - hydrogeological instability	Yes	1	1.00
		No	0	0.00
3	Project objectives	Completing of existing dams or unfinished dams	3	1.00
		Recovery or extension of the reservoir' capacity	2	0.70
		Improvement of the derivation' efficiency	1	0.30
4	Catchment area	EI > 500.000	3	1.00
		300.000 ≤ EI ≤ 500.000	2	0.70
		EI < 300.000	1	0.30
5	Co-financing	Yes	1	1.00
		No	0	0.00
6	Project type	Securing	4	1.00
		Extraordinary maintenance	3	0.75
		Completion	2	0.50
		New intervention	1	0.25
7	Possibility of subdivision in lots	Yes	1	1.00
		No	0	0.00
8	Project stage	Executive project	4	1.00
		Final authorizing project	3	0.75
		Definitive technical project	2	0.50
		Feasibility project	0	0.25
9	Project effectiveness	< 25€/EI	3	1.00
		>=25 €/EI <50 €/EI	2	0.70
		>=50€/EI	1	0.30
10	Territorial effectiveness	> 40% very sensitive danger *(Basilicata, Marche, Molise, Puglia, Sicily, and Sardinia)*	2	1.00
		> 40% moderately sensitive danger *(Abruzzo, Campania, Emilia-Romagna, Lazio, Piedmont, Tuscany, Umbria, and Veneto)*	1	0.50
		little sensitive *(other Regions)*	0	0.00
11	District priority	Strategic	4	1.00
		Relevant	3	0.75
		Important	2	0.50
		Required	1	0.25

Among the financed projects, 2 of them concerned the increase in storage capacity to improve the availability of water for agriculture; the remaining projects concerned improving the efficiency of the main irrigation supply networks in order to achieve better efficiency in water use and water saving in agriculture.

Under the same Plan, other projects were selected by the Ministry of Infrastructure using the same methodology for a total of 30 projects for about 250 million euros.

Table 4. List of scores awarded to selected projects for each criterion: evaluation matrix.

Project	Criteria												
Position	Water resource use	Project objectives	Catchment area	Co-financing	Project type.	Possibility subdivision in lots	Project stage	Project effectiveness	Site sensitivity - seismicity	Site sensitivity - hydrogeological instability	Territorial effectiveness	District priority	summary Indicator
1	3	1	3	0	4	1	4	3	2	1	1	3	26
2	3	2	1	0	4	1	4	3	1	1	1	3	24
3	3	2	1	0	4	0	4	3	1	1	1	3	23
4	1	1	3	0	3	1	4	3	1	0	2	4	23
5	1	1	3	0	3	1	4	3	1	0	2	4	23
6	3	1	1	0	3	1	4	1	3	1	1	4	23
7	1	1	3	0	3	1	4	3	2	0	1	3	22
8	3	1	3	0	3	1	4	3	1	0	0	3	22
9	1	1	1	0	4	0	4	3	3	0	1	4	22
10	1	1	1	0	3	1	4	1	3	1	2	4	22

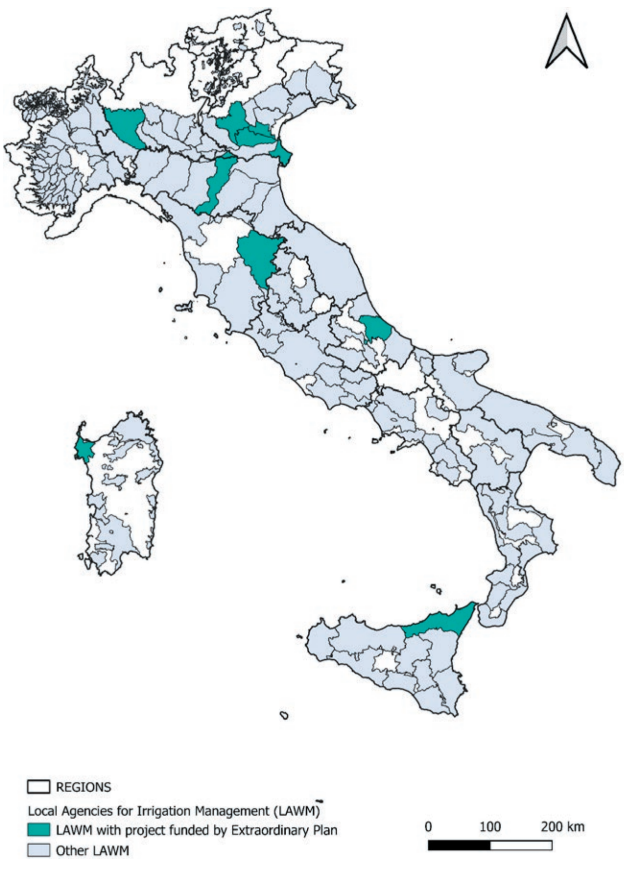

Figure 1. Maps of the Italian LAWMs. The blue polygons indicate the LAWMs that had their projects funded under the Extraordinary Plans from Mipaaf (*author's extrapolation of SIGRIAN data).*

3.6 Sensitivity analysis

Two other assumptions of weight allocation to the criteria were tested to apply sensitivity analyses within this study. Both were designed to follow the aims and rules of the Fund, but by making changes in the order of criteria However, the new assignations were made without a profound distortion of the priorities expressed by the Technical Committee.

In these new assignations, the correlation between the priorities expressed in the relevant law and the criteria that best represented them was considered.

The decision of the Technical Committee was amended to stress the weight of the criteria in two ways. Firstly, the importance was increased for criteria providing for the effects on the environment and community (e.g. number of people involved, mitigation of desertification, District priority, etc.), and the importance was decreased for criteria providing for the feasibility properties of the project (such as cost-efficiency ratio, possibility subdivision in lots, etc.) (R2). Then, the opposite point of view was applied (R3).

In R2, the most important criteria were established to be the District priority, the basin users, the seismicity of the site, the territorial effectiveness, and the project stage (weight 4), followed by the project objectives and project type (weight 3). They all described some aspect of the effect of the intervention, except for the project stage. The latter criterion had no effect on the final ranking of alternatives, but it could not be deleted or modified, as explained above (see paragraph 3.3). The lower weights were for project properties, such as co-financing, the possibility of subdivision in lots (weight 0.5), water resource use (weight 1), project effectiveness, project type, and hydrogeological instability of the site (weight 2). The Technical Committee associated with the latter criterion the same weight as class 4 in seismic risk. In this way, seismic risk was emphasized more than hydrogeological risk, compared to the priorities expressed by the legislation, where priority was given to interventions in seismic area 1 or 2 and those affected by hydrogeological risk. In R2, the same trend was maintained but the presence of hydrogeological instability was associated with the same weight as the seismic risk class 3, shortening the distances between the two criteria.

On the contrary, in R3, the most important criteria were established as project effectiveness, project type, and project stage (weight 4), followed by water resource use, and the criteria on the effects (project objectives, basin users, site seismicity, District priority) (weight 3). The burden of co-financing and of the possibility of subdivision in lots were increased to 2. The lowest weights were placed on hydrogeological instability of the site and territorial effectiveness (weight 1).

Table 5 and Figure 2 summarize the weights adopted in the two tests in relation to those chosen by the Technical Committee (R1).

New summary indicators resulting for each alternative were obtained by multiplying the tested weights of the criteria by the normalized attributes score (see table 4). Then, as result of the aggregation with the scoring method, the alternatives were sorted according to R2 and R3. Table 6 shows the comparison of these alternative rankings for the first 10 projects. In both of the cases examined, two of the projects selected by the Technical Committee were not included in the top 10 ranking. Nevertheless, the comparison of the results for all 55 cases, by Spearman test (fig. 3), showed that there was a significant and strong correlation between the ranking performed based on R2 and R3 and the ranking performed on the basis of the assignment of the original weights (R1) (respectively 0.920 and 0.940, p-level<0,001, n=55). The results still showed a significant correlation when the Spearman test was calculated only on the top ten positions (respectively 0.641 and 0.681, p-level<0,05, n=10).

3.7 Discussions

Looking at the adopted approach, the involvement of all stakeholders was a strength in the methodology. Firstly, it ensured competence in all the involved disciplinary areas. In particular, the involvement of the RBDAs was very important as they are key players in water management and protection. Secondly, it ensured a high level of objectivity in the definition of criteria and weights. Indeed, the multidisciplinary Technical Committee allowed for setting criteria, attributes, and scores, including the objectives and constraints imposed by the financial instrument, and shared weight distribution between decision-makers was achieved. Finally, this approach facilitated the acceptance of results obtained by the stakeholders embodied by the Regions.

The absence of traditional normalization and the assignment of a predefined score to attributes represented

Table 5. Weights of the criteria according to the two tests (*criteria mostly linked to the definitions given in the reference law), compared to those assigned by the Technical Committee.

Main semantic area	Criteria	R1	Weight in tested hypothesis	
			R2	R3
Project properties	*Water resource use	3	2	3
Project properties	Co-financing	1	0.5	2
Project properties	Possibility subdivision in lots	1	0.5	2
Project properties	*Project stage	4	4	4
Project properties	Project effectiveness	3	2	4
Project properties / effects	Project type	4	3	4
Effects / Project properties	*Project objectives	3	3	3
Effects	*Basin users	3	4	3
Effects	*Site sensitivity - seismicity	4	4	3
Effects	*Site sensitivity - hydrogeological instability	1	2	1
Effects	Territorial *effectiveness*	2	4	1
Effects	*District priority	4	4	3
Total weight		33	33	33

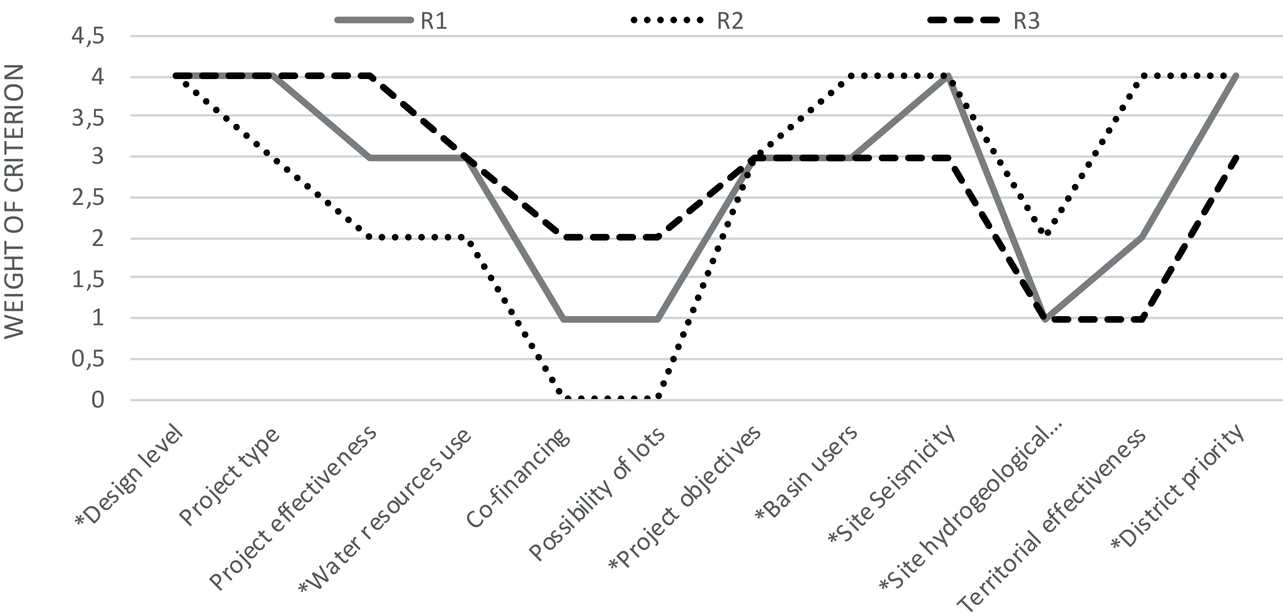

Figure 2. Graphic representation of the different weights of the criteria between the two tests and the assignment of the Technical Committee (*criteria mostly linked to the definitions reported in the reference law).

Table 6. The first 10 alternatives sorted by the summary indicator, obtained for R1 (the choices of the Technical Committee), R2, and R3 (the letters of the alphabet symbolize the alternatives, i.e. the projects).

Ranking of the alternatives (first 10 positions)		
by R1 adoption (technical committee)	by R2 adoption	by R3 adoption
A	A	A
B	D	B
C	E	H
D	L	D
E	B	E
F	F	C
G	C	G
H	Q	F
I	G	N
L	R	O

a practical advantage: the method was easy for all parties involved to understand, making them even more confident in the results of the application. This was important for the self-assessment that stakeholders had to carry out when submitting their project, and for the RBDAs, which had to express their priority mainly based on the information included in the self-assessment.

In addition, two elements could make the methodology suitable for financing projects by means of a call for proposals. The first one consists of the direct assignment of the score to the attributes to facilitate the self-assessment. The second is the production of a definitive ranking of the proposals, without comparison with other test rankings, coming from sensitivity analysis (e.g. Skonieczny et al. 2005). In fact, sensitivity analysis is not suitable for funding guided by calls for proposals, because in these cases the scores of the attributes and/or weights of the criteria must necessarily be unequivocal, defined, and published *a priori*.

However, sensitivity analysis was applied to this study to verify the stability of the results when the weights of the criteria were changed. The results showed a good correlation between the ranking made on the two test hypotheses and that applied by the Technical Committee. The differences between the rankings were not significant. However, the small variations imposed on the weights of the test criteria during sensitivity analysis are worth noting. Surely this choice influenced the results of the sensitivity analysis, overestimating the quality of the results. On the other hand, if there were a profound variation in weight assignations, this would have resulted in choices that overturned the very strict and detailed rules and priorities of the Fund.

Overall, the study seemed to confirm that the allocation of the weights through a technical committee and the involvement of stakeholders achieved adequate solidity of the results. The analysis of the results also suggests that this solidity is higher when the regulation behind

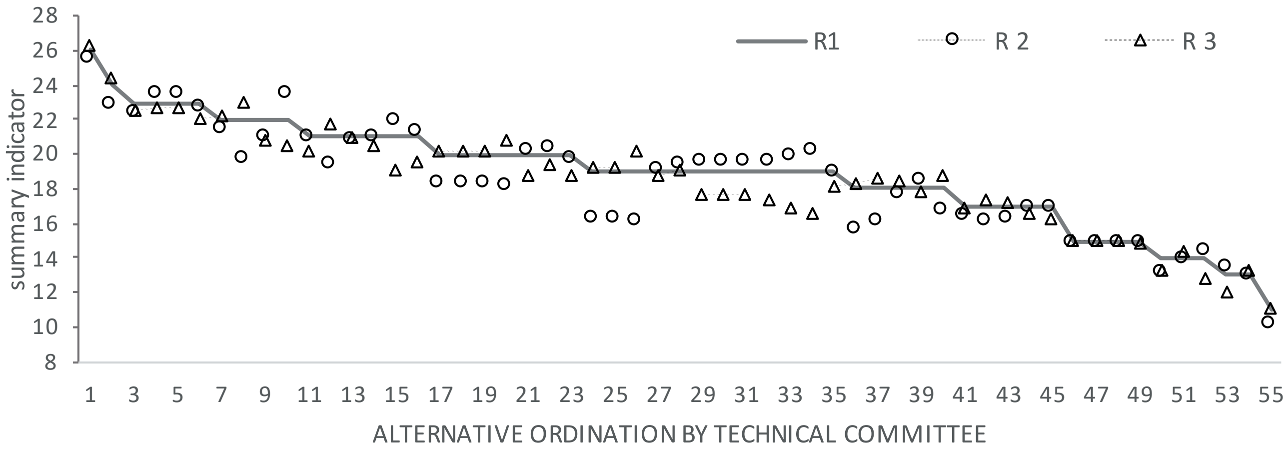

Figure 3. Graphic representation, for each alternative axis (X axis) of the summary indicator (Y axis) performed on the basis of R2 and R3 with those obtained from the assignment of the criteria of the Technical Committee.

the selection gives precise and detailed rules. This should reduce the discretion exercised by the Technical Committee.

4. MAIN CONCLUSIONS

Public infrastructure investments in water distribution networks are part of a broader framework of possible interventions (regulatory, risk management, investments, etc.) to cope with and adapt to climate change.

Recently, the European Green Deal Strategy also highlighted how climate change will continue to create significant stress in Europe despite mitigation efforts. Hence, the consideration of climate adaptation in public and private investments is an essential topic.

The MCA method proved to be a very useful tool for choosing between different investment alternatives. When it is well-designed, it allows for the inclusion of different quantitative and qualitative criteria that can be measured in a single evaluation process. This has also made it possible to weight these criteria according to the priorities assigned by decision makers.

However, the MCA procedure is articulated and complex, due to the need to develop an approach that represents the multiplicity of objectives. There is a risk that the results achieved will be strongly influenced by subjective choices made at some of the various stages. This can be a critical point. That is why sensitivity analysis should be applied. However, in some cases like those presented, a profound change in weight allocation for testing robustness is limited by the need to respect the priorities and constraints imposed by the related regulation. That is why decision maker and stakeholder involvement are even more necessary to achieve realistic and acceptable results.

During the application of the methodology described, certain strengths and weaknesses came to light. One of the main strengths was the participatory approach used to identify the decision-making network (Ministries and RBDAs) and stakeholders (Regions and LAWMs). The main weakness lies in the fact that the weights adopted can only be controlled ex-post, shifting the variation to weights to compare the results obtained.

The methodology applied has the advantage of being applicable in the future also in the case of funding based on calls for proposals, for which the scores of the attributes and/or the weights of the criteria must be defined and published *a priori*. The ex-post sensitivity analysis, carried out by modifying the weights with due regard for the priorities and limitations of the Fund, confirmed the solidity of the classification on the total number of cases. This solidity seems to be favoured precisely by the presence of accurate rules and priorities of the fund, which reduce the margin of discretion entrusted to the technical committee.

MCA is a useful informative support for policy decisions, but it is important to keep in mind that it is not an “automatic” method for land management.

ACKNOWLEDGEMENT

The authors would like to thank Luca Adolfo Folino and Adriano Battilani for their help and cooperation in revising the English.

REFERENCES

Adem Esmail, B., Geneletti, D. (2018). Multi-criteria decision analysis for nature conservation: A review of 20 years of applications. Methods in Ecology and Evolution, 9(1), 42-53. (DOI: https://doi.org/10.1111/2041-210X.12899)

Belton, S., Stewart, T.S., 2002. Multiple Criteria Decision Analysis. An Integrated Approach. Kluwer Academic Publishers, Massachusetts.

Budget Law 2018. Law December 27, 2017, No. 205. (https://www.gazzettaufficiale.it/eli/id/2017/12/29/ https://www.gazzettaufficiale.it/eli/id/2017/12/29/17G00222/sg17G00222/sg)

Ceccarelli, T., Giordano, F., Luise, A., Perini, L., Salvati, L. (2006). La vulnerabilità alla desertificazione in Italia: raccolta, analisi, confronto e verifica delle procedure cartografiche di mappatura e degli indicatori a scala nazionale e locale. APAT, CRA, CNLSD, Manuali e linee guida, 40(2006), 1-128.

Clef, T. (2013). Exploratory Data Analysis in Business and Economics: An Introduction Using SPSS, Stata, and Excel. Springer Science and Business Media.

Croce, A. (2015). Vascular flora of eight water reservoir areas in southern Italy. Check List, 11(2), 1593 (DOI: https://doi.org/10.15560/11.2.1593).

Cugusi, V., Plaisant, A. (2019). Integrated management of water resources. Federico II Open Access University Press (DOI: 10.6093/978-88-6887-054-6).

Deacon, C., Samways, M. J., Pryke, J. S. (2018). Artificial reservoirs complement natural ponds to improve pondscape resilience in conservation corridors in a biodiversity hotspot. PloS one, 13(9) (https://doi.org/10.1371/journal.pone.0204148).

European Parliament, (2000). Dir. 2000/60/CE. Water Framework Directive (2000/60/CE) (http://eur-lex.europa.eu/legal-content/IT/TXT/?uri=CELEX:32000L0060).

European Commission, (2007). Communication from the Commission to the Council and the European Parliament, Addressing the challenge of water scarcity and droughts in the European Union. Brussels, 18.07.07, COM(2007)414 final (https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2007:0414:FIN:EN:PDF)

European Commission, (2013). Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - An EU Strategy on adaptation to climate change (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52013DC0216).

European Commission, (2019). Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - The European Green Deal (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2019:640:FIN)

Figueira, J., Greco, S., Ehrgott, M. (2005). Multi Criteria Decision Analysis: State of the Art Surveys. Springer, New York, NY, (doi:10.5937/ekonhor1802189K).

Hayashi, K., (2000). Multi-criteria analysis for agricultural resource management:a critical survey and future perspectives. Eur. J. Oper. Res. 122, 486–500.

Kangas, J., Kangas, A., Leskinen, P., Pyka¨la¨inen, J., (2001). MCDM methods in strategic planning of forestry on state-owned lands in Finland: applications and experiences. J. Multi-Criteria Decis. Anal. 10, 257–271

ISPRA, (2018). 14th report «Gli Indicatori del Clima in Italia nel 2018», ISPRA (ISBN: 978-88-448-0955-3).

Malczewski, J., (1999). GIS and Multi-Criteria Decision Analysis. John Wiley &Sons, Inc., New York.

Malczewski, J.; Rinner, C. (2015). Multicriteria decision analysis in geographic information science. New York: Springer, pp. 331

Mascara, R. (2010). 2.2 Fauna vertebrata. CASPUR-CIBER Publishing, 2010, 29-43.(http://archiveciberpublishing.cineca.it/article/viewFile/9887/9208).

Mahato, A. (2014). Climate change and its impact on agriculture. International Journal of Scientific and Research Publications, 4(4), 1-6.

Mendoza, G.A., Campbell, G.E., Rolfe, G.L., (1986). Multiple objective programming: an approach to planning and evaluation of agroforestry systems. Part 1. Model description and development. Agric. Syst. 22, 243–253.

Mendoza, G. A., Martins, H. (2006). Multi-criteria decision analysis in natural resource management: A critical review of methods and new modelling paradigms. Forest ecology and management, 230(1-3), 1-22.

OECD, (2015). OECD Principles on Water Governance. OECD, Paris, France,. Available online: www.oecd.org/governance/oecd-principles-on-water-governance.htm.

OECD, (2016). OECD Council Recommendation on Water. (http://www.oecd.org/water/recommendation/).

Romero, C., Rehman, T., (1987). Natural resources management and the use of multiple-criteria decision making techniques: a review. Eur. Rev. Agric. Econ. 14 (1), 6–89.

Skonieczny, G. T. B., Torrisi, B., Cappellano, D. (2005). L'analisi Multi Criterio Per La Valutazione Di Progetti

Pubblici: Il Software e Un'analisi Empirica. Statistica Applicata Vol. 17, n. 3, 2005 (http://sa-ijas.stat.unipd.it/sites/sa-ijas.stat.unipd.it/files/451-468.pdf)

Steiguer, J.E., Liberti, L., Schuler, A., Hansen, B., 2003. Multi-criteria decision models for forestry and natural resources management: an annotated bibliography. General Technical Report NE-307. U.S.D.A. Forest Service, Northeastern Research Station, Newton Square, PA.

Tarp, P., Helles, F., (1995). Multi-criteria decision making in forest management planning—an overview. J. Forest Econ. 1 (3), 273–306.

Yoon, K. P., & Hwang, C. L. (1995). Multiple attribute decision making: an introduction (Vol. 104). Sage publications.

Zeleny, M., 1984. MCDM: Past Decade and Future Trends: A Source Book of Multiple Criteria Decision Making. JAI Press, Greenwich.

Zucaro R., Antinoro C., Giannerini G. (2017). Characterization of drought in Italy applying the Reconnaissance Drought Index". In: European Water 60: 313-318 (ISSN 1105-7580)

https://sigrian.crea.gov.it

http://dania.crea.gov.it/

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

Citation: E. Lamonaca, F.G. Santeramo, A. Seccia (2021). Climate changes and new productive dynamics in the global wine sector. *Bio-based and Applied Economics* 10(2): 123-135. doi: 10.36253/bae-9676

Received: September 5, 2020
Accepted: December 16, 2020
Published: October 28, 2021

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.

ORCID
EL: 0000-0002-9242-9001
FGS: 0000-0002-9450-4618
AS: 0000-0003-4549-6479

Climate changes and new productive dynamics in the global wine sector

Emilia Lamonaca*, Fabio Gaetano Santeramo, Antonio Seccia

University of Foggia, Italy
* Corresponding author. E-mail: emilia.lamonaca@unifg.it

Abstract. Climate change has the potential to impact the agricultural sector and the wine sector in particular. The impacts of climate change are likely to differ across producing regions of wine. Future climate scenarios may push some regions into climatic regimes favourable to grape growing and wine production, with potential changes in areas planted with vines. We examine which is the linkage between climate change and productivity levels in the global wine sector. Within the framework of agricultural supply response, we assume that grapevines acreage and yield are a function of climate change. We find that grapevines yield suffers from higher temperatures during summer, whereas precipitations have a varying impact on grapevines depending on the cycle of grapevines. Differently, acreage share of grapevines tends to be favoured by higher annual temperatures, whereas greater annual precipitations tend to be detrimental. The impacts vary between Old World Producers and New World Producers, also due to heterogeneity in climate between them.

Keyword: climate change, acreage response, yield response, Old World producers, New World producers.
JEL code: F18, Q11, Q54.

1. INTRODUCTION

In both academic research and policymaking agenda there is growing awareness that climate change and the agri-food sector are closely related, and that those links deserve investigation and understanding to analyse the evolution of global agriculture, and to anticipate future challenges such as climate change adaption and mitigation (Falco et al., 2019; Santeramo et al., 2021).

Agriculture, on which human welfare depends, is severely affected by climate change. Some adverse effects, already observed, are likely to intensify in the future, contributing to declines in agricultural production in many regions of the world, fluctuations in world market prices, growing levels of food insecurity (Reilly and Hohmann, 1993; Meressa and Navrud, 2020). Adaptation potential and adaptation capability to climate change may exacerbate differences between regions. In a globalised world, the macro-level impacts of climate change are driven by comparative advantage between regions (Bozzola et al., 2021). If impacts of climate change on productivity

Firenze University Press | www.fupress.com/bae

differ between regions, then adjustments through production patterns may dampen the adverse effects of climate change (Costinot et al., 2016; Gouel and Laborde, 2021). Although the agricultural sector is identified as the most sensitive and vulnerable sector to climate change (e.g., Deschenes and Greenstone, 2007), the effects of climate change on the wine sector and on different producing regions (i.e., Old World Producers, New World Producers) is still an open question. How do productivity levels react to changes in climate? Do climate change impacts on production patterns differ between Old World Producers and New World Producers?

As suggested by Mozell and Thach (2014), the narrow climatic zones for growing grapes may be severely affected both by short-term climate variability and long-term climate change. A vast majority of earlier studies on the impacts of climate change have analysed the effects on domestic markets, leaving underinvestigated the effects on world production (Reilly and Hohmann, 1993). In the wine-related literature, previous studies reveal that the impacts of climate change are likely to differ across producing regions of wine. Jones et al. (2005) suggest that, currently, Old World Producers (i.e., European regions) benefit of better growing season temperatures than New World Producers. However, future climate scenarios may push some regions into climatic regimes favourable to grape growing and wine production (Lamonaca and Santeramo, 2021). All in all, there is the potential for relevant changes in areas planted with vines due to changes in climate (Moriondo et al., 2013; Seccia and Santeramo, 2018).

Projected scenarios of future climate change at the global and wine region scale are likely to impact the wine market. In particular, spatial changes in viable grape growing regions, and opening new regions to viticulture would determine new productive scenarios in the wine sector at the global level.

Given this background, our contribution aims at understanding how productive patterns allow different producing regions (e.g., Old World Producers, New World Producers) to respond to changes in climate. Specifically, we examine the linkage between climate change and productivity levels in the global wine sector. In this regard, Rosenzweig and Parry (1994) argue that doubling of the atmospheric carbon dioxide concentration would lead to only a small decrease in global agricultural production. In addition, Reilly and Hohmann (1993) suggest that interregional adjustments in production buffer the severity of climate change impacts both at global and domestic level. From a methodological perspective, the study of agricultural supply response has traditionally decomposed it in terms of acreage and yield responses (e.g., Haile et al., 2016; Kim and Moschini, 2018). Our contribution examines how climate change affects acreage and yield response for grapevines. To this aim, we assume that land allocations are consistent with the choices of a representative farmer who maximises expected profit. We posit that cropland can be allocated between grapevines and all other crops. Because these two allocation choices exhaust the set of possible land allocations, total county cropland is assumed to be fixed. Thus, the decision problem can be stated as that of choosing acreage. We assume that the acreage shares are a function of expected per acre revenue, given by the product between the output price and expected yield, and of climate change. Investigating both the responsiveness of grapevine acreage and yield to climate change allows us to conclude on the global supply response. While our cross-countries analysis is informative on the production patterns in the wine sector at a global scale, it cannot conclude on the effects of climate change at the micro-level (e.g., grape growers, wine producers). Indeed, a country-level analysis does not capture differences within countries in terms of both grapevine yield and climate variability, particularly in geographically heterogeneous countries such as the United States, Canada, Russia, China (Kahn et al., 2019).

2. ESTIMATING THE RELATIONSHIP BETWEEN CLIMATE CHANGE AND GRAPEVINES PRODUCTION

2.1 Yield response equation

Following Kim and Moschini (2018), we postulate a simple linear equation for yield response. In detail, the expected grapevines yield of county i at time $t(y_{it})$ is modelled as:

$$y_{it} = \alpha + \alpha_i + \beta T_t + \boldsymbol{\gamma}'\boldsymbol{X}_{it,s} + \varepsilon_{it} \tag{1}$$

where α_i are country-specific intercepts; T_t is a linear trend variable and β the related parameter; the vector $\boldsymbol{X}_{it,s}$ includes climate variables specific for county i, time t, and season s (i.e. 30-years rolling average seasonal temperatures and precipitations, $Temp_{it,s}$ and $Prec_{it,s}$), we also posit a quadratic relationship between climate and yields (i.e. $Temp^2_{it,s}$ and $Prec^2_{it,s}$); $\boldsymbol{\gamma}'$ is the vector of parameter of interest[1]; α and ε_{it} are a constant and the error term. Following the climate literature (e.g.,

[1] It is worth noting that the parameter captures the climate sensitivity of grapevine yield without considering the implicit adaptation to climate change, differently from analyses based on the Ricardian model of climate change (e.g., Mendelsohn et al., 1994).

Kurukulasuriya et al., 2011; Massetti et al., 2016), we use a four-season model, assuming that seasonal differences in temperatures and precipitations are likely to impact grapevines productivity. However, we exclude climate normals of the winter season which is characterised by the dormancy of grapevines; in fact, the annual growth cycle of grapevines begins with bud break in the spring season and culminate in leaf fall in the autumn season.

We explore the relationship between grapevines yield and climate variables to estimate the potential effects of climate change using either ordinary least squares (OLS) or quantile regression (QR). The model in equation (1) is estimated in an OLS fashion on the whole sample and on subsamples of Old World Producers and New World Producers. The properties of QR have motivated its application in the context of agriculture and weather, mostly focusing on the impact of climate change on various crop yield distributions (Conradt et a., 2015). The QR facilitates a thorough analysis of the differential impact of climate change across the yield distribution; a QR approach is useful in such situations and for considering asymmetry and heterogeneity in climatic impacts (Barnwal and Kotani, 2013).

2.2 Acreage response equation

Total county cropland (A) is assumed to be fixed and land allocations are presumed to be consistent with the choices of a representative farmer who maximises expected profit. We posit that agricultural land can be devoted to two alternative uses, grapevines and all other crops. The decision problem can be stated as that of choosing acreage shares $s_k \equiv A_k / A$, where A_k is the acreage allocated to the k-th use (k = 1 for grapevines and k = 2 for all other crops). Because A is fixed, increased land allocation to any one crop is equivalent to an increase in its share s_k, maintaining the land constraint $s_1 + s_2 = 1$[2].

Empirically, observed acreage share of grapevines in county i at time $t(s_{it})$ is modelled as:

$$s_{it} = \lambda + \lambda_i + \theta T_t + \varphi s_{it\text{-}1} + \psi \hat{r}_{it} + \boldsymbol{\omega}'\mathbf{Z}_{it} + v_{it} \quad (2)$$

where the set of conditioning variables includes country-specific trend effects, λ_i; a time trend, T_t, capturing exogenous technological progress; expected per acre revenue, $\hat{r}_{it}$; past acreage shares, $s_{it\text{-}1}$, climate variables, $\mathbf{Z}_{it}$, which may directly affect planting decisions (i.e. 30-years rolling average annual temperatures and precipitations, $Temp_{it}$ and $Prec_{it}$, and their squares, $Temp^2_{it}$ and $Prec^2_{it}$). The term λ is a set constant terms; θ, φ, and ψ are parameters to be estimated, $\boldsymbol{\omega}'$ is the vector of climate-specific parameters; v_{it} is the error term. The term $s_{it\text{-}1}$ allows us to account for the behaviour of producers that adjust their acreage when they realise that the desired acreage differs from the acreage realised in the previous year; it captures the dynamic effects on acreage allocation (Santeramo, 2014). Following Kim and Moschini (2018), we interact own output price and expected yields estimated in equation (1), to obtain the expected per acre revenue (i.e., $\hat{r}_{it} = p_{it} \cdot \hat{y}_{it}$). Since our study is a country-level analysis, consistent with Hendricks et al. (2014) we assume that the country-level expected prices are exogenous: this assumption allows us to deal with potential endogeneity of prices. In order to compute the expected per acre revenue variables for the acreage response equations, we rely on the OLS estimate of equation (1).

We follow an approach similar to Haile et al. (2016) and Kim and Moschini (2018) and estimate the model in equation (2) using a system generalised method-of-moments (GMM) estimator, based on a one-step estimation with robust standard errors. In fact, applying OLS estimation to a dynamic panel data regression model, such as in equation (2), results in a dynamic panel bias because of the correlation of the lagged dependent variable with the country-fixed effects (Nickell, 1981). Since current acreage is a function of the fixed effects (λ_i), lagged acreage is also a function of these country-fixed effects. This violates the strict exogeneity assumption, thus the OLS estimator is upward biased and inconsistent. A solution to this issue consists in transforming the data and removing the fixed effects. However, under the within-group transformation, the lagged dependent variable remains correlated with the error term, and therefore the fixed-effects estimator is downward biased and inconsistent. To overcome these problems, the GMM is a more efficient estimator that allows the estimate of a dynamic panel difference model using lagged endogenous and other exogenous variables as instruments. In particular, the system GMM technique transforms the instruments themselves in order to make them exogenous to the fixed effects (Roodman, 2009).

[2] Due to a land constraint, a representative farmer may decide to allocate more (less) acreage to grapevine reducing (increasing) the share of acreage devoted to other crops to maximise expected profits. This may be a sort of implicit adaptation to climate conditions. For instance, due to warmer temperatures, acreages devoted to grapevine in Italy may increase to the detriment of acreage intended to other production (e.g., apple tree, pear tree). As suggested in Ricardian literature in climate change economics (e.g., Timmins, 2006; Kurukulasuriya et al., 2011; Bozzola et al., 2018).

Table 1. Descriptive statistics for key variables.

Variable	Unit	All producers	Old World Producers	New World Producers
Acreage	ha	303,640 (±347,791)	560,850 (±435,259)	160,745 (±162,051)
Share of acreage	-	0.01 (±0.02)	0.02 (±0.00)	0.001 (±0.001)
Yield	t/ha	10.50 (±4.59)	3.96 (±1.22)	12.09 (±1.13)
Price	USD/t	779.27 (±448.80)	528.60 (±40.70)	708.32 (±396.59)
30-years average temperature (annual)	°C	10.37 (±8.51)	10.86 (±1.87)	10.10 (±10.52)
30-years average temperature (spring)	°C	9.90 (±9.08)	9.70 (±1.54)	10.01 (±11.28)
30-years average temperature (summer)	°C	18.76 (±4.76)	18.26 (±2.54)	19.04 (±5.61)
30-years average temperature (autumn)	°C	10.92 (±8.21)	11.57 (±2.03)	10.55 (±10.12)
30-years average precipitation (annual)	mm	68.55 (±36.13)	71.89 (±17.46)	66.69 (±43.09)
30-years average precipitation (spring)	mm	62.35 (±34.87)	67.18 (±11.14)	59.66 (±42.50)
30-years average precipitation (summer)	mm	82.17 (±44.21)	61.95 (±19.52)	93.40 (±49.81)
30-years average precipitation (autumn)	mm	74.56 (±44.14)	82.93 (±24.25)	69.91 (±51.47)

Note: Average values and standard deviation in parentheses.

3. DATA SOURCES AND SAMPLE DESCRIPTION

The empirical analysis relies on a rich dataset of historical temperature and precipitation data (from 1961 to 2015) and historical trade flows data (from 1996 to 2015[3]) for 14 countries. The selected countries are Argentina, Australia, Brazil, Canada, China, France, Germany, Italy, New Zealand, Russian Federation, South Africa, Spain, the United Kingdom, the United States. They account for more than two-third of the volume of wine production (70% in 2016, Global Wine Markets, 1860 to 2016 database). This group of countries includes both Old Works Producers and New World Producers and countries belonging to Northern or Southern Hemisphere[4].

Table 1 provides descriptive statistics for key variables, also distinguishing between Old World Producers and New World Producers.

Historical country-specific monthly average temperature and precipitation data have been collected from the Climate Change Knowledge Portal World Bank (World Bank, 2018). Annual and seasonal climatologies (i.e., rolling 30-years averages[5]) of temperature (in °C) and precipitations (mm) have been constructed using historical weather data. As for seasonal climatologies, monthly data have been clustered into three-month seasons: December (of the previous year) through February as winter, March through May as spring, June through August as summer, and September through November as autumn. These seasonal definitions have been adjusted for the fact that seasons in the Southern and Northern Hemispheres occur at exactly the opposite months of the year.

The annual 30-years average temperature is 10.37 °C (table 1). Within this group, annual average temperatures are about 1 °C higher for Old World Producers than for New World Producers, reflecting the fact that New World Producers are mostly located to lower latitudes (figure 1). The difference in average temperatures between Old World Producers and New World Producers tends to be higher during winter (3.97 °C of Old World Producers and 0.77 °C of New World Producers; table 1).

The annual 30-years average precipitation is 68.55 mm and is about 5 mm greater in Old World Producers

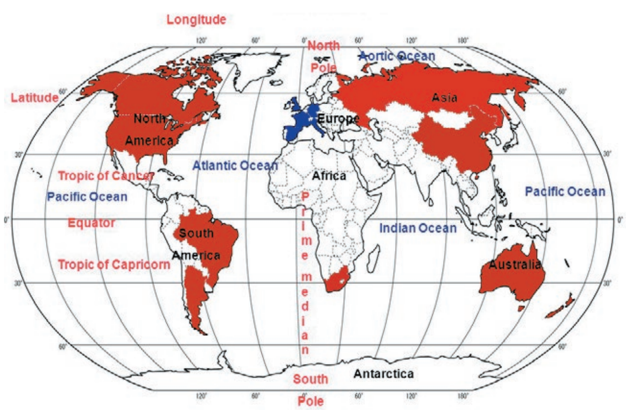

Figure 1. List of countries. Source: elaboration on Anderson and Nelgen (2015). Notes: Old World Producers in blue, New World Producers in red.

[3] The longer time period used for climate data allows to build climatologies (i.e. 30-years averages) of temperature and precipitations: in 1996 (the starting point of the final dataset) climate normal is based on a real 30-years average.

[4] The list of countries by group is presented in Appendix A.1.

[5] Differently from other studies that aggregated to data by weighting each information at the grid level by the amount of agricultural area the grid contains (e.g., Gammans et al., 2017), we use simple average of climate data aggregated at the country level.

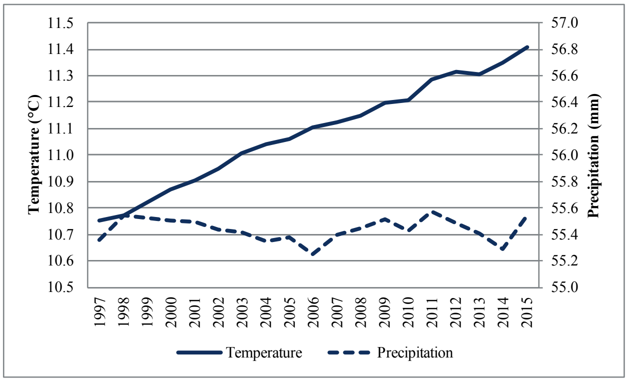

Figure 2. Median 30-years temperatures and precipitations in 1997-2015. Source: elaboration on data from CRU of University of East Anglia. Note: data refer to the sample of 14 major producers of wine.

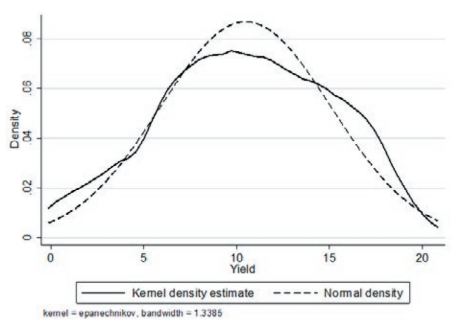

Figure 3. Distribution and descriptive statistics for grapevines yield.

than in New World Producers. However, seasonal differences are observed: during summer, the level of precipitations is much lower in Old World Producers than in New World Producers (table 1).

In our sample, we observe a 6% increase in median values of 30-years average temperature over twenty years (figure 2).

As suggested in Jones et al. (2005), Old World Producers benefit of better growing seasons as compared to New World Producers. It should be kept in mind, however, that the strength of seasonality varies significantly across the globe, with seasons being more homogenous around the Equator.

Country-specific annual data on areas planted with vines (in ha) and yields of areas planted with vines (in t/ha), collected from the FAOSTAT database, are described in table 1. The FAOSTAT database also provides country-level annual acres for agricultural land. Total agricultural land includes two components: i.e., cropland (arable land and land under permanent crops) and land under permanent meadows and pastures. In the methodological framework, we assume that agricultural land can be devoted to two alternative uses, grapevines and all other crops. The latter category should capture all acres that could have been not planted to grapevines. Hence, we obtain the category all other uses as the difference between total agricultural land and acres planted with vines. In our model, we also use country-specific annual price data for grapes (USD/t), collected from the FAOSTAT database. In order to obtain the reduced per acre revenue, we interact own output price and expected yields estimated in equation (1).

Within our sample, despite the expansion of areas planted with vines in New World Producers during the last decades, acres intended to grape growing are, on average, more than three times larger in Old World Producers (561 thousands ha with respect to 161 thousands ha, table 1). However, grapevines yields are much larger for New World Producers (12.09 t/ha) than for Old World Producers (3.96 t/ha).

Yields are often not normally distributed but are negatively skewed (e.g., Swinton and King, 1991). This is also what we find in the distribution of grapevines yield in our sample (figure 3). A distribution of yield different from a normal distribution may be associated with the frequent occurrence of outliers; for instance, yield realisations may not follow the pattern described by the majority of yield observations (Conradt et al., 2015).

It is worth noting that countries with grapevines yields within 25^{th} percentile are Canada, Spain, France, United Kingdom, New Zealand, Russian Federation, whereas countries with yields of grape within 75^{th} percentile are Argentina, Australia, Brazil, China, Germany, United States, South Africa.

4. RESULTS AND DISCUSSION

4.1 Yield response

The estimation results for the yield response, based on equation (1), are reported in tables 2 (OLS estimates)[6] and 3 (QR estimates). The results in table 2 show that the higher the average temperatures in producing countries during summer, the lower the grapevines yield. Greater precipitations are beneficial for yield during the early growing season (i.e., spring), but detrimental during the

[6] In a sensitivity analysis, we analyse the effects of annual climatic variables on grapevine yields. The results, reported in table A.2 in the Appendix, highlight differences between Old World Producers and New World Producers. While higher annual average temperatures are detrimental (up a certain threshold) for Old World Producers, New World Producers benefit of greater annual average temperatures and precipitations.

late growing season and the harvest time (i.e. summer and autumn). The relationship between summer climate and yields is nonlinear[7]. The overall effects are mostly driven by the impacts of climate change on grapevines yields of New World Producers. Differently, grapevines yield of Old World Producers seem not affected by climate change. The results are consistent with evidence from vine-related literature. In fact, Merloni et al. (2018) report that higher temperatures can have a negative impact on grapevines yield and quality. An increase in extreme high temperatures in summer may have adverse consequences on grapevines phenology (Briche et al., 2014). In addition, Ramos et al. (2008) suggest that seasonal distribution of precipitation matter, with larger rainfall levels being crucial for grapevines at the beginning of the growing season (i.e., spring) whereas more stable precipitations are desirable from flowering to ripening (i.e., summer and autumn).

The OLS approach is applied when the dependent variable is normally distributed, whereas QR is employed when the variable is not normally distributed (see figure 3). The QR (median) is more robust to outliers than mean regression (OLS)[8]. Furthermore, QR provides a clearer understanding of the data by assessing the effects of explanatory variables on the location and the scale parameters of the model (Conradt et a., 2015).

The results of the QR reported in table 3 mostly confirm the non-linear relationship between grapevines yields and average temperatures in producing countries during summer. No substantial differences are observed across different quantiles of the distribution of grapevines yields. Differently, the results reveal that lower yield realisations (i.e., within 25th percentile) tend to be most affected by greater precipitations during the harvest time (i.e., autumn). It is worth noting that countries with grapevines yields within 25th percentile are mostly cool climate wine regions such as Canada and Russian Federation. Cool regions tend to have also higher rainfall levels and yields tend to be lower on average, rising production costs (Anderson, 2017).

Table 2. Estimation results for grapevines yields, OLS.

Variables	Dependent variable: yield		
	All producers	Old World Producers	New World Producers
Temperature (spring)	1.4440	-9.5441	-1.4800
	(1.7044)	(12.7571)	(2.1761)
Temperature-squared (spring)	-0.3044***	0.3965	-0.2577**
	(0.0747)	(0.5755)	(0.1209)
Temperature (summer)	-16.3650**	-22.5187	-1.8786
	(7.1026)	(14.6183)	(11.2236)
Temperature-squared (summer)	0.4258**	0.4752	0.3047
	(0.1955)	(0.3634)	(0.3264)
Temperature (autumn)	0.6543	-0.6787	-0.5129
	(1.9410)	(12.3068)	(2.3252)
Temperature-squared (autumn)	0.0761	-0.0685	0.1321
	(0.0888)	(0.4882)	(0.1181)
Precipitation (spring)	0.5227*	0.4326	0.8057*
	(0.2795)	(0.7043)	(0.4339)
Precipitation-squared (spring)	-0.0041***	-0.0035	-0.0052***
	(0.0015)	(0.0048)	(0.0019)
Precipitation (summer)	-0.3230*	-0.0678	-0.0427
	(0.1906)	(0.3849)	(0.3922)
Precipitation-squared (summer)	0.0013	-0.0001	0.0005
	(0.0009)	(0.0022)	(0.0013)
Precipitation (autumn)	-0.3507**	-0.3838	-0.4272
	(0.1601)	(0.4282)	(0.3758)
Precipitation-squared (autumn)	0.0019**	0.0019	0.0019
	(0.0008)	(0.0020)	(0.0017)
Time trend	0.1392***	0.3459*	0.0109
	(0.0477)	(0.1756)	(0.1007)
Observations	280	100	180
R-squared	0.9314	0.9656	0.8930

Notes: OLS estimate of equation (1) on the whole sample (All producers) and subsamples of Old World Producers and New World Producers. All specifications include country-specific constants. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

[7] The results are robust also controlling for different combinations of fixed effects: the results are reported in tables A.3 and A.4 in the Appendix. We further detect a non-linear relationship between grapevine yield and summer precipitation controlling for time fixed effects (common to all countries) and country-specific fixed effects. Differently, we cannot conclude on the relationship between grapevine yield and detrended climate variables obtained from the yearly weather deviation from the long-run climate (30-year rolling average), as recently proposed by Khan et al. (2019). The result is not surprising: while detrended climate variables capture short-run changes in climate conditions (i.e., weather shocks), 30-year rolling average temperatures and precipitations inform on long-run changes in climate conditions: It is unlikely that weather shocks on a year-by-year basis affect the responsiveness of the viticultural sector, but long-run changes in climate capture structural changes in the sector and are more likely to influence production decisions of a multi-year crop. A comparison between short- and long-run analyses is reported in table A.5 in the Appendix.

[8] We conduct a multidimensional outlier detection analysis based on the 'bacon' algorithm, which identifies outliers based on the Mahalanobis distances (Billor et al., 2000, Weber, 2010). The algorithm allows the identification and removal of observations characterised by implausibly large or low entries of key variables. The results of the model estimated without outliers, reported in tables A.6 and A.7 in the Appendix, confirm the main results, although the effect of temperatures and precipitations on grapevine yields tend to be lower.

Table 3. Estimation results for grapevines yields, quantile regression.

Variables	Dependent variable: yield		
	25th percentile	50th percentile	75th percentile
Temperature (spring)	0.8721	0.7711	1.3070
	(1.9059)	(1.8734)	(2.3574)
Temperature-squared (spring)	-0.1418*	-0.2405***	-0.3368***
	(0.0756)	(0.0812)	(0.1073)
Temperature (summer)	-22.4737***	-27.0681***	-23.1306***
	(4.5501)	(7.0368)	(7.0902)
Temperature-squared (summer)	0.5454***	0.7064***	0.6102***
	(0.1219)	(0.1864)	(0.1763)
Temperature (autumn)	3.0239	1.9043	2.2129
	(2.1210)	(1.2873)	(2.4223)
Temperature-squared (autumn)	-0.1279	-0.0515	0.0525
	(0.0813)	(0.0611)	(0.0998)
Precipitation (spring)	0.2402	0.6707**	0.4740
	(0.2974)	(0.2899)	(0.2913)
Precipitation-squared (spring)	-0.0024	-0.0048***	-0.0035*
	(0.0018)	(0.0017)	(0.0018)
Precipitation (summer)	-0.2866	-0.0272	-0.1956
	(0.2024)	(0.1155)	(0.1925)
Precipitation-squared (summer)	0.0014	-0.0001	0.0011
	(0.0012)	(0.0006)	(0.0011)
Precipitation (autumn)	-0.3157*	-0.1921	-0.1535
	(0.1691)	(0.1477)	(0.1627)
Precipitation-squared (autumn)	0.0019**	0.0011*	0.0010
	(0.0008)	(0.0006)	(0.0007)
Time trend	0.1523***	0.1796***	0.1024*
	(0.0574)	(0.0534)	(0.0545)
Observations	280	280	280

Notes: QR estimate of equation (1) on the whole sample. All specifications include country-specific constants. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table 4. Estimation results for grapevines acreage, Old World Producers and New World Producers.

Variables	Dependent variable: acreage share		
	All Producers	Old World Producers	New World Producers
Lagged acreage share	0.995***	0.795***	0.953***
	(0.001)	(0.046)	(0.012)
Expected per acre revenue	-0.00003	-0.163	-0.0003
	(0.00003)	(0.109)	(0.001)
Temperature (annual)	0.107***	38.983*	0.131***
	(0.019)	(22.496)	(0.020)
Temperature-squared (annual)	-0.006***	-0.134	-0.008***
	(0.001)	(1.574)	(0.001)
Precipitation (annual)	-0.107***	18.447	-0.122***
	(0.033)	(11.384)	(0.028)
Precipitation-squared (annual)	0.001***	-0.120	0.001***
	(0.0002)	(0.081)	(0.0001)
Test for AR(1): p-value	0.096	0.106	0.239
Test for AR(2): p-value	0.238	0.326	0.266
Sargan test: p-value	0.134	0.592	0.926
Number of instruments	149	47	123

Notes: One-step generalised method-of-moments (GMM) estimate of equation (2) on the whole sample and on subsamples of Old World Producers and New World Producers. All specifications include a constant and a time trend. Coefficients and standard errors estimated are of the order of 10^{-6} for 'expected per acre revenue' and of 10^{-4} for climate variable. Observations are 198 for all producers, 47 for Old World Producers and 151 for New World Producers. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

4.2 Acreage response

Table 4 presents the estimation results under the acreage models. All dynamic models (All Producers, Old World Producers and New World Producers) are based on a one-step GMM estimator. The Arellano-Bond test for autocorrelation is used to test for serial correlation in levels. The test results indicate that the null hypothesis of no second-order autocorrelation in residuals cannot be rejected, indicating the consistency of the system GMM estimators. According to the Sargan test results, we fail to reject the null hypothesis of instrument exogeneity: the system GMM estimators are robust but weakened by many instruments.

We fail to find a significant acres-price relationship, which could imply that many grapevines' producers do not form their price expectations on the basis of information on expected per acre revenues.

More importantly, the estimation results reveal that higher annual temperatures in producing countries are beneficial for grapevines acreage share. This is true for both Old and New World Producers, despite the effects are much larger in Old World Producers. As suggested in Ruml et al. (2012), among the many climatic factors affecting wine production, temperature appears to be most important.

Differently, severe rainfall levels is significantly associated with less grapevines share. The negative effects of greater annual precipitations is entirely associated with New World Producers, whereas the Old World Producers seem not affected by changes in the rainfall levels.

5. CONCLUDING REMARKS

Climate change has the potential to impact the agricultural sector and the wine sector in particular (Mozell and Thach, 2014). Most of the previous studies analysing the impact of climate change on agriculture do not consider the effects of climate change on world production, markets and trade patterns (Reilly and Hohmann, 1993). Our analysis allowed us to understand if climate change is able to affect productivity levels of grapevines. Overall, we found that grapevines yield suffers from higher temperatures during summer, whereas precipitations have a varying impact on grapevines depending on the cycle of grapevines. In particular, we observed that greater precipitations are beneficial during the early growing season (spring), but detrimental during the late growing season and the harvest time (summer and autumn). Differently, acreage share of grapevines tends to be favoured by higher annual temperatures, whereas greater annual precipitations tend to be detrimental. The impacts however vary between Old World Producers and New World Producers, also due to heterogeneity in climate between them: the effects of temperatures are less pronounced for New World Producers, whereas precipitations have no effects for Old World Producers. As suggested in previous studies (e.g., Jones et al., 2005), Old World Producers benefit of better growing season, but climate change may push New World Producers into more favourable climatic regimes.

The opening of new regions, benefiting of better climatic regimes, to viticulture would determine new productive scenarios and, as a result, new trade dynamics (Macedo et al., 2019). New productive scenarios are likely to favour the production of varietal wines from autochthonous grapes whose quality is strongly related to microclimatic and pedological conditions (Seccia et al., 2017). In addition, changes in trade regulations, that have largely influenced the agri-food market, are modifying also global trade of wine (Santeramo et al., 2019; Seccia et al., 2019). Such dynamics should not be neglected. Future research should be intended to examine how climate change could affect global trade of wine and to understand how importers and exporters could react to new trade dynamics, due to climate change, in terms of trade regulations.

ACKNOWLEDGMENT

The research has been supported by a Research Grant funded by the International Organisation of Vine and Wine (OIV).

The authors are grateful to Dr. Martina Bozzola for collection and organisation of climate data, to Tatiana Svinartchuk, Tony Battaglene, and to the seminar audiences at the 9th AIEAA Conference and the EGU General Assembly 2021 for helpful comments.

REFERENCES

Anderson, K. (2017). How might climate changes and preference changes affect the competitiveness of the world's wine regions? *Wine Economics and Policy* 6(1): 23-27.

Anderson, K., and Nelgen, S. (2015). Global Wine Markets, 1961 to 2009: A Statistical Compendium. University of Adelaide Press.

Barnwal, P., and Kotani, K. (2013). Climatic impacts across agricultural crop yield distributions: An application of quantile regression on rice crops in Andhra Pradesh, India. *Ecological Economics* 87: 95-109.

Billor, N., Hadi, A.S. and Velleman, P.F. (2000). BACON: Blocked adaptive computationally efficient outlier nominators. *Computational Statistics & Data Analysis* 34: 279-298.

Bozzola, M., Lamonaca, E., and Santeramo, F.G., (2021). *On the impact of climate change on global agri-food trade*. Working Paper.

Bozzola, M., Massetti, E., Mendelsohn, R., and Capitanio, F. (2018). A Ricardian analysis of the impact of climate change on Italian agriculture. *European Review of Agricultural Economics* 45(1): 57-79.

Briche, E., Beltrando, G., Somot, S., and Quénol, H. (2014). Critical analysis of simulated daily temperature data from the ARPEGE-climate model: application to climate change in the Champagne wine-producing region. *Climatic Change* 123(2): 241-254.

Conradt, S., Finger, R., and Bokusheva, R. (2015). Tailored to the extremes: Quantile regression for index-based insurance contract design. *Agricultural Economics* 46(4): 537-547.

Costinot, A., Donaldson, D., and Smith, C. (2016). Evolving comparative advantage and the impact of climate change in agricultural markets: Evidence from 1.7 million fields around the world. *Journal of Political Economy* 124(1): 205-248.

Deschenes, O., and Greenstone, M. (2007). The Economic Impacts of Climate Change: Evidence from Agricultural Output and Random Fluctuations in Weather. *The American Economic Review* 97(1): 354–85

Falco, C., Galeotti, M., and Olper, A. (2019). Climate change and migration: Is agriculture the main channel? *Global Environmental Change* 59: 101995.

Gammans, M., Mérel, P., and Ortiz-Bobea, A. (2017). Negative impacts of climate change on cereal yields:

statistical evidence from France. *Environmental Research Letters* 12(5): 054007.

Gouel, C., and Laborde, D. (2021). The crucial role of domestic and international market-mediated adaptation to climate change. *Journal of Environmental Economics and Management* 106: 102408.

Haile, M.G., Kalkuhl, M., and von Braun, J. (2016). Worldwide acreage and yield response to international price change and volatility: a dynamic panel data analysis for wheat, rice, corn, and soybeans. *American Journal of Agricultural Economics* 98(1), 172-190.

Hendricks, N.P., Smith, A., and Sumner, D.A. (2014). Crop supply dynamics and the illusion of partial adjustment. *American Journal of Agricultural Economics* 96(5): 1469-1491.

Jones, G.V., White, M.A., Cooper, O.R., and Storchmann, K. (2005). Climate change and global wine quality. *Climatic Change* 73(3): 319-343.

Kahn, M.E., Mohaddes, K., Ng, R.N.C., Pesaran, M.H., Raissi, M., and Yang, J-C. (2019). *Long-term macroeconomic effects of climate change: A cross-country analysis*. National Bureau of Economic Research Working Paper.

Kim, H., and Moschini, G. (2018). The dynamics of supply: US corn and soybeans in the biofuel era. *Land Economics* 94(4): 593-613.

Kurukulasuriya, P., Kala, N., and Mendelsohn, R. (2011). Adaptation and climate change impacts: a structural Ricardian model of irrigation and farm income in Africa. *Climate Change Economics* 2(2): 149-174.

Lamonaca, E., and Santeramo, F.G. (2021). Climate changes and Dynamics of the Agricultural Productions in the Mediterranean Region. EGU General Assembly 2021, online, 19–30 Apr 2021, EGU21-1104, https://doi.org/10.5194/egusphere-egu21-1104, 2021.

Macedo, A., Rebelo, J., and Gouveia, S. (2019). Export propensity and intensity in the wine industry: a fractional econometric approach. *Bio-based and Applied Economics* 8(3): 261-277.

Massetti, E., Mendelsohn, R., and Chonabayashi, S. (2016). How well do degree days over the growing season capture the effect of climate on farmland values? *Energy Economics* 60: 144-150.

Meressa, A.M., and Navrud, S. (2020). Not my cup of coffee: Farmers' preferences for coffee variety traits–Lessons for crop breeding in the age of climate change. *Bio-based and Applied Economics* 9(3): 263-282.

Merloni, E., Camanzi, L., Mulazzani, L., and Malorgio, G. (2018). Adaptive capacity to climate change in the wine industry: A Bayesian Network approach. *Wine Economics and Policy* 7(2): 165-177.

Mendelsohn, R., Nordhaus, W., and Shaw, D. (1994). The impact of global warming on agriculture: a Ricardian analysis. *American Economic Review* 84: 753–771.

Moriondo, M., Jones, G.V., Bois, B., Dibari, C., Ferrise, R., Trombi, G., and Bindi, M. (2013). Projected shifts of wine regions in response to climate change. *Climatic Change* 119(3-4): 825-839.

Mozell, M.R., and Thach, L. (2014). The impact of climate change on the global wine industry: Challenges & solutions. *Wine Economics and Policy* 3(2): 81-89.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica* 1417-1426.

Ramos, M.C., Jones, G.V., and Martínez-Casasnovas, J.A. (2008). Structure and trends in climate parameters affecting winegrape production in northeast Spain. *Climate Research* 38(1): 1-15.

Reilly, J., Hohmann, N. (1993). Climate change and agriculture: the role of international trade. *The American Economic Review* 83(2): 306-312.

Roodman, D. (2009). How to do xtabond2: An introduction to difference and system GMM in Stata. *The Stata Journal* 9(1): 86-136.

Rosenzweig, C., Parry, M.L. (1994). Potential impact of climate change on world food supply. *Nature* 367(6459): 133-138.

Ruml, M., Vuković, A., Vujadinović, M., Djurdjević, V., Ranković-Vasić, Z., Atanacković, Z., Sivčev, B., Marković, N., Matijašević, S., and Petrović, N. (2012). On the use of regional climate models: implications of climate change for viticulture in Serbia. *Agricultural and Forest Meteorology* 158: 53-62.

Santeramo, F.G. (2014). *On the estimation of supply and demand elasticities of agricultural commodites*. Intl Food Policy Res Inst.

Santeramo, F.G., Miljkovic, D., and Lamonaca, E. (2021). Agri-food trade and climate change. *Economia agro-alimentare/Food Economy* 23(1), [In press].

Santeramo, F.G., Lamonaca, E., Nardone, G., and Seccia, A. (2019). The benefits of country-specific non-tariff measures in world wine trade. *Wine Economics and Policy* 8(1): 28-37.

Seccia, A., and Santeramo, F.G. (2018). Impacts of climate change on the wine sector in Italy and mitigation and adaptation strategies. In R. Compés López, V. Sotés Ruiz: *El sector vitivinícola frente al desafío del cambio climático. Estrategias públicas y privadas de mitigación y adaptación en el Mediterráneo*. Cajamar Caja Rural, pp. 91-115. ISBN-13: 978-84-95531-92-6.

Seccia, A., Carlucci, D., Santeramo, F.G., Sarnari, T., and Nardone, G. (2017). On the effects of search attributes on price variability: An empirical investigation on quality wines. *BIO Web of Conferences* 9, 03014.

Seccia, A., Santeramo, F.G., Lamonaca, E., and Nardone, G. (2019). On the effects of bilateral agreements in world wine trade. *BIO Web of Conferences* 12, 03009.

Swinton, S.M., and King, R.P. (1991). Evaluating robust regression techniques for detrending crop yield data with nonnormal errors. *American Journal of Agricultural Economics* 73: 446-451.

Timmins, C. (2006). Endogenous land use and the Ricardian valuation of climate change. *Environmental and Resource Economics* 33: 119–142.

Weber, S. (2010). Bacon: An effective way to detect outliers in multivariate data using Stata (and Mata). *The Stata Journal* 10(3): 331-338.

World Bank (2018). *Metadata of the Climate Change Knowledge Portal*.

APPENDIX

Table A.1. List and description of countries in the sample.

Country	ISO 3	Wine producer	Hemisphere	30-years annual average temperature (°C)	30-years annual average precipitation (mm)
Argentina	ARG	New World Producer	Southern	14.44	49.16
Australia	AUS	New World Producer	Southern	21.76	40.47
Brazil	BRA	New World Producer	Southern	25.14	148.20
Canada	CAN	New World Producer	Northern	-6.47	38.77
China	CHN	New World Producer	Northern	6.94	48.29
Germany	DEU	Old World Producer	Northern	9.28	61.12
Spain	ESP	Old World Producer	Northern	13.84	50.92
France	FRA	Old World Producer	Northern	11.41	71.61
United Kingdom	GBR	Old World Producer	Northern	8.94	103.42
Italy	ITA	Old World Producer	Northern	12.51	78.70
New Zealand	NZL	New World Producer	Southern	10.06	145.83
Russia	RUS	New World Producer	Northern	-5.43	36.64
United Stated	USA	New World Producer	Northern	7.50	55.57
South Africa	ZAF	New World Producer	Southern	18.13	40.89

Source: Wine producer classification follows Anderson and Nelgen (2015).

Table A.2. Estimation results for grapevines yields, OLS.

Variables	Dependent variable: yield		
	All producers	Old World Producers	New World Producers
Temperature (annual)	1.3078	-22.4180***	5.2902***
	(1.4604)	(7.5813)	(1.8500)
Temperature-squared (annual)	-0.0215	0.6741***	0.0892**
	(0.0344)	(0.1969)	(0.0423)
Precipitation (annual)	0.1755	0.3731	1.1522**
	(0.4226)	(0.9870)	(0.4877)
Precipitation-squared (annual)	-0.0021	-0.0025	-0.0058**
	(0.0022)	(0.0052)	(0.0026)
Time trend	0.0400	0.2498	-0.0490
	(0.0479)	(0.1578)	(0.0593)
Observations	280	100	180
R-squared	0.9148	0.9626	0.8758

Notes: OLS estimate of equation (1) on the whole sample (All producers) and subsamples of Old World Producers and New World Producers. All specifications include country-specific constants. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.

Table A.3. Estimation results for grapevines yield: controlling for different combinations of fixed effects.

Variables	Our results	Sensitivity analysis
Temperature (spring)	1.4440	2.2203
	(1.7044)	(1.8717)
Temperature-squared (spring)	-0.3044***	-0.3176***
	(0.0747)	(0.0794)
Temperature (summer)	-16.3650**	-16.1260**
	(7.1026)	(7.4473)
Temperature-squared (summer)	0.4258**	0.4022**
	(0.1955)	(0.2013)
Temperature (autumn)	0.6543	0.0276
	(1.9410)	(2.3118)
Temperature-squared (autumn)	0.0761	0.1007
	(0.0888)	(0.0948)
Precipitation (spring)	0.5227*	0.5692**
	(0.2795)	(0.2844)
Precipitation-squared (spring)	-0.0041***	-0.0041***
	(0.0015)	(0.0015)
Precipitation (summer)	-0.3230*	-0.3870*
	(0.1906)	(0.2034)
Precipitation-squared (summer)	0.0013	0.0015*
	(0.0009)	(0.0009)
Precipitation (autumn)	-0.3507**	-0.3009*
	(0.1601)	(0.1607)
Precipitation-squared (autumn)	0.0019**	0.0017**
	(0.0008)	(0.0008)
Country fixed effects	Yes	Yes
Time trend	Yes	No
Time fixed effects	No	Yes
Country-time fixed effects	No	No
R-squared	0.9314	0.9386

Notes: OLS estimate of yield response equation. Observations are 280. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table A.4. Estimation results for grapevines acreage: controlling for different combinations of fixed effects.

Variables	Our results	Sensitivity analysis
Lagged acreage share	0.995***	0.995***
	(0.001)	(0.002)
Expected per acre revenue	-0.00003	0.002
	(0.00003)	(0.003)
Temperature (annual)	0.107***	0.095***
	(0.019)	(0.021)
Temperature-squared (annual)	-0.006***	-0.006***
	(0.001)	(0.001)
Precipitation (annual)	-0.107***	-0.133***
	(0.033)	(0.047)
Precipitation-squared (annual)	0.001***	0.001***
Country fixed effects	Yes	Yes
Time trend	Yes	No
Time fixed effects	No	Yes

Notes: One-step generalised method-of-moments (GMM) estimate of acreage response equation. Coefficients and standard errors estimated are of the order of 10^{-6} for 'expected per acre revenue' and of 10^{-4} for climate variable. Observations are 198. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.

Table A.5. Estimation results for grapevines yield: controlling for detrended climate variables.

Variables	Our results (Long-run analysis)	Sensitivity analysis (Short-run analysis)
Temperature (spring)	1.4440	0.1500
	(1.7044)	(0.1418)
Temperature-squared (spring)	-0.3044***	0.0164
	(0.0747)	(0.0900)
Temperature (summer)	-16.3650**	0.1692
	(7.1026)	(0.2820)
Temperature-squared (summer)	0.4258**	-0.2140
	(0.1955)	(0.1384)
Temperature (autumn)	0.6543	0.2483
	(1.9410)	(0.1584)
Temperature-squared (autumn)	0.0761	-0.1644**
	(0.0888)	(0.0820)
Precipitation (spring)	0.5227*	-0.0050
	(0.2795)	(0.0088)
Precipitation-squared (spring)	-0.0041***	-0.0002
	(0.0015)	(0.0005)
Precipitation (summer)	-0.3230*	0.0039
	(0.1906)	(0.0093)
Precipitation-squared (summer)	0.0013	-0.0005
	(0.0009)	(0.0003)
Precipitation (autumn)	-0.3507**	0.0071
	(0.1601)	(0.0056)
Precipitation-squared (autumn)	0.0019**	0.0002
	(0.0008)	(0.0002)
R-squared	0.9314	0.9177

Notes: OLS estimate of yield response equation. Observations are 280. Detrended climate variables in the sensitivity analysis are obtained from the yearly weather deviation from the long-run climate (30-year rolling average). All specifications include country-specific constants and the time trend. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Table A.6. Multidimensional outlier detection analysis.

	5^{th} percentile	10^{th} percentile	15^{th} percentile
Total number of observations	280	280	280
BACON outliers	0	0	20
Non-outliers remaining	208	208	260

Table A.7. Estimation results for grapevines yields: OLS with and without outliers and QR.

Variables	OLS		QR		
	All observations (A)	Observations w/out outliers (B)	25^{th} percentile (C)	50^{th} percentile (D)	75^{th} percentile (E)
Temperature (spring)	1.4440	1.6527	0.8721	0.7711	1.3070
	(1.7044)	(1.7917)	(1.9059)	(1.8734)	(2.3574)
Temperature-squared (spring)	-0.3044***	-0.3114***	-0.1418*	-0.2405***	-0.3368***
	(0.0747)	(0.0765)	(0.0756)	(0.0812)	(0.1073)
Temperature (summer)	-16.3650**	-14.7502*	-22.4737***	-27.0681***	-23.1306***
	(7.1026)	(7.7445)	(4.5501)	(7.0368)	(7.0902)
Temperature-squared (summer)	0.4258**	0.3653*	0.5454***	0.7064***	0.6102***
	(0.1955)	(0.2163)	(0.1219)	(0.1864)	(0.1763)
Temperature (autumn)	0.6543	0.2605	3.0239	1.9043	2.2129
	(1.9410)	(2.1218)	(2.1210)	(1.2873)	(2.4223)
Temperature-squared (autumn)	0.0761	0.1037	-0.1279	-0.0515	0.0525
	(0.0888)	(0.0967)	(0.0813)	(0.0611)	(0.0998)
Precipitation (spring)	0.5227*	0.5162*	0.2402	0.6707**	0.4740
	(0.2795)	(0.2777)	(0.2974)	(0.2899)	(0.2913)
Precipitation-squared (spring)	-0.0041***	-0.0041***	-0.0024	-0.0048***	-0.0035*
	(0.0015)	(0.0015)	(0.0018)	(0.0017)	(0.0018)
Precipitation (summer)	-0.3230*	-0.3643	-0.2866	-0.0272	-0.1956
	(0.1906)	(0.2388)	(0.2024)	(0.1155)	(0.1925)
Precipitation-squared (summer)	0.0013	0.0013	0.0014	-0.0001	0.0011
	(0.0009)	(0.0009)	(0.0012)	(0.0006)	(0.0011)
Precipitation (autumn)	-0.3507**	-0.3302**	-0.3157*	-0.1921	-0.1535
	(0.1601)	(0.1629)	(0.1691)	(0.1477)	(0.1627)
Precipitation-squared (autumn)	0.0019**	0.0019**	0.0019**	0.0011*	0.0010
	(0.0008)	(0.0008)	(0.0008)	(0.0006)	(0.0007)
Observations	280	260	280	280	280
R-squared	0.9314	0.9037			

Notes: OLS and QR estimate of yield response equation. Robust standard errors are in parentheses.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI ECONOMIA AGRARIA E APPLICATA

OPEN ACCESS

Citation: N. Raina, M. Zavalloni, S. Targetti, R. D'Alberto, M. Raggi, Davide Viaggi (2021). A systematic review of attributes used in choice experiments for agri-environmental contracts. *Bio-based and Applied Economics* 10(2): 137-152. doi: 10.36253/bae-9678

Received: September 5, 2020
Accepted: December 4, 2020
Published: October 28, 2021

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.

Editor: Simone Cerroni.

ORCID
NR: 0000-0002-7617-4731
MZ: 0000-0002-6291-7653
ST: 0000-0002-2154-546X
RDA: 0000-0002-7227-7485
MR: 0000-0001-6960-1099
DV: 0000-0001-9503-2977

A systematic review of attributes used in choice experiments for agri-environmental contracts

Nidhi Raina*, Matteo Zavalloni, Stefano Targetti, Riccardo D'Alberto, Meri Raggi, Davide Viaggi

University of Bologna, Italy
*Corresponding author. E-mail: nidhi.raina@unibo.it

Abstract. Contract attributes are strong motivators for eliciting farmers' preferences for a particular agri-environmental scheme. Our study aims to conduct a systematic literature review to highlight the attributes used in choice experiment studies of agri-environmental schemes using the PRISMA framework. We obtained 34 studies for an in-depth review, through which we extracted 32 attributes that were classified into five typologies: 'monetary' (7 attributes), 'general' (4 attributes), 'flexibility' (6 attributes), 'prescription' (12 attributes), and 'purpose' (3 attributes). Though monetary attributes should theoretically define farmers' choices; general design and flexibility attributes are more critical for farmers' participation and willingness to accept. The study also discusses the lesser-used attributes that could be potentially explored in future studies. Thus, our review can be used as a reference by future AES studies to select their bundle of choice attributes and test with a broader range of attributes in their choice experiments.

Keywords: choice experiment, agri-environmental schemes, willingness to accept, contract attributes, systematic literature review
JEL codes: Q15, Q20, Q57.

1. INTRODUCTION

Farmers' decision to participate and their willingness to accept (WTA) a particular agri-environmental scheme (AES) is affected by the contract's design. Studies have tried to investigate the choice behaviors of farmers using various methodologies. The choice experiment (CE) methodology, a type of stated preference method, is widely applied in valuation studies and is useful for analyzing different policy scenarios (Kanchanaroek & Aslam, 2018). CEs are based on the theory of consumer choice, which states that individuals' choices depend on utility or value gained from the attributes of the goods being consumed (Lancaster, 1966). Utility generally depends on attributes of the choices and socio-economic characteristics of an individual. So, CEs provide an attribute-based approach that can investigate individual preferences (Chèze et al., 2020) as well as quantify the trade-offs between the alternatives (Hynes et al., 2011). Thus, the CE method is par-

Firenze University Press | www.fupress.com/bae

ticularly suited for evaluating choices among different AESs and to elicit farmers' or landowners' preferences for different attributes in a contract (Espinosa-Goded et al., 2010; Horne, 2006; Ruto & Garrod, 2009, etc.). Many studies have reported that even though socio-economic, demographic, or cultural characteristics can influence farmers' preferences, such findings are usually insufficient to quantify these choices (Dachary-Bernard & Rambonilaza, 2012; Dramstad et al., 2006; Swanwick, 2009, etc.). Thus, CEs can be a useful tool to understand specific preferences by evaluating farmers' behavior towards contract attributes.

Studies generally use evidence from previous literature to select the contract attributes and their levels for their CE. There exists a plethora of literature on the motivations and attitudes of farmers exhibiting conservation behavior that the AES studies use while choosing attributes (Greiner, 2016; Le Coent et al., 2017). Few studies have conducted in-depth literature reviews to understand why farmers join a particular AES (like, Lastra-Bravo et al., 2015) and the attractive attributes in a contract that motivate farmers' participation (like, Brandyberry, 2015). Lastra-Bravo et al. (2015) collected 160 variables through a review of AES studies which they classified into five different categories that depicted the socio-economic and demographic conditions of the farm and the farmers. However, they studied trade-offs between attributes within only one category: 'farmers' attitudes towards agri-environmental schemes.' Thus, there is still a substantial knowledge gap in the literature about attribute selection for contract design because of the lack of a definitive catalog of management and policy-based attributes used by previous studies. State of the art has majorly focused on reviewing the measures included in the AESs (e.g., Lastra-Bravo et al., 2015 and Rakotonarivo et al., 2016), but no study has specifically concentrated on reviewing the contract attributes used for designing the CEs. This gap creates a divide between contract attributes studied by researchers and actual attributes preferred by the farmers, which may lead to inefficient contract designs. Also, studies shortlist choice attributes using previous literature, but there is a lack of studies that employ a systematic review approach. Some studies such as Uthes & Matzdorf (2013) reviewed the literature on agri-environmental measures (AEMs). However, they did not use a systematic method, thus, they covered a broad spectrum of AEMs that does not focus on using the CE methodology to examine farmers' choices. One recent study by Mamine et al. (2020) did conduct a meta-analysis of 79 AES studies that use the CE method to evaluate farmers' preferences. However, they did not conduct a systematic review and grouped the extracted 290 attributes into only two categories – commitments and incentives.

Mamine et al. (2020) haven't been the first to classify contract attributes into different sub-types. Many AES studies that use the CE methodology classify the choice attributes as monetary and non-monetary. Usually, AES studies include a monetary attribute related to payment level (expressed in currency per hectare per year) to estimate the WTA of the various AES designs (Espinosa-Goded et al., 2013; Espinosa-Goded et al., 2010; etc.). The monetary attribute can also be either funding schemes (e.g., climate premium), international price fluctuations, additional incentives, conditional bonus, etc. (Kuhfuss et al., 2015; Pröbstl-Haider et al., 2016; etc.). The various types of non-monetary attributes can either be management attributes (like 'biodiversity' and 'carbon sequestration' as environment management attributes used in the study by Mäntymaa et al. (2018) and 'cover crops area size' as an agriculture-management attribute in the study by Villanueva et al. (2015a), or policy design attributes (like 'collective participation' and 'monitoring' by Villanueva et al. (2015a)), or theory-relevant attributes (like 'recommendation') and policy-relevant attributes (like 'share of farm') (Villamayor-Tomas et al., 2019), etc. Ruto & Garrod (2009) labeled agri-environmental policy options as their key design attributes (like, 'duration of AES contract,' 'per hectare payment rate,' etc.), differentiating them from payment levels. Similarly, Le Coent et al. (2017) categorized the contract attributes as: attributes that have a direct effect on farmers' compliance costs (levels and types of environmental efforts) and attributes related to contract design ('length of contract,' 'contract cancellation options,' 'contract flexibility,' etc.). They extended the categorization to introduce a novel attribute called 'purpose' which they tested via a CE. Dupras et al. (2018) also categorized attributes as either visual aspects (like 'crop diversity') or personal attributes (like 'family heritage,' 'emotional attachment,' etc.). Christensen et al. (2011) also categorized their contract attributes into three categories: flexibility in contract terms ('contract length'), flexibility in practical management ('buffer zone width'), and economic incentive ('subsidy in euro/hectare/year'). These numerous categorizations can be incoherent for future studies when selecting attributes, which calls for comprehensible and practical typologies. One of the ways to do it is by systematically collating all the attributes from previous studies and sorting them according to their usage.

Thus, we aim to conduct a systematic review of AES studies' recent literature that uses CEs to reveal the common attributes they use for testing contract designs and farmers' preferences for those contract features. Our study also tries to categorize the attributes into broad typologies and highlight the lesser-used attributes that can be explored in future AES studies.

A systematic literature review is used to collect and analyze data from relevant previous studies and identify empirical evidence to satisfy a specific hypothesis or research question (Armstrong et al., 2011; Petticrew & Roberts, 2008; Siddaway et al., 2019). We use a systematic review since it has a considerable edge over a narrative review as it is more organized and has reduced bias (Koutsos et al., 2019). There have been several proposed methods for conducting a systematic review, and they are usually classified by the research discipline. E.g., the EKLIPSE project report on different methodologies suggests using either the Cochrane method (Higgins et al., 2019), Campbell collaboration protocol (Kugley et al., 2017), or the Collaboration for Environmental Evidence (2013) method for conducting a systematic review in the domain of environmental-related sciences (Dicks et al., 2017). Another novel approach is the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) methodology that illustrates the flow of information in different phases of a systematic review. PRISMA has been widely in different research disciplines, and has been cited more than 25,000 times, and endorsed in over 400 journals (Page et al., 2018). In agricultural sciences, systematic reviews have been a recent change from the traditional narrative reviews (Koutsos et al., 2019). Koutsos et al. (2019) proposed a framework for conducting systematic review specifically for agricultural sciences by extending the basic steps of the PRISMA Flowchart (illustrated by Moher et al., 2010). Hence, we use the framework by Koutsos et al. (2019) to identify specific studies that use the CE methodology for AES studies and shortlist the attributes used in such studies.

This paper is organized as follows: in Section 2, we give a detailed account of our methodology and how we shortlisted the studies for the review; in Section 3, we describe our results and then discuss our outcomes in Section 4. We conclude our study in Section 4, highlighting possible future implications of this review.

2. METHODOLOGY

PRISMA is an evidence-based method for reporting in systematic reviews and meta-analyses. It has been published in several journals to encourage its dissemination and citation (like BMJ, Plos, Springer, etc.). In this study, we use the PRISMA flowchart and checklist downloaded from Moher et al. (2010) and apply it to our study as explained for agricultural science reviews by Koutsos et al. (2019). Koutsos et al. (2019) tested the framework on a simple case to assess the methodology's ease and efficacy and thus, promote its adoption among agro-scientists. Their framework included the following six steps which we also used in this study:

2.1 Scoping

We set the following research questions to achieve the objective of this review.

- **RQ1:** How many and what are the common contract attributes used by studies while designing a CE for eliciting farmers' preferences for AESs?
- **RQ2:** What are the different typologies that the attributes can be classified into?
- **RQ3:** How can the lesser-used attributes influence farmers' WTA?

2.2 Planning

We conducted an extensive search to identify the studies relevant to our RQs. For that, we shortlisted keywords (and Boolean operators) and selected the digital database for the search. We tested a range of keywords before finalizing on the following: 'choice experiment', 'agri-environmental', 'contracts', 'schemes', 'measures.' We chose two digital databases for our search: Scopus Database (https://www.scopus.com/) and Web of Science (WOS) (https://apps.webofknowledge.com/).

2.3 Identification

We performed the search (query execution) using various combinations of keywords. We also decided to use no additional filters (like year, subject area, document type, document language, etc.) for the search. We executed the query in May 2020. In total, we found 110 documents (from Scopus and WOS).

Scopus search

- Search string: choice AND experiment AND agr*-environmental AND contracts OR schemes OR measures
- Outputs: 56 documents from 2006–2020; included 55 Articles and 1 Conference Paper.

WOS search

- Search string: "choice experiment" AND agr*-environmental schemes OR "choice experiment" AND agr*-environmental contracts OR "choice experiment" AND agr*-environmental measures.

- Outputs: 54 documents from the years 2006 – 2020; included 51 Articles, 2 Reviews, and 1 Conference Paper.

2.4 Screening

We assessed the quality of the resulting documents from the search query by first deleting 40 duplicated documents, and then conducting initial screening of the remaining 70 documents by skimming through titles and abstracts. Out of the 70 studies, we excluded 12 publications. Some of the common reasons for exclusion were either the document was completely unrelated to the search query, or the study did not use the CE method. E.g., two studies (Bartkowski & Bartke, 2018 and Dessart et al., 2019) are reviews of other empirical studies related to AESs, but not related to AESs that use CE methodology, hence were excluded.

2.5 Eligibility

We applied content-based quality checks of the full paper for the remaining 58 documents to make sure the selected studies aligned with our objectives. For that, we set inclusion/exclusion criteria for effective checks, as suggested by Khan et al. (2003). The inclusion/exclusion criteria we applied to the studies were as follows:

a) The study should have used a CE to explore farmers' willingness to participate in or accept an AES
b) The survey respondents should be specifically farmers
c) The study should have recorded AES for public goods, not private benefits

Based on our criteria, 34 studies were finally selected for review with specific reasons for exclusion, like, study design, study measures, type of survey respondents or sample-type, etc., with specific reasons for the exclusion provided in Appendix 1.

2.6 Presentation

We concluded the review by presenting the evidence, summarizing it, and interpreting it to answer our research questions. Using the PRISMA flowchart (extracted from Moher et al., 2010), we mapped out the number of articles identified included or excluded (Figure 1). We tabulated the study characteristics and choice attributes and their levels found in each study for data synthesis to answer the research questions (Appendix 2). Similar attributes were grouped and the frequency of their occurrence was noted using MS Excel (Appendix 3). We then classified the attributes on basis of different typologies, which are discussed in the following sections.

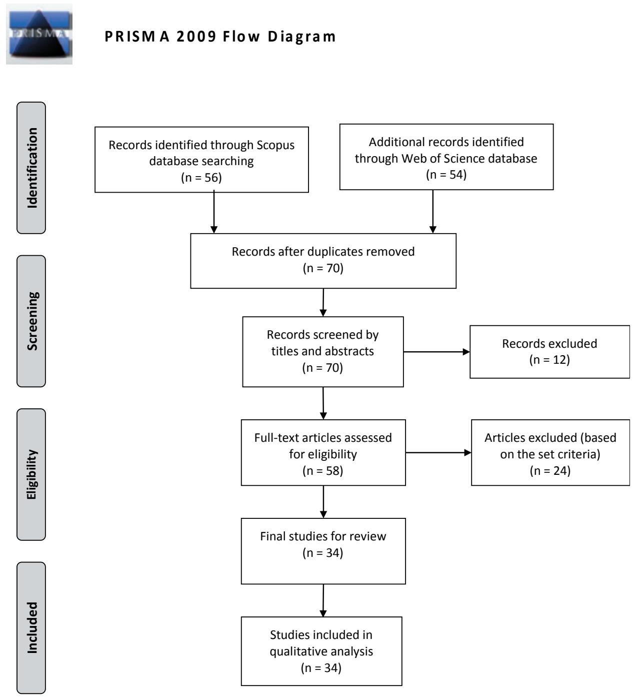

Figure 1. Prisma Flowchart filled with study results. Source: Moher et al. (2010).

3. RESULTS

We derived 177 attributes in total from the 34 reviewed studies (Appendix 3). The duplicated attributes are collated together, and the resulting 32 unique attributes are depicted in Table 1. By categorizing similar attributes, five main typologies emerge: 'monetary attributes,' that can be used as a means to calculate potential monetary trade-offs among attributes ('payment,' 'bonus,' 'fine,' etc.); 'general attributes,' that outline the general preferences of a contract ('area,' 'duration,' etc.), 'flexibility attributes,' that indicate contract flexibilities (over a duration, over an area, over prescriptions, etc.), 'prescription attributes,' that include management, technical, and policy-related specifications across alternative contracts ('communal participation,' 'risk,' 'farmer recommendation,' 'eco-label,' 'monitoring,' etc.), and 'purpose attributes' that define the purpose of the AESs and have a direct effect on farmers' compliance costs (either through chemical reductions or through

Table 1. Attributes found in the review.

	Attributes	Frequency	Relation with WTA
MONETARY ATTRIBUTES			
1	Payments (€/ha/year) or compensation; for animals (€/animal/year)	34	Same as WTA
2	Conditional Bonus/Incentive	6	+
3	Potential price fluctuation	2	-
4	Cost ceiling for compensation	1	+
5	Gross margin (€/ha/year) or (%)	1	+
6	Compost price per trolley (in currency)	1	+
7	Fine (in case of infringement)	1	-
GENERAL ATTRIBUTES			
8	Duration of contract	17	-
9	Area enrolled in contract (%)	15	-
10	Availability of technical training/ scheme support/assistance	8	+
11	Average time spent on paperwork/ administration	2	-
FLEXIBILITY ATTRIBUTES			
12	Flexibility over adherence to scheme prescriptions	11	+
13	Flexibility over what areas of the farm are entered into the scheme	7	+
14	Flexibility of duration or cancellation of contract	6	+
15	Flexibility to change agricultural practice (fertilizers, pesticides, manure)	6	+
16	Non-participation: flexibility to opt-out	2	+
17	Flexibility of dates for working on fields	3	+
PRESCRIPTION ATTRIBUTES			
18	Monitoring	9	Not significant
19	Communal participation or compensation	7	+/-
20	Maximum grazing (stocking density)	4	+
21	More labor days for work	2	-
22	Coordination with neighbors	1	+
23	Recommendation	1	+
24	Likelihood of complete crop failure (time in years)	1	-
25	Data provision type	1	+/-
26	Process optimization	1	+
27	Input risk	1	-
28	Conservation Outcome risk	1	-
29	Eco-label	1	+
PURPOSE ATTRIBUTES			
30	Allocation of land to some environmental activity(s)	15	+/-
31	Ecological focus areas (%)	5	-
32	Reduction of chemicals (%)	4	-

other environmental efforts like 'biodiversity conservation'). We found 7 monetary attributes, 5 general attributes, and 5 attributes related to flexibilities in contracts. We also found 11 prescription attributes and 3 purpose attributes that are specific to the purpose of the AES. We discuss the attributes below in detail and how they impact farmers' participation and WTA. The lesser-used attributes have been used in only one study, and we also discuss their potential for future studies.

3.1 Monetary attributes

Monetary attributes signify those contract features that are specified in monetary terms. These include contract payments that promote farmers' participation and keep agricultural policy budgets under control (Villamayor-Tomas et al., 2019), or economic incentives that motivate farmers' adherence to the terms of the contract (like 'fine') (Alló et al., 2015). We observed 7 attributes that could fall under this typology.

3.1.1 Payment

A typical contract dictates farmers modify their farming practices for per-hectare (annual) payments. So, every CE includes a monetary cost/benefit attribute called 'payment' that allows for evaluating welfare estimates, i.e., willingness to pay (WTP) or willingness to accept (WTA) compensation, for changes in the levels of contract attributes (Birol, 2012). The monetary attribute can not only evaluate the farmer preferences, but it can also help estimate the public expenditure needed for each new design of a contract. Thus, 'payment' is an essential attribute for informing AES policy design (Espinosa-Goded et al., 2010). We observed that all reviewed studies used this attribute, and it is generally depicted in currency per hectare per annum. Though farmers' WTA for changes in different attribute values can be calculated using payment as an attribute in CEs, payment can also cover the combination of opportunity costs, management costs, monitoring cost, risk premium, and profit margin in an AES (Greiner et al., 2014) which a respondent needs to be aware of while choosing AES options.

However, the impact of other attributes affects payment amounts hugely. The trade-offs the farmers are willing to make in exchange for different levels of payments are interesting to analyze. E.g., Ruto & Garrod (2009) observed that farmers would easily trade-off approximately 10% of their current payments in exchange for increased flexibility over what lands to enter in the contract or what measures to enroll in the AES. Similar results have been noticed in other studies. Espinosa-Goded et al. (2010) also observed that relaxing the restriction on grazing areas could increase farmer participation and decrease the budget of the contract. Similarly, Santos et al. (2016) noted that technical support is more important for the farmers than subsidy amounts. The same study estimated that farmers would give up around 400€ per hectare per year for increasing the cattle density by one livestock unit per hectare, reflecting the high opportunity costs of extensification of grazing in Portuguese *montados* (Santos et al., 2015). Furthermore, Wainwright et al. (2019) observed a non-linear relationship between payment values and farmers' participation, which indicates the high significance of other contract attributes. Villanueva et al. (2017) also observed that farmers required higher compensation for programs with very high levels of demand and low flexibilities. Pröbstl-Haider et al. (2016) also observed that, farmers are not ready to sway from intensive cropping even with higher compensations. Thus, even though payment is the only monetary attribute in most of the AES studies, farmers' preferences depend on a wider set of factors than just the monetary factors.

3.1.2 Conditional Bonus/Incentives (one-time only)

A conditional bonus is paid in addition to the annual compensation payments per hectare as an incentive to farmers to favor higher participation rates and land enrolment in AESs and achieve higher targets of contract purposes. Kuhfuss et al. (2015) and Roussel et al. (2019) used the attribute on the condition of additional chemical reductions per year. Similarly, Villanueva et al. (2017) offered a fixed incentive at the end of the contract period (after 5 years) on the condition of improvements in the provision of biodiversity and soil functionality. This attribute should theoretically positively affect farmers' participation; however, it is highly influenced by other contract features. Since the bonus is conditional, farmers may not agree to stringent conditions of the contract. Roussel et al. (2019) observed a high preference of the farmers towards the bonus. In contrast, Kuhfuss et al. (2015) observed higher initial participation but, the bonus had no effect on the individual area enrolled in the scheme. Only if the bonus would be used as in collective performance, it efficiently increased the total area enrolled, which signifies the use of this attribute for analyzing collective contract types. Some studies also showed that additional bonus was insignificant for farmers, and they would instead prefer higher flexibilities in contracts than additional payments. E.g., the attribute 'premium for results' used by Villanueva et al. (2017) had no significance on farmers' participation. Also, Chang et al. (2017) observed that farmers are reluctant to reduce fertilizer consumption even when incentivized with additional payments.

3.1.3 Other monetary attributes

Pröbstl-Haider et al. (2016) studied the influence of the attribute 'potential price fluctuations' in their CE since international market prices are of increasing importance in their study region (March–Thaya floodplains, Vienna). Their study observed that farmers chose an AES on the basis of price fluctuations play rather than on the value of the environmental premium.

Another attribute that is important for exploring in future studies is 'Fine.' Alló et al. (2015) used it in their study to analyze the farmer's moral hazard and free-riding behavior under an AES. Though the 'fine' attribute is similar to 'monitoring'; however, unlike monitoring, it is a monetary attribute, and will expectedly increase the WTA, but has not been tested sufficiently in AES studies.

Other market-based monetary attributes like 'gross margin' and 'cost ceiling' have been used in individual studies as an addition to the payment attribute to test the effect of additional monetary factors on WTA. They also positively impact WTA; however, they are contract-specific attributes that reflect farmers' profits rather than the policy design of an AES.

3.2 General attributes

We found 4 general attributes including the basic contract design elements (such as 'contract length,' 'contract area,' etc.). Every contract has at least one general attribute, which defines the basic contract regulations. Even though theoretically, monetary attributes are of the highest importance to farmers while choosing an AES, many studies have observed the general attributes could sway farmers' preferences for an AES (Christensen et al., 2011; Greiner, 2016; Hasler et al., 2019; Lienhoop & Brouwer, 2015). The basic design elements of a contract can thus influence farmers' WTA significantly.

3.2.1 Duration of contract

The contract duration is an important attribute to determine farmers' WTA. We observed 17 out of selected 34 studies used this attribute in their CEs. In almost all the studies, the farmers preferred shorter contracts, except in the study by Franzén et al. (2016), wherein it was insignificant. Most studies show that increasing contract duration requires higher compensation by the farmers. E.g., Ruto & Garrod (2009) observed that farmers demand an increase of 1% of the current payments for a year's increase in the contract duration.

3.2.2 Area enrolled in contract (%)

We observed 15 studies used this attribute to test its impacts on contract design, and 8 out of those showed that farmers prefer to enroll shorter areas into the contracts, while 6 showed no role of significance. Studies have indicated this as a conflict between agricultural intensification and conservation (De Salvo et al., 2018; Espinosa-Goded et al., 2010; Villamayor-Tomas et al., 2019; Villanueva et al., 2015a). Farmers also have a high reluctance and strong disutility for larger conservation areas or larger forest sizes. E.g., Lienhoop & Brouwer (2015) noted that farmers do not find large-scale afforestation projects attractive and demand very high costs for such a contract. Other studies also proved that farmers are willing to accept smaller subsidies for smaller areas enrolled in the contracts. Hasler et al. (2019) observed that the Danish farmers required an increase of 1% in their payments for every additional 1% of arable land enrolled in the contract, thus making this attribute important for considering payment amounts. Similarly, Villanueva et al. (2015) also reported that only 44% of the farmers surveyed would accept a low-to-medium increase in compensation amounts for 1% of the increase in cover crops area, while the rest would either not enroll more areas or ask for higher compensation amounts. Enrolling larger areas into the contract increases the probability of adopting more restrictive measures, so farmers prefer to enroll smaller areas (Roussel et al., 2019).

3.2.3 Availability of technical training/ scheme support

We found 8 studies that used 'technical training/ scheme support' as an attribute for analyzing farmers' WTA. The majority of the studies observed that technical support is welcomed by farmers and can lead to higher participation and lower compensation payments (Christensen et al., 2011; Espinosa-Goded et al., 2010; Hasler et al., 2019; Kuhfuss et al., 2015; Ruto & Garrod, 2009). However, farmers did not consider scheme support important for a conservation program in some studies (Franzén et al., 2016; Wainwright et al., 2019). Furthermore, the attribute is highly preferred when it is provided free of cost (Christensen et al., 2011; Kuhfuss et al., 2015). Santos et al. (2016) attributed technical support as the second most observed factor influencing farmers' participation in future AESs, though it was not included as an attribute in their CE.

3.3 Flexibility attributes

The flexibility in a contract is one of the key factors that facilitate its adoption. Flexibility can be in plot selection, prescription selection, or withdrawal from the contract (Christensen et al., 2011; Kuhfuss et al., 2015; Ruto & Garrod, 2009; etc.), which can influence compensation amounts immensely. Usually, studies have noted that higher flexibilities in contracts can lead to lower WTA. E.g., Lienhoop & Brouwer (2015) observed that only a smaller percentage of farmers were influenced by the payment levels of the AESs, as compared to more farmers preferring to have the option to return to agriculture after the contract ends.

3.3.1 Flexibility over adherence to scheme prescriptions

Flexibility in scheme prescription measures or the choice of choosing management type is another attribute many studies deem as important for their CEs. It generally has a positive correlation with farmer participation. The 11 studies that use this attribute observed that farmers preferred higher flexibility. Latacz-Lohmann & Breustedt (2019) observed that offering flexibility to farmers like allowing organic fertilizer to be used (compared to no fertilization) reduced the compensation requirement by 127.40€. Even the studies not using this attribute have reported farmers' preferences for higher flexibility in measures and management practices (Christensen et al., 2011; Espinosa-Goded et al., 2010; Villanueva et al., 2015b, etc.)

3.3.2 Flexibility over what areas of the farm are entered into the scheme

The flexibility of the area under contract has a positive significance in most studies (e.g., Alló et al., 2015; Christensen et al., 2011; Greiner, 2016; Ruto & Garrod, 2009). Though 7 studies have mainly used this attribute, other studies have analyzed it through the attribute 'area size under contract.' However, this attribute is different from contract area size enrolled as it allows the farmers to choose the area size, conservation activity on that area, and the duration of being enrolled for that area. Thus, this attribute is an integration of different flexibility options which can lead to higher participation and lower compensation amounts. E.g., Christensen et al. (2011) observed that an average farmer could give up 43€/ha/year for flexible buffer zone width.

3.3.3 Flexibility of duration or cancellation of contract

Many farmers consider the opportunity to terminate the contract at any time to be an important pre-condition for participation (as shown in studies by Broch & Vedel, 2012; Christensen et al., 2011; Hasler et al., 2019, etc.). Generally, this attribute has a positive correlation with farmer participation. Farmers prefer this possibly because canceling the contract at will would allow them to switch to more intensive farming when market prices increase (Mariel & Meyerhoff, 2018). This attribute can also be used as an incentive for participation (Greiner, 2016; Hasler et al., 2019).

3.3.4 Flexibility to change agricultural practices (fertilizers, pesticides, manure)

Studies have shown that flexibility in contract regulations is more important for farmer participation than pre-determined changes in agricultural practices. Studies provide this choice of changing agricultural practices at will in their CEs to determine the trade-offs between compensation amounts and conservation efforts. E.g., Kuhfuss et al., (2015) observed that farmers would not include their whole vineyard in the contract unless they have the flexibility to use chemicals in some farm areas. Similarly, Latacz-Lohmann & Breustedt (2019) observed that allowing organic fertilizers, instead of prohibiting all fertilization, reduced the compensation amount by 127.40€. Likewise, Villanueva et al. (2017) also observed that compensation amounts were reduced with increasing levels of insecticidal treatments allowed in the contracts. Their study showed that farmers' WTA is lowest for limited treatment and highest for non-treatment, indicating that farmers are reluctant to give up chemical treatments altogether. However, only 6 studies used this attribute; thus, there is a greater scope of experimenting with different conservation options.

3.3.5 Non-participation: flexibility to opt-out

Though all the studies (like Broch & Vedel, 2012; Christensen et al., 2011; Espinosa-Goded et al., 2010; Kuhfuss et al., 2015; Ruto & Garrod, 2009; etc.) use it in their choice cards when conducting a CE; however, only 2 studies used it specifically as an attribute for the CE (Le Coent et al., 2017 and Roussel et al., 2019). Not including it as an attribute could be because the coding of variables in the CE testing model with an opt-out option poses several challenges (Le Coent et al., 2017). The opt-out option is generally used in CE to give the farmers the voluntary choice of choosing an AES. Villamayor-Tomas et al. (2019) noted that 37% of farmers chose the opt-out option; however, he suggested exploring further whether this would affect the main findings. Roussel et al. (2019) studied the attribute to understand farmers' preference to keep their current practices. This attribute generally positively correlates to farmers' preferences since it avoids them facing a forced choice.

3.4 Prescription attributes

Most of the attributes in the reviewed studies were prescription attributes that defined the technical and management aspects of the contracts. We found 16 such attributes used in 5 or less than 5 studies; however, most are uniquely used (only in one study) and are also discussed under lesser-used attributes in the Discussions section. Researchers use attributes like 'monitoring' are to check for non-compliance among farmers (9 studies use this attribute). However, monitoring is costly, and the balance between non-compliance and monitoring is often ignored (Vedel et al., 2015). We observed that the monitoring attribute was insignificant in most of the studies indicating that it plays a minor role in farmers' choice of participating in an AES (Greiner, 2016; Rodríguez-Entrena et al., 2019; Villanueva et al., 2015b, 2015a; Villanueva et al., 2017). However, only Broch & Vedel (2012) and Vedel et al. (2015) observed that monitoring had a significantly negative impact on respondents' utility and led to increased WTA. The reason for the negative attitude towards monitoring could be the farmer's mistrust of the system or the farmer's perception of the system controlling him (Broch & Vedel, 2012).

'Communal participation' or 'communal schemes' are also attractive to farmers since they induce a 'neighbor-effect' among farmers, leading to increased participation in the AES. Communal management can have mixed results on farmers' WTA. Studies such as Hope et al. (2008) and Villanueva et al. (2017) reported a positive correlation to farmers' preferences. Hope et al. (2008) reported that farmers prefer working as a group rather than as individuals. Villanueva et al. (2017) reported that older farmers (> 60 years) show a higher willingness for collective participation than younger farmers in olive groves of plain areas. Even though only 7 studies have used this attribute, many other studies mention similar factors that indicate that farmers' have high utility for community participation and management. E.g., Aslam et al. (2017) observed that social pressure and social networks could increase farmers' acceptance for contracts. Similarly, Alló et al. (2015) tested the variable 'social trust' to evaluate whether farmers believe their neighbors fully comply with the contract terms, and observed that majority of respondents think that their neighbors will comply. This compliance indicates that the attribute should be tested in CEs for collective contract types. However, some studies also observed that farmers prefer individual management and discrete compensation, like Rodríguez-Entrena et al. (2019) noted that collective participation leads to a higher degree of uncertainty among the farmers. Similarly, Villanueva et al. (2015a) suggested that most farmers showed medium to high WTA for collective participation because they anticipated loss of freedom of their farm management due to community participation.

Other attributes that span under the umbrella of 'neighbor-effect' include 'coordination with neighbors' and 'recommendation.' Neighbor-effect generally positively correlates with farmers' participation. Villanueva, et al. (2017) noted that farmers are more willing to participate at lower transaction costs if the neighbors also participate. Also, the attribute 'farmers' recommendation' used by Villamayor-Tomas et al. (2019) exhibited a positive significance to farmers' acceptance, whereas the attribute 'scientist recommendation' had no significant impact. The attribute is also similar to 'communal participation', with the only difference being that this tests the farmer's preferences to his immediate neighbor's preferences, whereas the latter is on the level of the whole community. De Salvo et al. (2018) suggested that neighbor-effect can improve acceptability of AESs and achieve cost-effectiveness of contracts, and hence farmers' preferences for 'local context' should be considered by policymakers.

'Grazing intensity' or 'Stocking density' is another attribute that 4 studies included for testing farmers' preferences for a reduction in grazing intensity or the number of animals per hectare. The studies (Breustedt et al., 2013b; Latacz-Lohmann & Breustedt, 2019; Santos et al., 2015) show that stricter prescriptions for lesser grazing lead to higher compensations, thus higher WTA.

Non-monetary incentives have also been overlooked by all the studies except one. Chang et al. (2017) used the 'eco-label' attribute to incentivize farmers who successfully complied with the AES standards and observed that farmers would readily exchange an eco-label for lower compensation amounts. So, including non-monetary incentives like eco-label can also help lower the farmers' WTA.

'Risk' is another attribute that has been used in the study by Star et al. (2019) that explored how input or outcome risk limits the farmers' willingness to implement environmental measures. Their study reported that higher levels of either risk would reduce participation and increase the compensation amount. This attribute should be extensively tested especially in the face of climate and socio-economic uncertainties.

3.5 Purpose attributes

These attributes are different from the contract design attributes as they specifically iterate the purpose for which the farmer will accept the contract prescriptions. The purpose of an AES could be a conservation activity, afforestation, land allocation for environmental activity, chemical reduction, etc., which is what these attributes offer.

3.5.1 Allocation of land to some environmental activity(s)

Attributes like 'maintenance of soil organic matter,' 'protection of soil from water erosion,' 'recreational access,' 'biodiversity improvements,' 'forest co-benefits,' 'afforestation,' etc. are different types of environmental and conservation activities that define the contract motives. Some studies like Broch & Vedel (2012) used the attribute 'purpose' specifically to combine different conservation activities into one choice for their CE (biodiversity, water protection, or recreation). Le Coent et al. (2017) also used 'purpose' as a separate attribute to highlight farmers' preferences between different conservation activities. One of the significant inferences from testing this attribute has been that most farmers prefer conservation over compensation (according to the studies by Le Coent et al., 2017; Lienhoop & Brouwer, 2015; Santos et al., 2015; Vedel et al., 2015). Greiner (2016) also used this attribute to understand the significance of different conservation activities; however, he observed that 33% of farmers found the choice insignificant, rather focused on payment values and contract duration.

3.5.2 Ecological focus area

Though 5 out of 34 reviewed studies used this attribute in their CE; however, 4 of these studies use the same set of choice attributes in their CE (Rodríguez-Entrena et al., 2019; Villanueva et al., 2015b, 2015a; Villanueva et al., 2017). According to Villanueva et al. (2017, p6), this attribute was included in the CE to "*explore a hypothetical future implementation of the EFA requisite of the Common Agricultural Policy (CAP) 'green payment' in permanent crops such as olive groves*". Some previous studies have also mentioned EFA in their articles but do not test it in their CEs; like Breustedt et al. (2013) and Villamayor-Tomas et al. (2019).

Overall, studies using this attribute observed that farmers have a negative preference for EFAs, since agreeing to it would mean dedicating additional areas to ecological functions than stated in the contract. A similar attribute called 'Naturalization' used by Rocchi et al. (2017) defines conversion of agricultural areas to pastures, using particular species with a high natural value. However, farmers in their study show the least interest in this attribute.

3.5.3 Reduction of chemicals (%)

This attribute is typically used to study the compensation payments that would be required for a higher reduction in chemicals. Kuhfuss et al. (2015) found that higher chemical reduction can lead farmers to enroll more farm areas in the AES because chemical reduction needs higher investment in equipment that becomes more cost-efficient if used on the whole farm rather than just small areas. Chang et al. (2017) observed that after a point, farmers show high reluctance to further reductions of chemical fertilizer use even when additional payments are offered. Similarly, Kanchanaroek & Aslam (2018) also observed that shorter contract lengths and a lower reduction in chemical input together lowered the WTA substantially. 3 out of 4 studies using this attribute reported that chemical reduction negatively impacts farmers' participation and increases their WTA. Only Rocchi et al. (2017) observed that most of their respondents are interested in reducing nitrates. Chang et al. (2017) suggested that farmers should be incentivized if they agree to an additional reduction of chemical fertilizers.

4. DISCUSSIONS

Our study used a systematic review for a reliable and transparent method of reviewing previous AES literature that uses CE to elicit farmers' preferences to alternative AESs. We set three specific research questions that this review hoped to answer and discuss. We listed out 32 attributes used by studies as shown in Appendix 3 and defined and analyzed in the Results section, which answers our first research question. The most common attribute used by all studies is the payment attribute that can help estimate the monetary value of other attributes. However, AES studies aim to find incentives other than monetary payments for estimating farmers' WTA (Villamayor-Tomas et al., 2019). The contract purpose is present in all studies, which could include either 'allocation of land to environmental activity,' or 'chemical reductions,' or 'changing the land to an ecological focus area.' The purpose of the contract helps in deducting the conservation versus compensation behavior of the farmers. The general contract design is shaped by attributes such as 'duration of contract,' 'area enrolled under contract,' and 'availability of scheme support/additional training,' which are usually the first few attributes in the choice cards of AES studies. Attributes indicating flexibility in overall contract terms and environmental goals have shown to increase farmers' acceptance and participation (like Christensen et al., 2011; Espinosa-Goded et al., 2010; Ruto & Garrod, 2009; etc.); thus, most studies also include a flexibility attribute. The management, technical, and policy prescriptions can also be tested for an effective policy design through a CE. These can include attributes such as 'collective participation,' 'monitoring,' 'farmer recommendation,' etc. They can also be a novel attribute that has not been tested before, like 'risk.'

Upon surveying the common attributes, five main typologies were established under which all the extracted attributes could be classified, which answers our second research question. At least one attribute under each typology must be used in the AES study for an effective outcome and to remove subjectivity bias among researchers designing CE. Our classification includes monetary attributes, general attributes, flexibility attributes, prescription attributes, and purpose attributes, which have been discussed in detail in the Results section.

Economic factors of farmers' WTA has been well-understood and widely discussed by many studies (like Christensen et al., 2011; Lastra-Bravo et al., 2015; Santos et al., 2016, etc.) which can include the level of compensation, transaction costs, duration, and flexibility of contracts, availability of scheme support, etc. However, equally important cognitive, behavioral, and societal factors have not been discussed enough in AES studies. Farmers' attitudes and values, perceptions about conservation and compensation, and social norms like collective participation can influence farmer participation in an AES (Kuhfuss et al., 2015; Villamayor-Tomas et al., 2019). Many studies have also inferred upon the farmers' dilemma between compensation and conservation. Le Coent et al. (2017) conducted their CE with two types of contracts: compensation and conservation contracts. They reported that farmers preferred to participate in a contract with a biodiversity conservation objective than with a biodiversity compensation objective and exhibit higher WTA for enrolling into the compensation contract. On the contrary, a study by Villamayor-Tomas et al. (2019) showed conservation programs tend to harm farmers' utility and were not preferred by the farmers. Studies have also noted that when the conservation options restrict the land-use options for the farmers, their WTA for conservation measures increases (Aslam et al., 2017; Hope et al., 2008; Pröbstl-Haider et al., 2016). This disparity between what has been tested and what can be tested prompted us to discuss the lesser-used attributes.

Our review also found 12 uniquely used attributes, and we explored their utility for further studies, as per our research question 3. Most of these attributes are prescription attributes, that are specific to the contract area and type and might not be replicable over other AESs. However, some of the attributes can be studied over different contract types and must be explored more. One such novel monetary attribute is 'fine' used by Alló et al. (2015), which could be applied for any law infringement. Even though other studies have also tried to test compliance through economic incentives (Kuhfuss et al., 2015) or monitoring (Broch & Vedel, 2012); however, fine is the only attribute that enforces an economic penalty on non-compliance to the contract, and thus should be tested in more studies. Attributes such as 'coordination' and 'recommendation' are prescription attributes that play on social psychology and behavioral economics to positively influence the choice of farmers to participate in an AES if there is already a high level of participation (Kuhfuss et al., 2015). This indicates that farmers care not only about the economic incentives of the contracts but also of their "reputation" (Villamayor-Tomas et al., 2019), which can be tested through attributes exhibiting neighbor-effect. 'Risk' is another prescription attribute that has only been used in one study (in Star et al., 2019). Though many other AES studies talk about farmers' perceptions of risk and uncertainty as core reasons for non-participation (e.g., Hellerstein et al., 2015; Schilizzi & Latacz-Lohmann, 2016; Whitten et al., 2013; etc.); however it has not been studied in their CEs. Though Star et al. (2019) studied the input and output risks endured by landholders, their study did not consider institutional, production, or market risks that are also critical in designing efficient agri-environmental policies. Another interesting attribute is an 'eco-label' that has been tested in one study (by Chang et al., 2017) that farmers appreciated more than higher compensation amounts. However, such non-monetary incentives are not usually tested in EU studies, but with the rise in local certification schemes, more AESs could have such attributes.

Another variable of interest that hasn't been tested in any study but has shown to lower farmers' WTA and increase participation (Breustedt et al., 2013; Latacz-Lohmann & Breustedt, 2019) which is '*farmers' previous participation in an AES contract*.' However, Wainwright et al. (2019) noted that farmers already enrolled in an AES scheme were more likely not to select a contract option. Thus, this is a possible attribute that can be explored through future CE studies.

This study can thus be used as a reference for other AES studies that use literature review for selecting the attributes for their CE from various categories. It also provides a systematic framework for organizing literature that can be applied to newer AES studies. This study can also help shortlist attributes for future CE testing that can evaluate specific aims of CAP post-2020 like penalties to non-compliance (like fine) and alternatives to greening through certification schemes (like eco-label).

5. CONCLUSIONS

Our study aimed to highlight the common attributes that are used in a CE for studying farmers' acceptance of choice of agri-environmental contracts using a systematic review of literature while also categorizing the attributes into definitive typologies and glancing at the utility of lesser-used attributes. In conclusion, we found 32 attributes that could fit in five distinct typologies: 7 monetary attributes, 4 general attributes, 6 flexibility attributes, 12 prescription attributes, and 3 purpose attributes. Contract design attributes can impact compensation amounts hugely; e.g., general contract attributes (like smaller area and shorter duration) and flexibility attributes (such as higher flexibility of participation, contract area, contract duration, management, etc.) are highly preferred by the farmers and can lower their WTA and increase their participation. Technical support and scheme assistance are also positively welcomed by the farmers. Overall, the commonly used attributes are an indicator of those contract features that previous studies have tested repeatedly with CEs, and have shown consistent outcomes, e.g., shorter contract duration and the lesser enrolled area is preferred by farmers in most of the studies. However, some attributes also show varied results, e.g., monitoring has been insignificant for farmer acceptance in most of the studies and was found to be negatively related to farmer acceptance in two studies. Moreover, attributes that can directly address some of the emerging issues in EU's CAP reform features, such as result-based contracts (e.g., 'conditional monetary bonus' attribute used by Roussel et al., 2019) and collective contracts (like 'collective participation' and 'communal management' attribute used by Villanueva et al., 2017) have not been tested in many studies. They can be comprehensively analyzed in future AES studies.

We also found attributes that have theoretically been shown to be critical for AES selection but have been overlooked by most of the studies. These are non-monetary incentives, fine, recommendation, risk, coordination with neighbors, etc. The reasons for this exclusion could probably be a lack of literature to support their importance, or maybe these attributes require exhaustive coding in models. Market-based and value-chain attributes such as crop failure, price fluctuations, climate risks, etc. have also not been explored much which can become important under uncertain future scenarios (like climate change, socio-economic change, etc.). Thus, the lesser-used attributes are also an important indicator of farmers' acceptance of a contract and should be studied intensively.

Our review indicates that CEs should take more advantage of the virtual environment they are set to test and should experiment on a broader range of attributes across different areas and contract types. We hope that our systematic review can be used as a repository for choosing choice attributes for future studies and our typologies can be used to make a choice bundle that can fully explain both the farmer perceptions and value of a particular landscape.

FUNDING

This work was supported by Research Executive Agency (REA), under the powers delegated by the European Commission, under the European Union's Horizon 2020 Research and Innovation Program through the project CONSOLE, Grant Agreement No. 817949. This work does not necessarily reflect the view of the EU and in no way anticipates the Commission's future policy.

ACKNOWLEDGEMENTS

We thank the anonymous reviewers for their insightful comments and suggestions that significantly improved the manuscript.

REFERENCES

Alló, M., Loureiro, M. L., & Iglesias, E. (2015). Farmers' Preferences and Social Capital Regarding Agri-environmental Schemes to Protect Birds. *Journal of Agricultural Economics*, *66*(3), 672–689. https://doi.org/10.1111/1477-9552.12104

Armstrong, R., Hall, B. J., Doyle, J., & Waters, E. (2011). "Scoping the scope" of a cochrane review. *Journal* *of Public Health*, *33*(1), 147–150. https://doi.org/10.1093/pubmed/fdr015

Aslam, U., Termansen, M., & Fleskens, L. (2017). Investigating farmers' preferences for alternative PES schemes for carbon sequestration in UK agroecosystems. *Ecosystem Services*, *27*, 103–112. https://doi.org/10.1016/j.ecoser.2017.08.004

Bartkowski, B., & Bartke, S. (2018). Leverage points for governing agricultural soils: A review of empirical studies of European farmers' decision-making. *Sustainability (Switzerland)*, *10*(9). https://doi.org/10.3390/su10093179

Birol, E. (2012). *Munich Personal RePEc Archive Choice Experiments Informing Environmental Policy : A European Perspective*. *38232*.

Brandyberry, M. (2015). Program attributes that impact a farmers willingness-to-accept participation in a high oleic soybean (hos) segregation program: a choice experiment. In *Masters Thesis* (Issue May). The University of Missouri, Columbia.

Breustedt, G., Schulz, N., & Latacz-Lohmann, U. (2013a). Calibrating agri-environmental schemes using a two-stage discrete choice experiments . *German Journal of Agricultural Economics*, *62*(4), 259–275.

Breustedt, G., Schulz, N., & Latacz-Lohmann, U. (2013b). Ermittlung der Teilnahmebereitschaft an Vertragsnaturschutz-programmen und der dafür notwendigen Ausgleichszahlungen mit Hilfe eines Discrete-Choice-Experimentes Factors affecting Participation and Compensation Requirements in Agri-Environmental Schemes: *Gjae*, *62*(4), 244–258. www.gjae-online.de

Broch, S. W., & Vedel, S. E. (2012). Using Choice Experiments to Investigate the Policy Relevance of Heterogeneity in Farmer Agri-Environmental Contract Preferences. *Environmental and Resource Economics*, *51*(4), 561–581. https://doi.org/10.1007/s10640-011-9512-8

Chang, S. H. E., Wuepper, D., Heissenhuber, A., & Sauer, J. (2017). Investigating rice farmers' preferences for an agri-environmental scheme: Is an eco-label a substitute for payments? *Land Use Policy*, *64*, 374–382. https://doi.org/10.1016/j.landusepol.2017.03.014

Chèze, B., David, M., & Martinet, V. (2020). Understanding farmers' reluctance to reduce pesticide use: A choice experiment. *Ecological Economics*, *167*, 106349. https://doi.org/https://doi.org/10.1016/j.ecolecon.2019.06.004

Christensen, T., Pedersen, A. B., Nielsen, H. O., Mørkbak, M. R., Hasler, B., & Denver, S. (2011). Determinants of farmers' willingness to participate in subsidy schemes for pesticide-free buffer zones-A choice experiment study. *Ecological Economics*, *70*(8), 1558–1564. https://doi.org/10.1016/j.ecolecon.2011.03.021

Collaboration for Environmental Evidence. (2013). Guidelines for Systematic Reviews in Environmental Management. In *Environmental Evidence* (Issue Version 4.2). http://www.environmentalevidence.org/wp-content/uploads/2014/06/Review-guidelines-version-4.2-final.pdf

Dachary-Bernard, J., & Rambonilaza, T. (2012). Choice experiment, multiple programmes contingent valuation and landscape preferences: How can we support the land use decision making process? *Land Use Policy*, *29*(4), 846–854.

De Salvo, M., Cucuzza, G., Cosentino, S. L., Nicita, L., & Signorello, G. (2018). Farmers' preferences for enhancing sustainability in arable lands: Evidence from a choice experiment in sicily (Italy). *New Medit*, *17*(4), 57–70. https://doi.org/10.30682/nm1804e

Dessart, F. J., Barreiro-Hurlé, J., & van Bavel, R. (2019). Behavioural factors affecting the adoption of sustainable farming practices: a policy-oriented review. *European Review of Agricultural Economics*, *46*(3), 417–471.

Dicks, L., Haddaway, N., Hernández-Morcillo, M., Mattsson, B., Randall, N., Failler, P., Ferretti, J., Livoreil, B., Saarikoski, H., Santamaria, L., Rodela, R., Velizarova, E., & Wittmer, H. (2017). *Knowledge synthesis for environmental decisions: an evaluation of existing methods, and guidance for their selection, use and development - a report from the EKLIPSE project*. http://www.eklipse-mechanism.eu/apps/Eklipse_data/website/EKLIPSE_D3-1-Report_FINAL_WithCovers_V6.pdf%5Cnhttp://www.eklipse-mechanism.eu/eklipse_outputs

Dramstad, W. E., Tveit, M. S., Fjellstad, W. J., & Fry, G. L. A. (2006). Relationships between visual landscape preferences and map-based indicators of landscape structure. *Landscape and Urban Planning*, *78*(4), 465–474.

Dupras, J., Laurent-Lucchetti, J., Revéret, J. P., & DaSilva, L. (2018). Using contingent valuation and choice experiment to value the impacts of agri-environmental practices on landscapes aesthetics. *Landscape Research*, *43*(5), 679–695. https://doi.org/10.1080/01426397.2017.1332172

Espinosa-Goded, M, Barreiro-Hurlé, J., & Dupraz, P. (2013). Identifying additional barriers in the adoption of agri-environmental schemes: The role of fixed costs. *Land Use Policy*, *31*, 526–535. https://doi.org/10.1016/j.landusepol.2012.08.016

Espinosa-Goded, M., Barreiro-Hurlé, J., & Ruto, E. (2010). What do farmers want from agri-environmental scheme design? A choice experiment approach. *Journal of Agricultural Economics*, *61*(2), 259–273. https://doi.org/10.1111/j.1477-9552.2010.00244.x

Franzén, F., Dinnétz, P., & Hammer, M. (2016). Factors affecting farmers' willingness to participate in eutrophication mitigation — A case study of preferences for wetland creation in Sweden. *Ecological Economics*, *130*, 8–15. https://doi.org/10.1016/j.ecolecon.2016.05.019

Greiner, R. (2016). Factors influencing farmers' participation in contractual biodiversity conservation: A choice experiment with northern Australian pastoralists. *Australian Journal of Agricultural and Resource Economics*, *60*(1), 1–21. https://doi.org/10.1111/1467-8489.12098

Greiner, R., Bliemer, M., & Ballweg, J. (2014). Design considerations of a choice experiment to estimate likely participation by north Australian pastoralists in contractual biodiversity conservation. *Journal of Choice Modelling*, *10*(1), 34–45. https://doi.org/10.1016/j.jocm.2014.01.002

Hasler, B., Czajkowski, M., Elofsson, K., Hansen, L. B., Konrad, M. T., Nielsen, H. Ø., Niskanen, O., Nõmmann, T., Pedersen, A. B., Peterson, K., Poltimäe, H., Svensson, T. H., & Zagórska, K. (2019). Farmers' preferences for nutrient and climate-related agri-environmental schemes: A cross-country comparison. *Ambio*, *48*(11), 1290–1303. https://doi.org/10.1007/s13280-019-01242-6

Hellerstein, D., Higgins, N. A., & Roberts, M. (2015). Options for improving conservation programs: Insights from auction theory and economic experiments. *Amber Waves, February*.

Higgins, J., Thomas, J., Chandler, J., Cumpston, M., Li, T., Page, M., & Welch, V. (2019). *Cochrane Handbook for Systematic Reviews of Interventions version 6.0* (July 2019). Cochrane, 2019.

Hope, R., Borgoyary, M., & Agarwal, C. (2008). Smallholder preferences for Agri-environmental change at the Bhoj Wetland, India. *Development Policy Review*, *26*(5), 585–602. https://doi.org/10.1111/j.1467-7679.2008.00424.x

Horne, P. (2006). Forest owners' acceptance of incentive based policy instruments in forest biodiversity conservation - A choice experiment based approach. In *Silva Fennica Monographs* (Vol. 40, Issue 1, pp. 169–178).

Hynes, S., Campbell, D., & Howley, P. (2011). A holistic vs. an attribute-based approach to agri-environmental policy valuation: Do welfare estimates differ? *Journal of Agricultural Economics*, *62*(2), 305–329. https://doi.org/10.1111/j.1477-9552.2010.00287.x

Kanchanaroek, Y., & Aslam, U. (2018). Policy schemes for the transition to sustainable agriculture—Farmer preferences and spatial heterogeneity in northern Thailand. *Land Use Policy*, *78*(September 2017), 227–235. https://doi.org/10.1016/j.landusepol.2018.05.026

Khan, K., Kunz, R., Kleijnen, J., Antes, G., Pesaran, M. H., Rakotonarivo, O. S., Schaafsma, M., Hockley, N., & Snyder, H. (2003). A systematic review of the reliability and validity of discrete choice experiments in valuing non-market environmental goods. *Journal of Environmental Management*, *21*(July), 333–339. https://doi.org/10.1016/j.jbusres.2019.07.039

Koutsos, T. M., Menexes, G. C., & Dordas, C. A. (2019). An efficient framework for conducting systematic literature reviews in agricultural sciences. *Science of the Total Environment*, *682*, 106–117. https://doi.org/10.1016/j.scitotenv.2019.04.354

Kugley, S., Wade, A., Thomas, J., Mahood, Q., Jørgensen, A. K., Hammerstrøm, K., & Sathe, N. (2017). Searching for studies: a guide to information retrieval for Campbell systematic reviews. *Campbell Systematic Reviews*, *13*(1), 1–73. https://doi.org/10.4073/cmg.2016.1

Kuhfuss, L., Préget, R., Thoyer, S., Hanley, N., Kuhfuss, L., Préget, R., Thoyer, S., & Hanley, N. (2015). *Nudging farmers to sign agri-environmental contracts : the effects of a collective bonus To cite this version : HAL Id : hal-01148581 University of St . Andrews Discussion papers in Environmental Economics*. *October*. https://doi.org/10.13140/RG.2.1.1615.9447

Lancaster, K. J. (1966). A new approach to consumer theory. *Journal of Political Economy*, *74*(2), 132–157.

Lastra-Bravo, X. B., Hubbard, C., Garrod, G., Tolón-Becerra, A., Uthes, S., Matzdorf, B., Rakotonarivo, O. S., Schaafsma, M., & Hockley, N. (2015). What drives farmers' participation in EU agri-environmental schemes?: Results from a qualitative meta-analysis. *Environmental Science and Policy*, *54*(1), 98–109. https://doi.org/10.1016/j.envsci.2015.06.002

Latacz-Lohmann, U., & Breustedt, G. (2019). Using choice experiments to improve the design of agri-environmental schemes. *European Review of Agricultural Economics*, *46*(3), 495–528. https://doi.org/10.1093/erae/jbz020

Le Coent, P., Préget, R., & Thoyer, S. (2017). Compensating Environmental Losses Versus Creating Environmental Gains: Implications for Biodiversity Offsets. *Ecological Economics*, *142*, 120–129. https://doi.org/10.1016/j.ecolecon.2017.06.008

Lienhoop, N., & Brouwer, R. (2015). Agri-environmental policy valuation: Farmers' contract design preferences for afforestation schemes. *Land Use Policy*, *42*, 568–577. https://doi.org/10.1016/j.landusepol.2014.09.017

Mamine, F., Fares, M., & Minviel, J. J. (2020). Contract Design for Adoption of Agrienvironmental Practices: A Meta-analysis of Discrete Choice Experiments. *Ecological Economics*, *176*(April), 106721. https://doi.org/10.1016/j.ecolecon.2020.106721

Mäntymaa, E., Ovaskainen, V., Juutinen, A., & Tyrväinen, L. (2018). Integrating nature-based tourism and forestry in private lands under heterogeneous visitor preferences for forest attributes. *Journal of Environmental Planning and Management*, *61*(4), 724–746. https://doi.org/10.1080/09640568.2017.1333408

Mariel, P., & Meyerhoff, J. (2018). A More Flexible Model or Simply More Effort? On the Use of Correlated Random Parameters in Applied Choice Studies. *Ecological Economics*, *154*(April), 419–429. https://doi.org/10.1016/j.ecolecon.2018.08.020

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2010). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *International Journal of Surgery*, *8*(5), 336–341. https://doi.org/10.1016/j.ijsu.2010.02.007

Page, M. K., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T., Mulrow, C. D., Shamseer, L., & Moher, D. (2018). *Updating the PRISMA reporting guideline for systematic reviews and meta-analyses: study protocol*. 1–21. https://osf.io/2v7mk/?show=revision

Petticrew, M., & Roberts, H. (2008). *Systematic reviews in the social sciences: A practical guide*. John Wiley & Sons.

Pröbstl-Haider, U., Mostegl, N. M., Kelemen-Finan, J., Haider, W., Formayer, H., Kantelhardt, J., Moser, T., Kapfer, M., & Trenholm, R. (2016). Farmers' Preferences for Future Agricultural Land Use Under the Consideration of Climate Change. *Environmental Management*, *58*(3), 446–464. https://doi.org/10.1007/s00267-016-0720-4

Rakotonarivo, O. S., Schaafsma, M., & Hockley, N. (2016). A systematic review of the reliability and validity of discrete choice experiments in valuing non-market environmental goods. *Journal of Environmental Management*, *183*, 98–109. https://doi.org/10.1016/j.jenvman.2016.08.032

Rocchi, L., Paolotti, L., & Fagioli, F. F. (2017). Defining agri-environmental schemes in the buffer areas of a natural regional park: An application of choice experiment using the latent class approach. *Land Use Policy*, *66*(April), 141–150. https://doi.org/10.1016/j.landusepol.2017.04.033

Rodríguez-Entrena, M., Villanueva, A. J., & Gómez-Limón, J. A. (2019). Unraveling determinants of inferred and stated attribute nonattendance: Effects on farmers' willingness to accept to join agri-environmental schemes. *Canadian Journal of Agricultural Economics*, *67*(1), 31–52. https://doi.org/10.1111/cjag.12169

Roussel, S., Tardieu, L., & Vaissière, A.-C. (2019). Compensation écologique et agriculture : est-ce compatible ? *Revue Économique*, *70*, 123–137. https://www.cairn-int.info/revue-revue-economique-2019-1-page-123.htm?contenu=resume

Ruto, E., & Garrod, G. (2009). Investigating farmers' preferences for the design of agri-environment schemes: A choice experiment approach. *Journal of Environmental Planning and Management*, *52*(5), 631–647. https://doi.org/10.1080/09640560902958172

Santos, R., Clemente, P., Brouwer, R., Antunes, P., & Pinto, R. (2015). Landowner preferences for agri-environmental agreements to conserve the montado ecosystem in Portugal. *Ecological Economics*, *118*, 159–167. https://doi.org/10.1016/j.ecolecon.2015.07.028

Schilizzi, S., & Latacz-Lohmann, U. (2016). Incentivizing and tendering conservation contracts: The trade-off between participation and effort provision. *Land Economics*, *92*(2), 273–291. https://doi.org/10.3368/le.92.2.273

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to Do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses. *Annual Review of Psychology*, *70*(1), 747–770. https://doi.org/10.1146/annurev-psych-010418-102803

Star, M., Rolfe, J., & Barbi, E. (2019). Do outcome or input risks limit adoption of environmental projects: Rehabilitating gullies in Great Barrier Reef catchments. *Ecological Economics*, *161*(September 2018), 73–82. https://doi.org/10.1016/j.ecolecon.2019.03.005

Swanwick, C. (2009). Society's attitudes to and preferences for land and landscape. *Land Use Policy*, *26*, S62–S75.

Uthes, S., & Matzdorf, B. (2013). Studies on agri-environmental measures: A survey of the literature. *Environmental Management*, *51*(1), 251–266. https://doi.org/10.1007/s00267-012-9959-6

Vedel, S. E., Jacobsen, J. B., & Thorsen, B. J. (2015). Contracts for afforestation and the role of monitoring for landowners' willingness to accept. *Forest Policy and Economics*, *51*, 29–37. https://doi.org/10.1016/j.forpol.2014.11.007

Villamayor-Tomas, S., Sagebiel, J., & Olschewski, R. (2019). Bringing the neighbors in: A choice experiment on the influence of coordination and social norms on farmers' willingness to accept agro-environmental schemes across Europe. *Land Use Policy*, *84*(March), 200–215. https://doi.org/10.1016/j.landusepol.2019.03.006

Villanueva, A. J., Gómez-Limón, J. A., Arriaza, M., & Rodríguez-Entrena, M. (2015a). Assessment of greening and collective participation in the context of agri-environmental schemes: The case of Andalusian irrigated olive groves. *Spanish Journal of Agricultural Research*, *13*(4). https://doi.org/10.5424/sjar/2015134-7376

Villanueva, A. J., Gómez-Limón, J. A., Arriaza, M., & Rodríguez-Entrena, M. (2015b). The design of agri-environmental schemes: Farmers' preferences in southern Spain. *Land Use Policy*, *46*, 142–154. https://doi.org/10.1016/j.landusepol.2015.02.009

Villanueva, A, Gómez-Limón, J., & Rodríguez-Entrena, M. (2017). Valoración de la oferta de bienes públicos por parte de los sistemas agrarios: El caso del olivar de montaña en Andalucía. *Economia Agraria y Recursos Naturales*, *17*(1), 25–57. https://doi.org/10.7201/earn.2017.01.02

Villanueva, A., Rodríguez-Entrena, M., Arriaza, M., & Gómez-Limón, J. (2017). Heterogeneity of farmers' preferences towards agri-environmental schemes across different agricultural subsystems. *Journal of Environmental Planning and Management*, *60*(4), 684–707. https://doi.org/10.1080/09640568.2016.1168289

Wainwright, W., Glenk, K., Akaichi, F., & Moran, D. (2019). Conservation contracts for supplying Farm Animal Genetic Resources (FAnGR) conservation services in Romania. *Livestock Science*, *224*(March), 1–9. https://doi.org/10.1016/j.livsci.2019.03.016

Whitten, S. M., Reeson, A., Windle, J., & Rolfe, J. (2013). Designing conservation tenders to support landholder participation: A framework and case study assessment. *Ecosystem Services*, *6*, 82–92.

BAE
Bio-based and Applied Economics

AIEAA
ASSOCIAZIONE ITALIANA DI
ECONOMIA AGRARIA E APPLICATA

Citation: C. Geoghegan, A. Kinsella, C. O'Donoghue (2021). The effect of farmer attitudes on openness to land transactions: evidence for Ireland. *Bio-based and Applied Economics* 10(2): 153-168. doi: 10.36253/bae-9746

Received: September 16, 2020
Accepted: June 23, 2021
Published: October 28, 2021

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.

Editor: Fabio Bartolini.

ORCID
CG: 0000-0002-7023-6313
AK: 0000-0001-5670-9025
COD: 0000-0003-3713-5366

The effect of farmer attitudes on openness to land transactions: evidence for Ireland

Cathal Geoghegan*, Anne Kinsella, Cathal O'Donoghue

Teagasc, the Irish Agriculture and Food Development Authority; National University of Ireland, Galway
*Corresponding author. E-mail: cathal.c.geoghegan@nuigalway.ie

Abstract. Ireland suffers from very low levels of farmland mobility by European standards. This paper examines the role of attitudes in farmers' openness toward land transactions using a nationally representative survey of Irish farmers across the major farm systems. The results show that attitudinal factors are a significant predictor of openness to land mobility, both on the supply and demand side of the market. Additionally, there appears to be a greater demand amongst farmers for temporary land transactions such as land leasing arrangements than is currently seen in at market level.

Keywords: land markets, attitudes, Ireland.

1. INTRODUCTION

Land mobility is becoming an increasingly important issue for European agriculture. The enhanced market orientation of European agriculture and reduced reliance on subsidies requires farmers to be more efficient in their use of factors of production. This is coupled with European farmers getting older on average and the need amongst young European farmers for access to land (Davidova & Thomson, 2014; Zondag, 2015). Access issues are further complicated by the increasing land concentration in Europe, with more land being held by fewer farmers (Kay et al., 2015; van der Ploeg et al., 2015).

Agricultural land transactions in Europe occur within a range of national institutional and regulatory environments (Ciaian et al., 2010; Ciaian et al., 2012; Needham et al., 2011). One consequence of these diverse land governance frameworks is that land sales and land rental markets may operate uniquely from country to country. Despite an integrated agricultural market and the longstanding Common Agricultural Policy, the share of rented land varies between 20 and 80 per cent across the EU (Ciaian et al., 2010). Preferences for land ownership over land rental or vice versa have been linked to capital market imperfections, farm profitability and government regulations (Swinnen et al., 2016).

At an EU policy level, tension exists between encouraging land mobility so as to enable the structural change required for farms to reach an eco-

Firenze University Press | www.fupress.com/bae

nomically viable size and protecting the family farming model which accounts for 97 per cent of European farms (Davidova & Thomson, 2014; Hennessy, 2014). Enabling land to change hands but also maintaining local connections to rural areas requires a nuanced policy response. Individual member states have tried to balance these policy priorities by giving young, local farmers first refusal when land becomes available locally or by providing brokerage type services between young and retiring farmers (Ingram & Kirwan, 2011; Piet et al., 2012).

In this context, the abolition of the quota on milk production in 2015 presents an opportunity for structural change in European agriculture (Dervillé et al., 2016; Groenveld et al., 2016). The abolition of quota means that for farmers looking to increase production, land rather than quota rights will be the scarcest production factor (Boere et la., 2015). The potential for farmers to adapt to a post-quota landscape depends on many factors including demographics, socio-economic characteristics and the availability of inputs (Chevalier et al., 2012; Kempen et al., 2011). Land is an input of particular importance, especially in an Irish context. Irish dairy farming depends upon a grass-based rather than feed-based production system, meaning a sufficient supply of land is necessary to increase dairy production (Dillon et al., 2008). However, Ireland suffers from very low levels of land mobility by European standards (Ciaian et al., 2010). This means that accessing extra land for dairy farming may prove difficult. Despite efforts from policymakers to encourage long-term leasing arrangements, most rented land in Ireland is accessed through short-term, 11-month "conacre" contracts, unsuitable for the long-term infrastructural provisions that are required by dairy farmers (O'Neill & Hanrahan, 2012).

Irish land markets have traditionally been quite static, with land rarely changing hands. The dominant means of transfer of ownership is through non-market arrangements, usually inheritance, which is often attributed to the strong emotional attachment to land in Ireland (Donnellan et al., 2008). Rented land (both conacre and long-term leasing) only accounts for 18% of Utilisable Agricultural Area (UAA) in Ireland (Geoghegan & O'Donoghue, 2018). Due to the illiquid land market in Ireland, little information exists about what drives agricultural land transactions. This is especially true in relation to the supply of land. This study attempts to fill this information gap by examining the attitudes of Irish farmers to agricultural land mobility.

Given the lack of information about the characteristics of farmers who participate in land markets, an ex-ante approach is proposed to determine which types of farmers are open to land transactions. Previous research has concentrated on the use of stated intentions surveys to accomplish this task by asking what the farmer will do in the future (Breen et al., 2005; Lobley & Butler, 2010). However, given the static history of the Irish farmland market and stable policy conditions, it is not anticipated that many Irish farmers outside the dairy sector intend to change their current land allocation. Therefore, a more exploratory analysis is required to identify farmers who would be open to land market participation.

This study therefore aims to ask three main questions:

- Are farmers open to entering the land market? Generally speaking, farmers can either supply or demand land. This study will focus on farmers' openness to selling or leasing out land on the supply side and buying or leasing in land on the demand side. This contributes to the literature by quantifying land demand and supply in a context where market information is either missing or incomplete.
- What distinguishes famers who are open to entering the land market from those that are not? In addition to agronomic and socioeconomic differences, do farmers interested in land transactions approach farming from a different attitudinal standpoint than farmers uninterested in land mobility?
- Given the desire of policymakers to encourage long-term leasing amongst Irish farmers, are there differences between farmers interested in leasing and those interested in permanent transactions such as buying and selling?

This paper is structured as follows. Section 2 looks at the policy context of land mobility in greater detail, paying specific attention to the Irish situation. Section 3 deals with the methodology and data used in the study. Section 4 looks at the results of logistic regressions examining farmers' openness to entering the land market while Section 5 provides a discussion of the results and their impact on policy.

2. POLICY CONTEXT AND RELATED LITERATURE

A lack of land mobility has long been seen as an impediment to structural change in Irish agriculture (Commins, 2001; Inter-Departmental Committee on Land Structure Reform, 1978; Maguire, 1983). Currently, the issue of land mobility is of interest to policymakers in light of public policy commitments to increase the output of Irish agriculture in the coming years (DAFF, 2010; DAFM 2015). One particular commitment is to increase dairy output by 50% by the year 2020, with sectoral growth expected to continue beyond that date[1]. Achieving this target, as well as future growth, will require the acquisition of additional land by dairy farmers (Dillon et al., 2008; Geoghegan & O'Donoghue, 2018; Läpple & Hennessy, 2012).

Currently, cattle farming is the dominant form of agriculture in Ireland, accounting for 57% of land (Geoghegan & O'Donoghue, 2018). Dairy farming accounts for 14.9% of agricultural land, with sheep farming taking place on 12.3% of land. Despite making up the largest share of farmland usage in Ireland, the average cattle farm has consistently returned negative market incomes over recent years and is dependent upon subsidies for survival (Hennessy & Moran, 2016). Only dairy farming has been consistently profitable, on average, over recent years. Land rental market simulation modelling by Loughrey and Hennessy (2019) suggests that a land market based solely on farm profit maximisation would lead to significant increases in farm size concentration with dairy and tillage farms growing at the expense of cattle and tillage.

Most Irish farms are owner-occupied, with the land owner generally being the farm operator (Donnellan et al., 2008). Farm ownership generally transfers through inheritance, with a single family member usually inheriting the intact farm structure. As a result, farmland rarely comes onto the open market. Land mobility outside of intra-family transfer is dependent upon land rental and sales markets. Attempts have been made at a policy level to increase land mobility in Irish agriculture, most notably the introduction of tax exemptions to incentivise the long-term leasing of land. Traditionally, land has been rented in Ireland on a short-term, 11-month basis. To encourage longer term leasing agreements, tax incentives were first introduced in 1985. These incentives allowed income derived from the long-term leasing of land (minimum of five years) to be exempt from income tax up to specified limits. Over time, these exemption limits have increased, with higher limits being added for leases of longer periods. By 2015, up to €40,000 per year can be earned free of income tax for leases of 15 years or longer. Other policy measures to encourage land mobility have been introduced including stamp duty exemptions for young farmers acquiring land, the promotion of farm partnerships and capital gains relief to encourage land consolidation (Macra na Feirme, 2015; DAFM, 2018).

Studies concerning land mobility in Ireland have mostly focused on the succession and inheritance aspect of land transfer (Hennessy & Rehman, 2007; Kennedy, 1991). It has been found that policy instruments incentivising either the early retirement of older farmers or the installation of younger farmers on farms have had limited success in increasing the level of land mobility (Bika, 2007; Gillmor, 1999). Land mobility studies in Ireland outside succession and inheritance processes have been relatively rare. Conway (1986) studied land leasing practices in the west of Ireland and found that although potential lessees were willing the pay more for land than the prevailing rate, potential lessors were generally not interested in leasing out land as long as they were able to continue farming the land themselves. Jenkins (1997) found in a study of leasing activity in the south-east of Ireland that commercial tillage[2] and non-local[3] farmers were predominant in the rental market, with land being supplied by older farmers operating smaller farms.

Bogue (2013) found that three-quarters of farmers with no successor would consider renting out land on either a long or short-term basis when they themselves were no longer able to farm at their current level. This compared with 28% of farmers who would consider selling their land in the same situation. Banovic et al. (2015) found general support for policy measures incentivising land mobility amongst Irish farmers but also found that surveyed farmers were reluctant to take advantage of the policy measures themselves.

O'Neill and Hanrahan (2012) examined Irish farmers' land market decisions from the perspective of the decoupling of agricultural support payments from agricultural production. Following decoupling, Irish farmers are required to maintain the area of land on which they claim their single payment in a state fit for agricultural production although actual production is not required. The authors found that decoupling led to a modest reduction in net land rental on average but a lack of information on consolidation, where famers whose land rental agreements had expired could transfer payments from areas where they no longer rented to land that they still possessed, made the true impact of decoupling on land decisions difficult to assess.

Due to the low number of transactions in Irish land markets, as well as the lack of literature in the area, little information exists about the characteristics and attitudes of Irish farmers who enter the land market. Therefore, this study includes a wide range of factors which may drive willingness to enter the land market. As well as structural and socio-economic factors, farmer attitudes are considered. Farmer behaviour has been shown to be

[1] The 50% increase is compared to the output of the average of total production between 2008 and 2010. This target was achieved in 2018, two years ahead of schedule.

[2] Specialist tillage farmers for who tillage accounts for at least two-thirds of the farm's total standard gross margin.

[3] Greater than 10 kilometres away.

affected by a multiplicity of farming goals and attitudes (Willock et al., 1999a). There is a large literature on the attitudes and objectives of farmers and the impact of these on farming behaviour with farming attitudes being identified as important to risk aversion, innovation, diversification, off-farm work, environment, production, management, legislation, stress, pessimism and satisfaction toward farming (Willock, 1999b provides a review of the literature). Non-economic objectives such as farmer lifestyle have also been shown to strongly affect farmer decisions (Howley et al., 2015; Marr et al., 2019). Studies related to attitudes of farmers toward land have tended to focus on land use, especially in terms of environmental issues (Mills et al., 2013; Wilson, 1996). Given the absence of information about farmers in the Irish land market, these factors will provide a sense of what drives farmers in their consideration of land transactions.

3. CASE STUDY AND METHODOLOGY

This paper uses a nationally representative survey to examine the willingness of Irish farmers to engage in a land transaction. Given the binary nature of this proposition (the farmer either does or does not want to engage in the transaction), a logit model is utilised. Four logit models are used to examine the willingness of farmers to lease land in, lease land out, buy land and sell land. One difficulty with interpreting non-linear models such as the logit is that unlike linear models, an explanatory variable's coefficient does not equal its marginal effect. A given change in an explanatory variable x will usually have less effect when the response probability $P(y = 1|x)$ is near the extreme values of zero or one as compared with middle values. Therefore, this study uses odds ratios to interpret the marginal effects of the explanatory variables. Odds ratios in logit models can be interpreted as the effect of a one unit change in x in the predicted odds ratio with the other variables in the model held constant. The odds of $P(y = 1|x)$ increase multiplicatively by $e^{\beta}$for a one unit increase in x, holding all other variables constant.

In order to determine the attitudinal orientation associated with farmers in the sample, a set of attitudinal statements was included as part of the survey questionnaire. Principal Component Analysis (PCA) is used to identify underlying structural relationships between farmer responses to these attitudinal statements. PCA finds the linear combination that explains the maximum amount of variance among the observed variables – called the "first principal component". It also finds another, orthogonal (uncorrelated) linear combination that explains the maximum amount of remaining variance ("second principal component"), and so on until all variance is explained (Hamilton, 2013). PCA thus serves as a data reduction technique, allowing the analysis of the attitudinal statements to be simplified. Each principal component has an eigenvalue, which represents the standardised variance explained by the component. Principal components with values of less than one eigenvalue explain less than the equivalent of one variable's variance so are set aside for purpose of analysis (Abdi & Williams, 2010). Following the PCA, varimax orthogonal rotation is used to further simplify the factor structure.

4. DATA

This paper's analysis of farmer attitudes to land mobility is based on a survey of 837 Irish farmers in 2014 and 2015. The survey used random probability sampling to survey a representative number of farmers from each county in Ireland. In order to achieve a representative geographical spread, a starting point was randomly selected in each county with every third farmer being selected to participate in the study. The survey continued in each county until a quota of respondents in each county was reached. Quota sampling set demographic quotas on the sample based on known population distribution figures. The quotas used here were based on known population distribution figures in relation to specific farm systems (dairy, cattle rearing, cattle other, sheep, tillage and mixed) taken from Central Statistics Office data (CSO, 2012)

The respondents were asked questions based on three different areas: current farm characteristics; attitudes to land, farming and future plans; and knowledge about land-based policy initiatives. The survey also contained 15 attitudinal questions using a four-level Likert scale ranging from "strongly disagree" to "strongly agree". The respondents could also choose a "don't know" option. There is little consensus regarding the correct number of response options or whether an odd number of response options should be used in order to allow a neutral, midpoint response (Sturgis et al., 2014). In the context of this study, it has been found that 4-point scales (as used here) yield similar levels of reliability compared to 5-pont scales which would contain a midpoint (Alwin, 2007). Neutral, midpoint responses can also represent hidden "don't know" answers (Sturgis et al., 2014). Therefore, it was decided to use a 4-point scale with an additional "don't know" option.

Table 1. Mean scores and percentage agreement with attitudinal statements.

	Mean scores	Percentage completely agreeing
It is important not to leave farm land idle	1.50	55.4
It is important for me to pass on my land in as good a shape or better than I received it	1.46	53.4
I enjoy farming much more than I would other potential sources of employment	1.32	48.1
Farming is a more rewarding job in terms of quality of life, independence and lifestyle than it is in terms of money	1.20	44.6
It is important not to be afraid of adopting new farming practices	1.15	32.4
I have to keep my farm running to ensure I have something to pass on to my children/next generation	1.13	42.1
To be successful in farming it is important for me to adapt and use new technologies (whether agri or non-agri technologies)	1.10	33.5
It is important to visit other farms to look at their methods	1.03	36.2
I don't think it is a good idea to take too many risks when it comes to farming	1.00	30.5
It is important for me to be respected by other farmers	1.00	30.6
I am good at finding different types of information to help me run my business	0.97	28.5
Agricultural land in Ireland is under-utilised	0.48	20.2
I am cautious about adopting new ideas and farm practices	0.37	16.6
My economic future on this present farm is bright	0.36	16.9
It makes more sense for me to join an agricultural scheme if my neighbours are also joining	0.13	17.4

The statements drew on previous work examining Irish farmers' attitudes toward farming decisions (Howley & Dillon, 2012; Howley et al., 2015), as well as input from experts. The attitudinal statements are listed in Table 1, as well as the mean scores and percentage of respondents completely agreeing with of each statement. Mean scores were computed by assigning a score to each level of agreement (2 for "strongly agree", 1 for "agree", -1 for "disagree" and -2 for "strongly disagree") and averaging the scores of the participants for each statement.

Four principal components with eigenvalues above one were generated by the PCA and rotation process, representing different attitudes toward farming among the respondents. These attitudes are related to the importance of innovation in farming, optimism about the future of agriculture, the non-economic benefits of farm work and conservatism regarding the farm business. A description of the attitudinal variables is available in Table 2. The factor loadings for each attitudinal statement onto the four principal components can be found in Table 3.

Respondents were asked about their openness to four forms of land transaction:

i. Land purchase;
ii. Land sale;
iii. Land lease in;
iv. Land lease out.

Respondents replied either "Yes" or "No" in terms of whether they were ever willing to engage in each form of transaction. Of the 837 farmers surveyed, 47% were willing to buy land, while 26% were willing to sell. In terms of leasing, 51% were willing to lease in land, while 29% were willing to lease out land. A logistic regression model is used to examine the probability of a farmer being open to each land transaction. The dependent variable is the willingness to engage in the land transaction (purchase land, sell land, lease land in, lease land out).

Besides the attitudinal variables described previously, explanatory variables utilised in the model include variables representing the farmer's age, plans for future farm production, whether the farmer has children or not, the presence/absence of a successor to take over the farm business, whether the farmer has an off-farm job or not, market farm income, value of entitlements, land prices, the percentage of household income derived from the farm business. Farm structure and agronomic variables such as farm size, farm system, soil type and stocking rate are also included (see Table 4). The final specifications of the regression models are shown in Tables 5 and 6. In most cases, respondents chose from a range of values rather than state exact values, so variables based on instances where respondents chose from a range of variables are treated as categorical variables. For categorical variables such as age and farm size, the reference categories are the categories most frequently chosen by respondents. For age, this is the 51-64 years category and for farm size, the 20-49 ha category.

Table 2. Description of attitudinal variables.

Attitudinal variable	Description
Innovative orientation	Farmers with a high ranking in this variable acknowledge the importance of technology and new ideas with regard to farming. They agree strongly with statements such as "It is important not to be afraid of adopting new farming practices" and "I am good at finding different types of information to help me run my business".
Pleasure of farming orientation	Farmers with a high ranking in this variable emphasise the non-economic benefits of farming, especially compared to non-farming employment. They are also concerned with their farming legacy. They agree strongly with statements such as "Farming is a more rewarding job in terms of quality of life, independence and lifestyle than it is in terms of money" and "It is important for me to pass on my land in as good a shape or better than I received it".
Conservative orientation	Farmers with a high ranking in this variable prefer to rely on traditional farming practices and dislike change. They agree strongly with statements such as "I don't think it is a good idea to take too many risks when it comes to farming" and "I am cautious about adopting new ideas and farming practices".
Agri-optimistic orientation	Farmers with a high ranking in this variable are optimistic about the future of agriculture and enjoy being farmers. They agree strongly with statements such as "My economic future on this present farm is bright" and "I enjoy farming much more than other potential sources of employment".

Table 3. Factor loadings of attitudinal statements.

Statement	Pleasure of farming	Innovative	Agri-optimistic	Conservative
Agricultural land in Ireland is under-utilised	0.1666	0.3447	0.2091	0.0107
I enjoy farming much more than I would other potential sources of employment	0.4027	0.0196	0.5615	0.0332
I am good at finding different types of information to help me run my business	0.1075	0.4731	0.5335	0.0634
My economic future on this present farm is bright	0.0619	0.285	0.662	0.0321
To be successful in farming it is important for me to adapt and use new technologies (whether agri or non-agri technologies)	0.1398	0.5872	0.2708	0.036
I have to keep my farm running to ensure I have something to pass on to my children/ next generation	0.5969	0.2275	0.2029	0.0479
I am cautious about adopting new ideas and farm practices	0.0407	0.0712	0.1231	0.7262
It is important for me to be respected by other farmers	0.0744	0.2416	0.3484	0.5341
It makes more sense for me to join an agricultural scheme if my neighbours are also joining	0.0508	0.2087	0.4206	0.4901
Farming is a more rewarding job in terms of quality of life, independence and lifestyle than it is in terms of money	0.5927	-0.119	0.3865	0.0128
It is important for me to pass on my land in as good a shape or better than I received it	0.6827	0.2444	0.1274	0.0055
It is important to visit other farms to look at their methods	0.1252	0.7124	0.1445	0.1457
It is important not to be afraid of adopting new farming practices	0.1569	0.7693	0.0685	0.0285
It is important not to leave farm land idle	0.6557	0.3514	0.0997	0.0135
I don't think it is a good idea to take too many risks when it comes to farming	0.2029	0.0144	0.1156	0.6099
Initial eigenvalues	2.29	2.23	1.73	1.55

Farm income and CAP entitlements payment data was collected as part of the survey but about 30% of the sample decided not to answer. In order to include farm income data, the missing information was replaced using farm income information from the 2014 Teagasc National Farm Survey (Hennessy & Moran, 2014), a yearly, nationally representative survey of Irish farmers which is Ireland's contribution to the Farm Accountancy Data Network (FADN). For CAP payments data, the missing data was replaced by assigning average per hectare CAP payments by farm system from the 2014 NFS in place of the missing values. Since per hectare CAP payments are closely related to farm system in Ireland, this seemed the most appropriate solution. Average land value and rental prices were sourced for the time period from the Irish Central Statistics Office (CSO) for land prices and Eurostat for land rental values, which are based on data from FADN. The data was available at the NUTS3 regional level (8 regions in Ireland) for land values and NUTS2 level (3 regions) for rental prices.

Table 4. Independent variables of land mobility model.

Variable	Description	Mean/ Mode[1]	Standard Deviation
Innovative orientation (Innovative)[2]	Factor variable measuring degree to which farmer feels technology and new ideas are important.	0	1
Pleasure of farming orientation (Pleasure of Farming)[2]	Factor variable measuring degree to which farmer enjoys farming as opposed to other occupations.	0	1
Agri-optimistic orientation (Agri Optimistic)[2]	Factor variable measuring degree to which farmer feels optimistic about the future of their farm.	0	1
Conservative orientation (Conservative)[2]	Factor variable measuring degree to which farmer is cautious about risk-taking and new ideas.	0	1
Farm Size[3]	Number of hectares farmed in 2014 (<10 ha, 10-19 ha, 20-49 ha, 50-74 ha, 75–99 ha, 100-149 ha, 150+ ha)	20-50ha[1]	N/A
Soil Quality[4]	Description of soil type on land (good soil, medium soil, poor soil)	Good[1]	N/A
Increase Future Production	Plans for farming over the next five years (aim to increase production, maintain current levels of production)	0.17	0.38
Decrease Future Production	Plans for farming over the next five years (aim to decrease production, maintain current levels of production)	0.09	0.28
Diversify Future Production	Plans for farming over the next five years (aim to increase diversification, maintain current levels of production)	0.09	0.28
Stocking Rate	Number of livestock units (LUs) per hectare	1.5	1.76
Farm System[5]	Main farm activity (dairy, cattle rearing, cattle other[6], tillage, sheep, mixed[7], other)	Cattle other[1]	N/A
Age	Age in years (<35 years, 35-44 years, 45-50 years, 51-64 years, 65+ years)	51-64[*]	N/A
Children	Does the farmer have any children (Yes, No)	0.71	0.45
Successor	Has the farmer identified a successor (Yes, No)	0.43	0.50
Household Income from Farming	Percentage of overall yearly household income derived from farming (0-25%, 26-50%, 51-75%, 76-100%)	76-100%[1]	N/A
Market Farm Income	Farm income after costs minus subsidies	2,996	10.680
Off-farm Job	Does the farmer have an off-farm job (Yes, No)	0.33	0.47
Entitlements Value	Value of farm CAP entitlement payments	10,282	14,212
Rent Price	Average regional per hectare farmland rental price	252	35
Land Price	Average regional per hectare farmland price	16099	4221

[1] Mode.
[2] Attitudinal variables have mean zero as each variable is standardised to mean zero as part of the PCA process.
[3] Farm size share by percentage: <10ha – 6%, 10-19ha – 20%, 20-49ha – 44%, 50-74ha – 15%, 75-99ha – 9%, 100-149ha – 4%, 150+ha – 2%.
[4] Soil quality is self-reported but definitions of each soil type were provided to aid respondents.
[5] Farm system share by percentage: dairy – 22%, cattle rearing – 14%, cattle other – 29%, tillage – 11%, sheep – 15%, mixed – 5%, other – 3%.
[6] Cattle other refers to cattle finishing farms where cattle are fattened up in preparation for slaughter.
[7] Mixed refers to farms that combine grazing livestock and field crops.

5. RESULTS

Four logistic regression models were created using the available data. The dependent variable in each case was willingness to engage in the stated land transaction. Two models analysed farmers' attitudes to the leasing of land. 417 farmers were open to leasing in land while 245 farmers were willing to lease out land. The results from these two models are presented in Table 5. Two models analysed farmers' attitude to permanent land transactions. 447 farmers were open to buying land while 218 farmers were willing to sell land. The results from these two models are presented in Table 6.

Attitudinal variables

The attitudinal variables derived from the PCA analysis were found to have a statistically significant impact on a farmer's willingness to enter the land market. The attitudinal orientation "Innovative" has a positive impact on a farmer's willingness to lease land. For every one unit increase in the orientation, the probability of leasing out land increases by a factor of 1.29 and of leasing in land by a factor of 1.21. The "Pleasure of Farming" variable has a negative impact on willingness to sell land. Additionally, it is positively correlated with a willingness to buy and lease in land.

Table 5. Factors related to the probability farmers are open to leasing land.

Lease Out	Coef.	Std. Err.	Odds Ratio	Lease In	Coef.	Std. Err.	Odds Ratio
Innovative	0.25***	0.09	1.29		0.19**	0.09	1.21
Pleasure of Farming	-0.13	0.08	0.88		0.18**	0.08	1.20
Conservative	-0.03	0.09	0.97		-0.21**	0.08	0.81
Agri-Optimistic	-0.13	0.09	0.88		0.21**	0.09	1.24
Good Soil	0.43	0.35	1.53		-0.45	0.32	0.64
Medium Soil	0.65*	0.35	1.92		-0.35	0.32	0.70
Cattle Rearing	0.18	0.25	1.20		0.25	0.26	1.28
Dairy	-0.79**	0.33	0.45		0.39	0.32	1.47
Tillage	-0.63**	0.30	0.53		0.29	0.29	1.34
Sheep	-0.70***	0.27	0.49		0.02	0.26	1.02
Mixed	-0.96**	0.44	0.38		-0.91**	0.41	0.40
Farm Size <10ha	0.08	0.40	1.08		-0.69	0.44	0.50
Farm Size 10-19ha	0.42*	0.23	1.52		-0.20	0.24	0.82
Farm Size 50-74ha	0.37	0.27	1.44		0.27	0.27	1.31
Farm Size 75-99ha	-0.11	0.41	0.89		0.31	0.40	1.36
Farm Size 100-149ha	0.59	0.54	1.80		-0.17	0.55	0.85
Farm Size >150ha	-0.23	0.96	0.79		0.22	0.98	1.24
Stocking Rate	-0.02	0.05	0.98		0.38***	0.09	1.46
Age <35	-1.11**	0.46	0.33		0.93**	0.40	2.52
Age 35-44	-0.03	0.25	0.97		0.01	0.25	1.01
Age 45-50	-0.28	0.27	0.75		-0.27	0.25	0.76
Age >65	0.21	0.21	1.23		-0.64***	0.21	0.53
Children	0.14	0.20	1.15		0.40**	0.20	1.49
Successor	-0.40**	0.18	0.67		-0.44**	0.18	0.64
Increase Future Production	-0.18	0.24	0.84		0.77***	0.24	2.16
Decrease Future Production	0.81***	0.28	2.26		-0.54*	0.33	0.58
Off-Farm Job	-0.11	0.21	0.89		0.53**	0.22	1.70
Household Income from Farming ≤ 25%	0.31	0.29	1.36		0.16	0.30	1.17
Household Income from Farming 26-50%	-0.04	0.25	0.96		-0.35	0.25	0.70
Household Income from Farming 51-75%	0.36	0.28	1.43		-0.52*	0.29	0.59
Farm Income	0.02*	0.01	1.02		0.02	0.01	1.02
Entitlements Value	0.01	0.02	1.01		0.02	0.02	1.02
Rent Price	0.00	0.00	1.00		-0.01***	0.00	0.99
Constant	-1.86**	0.78	0.16		2.83***	0.76	16.94
Pseudo R2	0.08***				0.19***		
AIC	999.13				1007.94		
BIC	1159.95				1168.75		
Observations	837				837		

Note: *** p<0.01, ** p<0.05, * p<0.1.

The "Conservative" variable is negatively related to the willingness to buy and lease in land while the "Agri-Optimistic" orientation is positively related to leasing in and buying land while negatively related to selling land.

Farm structure and agronomic variables

Of the farm system variables employed in the analysis, cattle rearing, cattle other, and mixed and dairy enterprises proved to be significantly related to willingness to enter the land market. In the "Lease Out" regression, dairy, tillage, sheep and mixed enterprise farmers were significantly less likely to be willing to lease out

Table 6. Factors related to the probability farmers are open to selling/buying land.

	Sell Land			Buy Land		
	Coef.	Std. Err.	Odds Ratio	Coef.	Std. Err.	Odds Ratio
Innovative	0.12	0.09	1.12	0.01	0.09	1.01
Pleasure of Farming	-0.25***	0.08	0.78	0.24***	0.08	1.27
Conservative	0.00	0.09	1.00	-0.23***	0.08	0.80
Agri-Optimistic	-0.19**	0.09	0.83	0.16*	0.09	1.17
Good Soil	-0.05	0.33	0.95	-0.05	0.32	0.95
Medium Soil	0.28	0.33	1.32	0.01	0.32	1.01
Cattle Rearing	-0.01	0.27	0.99	0.44*	0.26	1.55
Dairy	0.10	0.33	1.10	0.53*	0.31	1.70
Tillage	-0.14	0.32	0.87	0.33	0.30	1.39
Sheep	-0.18	0.27	0.83	-0.10	0.25	0.90
Mixed	-1.67***	0.59	0.19	-0.08	0.38	0.92
Farm Size <10ha	-0.04	0.41	0.96	-1.36***	0.47	0.26
Farm Size 10-19ha	0.03	0.25	1.03	-0.50**	0.24	0.60
Farm Size 50-74ha	0.04	0.28	1.04	-0.04	0.27	0.96
Farm Size 75-99ha	-0.04	0.41	0.96	0.23	0.40	1.25
Farm Size 100-149ha	0.04	0.54	1.04	-0.40	0.56	0.67
Farm Size >150ha	-2.04*	1.22	0.13	0.07	1.00	1.07
Stocking Rate	0.05	0.05	1.05	0.18***	0.07	1.20
Age <35	-0.28	0.41	0.75	1.37***	0.41	3.94
Age 35-44	0.32	0.25	1.38	0.56**	0.25	1.75
Age 45-50	0.56**	0.26	1.75	0.25	0.25	1.29
Age >65	-0.15	0.23	0.86	-0.50**	0.21	0.61
Children	0.14	0.21	1.15	0.63***	0.20	1.88
Successor	-0.50***	0.19	0.61	0.32*	0.17	1.37
Increase Future Production	-0.04	0.24	0.96	0.68***	0.25	1.98
Decrease Future Production	0.62**	0.30	1.86	-0.49	0.32	0.61
Off-Farm Job	-0.15	0.22	0.86	0.52**	0.22	1.69
Household Income from Farming ≤ 25%	0.22	0.30	1.25	0.17	0.29	1.19
Household Income from Farming 26-50%	0.43*	0.26	1.53	-0.08	0.25	0.92
Household Income from Farming 51-75%	0.41	0.30	1.51	-0.01	0.28	0.99
Farm Income	0.00	0.01	1.00	0.00	0.01	1.00
Entitlements Value	0.03*	0.02	1.03	0.03	0.02	1.03
Land Price	-0.00***	0.00	1.00	0.00	0.00	1.00
Constant	-0.72	0.54	0.49	-1.24**	0.51	0.29
Pseudo R2	0.08***			0.18***		
AIC	950.86			1018.68		
BIC	1111.68			1179.49		
Observations	837			837		

Note: *** p<0.01, ** p<0.05, * p<0.1.

land than the reference category of cattle other farmers. Stated differently, cattle rearing and cattle other farmers were significantly more willing to lease out land compared to all other farm systems. However, farm system was not significantly related to willingness to lease in land. Mixed farmers were significantly less willing to sell land than other farmers while dairy and tillage farmers were significantly more willing to buy land, albeit at the 10% significance level.

In general, significant effects for farm size were limited to either very small or very large farms. Farms under 20 hectares were the least likely to be willing to buy land compared with the most common farm size category. Farms of over 150 hectares were less willing to sell land than the most common farm size category. Stocking rate was a significantly related to land demand. In terms of leasing in land, an increase of one LU/ha increased the probability of being willing to lease in land by a factor 1.46. An increase of one LU/ha increased the probability of the farmer being open to buying land by a factor of 1.20.

Soil quality was also included as an explanatory variable in each regression model. Three soil categories were used: good, medium and poor. The good and medium categories were included as dummy variables, with poor quality soil acting as the reference category. Soil quality was a significant explainer of willingness to enter the land market in the "Lease Out" model, with farmers on medium quality soil being significantly more open to leasing out land than those in the reference category.

Demographic variables

Age effects relating to willingness to enter the land market can be seen amongst the youngest and oldest categories of farmers. The youngest category of farmers (those under the age of 35) was significantly more willing to lease in and buy land compared to older farmers. Additionally, the youngest farmers were significantly less willing to lease out land. Farmers in the oldest age category (65 years and older) were significantly less likely to demand land either through leasing or purchase. Farmers in the 45-50 years were more likely to be willing to sell land than any other age category.

The presence of a farm successor was a significant explanatory variable in all four models. Having a successor was associated with farmers being significantly less likely to be willing to lease out or sell land, compared with farmers without a successor. Having a successor decreased the likelihood of being willing to lease out land by a factor of 0.67 and sell land by a factor of 0.61, compared to farmers without a successor. Interestingly, farmers with a successor were more likely to be willing to buy land but significantly less likely to be willing to lease in land than those without a successor.

Farmers with children were significantly more willing to demand land than farmers without children. Farmers with children were more likely to be willing to lease in land by a factor 1.49 and more likely to be willing to buy land by a factor of 1.88, compared with farmers without children.

Financial variables

Farmers were asked what percentage of household income is made up of farm income. Responses were divided into four categories: 0-25%, 26-50%, 51-75% and 76-100% of household income coming from farm income. The reference category was farmers for whom 76-100% of household income came from their farm (the most common response). Farmers in the 51-75% farm income category were less likely to be open to leasing in land than those who rely on farm revenues for over 75% of household income, while those in the 26-50% farm income category were more open to selling land.

Farmers with an off-farm job were significantly more likely to be open to leasing in and buying land than farmers without off-farm employment. Farmers with off-farm jobs were more likely by a factor of 1.70 to be open to leasing in land and by a factor of 1.69 to buying land than those without off-farm jobs. Market farm income is positively associated with willingness to rent out land while subsidy income from entitlements was positively correlated with selling land at the 10% significance level. Agricultural land prices and land rents at the regional level are also modelled. Regional farmland prices are significantly negatively correlated with a willingness to sell land while regional land rent prices have a negative relationship to willingness to rent land in.

6. DISCUSSION

This study examined the extent to which Irish farmers would be willing to enter the agricultural land market. The results show that about half of farmers in the sample are open to buying or leasing in land while about a quarter of farmers sampled are open to selling or leasing out land. The results also show distinct profiles emerging for farmers demanding land, through either leasing in or purchase and farmers open to supplying land, whether through leasing out or sale.

Farmers demanding land are more likely to have a high ranking on the "Pleasure of Farming" and "Agri-Optimistic" attitudinal orientations and a low ranking on the "Conservative" orientation. They are also more likely to have children, be planning to increase farming activity in the next five years and have an off-farm job. They are more likely to be under 35 years of age and a have a high stocking rate. They are less likely to have farms of less than 10 hectares and be over 65 years of age.

The issue of agricultural land demand, especially in how it relates to young farmers, has arisen in recent years in the context of increasing farmland concentration in Europe (Conway et al., 2020; van der Ploeg, 2015). A reduction in farm numbers by approximately 3.8 million and an increase in farm size by about 36% was seen in the EU between 2005 and 2015 (Eurostat, 2017). These results confirm the desire of young, optimistic farmers to access land but whose ability to do so may be hampered in a competitive land market (Zagata et al, 2017).

Farmers open to supplying land are more likely to rank high on the "Innovative" orientation for leasing out and rank low on the "Pleasure of Farming" orientation for selling. They are more likely to be intent on decreasing farming in the next five years and are less likely to have a successor. They are also more likely to be only somewhat dependant on farm income, receiving greater than 25% but less than 50% of total household income from farming.

Farmers ranking high in the "Pleasure of Farming" orientation value the lifestyle benefits of farming over any pecuniary benefits associated with the profession. Farmers have been found to have a multiplicity of motivations for why they farm, many of which are non-economic in nature (Howley et al., 2015; Key & Roberts, 2009). For these farmers, land may not be seen as an economic resource but as a source of utility in and of itself. Therefore, it is not surprising that farmers with a high ranking in this orientation are opposed to releasing land and are open to increasing their land stock.

The finding that farmers with a high ranking in the "Innovative" orientation are more open to supplying land, both through leasing and sale, suggests that these farmers are less constrained by traditions of keeping land "in the family name". They may see land as just another input in the agricultural production process. Innovative farmers in the Irish context may be thought about as generating new combinations of existing resources (Bender & Laestadius, 2005).

The positive effect of having children and having a designated successor on willingness to buy land (and lease in land for the "Children" variable) fits in with the farm life cycle concept (Calus et al., 2008; Potter & Lobley, 1992). This farm life cycle concept suggests that a farm can be in one of three stages: growth, maturity or decline. Younger farmers are expected to grow, while older farmers are expected to be in the maturity or decline stages. However, farmers with a successor do not enter the decline stage but rather are more likely to want to grow the farm in order to leave a legacy for their successor (Calus et al., 2008; Inwood & Sharp, 2012). The finding that farmers with successors are more willing to buy land but are significantly less likely than farmers without successors to want to lease in land may be related to the lack of trust amongst Irish farmers in the leasing system (Banovic et al., 2015; Bogue, 2013).

Farmer age effects align with previous studies, with younger farmers most likely to want to add land, while farmers who are older are significantly less likely to want to increase their farm size (Gale, 1994; Lobley & Butler, 2010; Katchova & Ahearn, 2015; Weiss, 1999). Older farmers were not significantly more likely to want to lease out or sell land than average aged farmers, supporting the theory that older Irish farmers want to maintain land within the family unit rather than sell or lease it out to others (Banovic et al., 2015).

Farmers with off-farm jobs are more likely to want to add land through lease or purchase than full-time farmers. There is evidence in the literature that off-farm income may help to prevent farm exit by stabilising income (Breustedt & Glauben, 2007; Kimhi, 2000). Farmers in the study with off-farm employment are younger than full-time farmers (45% aged 50 and younger vs. 31% for full-time farmers) and may have difficulty accessing land in a manner similar to other young farmers across the EU (Zondag et al., 2015). Therefore, they may be aiming to increase land holdings going forward. Also, there may be a wealth effect for farmers with off-farm jobs with farmers using their off-farm income in order to acquire more land through increased credit capacity or ability to pay higher rents.

Regional farmland prices were negatively related to willingness to sell, a finding contrary to standard economic theory. It must be stated that Irish farmland markets are extremely local so prevailing regional prices would not be as significant to farmers' decision-making regarding land as the local market. Farmers may also be anticipating increasing land prices in the future. Irish farmland prices are heavily influenced by non-agricultural factors (Geoghegan & O'Donoghue, 2018), so increasing property prices in Ireland following the 2008 economic crash may be influencing farmers not to sell land until prices peak.

The openness of cattle farmers to leasing out land may be related to the difficult financial conditions facing cattle farmers in Ireland. Widespread protests amongst cattle farmers over low beef prices broke out during the collection of the survey which may have led to cattle farmers being particularly pessimistic when surveyed.[4] As a result, cattle farmers may have felt more open to leasing out land at this time.

The factors that significantly influence farmers' openness to temporary land transactions such as leasing also seem to significantly influence permanent transactions such as buying and selling. However, there are some notable exceptions to this finding. Cattle farmers are open to leasing out land but not selling land while dairy farmers are open to buying land but not leasing

[4] 496 of the study's participants were surveyed in winter 2014, of which 196 were cattle farmers.

in land. Cattle farmers' openness to leasing out may, as previously stated, have reflected particularly poor economic conditions at the time the survey was conducted. Their willingness to lease out rather than sell land may reflect a desire to reclaim the land for their own farming purposes once economic conditions for cattle farming improved.

7. CONCLUSIONS AND POLICY RECOMMENDATIONS

The aim of the study was to explore Irish farmers' attitudes towards land mobility and to build a profile of farmers who would be open to partaking in land transactions. Despite previous evidence that Irish farmers are reluctant to enter the land market (especially to supply land), this study shows that a considerable number of farmers are open to the possibility. It is important to understand what motivates farmers who are open to trading land. This is especially true in the absence of market data, as is the case in Ireland. This paper suggests that farmer attitudes are an important motivating force behind farmers' willingness to enter land markets. Farmers are not motivated solely by profit maximisation, as evidenced by the significance of the "Pleasure of Farming" and "Conservative" variables. Additionally, there appear to be a group of farmers amongst whom the traditional attachment to land is not as prevalent, as evidenced by the willingness of "Innovative" farmers to supply land through leasing. Therefore, policymakers must take account of these attitudes when designing policies to enable a more dynamic land market. Such policies should not just focus on economic incentives to encourage land mobility but also on encouraging discussion between farmers, successors, potential farmers, policymakers and agricultural professionals (farm advisors, solicitors, accountants etc.) so as to take less tangible factors such as attitudes and motivation into account.

Together with the economic and socio-demographic information presented here, a picture emerges of the types of farmer policymakers can target with land mobility policies. Young, optimistic farmers with higher than average stocking rates and plans for increasing production in the near future appear to be most likely to demand land. Innovative cattle farmers who are somewhat but not totally dependent on farm income and are planning to decrease farm activity in the near future are most likely to supply land. Policies that can both identify and mediate between these groups should be considered by policymakers. This can be done by policymakers engaging with farming organisations, through the organisation of information events and by aiding organisations such as the Land Mobility Service that facilitate land mobility (Macra na Feirme, 2019). Additionally, the promotion of joint farm ventures (JFVs) such as cooperatives, farm partnerships, share farming and contract rearing must be maintained (Cush & Macken-Walsh, 2016).

There is a similar level of openness amongst farmers to both permanent and temporary land transfer options. This is contrary to conventional thinking that Irish farmers are reluctant to take part in temporary land transactions such as land leasing. This shows that there may be greater demand amongst farmers for land leasing arrangements than is currently thought by policymakers. As a result, policies that can promote and facilitate such leasing arrangements should be encouraged. Since financial incentives in the form of tax breaks already exist, institutional solutions such as the establishment of intermediary entities to connect potential lessors and lessees or informational campaigns advertising the benefits of leasing may be appropriate.

Although numerous farm and farmer characteristics are examined in relation to openness to land transactions in this study, factors related to the socio-economic environment around the farm are considered outside of the scope of this paper. Such factors include social and identity pressures (Ní Laoire, 2005), local labour market conditions (Cavicchioli et al., 2019) and gender (Balaine, 2019). Further research examining the intersection between farm characteristics, farmer attributes and socio-economic conditions is required.

It should be noted that being open to land transactions does not necessarily mean that farmers will partake in a transaction in the future. This study does not examine the prices farmers are willing to pay and willing to accept for land. Although farmers may be willing to engage in land transactions, a mismatch between the prices farmers are willing to pay and willing to accept for land will prevent transactions from taking place. Therefore, further research is required to examine the extent of price mismatches and how they affect land markets in Ireland.

REFERENCES

Abdi, H., & Williams, L. J. (2010). Principal component analysis. *Wiley Interdisciplinary Reviews: Computational Statistics, 2,* 433–459. DOI: 10.1002/wics.101

Alwin, D.F. (2007). *Margins of error: A study of reliability in survey measurement.* Hoboken, NJ: Wiley

Balaine, L. (2019). Gender and the preservation of family farming in Ireland. *EuroChoices*, 18(3), 33-37. DOI: 10.1111/1746-692X.12242

Banovic, M., Duesberg, S., Renwick, A., Keane, M. T., & Bogue, P. (2014, April). The field: Land mobility measures as seen through the eyes of Irish farmers. In *The Agricultural Economics Society's 89th Annual Conference, University of Warwick, United Kingdom, 13-15 April 2014*. Retrieved from: http://hdl.handle.net/10197/6730

Bender, G., & Laestadius, S. (2005). Non-science based innovativeness. On capabilities relevant to generate profitable novelty. *Journal of Mental Changes, 11*(1-2), 123-170. Retrieved from: http://cat.inist.fr/?aModele=afficheN&cpsidt=17868457

Bika, Z. (2007). The territorial impact of the farmers' early retirement scheme. *Sociologia Ruralis*, *47*(3), 246-272. DOI: 10.1111/j.1467-9523.2007.00436.x

Boere, E., Peerlings, J., Reinhard, S., & Heijman, W. (2015). The dynamics of dairy land use change with respect to the milk quota regime. *European Review of Agricultural Economics*, *42*(4), 651-674. DOI: 10.1093/erae/jbv002

Bogue, P. (2013). *Land mobility and succession in Ireland*. Dublin: Macra na Feirme.

Breen, J. P., Hennessy, T. C., & Thorne, F. S. (2005). The effect of decoupling on the decision to produce: An Irish case study. *Food Policy, 30*(2), 129-144. DOI: 10.1016/j.foodpol.2005.03.001

Breustedt, G., & Glauben, T. (2007). Driving forces behind exiting from farming in Western Europe. *Journal of Agricultural Economics, 58*(1), 115-127. DOI: 10.1111/j.1477-9552.2007.00082.x

Calus, M., Van Huylenbroeck, G., & Van Lierde, D. (2008). The relationship between farm succession and farm assets on Belgian farms. *Sociologia Ruralis, 48*(1), 38-56. DOI: 10.1111/j.1467-9523.2008.00448.x

Cavicchioli, D., Bertoni, D., Frisio, D. G., & Pretolani, R. (2019). Does the future of a farm depend on its neighbourhood? Evidence on intra-family succession among fruit and vegetable farms in Italy. *Agricultural and Food Economics*, *7*(1), 1-17. DOI: 10.1186/s40100-019-0129-5

Central Statistics Office (2012). *Census of agriculture 2010*. Dublin: CSO. Retrieved from: https://www.cso.ie/en/media/csoie/releasespublications/documents/agriculture/2010/full2010.pdf

Chevalier, F., Veyssiere, L., Buccellato, T., Jicquello, J., & de Oteyza, C. (2012). *Analysis on future developments in the milk sector*. Prepared for the European Commission-DG Agriculture and Rural Development. Retrieved from: https://ec.europa.eu/agriculture/sites/agriculture/files/events/2013/milk- conference/ernst-and-young-report_en.pdf

Ciaian, P., Kancs, d'A., & Swinnen, J. (2010). *EU land markets and the common agricultural policy*. Brussels: Centre for European Policy Studies. Retrieved from: http://aei.pitt.edu/32642/1/65._EU_Land_Markets_and_the_CAP.pdf

Ciaian, P., Kancs, d'A., Swinnen, J., Van Herck, K, & Vranken, L. (2012). Institutional factors affecting agricultural land markets (Factor Markets Working Paper 16). Brussels: Centre for European Policy Studies. Retrieved from: http://ageconsearch.umn.edu/record/120251/files/FM_WP16%20CEPS%20on%20Institutional%20Factors%20Affecting%20Ag%20Land%20Markets_D15.3_final.pdf

Commins, P. (2001). *Future perspectives on rural areas.* Athenry: Rural Economy Research Centre.

Conway, A.G. (1986). Land leasing – findings of a study in the west region of the Republic of Ireland. *Irish Journal of Agricultural Economics and Rural Sociology, 11*, 1-18. Retrieved from: http://www.jstor.org/stable/25556545

Conway, S.F., Farrell, M., McDonagh, J., & Kinsella, A. (2020). Mobilising land mobility in the European Union: An under-researched phenomenon. *International Journal of Agricultural Management, 9,* 7-11. DOI: 10.5836/ijam/2020-09-7

Cush, P., & Macken-Walsh, Á. (2016). The potential for joint farming ventures in Irish agriculture: A sociological review. *European Countryside*, *8*(1), 33-48. DOI: 10.1515/euco-2016-0003

Davidova, S., & Thomson, K. (2014). *Family farming in Europe: challenges and prospects* (Directorate General for Internal Policies, Policy Department B: Structural and Cohesion Policies). Brussels: European Parliament. Retrieved from: http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529047/IPOL-AGRI_NT(2014)529047_EN.pdf

Davis, J., Caskie, P., & Wallace, M. (2009). Economics of farmer early retirement policy. *Applied Economics, 41*(1), 35-43. DOI: 10.1080/00036840600994211

Department of Agriculture, Fisheries & Food (2010). *Food Harvest 2020: A vision for Irish agri-food and fisheries.* Dublin: DAFF.

Department of Agriculture, Fisheries & the Marine (2015). *Food Wise 2025.* Dublin: DAFM.

Department of Agriculture, Fisheries & the Marine (2018). *Farm restructuring guidelines*. Dublin: DAFM. Retrieved from: https://web.archive.org/web/20190219233855/https://www.agriculture.gov.ie/media/migration/foodindustrydevelopmenttrademarkets/agri-foodandtheeconomy/CapitalGainsTaxStampDutyReliefGuidelines270718.pdf

Dervillé, M., Allaire, G., Maigné, É., & Cahuzac, É. (2017). Internal and contextual drivers of dairy restructuring: evidence from French mountainous areas and post-quota prospects. *Agricultural Economics*, *48*(1), 91-103. DOI: 10.1111/agec.12297

Dillon, P. A. T., Hennessy, T., Shalloo, L., Thorne, F., & Horan, B. (2008). Future outlook for the Irish dairy industry: A study of international competitiveness, influence of international trade reform and requirement for change. *International Journal of Dairy Technology, 61*(1), 16-29. DOI: 10.1111/j.1471-0307.2008.00374.x

Donnellan, T., Hanrahan, K., & Hennessy, T. (2008). *Study on the functioning of land markets in the EU member states under the influence of measures applied under the Common Agricultural Policy* (End of Project Report RMIS 5881). Athenry: Galway. Retrieved from: http://hdl.handle.net/11019/868

Eurostat (2017). *Farm indicators by agricultural area, type of farm, standard output, sex and age of the manager and NUTS 2 regions* [Data set]. Eurostat. Retrieved from: https://data.europa.eu/euodp/en/data/dataset/liNJaTm9RYIzdRdCJKuU2w

Gale Jr., H. F. (1994). Longitudinal analysis of farm size over the farmer's life cycle. *Review of Agricultural Economics*, *16*(1), 113-123. Retrieved from: http://www.jstor.org/stable/1349526

Geoghegan, C., & O'Donoghue, C. (2018). Socioeconomic drivers of land mobility in Irish agriculture. *International Journal of Agricultural Management*, *7*(2), 26-34.

Gillmor, D. A. (1999). The scheme of early retirement from farming in the Republic of Ireland. *Irish Geography*, *32*(2), 78-86. DOI: 10.1080/00750779909478602

Groeneveld, A., Peerlings, J., Bakker, M., & Heijman, W. (2016). The effect of milk quota abolishment on farm intensity: shifts and stability. *NJAS-Wageningen Journal of Life Sciences*, *77*, 25-37. DOI: 10.1016/j.njas.2016.03.003

Hamilton, L. C. (2012). *Statistics with Stata: Version 12*. Cengage Learning.

Hennessy, T. (2014). *CAP 2014–2020 Tools to enhance family farming: opportunities and limits.* (Directorate-General for Internal Policies. Policy Department B: Structural and Cohesion Policies). Brussels: European Parliament. Retrieved from: http://www.europarl.europa.eu/RegData/etudes/note/join/2014/529051/IPOL-AGRI_NT(2014)529051_EN.pdf

Hennessy, T., & Moran, B. (2015), *Teagasc national farm survey results 2014*. Teagasc: Athenry.

Hennessy, T., & Moran, B. (2016), *Teagasc national farm survey results 2015*. Teagasc: Athenry.

Hennessy, T. C., & Rehman, T. (2007). An investigation into factors affecting the occupational choices of nominated farm heirs in Ireland. *Journal of Agricultural Economics, 58*(1), 61-75. DOI: 10.1111/j.1477-9552.2007.00078.x

Howley, P., Buckley, C., Donoghue, C. O., & Ryan, M. (2015). Explaining the economic 'irrationality'of farmers' land use behaviour: The role of productivist attitudes and non-pecuniary benefits. *Ecological Economics, 109,* 186-193. DOI: 10.1016/j.ecolecon.2014.11.015

Howley, P., & Dillon, E. (2012). Modelling the effect of farming attitudes on farm credit use: a case study from Ireland. *Agricultural Finance Review, 72*(3), 456-470. DOI: 10.1108/00021461211277286

Ingram, J., & Kirwan, J. (2011). Matching new entrants and retiring farmers through farm joint ventures: Insights from the Fresh Start Initiative in Cornwall, UK. *Land Use Policy, 28*(4), 917-927. DOI: 10.1016/j.landusepol.2011.04.001

Inter-Departmental Committee on Land Structure Reform (1978). *Final report.* Dublin: Stationery Office.

Inwood, S. M., & Sharp, J. S. (2012). Farm persistence and adaptation at the rural–urban interface: Succession and farm adjustment. *Journal of Rural Studies, 28*(1), 107-117. DOI: 10.1016/j.jrurstud.2011.07.005

Jenkins, W. (1997). Land Leasing in Rural Ireland-some empirical findings from the south-east. *Irish Geography*, *30*(2), 99-105. DOI: 10.1080/00750779709478637

Kay, C., Peuch, J., & Franco, J. (2015). *Extent of farmland grabbing in the EU*. (Directorate-General for Internal Policies. Policy Department B: Structural and Cohesion Policies). Brussels: European Parliament. Retrieved from: http://www.europarl.europa.eu/RegData/etudes/STUD/2015/540369/IPOL_STU%282015%29540369_EN.pdf

Katchova, A. L., & Ahearn, M. C. (2015). Dynamics of farmland ownership and leasing: implications for young and beginning farmers. *Applied Economic Perspectives and Policy, 38*(2), 334-350. DOI: 10.1093/aepp/ppv024

Kempen, M., Witzke, P., Domínguez, I. P., Jansson, T., & Sckokai, P. (2011). Economic and environmental impacts of milk quota reform in Europe. *Journal of Policy Modeling, 33*(1), 29-52. DOI: 10.1016/j.jpolmod.2010.10.007

Kennedy, L. (1991). Farm succession in modern Ireland: Elements of a theory of inheritance. *The Economic History Review, 44*(3), 477-499. DOI: 10.1111/j.1468-0289.1991.tb01275.x

Key, N., & Roberts, M. J. (2009). Nonpecuniary benefits to farming: Implications for supply response to decoupled payments. *American Journal of Agricul-*

tural Economics, 91(1), 1-18. DOI: 10.1111/j.1467-8276.2008.01180.x

Kimhi, A. (2000). Is part-time farming really a step in the way out of agriculture? *American Journal of Agricultural Economics, 82*(1), 38-48. DOI: 10.1111/0002-9092.00004

Läpple, D., & Hennessy, T. (2012). The capacity to expand milk production in Ireland following the removal of milk quotas. *Irish Journal of Agricultural and Food Research*, *51,* 1-11. Retrieved from: http://www.jstor.org/stable/41756842

Le Mouël, C. (2004). *Agricultural land markets: Main issues in the recent literature*. Working Paper Series 2 of the IDEMA Project. Retrieved from: http://www.agrifood.se/idema/WPs/IDEMA_deliverable_2.pdf

Lobley, M., & Butler, A. (2010). The impact of CAP reform on farmers' plans for the future: Some evidence from South West England. *Food Policy, 35*(4), 341-348. DOI: 10.1016/j.foodpol.2010.04.001

Loughrey, J., & Hennessy, T. (2019). A microsimulation model for the land rental market in Irish farming. In *The International Microsimulation Association's 7th World Conference, National University of Ireland, Galway, Ireland, 19-21 June 2019*. DOI: 10.2139/ssrn.3630993

Macra na Feirme (2015). *Land mobility service end of pilot programme report 2014-2016.* Macra na Feirme: Dublin. Retrieved from: https://web.archive.org/web/20190219233554/http://landmobility.ie/wp-content/uploads/2017/04/LAND_mobility_2017_finalfinal.pdf

Macra na Feirme (2019). *Land mobility 2019 report.* Macra na Feirme: Dublin. Retrieved from: http://web.archive.org/web/20190711230808/http://landmobility.ie/wp-content/uploads/2019/07/LAND-Mobility-2019-Report.pdf

Maguire, D. (1983). *The land problem*. Dublin: Agri-Books.

Marr, E. J., & Howley, P. (2019). The accidental environmentalists: Factors affecting farmers' adoption of pro-environmental activities in England and Ontario. *Journal of Rural Studies, 68*, 100-111. DOI: 10.1016/j.jrurstud.2019.01.013

Mazorra, A. P. (2000). Analysis of the evolution of farmers' early retirement policy in Spain. The case of Castille and Leon. *Land Use Policy, 17*(2), 113-120. DOI: 10.1016/S0264-8377(00)00006-5

Mills, J., Gaskell, P., Reed, M., Short, C., Ingram, J., Boatman, N., Jones, N., Conyers, S., Carey, P., Winter, M., & Lobley, M. (2013). *Farmer attitudes and evaluation of outcomes to on-farm environmental management*. Report to Department for Environment, Food and Rural Affairs (Defra). CCRI: Gloucester. Retrieved from: www.fslra.ac.uk/media/universityofexeter/research/microsites/centreforruralpolicyresearch/pdfs/10570_FarmerAttitudesFinalReportIF01114.pdf

Morris, C., & Potter, C. (1995). Recruiting the new conservationists: Farmers' adoption of agri-environmental schemes in the UK. *Journal of Rural Studies, 11*(1), 51-63. DOI: 10.1016/0743-0167(94)00037-A

Needham, B., Segeren, A., & Buitelaar, E. (2011). Institutions in theories of land markets: illustrated by the Dutch market for agricultural land. *Urban Studies, 48*(1), 161-176. DOI: 10.1177/0042098009360682

Laoire, C. N. (2005). 'You're not a man at all!': Masculinity, responsibility, and staying on the land in contemporary Ireland. *Irish Journal of Sociology*, *14*(2), 94-114. DOI: 10.1177/079160350501400206

O'Neill, S., & Hanrahan, K. (2012). Decoupling of agricultural support payments: The impact on land market participation decisions. *European Review of Agricultural Economics*, *39*(4), 639-659. DOI: 10.1093/erae/jbr064

Piet, L., Latruffe, L., Le Mouël, C., & Desjeux, Y. (2012). How do agricultural policies influence farm size inequality? The example of France. *European Review of Agricultural Economics, 39*(1), 5-28. DOI: 10.1093/erae/jbr035

Potter, C., & Lobley, M. (1992). Ageing and succession on family farms: The impact on decision-making and land use. *Sociologia Ruralis, 32*(2-3), 317-334. DOI: 10.1111/j.1467-9523.1992.tb00935.x

Sturgis, P., Roberts, C., & Smith, P. (2014). Middle alternatives revisited: how the neither/nor response acts as a way of saying "I don't know"?. *Sociological Methods & Research*, *43*(1), 15-38. DOI: 10.1177/0049124112452527

Swinnen, J., Van Herck, K., & Vranken, L. (2016). The diversity of land markets and regulations in Europe, and (some of) its causes. *The Journal of Development Studies, 52*(2), 186-205. DOI: 10.1080/00220388.2015.1060318

Van der Ploeg, J. D., Franco, J. C., & Borras Jr, S. M. (2015). Land concentration and land grabbing in Europe: a preliminary analysis. *Canadian Journal of Development Studies/Revue canadienne d'études du développement*, *36*(2), 147-162. DOI: 10.1080/02255189.2015.1027673

Van Passel, S., Nevens, F., Mathijs, E., & Van Huylenbroeck, G. (2007). Measuring farm sustainability and explaining differences in sustainable efficiency. *Ecological Economics, 62*(1), 149-161. DOI: 10.1016/j.ecolecon.2006.06.008

Weiss, C. R. (1999). Farm growth and survival: econometric evidence for individual farms in Upper Austria. *American Journal of Agricultural Economics, 81*(1), 103-116. DOI: 10.2307/1244454

Willock, J., Deary, I.J., Edwards-Jones, G., Gibson, G.J., McGregor, M.J., Sutherland, A., Dent, J.B., Morgan, O. & Grieve, R. (1999a). The role of attitudes and objectives in farmer decision making: business and environmentally-oriented behaviour in Scotland. *Journal of Agricultural Economics, 50*(2), 286-303. DOI: 10.1111/j.1477-9552.1999.tb00814.x

Willock, J., Deary, I.J., McGregor, M.M., Sutherland, A., Edwards-Jones, G., Morgan, O., Dent, B., Grieve, R., Gibson, G., & Austin, E. (1999b). Farmers' attitudes, objectives, behaviors, and personality traits: The Edinburgh study of decision making on farms. *Journal of Vocational Behavior*, *54*(1), 5-36. DOI: 10.1006/jvbe.1998.1642

Wilson, G. A. (1996). Farmer environmental attitudes and ESA participation. *Geoforum*, *27*(2), 115-131. DOI: 10.1016/0016-7185(96)00010-3

Zagata, L., Hrabak, J., Lošťak, M., Bavorová, M., Ratinger, T., Sutherland, L. A., & McKee, A. (2017). *Research for AGRI Committee–Young farmers–policy implementation after the 2013 CAP reform*. Brussels: European Parliament, Policy Department for Structural and Cohesion Policies. Retrieved from: https://www.europarl.europa.eu/RegData/etudes/STUD/2017/602006/IPOL_STU(2017)602006_EN.pdf

Zagata, L., & Sutherland, L. A. (2015). Deconstructing the 'young farmer problem in Europe': Towards a research agenda. *Journal of Rural Studies, 38*, 39-51. DOI: 10.1016/j.jrurstud.2015.01.003

Zondag, M. J., Koppert, S., de Lauwere, C., Sloot, P., & Pauer, A. (2015). *Needs of young farmers*. Luxembourg: Publications Office of the European Union. Retrieved from: https://ec.europa.eu/agriculture/sites/agriculture/files/external-studies/2015/young-farmers/final-report-1_en.pdf

Finito di stampare da
Logo s.r.l. – Borgoricco (PD) – Italia

Bio-based and Applied Economics Focus and Scope

The journal *Bio-based and Applied Economics* (*BAE*) provides a forum for presentation and discussion of applied research in the field of bio-based sectors and related policies, informing evidence-based decision-making and policy-making. It intends to provide a scholarly source of theoretical and applied studies while remaining widely accessible for non-researchers.

BAE seeks applied contributions on the economics of bio-based industries, such as agriculture, forestry, fishery and food, dealing with any related disciplines, such as resource and environmental economics, consumer studies, regional economics, innovation and development economics. Beside well-established fields of research related to these sectors, *BAE* aims in particular to explore cross-sectoral, recent and emerging themes characterizing the integrated management of biological resources, bio-based industries and sustainable development of rural areas. A special attention is also paid to the linkages between local and international dimensions. *BAE*'s objectives are:

- to stimulate cross-fertilization between the above mentioned research fields;
- to synthesize and integrate lessons learned from current strands of literature in economics;
- to provide a forum for well-established scholars as well as promising young researchers;
- to increase the knowledge about assessment, design and evaluation of public policies;
- to promote the debate on issues relating to the economics profession and its consultancy activities;
- to discuss future research pathways on the above issues.

***BAE* publishes high quality research and review papers, after a timely and rigorous double blind peer review process. *BAE* also publishes book reviews.**

BAE

Bio-based and Applied Economics

Editorial

Full Research Articles

€ 50,00