Journal of Rural Studies 110 (2024) 103365

Contents lists available at ScienceDirect

Journal of Rural Studies

journal homepage: www.elsevier.com/locate/jrurstud

Determinants of agricultural diversification: What really matters? A review

Gianluca Grilli [a,b,*], Francesco Pagliacci [a], Paola Gatto [a]

[a] Department TESAF, Territorio e Sistemi Agro-Forestali, Universita' degli Studi di Padova, Via dell'Universita' 16, 35020 Legnaro, PD, Italy

[b] Department of Economics and Management, University of Trento, Italy

A R T I C L E I N F O

Keywords:
Agriculture
Review
Causality
On-farm
Off-*farm*
Risk management
Income stabilisation

A B S T R A C T

Diversification of farm activities is one of the strategies to reduce the risk associated to the farm business and stabilise farmers' income, in particular for smaller farms. Diversification may result in on-farm activities (e.g. agritourism) or off-farm, which indicates that farmers seek additional income in the labour or investment market off their farms. Understanding the determinants of diversification is important to anticipate farms that are more likely to diversify their activities, explore regional differences, and propose effective policies when decision–-makers believe that wider diversification is desirable. In this contribution, we review the scientific literature on on-farm and off-farm diversification and collect all the variables that have been included in the econometric specifications to offer a better picture of all the important determinants of diversification practices and improve future modelling. The review suggests that the number of factors that may influence diversification is large and most of the models fail to consider all the important factors, possibly due to lack of some important data in secondary dataset. An important implication is therefore to improve data collection for future applications. In addition, potential issues related to endogenous variables should be better highlighted. Lastly, it was noticed a dearth of contributions that explore regional and environmental factors that may be important to explain diversification.

1. Introduction

Agriculture is key to all economies as it provides food for people's livelihood. However, the output of agricultural commodities is subject to high uncertainty due to several factors, including price volatility, climate and weather conditions (especially under climate change), soil fertility, and geographical roughness (Pastusiak et al., 2017). The uncertainty in agricultural outputs is associated with unstable farm income, which often fluctuates year-on-year due to changing market, weather, and environmental conditions (Jetté-Nantel et al., 2011). These features of farming make the farm business especially risky. In order to survive the market, farmers must adopt effective strategies to improve economic sustainability of their businesses.

One of the strategies that all types of farmers may employ is the diversification of their activities (Adnan et al., 2020). Diversification has several benefits for farmers as it allows increasing their overall revenues due to the wider number of activities, as well as reducing their dependency on commodity prices and stabilise the overall economic return. Another benefit of diversification relates to risk management. In this regard, diversification in agriculture operates similarly to finance, where investors seek to allocate their funds to uncorrelated assets to reduce capital draw-downs and variance. In agriculture, diversification might stabilise income levels and reduce the overall investment risk (Ullah and Shivakoti, 2014). In this sense, diversification represents a form of insurance towards the unknown, which makes farms more resilient in the presence of adverse market or climatic conditions (Papaioannou, 2016; Ochieng et al., 2020; Mulungu et al., 2023).

In agriculture, common terms to define diversification are on-farm and off-farm activities (Ullah and Shivakoti, 2014), although the distinction is not always consistent (e.g. sometimes non-agricultural activities are called non-farm, see for example Dary and Kuunibe (2012)). In general, on-farm broadly refers to activities that are undertaken using agricultural assets, while off-farm assets of a different source. While both on-farm and off-farm activities can contribute to risk management, the motivations behind the choice of one over the other might be largely different (Iqbal et al., 2021; Jack et al., 2021). The scientific interest over agricultural diversification has increased over time, as more and more farms have adopted some forms of

* Corresponding author. Department TESAF, Territorio e Sistemi Agro-Forestali, Universita' degli Studi di Padova, Via dell'Universita' 16, 35020 Legnaro, PD, Italy.

E-mail address: gianluca.grilli@unitn.it (G. Grilli).

https://doi.org/10.1016/j.jrurstud.2024.103365
Received 22 September 2023; Received in revised form 3 July 2024; Accepted 28 July 2024
Available online 31 July 2024

diversification to survive. However, there are sizeable differences across countries. In 2014, Khanal and Mishra (2014) estimated that about one third of farms in the USA employ some forms of diversification, either on-farm or off-farms. In Europe, diversification vary across countries. For example, Pfeifer et al. (2009) reports that the Dutch agricultural census include 28 percent of farms engaging in diversification, whereas the share is much lower in Italy, where only about 13 percent of farms undertook at least one diversification activity in 2016 (Salvioni et al., 2020).

The scientific literature investigated several aspects of agricultural diversification (among others, Tamburini et al., 2020; van Leeuwen and Dekkers, 2013; Van der Ploeg et al., 2003). From the agricultural economics perspective, several contributions focused on the identification of socio-demographic, behavioural, environmental, and geographical determinants of on-farm and off-farm diversification (e.g., Mishra and Goodwin, 1997; Mishra et al., 2004; McNamara and Weiss, 2005). However, the variables included in the models to understand determinants differ and there is not a set of variables that are generally accepted to explain diversification. This situation is partly a result of different data availability among different geographical contexts. In fact, many contributions use secondary data (e.g., census data) that are collected in different ways across countries and over which the researchers have little or no control at all. Within this context, some questions arise: 1) what drives diversification, and what are its main determinants? 2) Are there causality issues that should be addressed? and 3) How effective are the existing datasets to explore diversification?

With this in mind, this contribution provides a systematic review of the literature on agricultural diversification, with the objective of understanding the main drivers of on-farm and off-farm diversification practices. To do this, the review collected studies that include econometric applications, in which a dependent variable that describe on-farm or off-farm diversification is regressed against a set of determinants. The systematic review aims to shed light on the most important variables that affect farmers' diversification choices. Considering that diversification in agriculture may be a policy goal (e.g. for farm risk management, rural development, and enhance environmental biodiversity), this review is particularly useful to design policies that aim to enhance agricultural diversification. To the best of the authors' knowledge, the paper by Pastusiak et al. (2017) is the only other available contribution that reviews the determinants of diversification, which is however non-systematic and restricted to off-farm decisions. In this work, we extend the review to on-farm diversification papers, and we undertake a systematic work of collection of the determinants, and report the frequency of use and the share of econometric models that estimate significant associations. An aim of the manuscript is therefore to provide evidence of the most important drivers of diversification, as well as potential drivers currently not frequently included in the estimations, in order to reduce the risk of omitted variable bias in future econometric modellling.

The rest of the manuscript is organised as follows: the second section reviews the frameworks under which farm diversification is analysed, as well as the measures and indicators of on-farm and off-farm diversification. The third section shows the results of the review, which consists of the list of documents retrieved and the list of independent variables used. The fourth section discusses the results and the relative importance of characteristics that affect on-farm and off-farm diversification. Lastly, the fifth section offers some conclusions.

2. Background

2.1. The frameworks of diversification

Farmers have several options when seeking to diversify their business, which are most commonly divided into on-farm and off-farm activities. On-farm include all activities that are undertaken using farms' assets, e.g. crop diversification, agritourism, production of renewable energy, contracting. On the other hand, farmers diversify off-farm when they have a source of income (a job or another business) outside the agricultural sector and are therefore part-time only farmers. This classification, however, is not universally accepted. Sometimes farm business is divided into on-farm, non-farm, and off-farm activities (e.g. Tittonell et al. (2010)), where on-farm indicates crop or livestock diversification, non-farm includes all connected activities (e.g. agritourism and renewable energy production), and off-farm remains the set of economic activities conducted outside the farm.

A popular model to classify farm activities has been proposed by Van der Ploeg et al. (2003), who proposed a farm-level framework to investigate rural development. This model is useful to study diversification because it considers farms as players that can undertake several diversified activities. According to this model, the farm enterprise entails three aspects: 1) the standard agricultural side, which concerns the production of agricultural goods (the agri-food supply chain), 2) the rural side, intended as the impact of the farm in the rural landscape and the natural values it contains, and 3) the mobilisation of resources, i.e. the allocation and use of resources inside or outside the farm. To contribute to rural development, all these three aspects should be developed. The agri-food supply chain can be enhanced with a set of *deepening* activities, i.e. activities that produce more value added per unit output. *Deepening activities* might be organic farming, short supply chains, and high quality productions. The rural side may be developed by *broadening* activities, which comprise actions that broaden farms' range of action. Examples of *broadening* activities are agritourism, nature and landscape management, new on-farm activities. Lastly, a process of *regrounding* through either cost reductions or off-farm activities may enhance the mobilisation of resources.

In this contribution, the distinction between on-farm and off-farm activities is adopted, where on-farm include all activities undertaken with farm's capital and off-farm otherwise. This choice best meets the classification of most papers included in the literature review. Indeed, only a few contributions use *broadening*, *deepening*, and *regrounding* as explanatory variables. In these cases, *broadening* and *deepening* are considered as on-farm diversification, whereas *regrounding* as off-farm diversification. In fact, *broadening* and *deepening* are all undertaken using farm's assets, and only *regrounding* includes off-farm.

2.2. The measures of on-farm diversification

On-farm diversification is relatively easy to measure with a high degree of accuracy in surveys. Frequently, farmers only have to indicate the activities they implement with the farm's capital. Based on data availability, on-farm diversification is measured as a binary variable, as a count of activities or through indices created *ad-hoc* to evaluate the degree of diversification or concentration of the activities. The binary variable only distinguishes between monocultural farms and farms that implement diversification, at least to a certain degree. Such analyses are easy to implement, but they might be overly simplistic because the extent of diversification is not considered. Alternatively, a count of diversification practices is a popular alternative when the set of activities is known but the relative importance of each activity (e.g., in terms of utilised land, utilised labour, or generated income) is not. Lastly, indices provide the highest degree of accuracy in the information because they are calculated on the basis of the relative importance of one activity with respect to the others. Popular indices to analyse diversification are: 1) the entropy index, 2) the Berry index, 3) the modified concentration ratio. These indices represent the benchmark for diversification studies and are calculated considering the relative quantity of input or output per each activity. They all range between 0 and 1, where 0 indicates the maximum degree of concentration of the activity (i.e. monoculture with no other ancillary activities) and 1 the largest degree of diversification. An exhaustive explanation of the formulas to calculate these indices is available in (McNamara and Weiss, 2005). A less popular index is the Herfindahl-Hirschman Index (HHI), which originates in the field of market analysis to evaluate the degree of competitiveness of firms in a given market. Differently from other indices, the HHI varies in the 0–10,000 range. In agricultural studies, this index has been adopted, among others, by Anosike and Coughenour (1990).

2.3. The measures of off-farm diversification

When farmers diversify off-farm, they are basically part-time farmers with a job in a non-agricultural business. Compared to on-farm diversification, off-farm diversification is less easy to measure because it relates to any income that farmers gain outside the farm. The set of activities is too large to be properly categorised, therefore most studies use simplified variables to capture off-farm diversification. The most common approaches to treat off-farm as a binary (yes-no) variable, to measure the share of income generated off the farm, or to assess the quantity of off-farm labour.

3. Methods

The literature review was conducted following the PRISMA guidelines, which represents the standard to conduct reviews and meta-analyses (Moher et al., 2010). The PRISMA procedure was developed in the health literature but has subsequently become the standard approach for reviews in a wide variety of scientific fields. The PRISMA guidelines aim to improve the reporting of reviews and define the flow of information when collecting primary studies through these four steps: 1) identification, 2) screening, 3) eligibility, and 4) inclusion. Identification is the step in which sources are retrieved from the database. In the screening process, duplicates or other useless documents are discarded. Subsequently, documents that do not match inclusion criteria are further eliminated in the eligibility stage. Lastly, inclusion indicates the step in which the final set of documents is gathered for subsequent exploration and analysis.

Considering that the primary objective of this review is to explore determinants of agricultural diversification, the following criteria were adopted for papers to be included in the review: 1) documents must use data of high-income countries, 2) the documents must include econometric models in their analyses, 3) the dependent variable must offer a measure of on-farm or off-farm diversification that is regressed against a set of determinants, and 4) documents must be published in English. The first criterion was included for a number of reasons. First, restricting the analysis to high-income economies allowed obtaining comparable records, as high-income and low- or middle-income countries are expected to be rather different from several points of views (e.g., their market structure, production systems, technology, importance of the primary sector in the national economy, and possibilities to diversify both on-farm and off-farm). Secondly, the topic of diversification in high income economies is currently investigated less than diversification in medium and low income countries, where the share of agriculture on the overall economy is larger and a robust and diversified agricultural sector represents a pre-condition for development (Di Bene et al., 2022; Johnston and Mellor, 1961). The criteria 2 and 3 restricted the search to quantitative studies that use micro-data to explore diversification. While we acknowledge that qualitative studies are useful to explore farmers' drivers to diversify, quantitative studies better explain causal relationships between variables and facilitate the collection of comparable contributions, they are therefore more appropriate for the purposes of this review.

The Identification phase for manuscript collection was carried out in Scopus (www.scopus.com) and Google Scholar (https://scholar.google.com/), i.e. two of the largest and most frequently used research databases to browse scientific literature. In Scopus, the search was undertaken on title, abstract, and keywords using the keywords 'Agriculture','Agricultural', 'Diversification', 'on-farm', 'off-farm' in combination.[1] Google Scholar does not allow restricting the search to title, abstract, or keywords, nor allows using the 'OR' operator. Therefore, several subsequent searches were carried out using the above words in combination. The search was not constrained to a specific timeframe, so that documents could have been published at any point in time. As it is often practice in review methods, including PRISMA applications (e.g., Yin et al., 2020; Kahrass et al., 2021), the initial list of documents was snowballed with additional documents that were either cited by papers in the original list or that cited the papers in the original list.

The total body of literature collected in the identification stage included 1653 documents, of which 647 were retrieved in Scopus and 985 in Google Scholar. Out of the total body of literature, 12 documents were removed because full-texts were not written in English and 103 were duplicates across the two databases. Therefore, the screening stage began with 1538 records. The screening of titles allowed removing 1431 entries, thus reducing the list of candidate documents to 107 entries. The subsequent snowball sampling added 7 further references to the body of literature. In this stage, the vast majority of papers were excluded because data were collected in emerging economies, whereas a minority of manuscripts were excluded because the title indicated that the study was not pertinent or adopted non-econometric techniques for the analysis. A subsequent review of the abstracts excluded a further 57 entries because inclusion criteria were not met. The set of documents that went through the eligibility stage was composed by 49 items. After a review of full-text articles, the body of literature that respected all the criteria was reduced to 37 documents. As several documents included more than one econometric model, the total number of models evaluated was 64.

4. Results

4.1. Descriptive statistics of the sample

The set of manuscripts in the review have been published on a timeframe of over 40 years, between 1980 and 2023. Eight studies were published before 2000, 9 between 2000 and 2010, the remaining 20 publications date after 2010. Fig. 1 shows the geographical distribution of the sources.

With respect to data sources, 13 studies (accounting for 26 econometric models) conducted their own field surveys, whereas 24 analysed secondary data from censuses or annual agricultural surveys. Globally, documents belong to 13 different Countries. The United States contribute with the largest number of manuscripts (13), followed by Italy with 6 papers. The rest of the countries contribute with a number of manuscripts in the 1–3 range. Of these studies, 4 American studies considered only one State of the Union, while the remaining 9 provided a country-wide analysis. In the rest of the world, regional studies account for 9 documents, while the rest are state-level analyses.

In terms of topics, 22 papers investigated off-farm diversification, 13 on-farm diversification, and 2 documents explored both types of diversification activities (Fig. 2).

Fig. 3 further shows the dependent variables that were selected in each specification of the econometric models. The binary variable was the most frequent in off-farm diversification analyses, while the count of activities prevails in on-farm diversification works. With respect to on-farm diversification studies, other common metrics to define diversification were a multinomial specification, followed by the entropy, Berry, concentration ratio, and HHI indexes. In off-farm studies, alternatives to

[1] the complete string of the Scopus search is the following: (TITLE-ABS-KEY (agriculture) AND TITLE-ABS-KEY (diversification) AND TITLE-ABS-KEY (on-farm) OR TITLE-ABS-KEY (off-farm)).

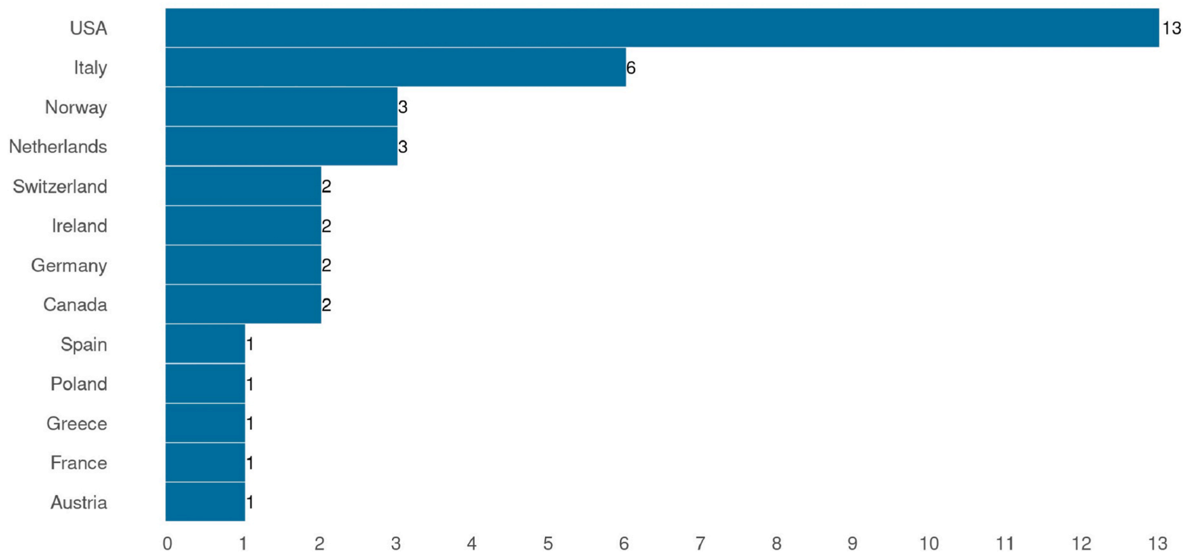


Fig. 1. Geographical distribution of the manuscripts.

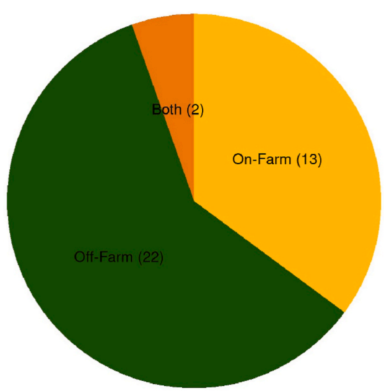
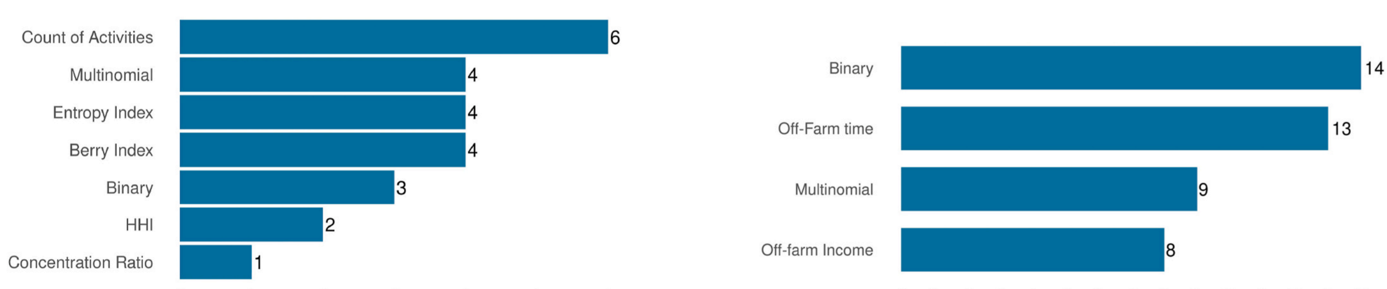


Fig. 2. Number of On-farm and off-Farm diversification studies.

Table 1
Number of Independent variables across models.

Number of covariates	Frequency
9	1
10	4
11	10
12	13
13	13
14	10
15	1
16	3
17	5
18	2
19	1
22	1



(a) On-farm (b) Off-farm

Fig. 3. Types of on-farm and off-farm dependent variables.

the binary specification of the dependent variables were off-farm working hours and off-farm income. The econometric models are largely affected by the nature of the dependent variable. When the dependent variable is binary, probit or logit models were the most common alternatives, whereas continuous variables are modelled with OLS. Count variables are modelled with Poisson and negative binomial models, often corrected for zero-inflated data, or by means of double hurdle models.

Moving to the description of model determinants, Table 1 displays the number of independent variables in each econometric specification of the review.[2] The simplest models include 9 independent variables, whereas larger models include up to 22 determinants of agricultural diversification, with a mode of 12 or 13.

[2] Fixed effects dummies for regional or time effects are excluded.

4.2. Determinants of diversification

The total list of independent variables used in econometric models to explore diversification is reported in Table 2, divided by on-farm and off-farm models. The list of determinants is divided into three large categories: 1) socio-demographic characteristics of the agricultural holder, 2) farm characteristics, 3) regional and environmental characteristics. Globally, the collected documents tested 18 socio-demographic characteristics, 33 farm characteristics, and 15 regional or environmental characteristics.

4.2.1. Socio-demographic determinants of diversification

With respect to socio-demographics, age is the variable that has been most commonly used by econometric models, in fact 61 out of 64 models included age as explanatory variable, 23 in on-farm models and 38 in off-farm models. Age entered econometric models either as a linear variable or paired with a quadratic term. Another popular variable is personal education or education in agriculture, which have been used 39 and 16 times, respectively. Gender of the farm conductor was included in 9 on-farm and 5 off-farm models, but it returned non-significant results in most cases. The household composition is frequently used in econometric specifications. In particular, marital status, household size and the number of children are common metrics to assess household structure. Some documents investigated the impact of household members working or living inside the farm, in particular in on-farm diversification models.

Several other socio-demographic characteristics have been tested, but their inclusion in econometric models of farm activity diversification is less common. In particular, individual experience in on-farm and off-farm activities, whether off-farm is a career choice (as opposed to an additional source of income that adds to the income generated in the farm), and whether the farmer has a successor within his or her family were all included less than 5 times in diversification models.\

4.2.2. Farm characteristics

The group of farm characteristics includes 33 variables that attempt to capture several aspects of the farm enterprise, including dimension, income, mechanisation of the production process, type of business and subsidies through national programmes of support payments. The most common variables that relate to the dimension of the farm are farm size (in hectares of land, which appears in 34 regression models), the share of land owned as opposed to the rented land, and the net worth of farm assets, included in 18 analyses. Five studies disentangled diversification behaviours of small farms, defined as farm with less than 5 ha of utilised land. Another indicator of farm size is the value of production sold, which was however considered less often, in 6 occasions. Lastly, availability and number of employees might also approximate the size of the farm, and this metric entered 7 econometric models. There is dearth of studies that include other indicators of farm enterprise. The debt to asset ratio was included 11 times in the analysis of diversification, while farm efficiency (defined as the ratio between output and input of production) 5 times. A few studies included a variable that captured income levels or income variability on diversification decisions. In particular, 9 studies about on-farm diversification included the level of off-farm income in their models, while only 2 studies about off-farm diversification include on-farm income to explain off-farm decisions. One study calculates income variability with respect to the previous year as a potential predictor of farmers entering the off-farm labour market.

Diversification appears to be influenced by the level of income support from national support payment programmes, i.e. the CAP in the European Union and the FAIR act in the United States. The level of payments to farmers was included in 24 studies and returned to be significant in 75% of the models. Other types of payments that farmers received mainly relate to environmental schemes, which were included only in one study in Switzerland (El Benni and Schmid, 2022).

The level of mechanisation and the use of modern technologies is another topic that has not been extensively investigated in diversification studies. In fact, only 3 studies included the availability of tractors or similar assets as predictor of diversification, whereas the use of computers and social media marketing has been considered 1 and 3 times, respectively.

In the literature, ownership has been subdivided between sole proprietors, family companies, or cooperatives, and the reference level is corporation in all cases. In general, the inclusion of ownership in diversification models is relatively rare, and the most common option is to consider a dummy that captures sole proprietors as opposed to any other type of ownership (8 times).

The last set of independent variables that belong to farm characteristics describe farm production. In particular, variables that capture arable or permanent crops were included 15 and 22 times, respectively. Animal husbandry were included as stoking levels (20 times) or, less commonly, divided by other types of animal breeds (hogs, poultry). Organic production, which is itself a form of on-farm diversification, was included as predictor 5 times, with mixed findings in terms of impact. In terms of transformation activities, dairy and beef production were considered 20 and 7 times, respectively. As covariates, they were significant in 90% and 43% of the models, respectively.

4.2.3. Regional and environmental determinants of diversification

Regional and environmental variables attempt to capture socio-economic and geographical characteristics of the place where the farm is located. Compared to farmers' and farms' characteristics, this set of variable is smaller as it includes 15 variables and less frequently used in econometric modelling, although in 17 models regional (or macro-regional) dummies capture average geographical differences. The most common variable is the urbanisation index (most commonly defined in terms of population number or density) that appears in 11 models, although it was significant only in 4 models. The location in urban areas (using rural areas as reference or *vice versa*) occurs in 11 models, but it returned significant coefficients only in 36% of the times. Location in mountain or hilly areas are two other aspects of interests, which are included in 9 and 7 models, respectively. These altitude variables proved to be good predictors of diversification, in fact they returned significant coefficient in more than 85% of the models. In 2 cases, altitude is also included as a continuous variable, returning a significant estimate in both models. An additional 7 studies capture farms located in "lagging behind" areas, which are alternatively defined in terms of: remoteness from urban areas, low per-capita GDP or low job opportunities. Distance from the biggest town was included 5 times and significant in 2 models. Other characteristics such as unemployment rate, hardiness zones, location in protected areas were occasionally considered in diversification studies, with a frequency of occurrence of 1 or 2 studies in total.

Lastly, some models included variables that capture the specific conditions in which farming is performed, namely the climate risk of the place and soil quality. However, these aspects were not common, as only occurred in 1 or 2 models.

5. Discussions

On-farm and off-farm diversification are both ways to reduce the risk associated with the farm business and to stabilise or increase income, with a growing interest in the academic debate. The interest for agricultural diversification is reflected in the number of papers published in recent years and the geographical dimension of the research. In fact, half of the papers collected in this review has been published after 2010 and the contributors offered data from 13 developed countries. Considering the importance that the scientific research attaches to diversification, a wider uptake of diversification activities should represent a goal for agricultural policy. In this framework, the results of this review are informative in a number of ways: 1) Determinants to include in future econometric studies, 2) shedding lights on endogeneity and causality issues, and 3) providing evidence for agricultural policy. We consider

Table 2
Determinants, Frequency of use and their impact on Diversification.

Variable	On-Farm Models			Off-Farm Models			All			Total occurrences	% significance
	Positive	Negative	Non-significant	Positive	Negative	Non-significant	Positive	Negative	Non-significant		
Socio-demographic characteristics:											
age	5	8	12	17	10	9	22	18	21	61	66%
age^2	2	1	0	1	13	6	3	14	6	23	74%
education in agriculture	5	1	2	1	5	2	6	6	4	16	75%
education	13	2	7	14	1	2	27	3	9	39	77%
career choice	1	0	0	1	1	0	2	1	0	3	100%
experience on-Farm	0	0	0	2	2	1	2	2	1	5	80%
experience off-Farm	0	0	0	1	0	0	1	0	0	1	100%
household size	3	0	2	5	3	6	8	3	8	19	58%
Household lives in the farm	2	0	0	0	0	1	2	0	1	3	67%
household work on farm	0	2	0	0	0	0	0	2	0	2	100%
number of children	0	0	0	4	8	3	4	8	3	15	80%
Gender	0	1	8	1	0	4	1	1	12	14	14%
Marital status	0	1	2	1	0	2	1	1	4	6	33%
Living expenses	0	0	0	1	0	0	1	0	0	1	100%
Full time farmer	1	0	0	0	3	0	1	3	0	4	100%
Succession within family	1	0	1	1	0	1	2	0	2	4	50%
smartphone ownership	0	0	0	1	0	0	1	0	0	1	100%
Individual risk preferences	0	0	2	2	3	2	2	3	4	9	56%
Farm characteristics:											
social Media Marketing	0	0	0	1	0	0	1	0	0	1	100%
Computerised farm	1	1	1	0	0	0	1	1	1	3	67%
Number of Employees	1	1	1	4	0	0	5	1	1	7	86%
insurance ownership	2	0	0	1	1	3	3	1	3	7	57%
marketing or production contract	0	0	2	0	0	0	0	0	2	2	0%
Diversification	4	0	1	6	2	3	10	2	4	16	75%
tractor availability	0	0	0	3	0	0	3	0	0	3	100%
Farm net worth	2	1	0	3	11	1	5	12	1	18	94%
Farm Efficiency	0	0	2	0	2	1	0	2	3	5	40%
farm size	9	2	1	4	10	8	13	12	9	34	74%
small Farm (<5 ha)	3	2	0	0	0	0	3	2	0	5	100%
Share of land owned	3	1	3	1	1	2	4	2	5	11	55%
self consumption	1	0	0	3	0	0	4	0	0	4	100%
Value of production sold	4	0	0	0	1	1	4	1	1	6	83%
on-farm income variability	0	0	0	1	0	0	1	0	0	1	100%
on-farm income	0	0	0	1	1	0	1	1	0	2	100%
Off-farm Income	1	0	6	0	1	1	1	1	7	9	22%
Debt to asset ratio	2	0	0	1	0	8	3	0	8	11	27%
Support Payments	3	0	0	5	8	6	8	10	6	24	75%
Biodiversity payments	0	0	0	1	0	0	1	0	0	1	100%
biodiversity payments2	0	0	0	0	1	0	0	1	0	1	100%
sole proprietor	2	0	3	2	0	1	4	0	4	8	50%
family ownership	0	1	1	0	1	0	0	2	1	3	67%
cooperative	0	0	1	0	0	0	0	0	1	1	0%
Arable crops	4	4	2	4	1	7	8	5	9	22	59%
Permanent crops	3	4	0	2	0	6	5	4	6	15	60%
stocking rate	2	2	3	3	5	5	5	7	8	20	60%
pastures	3	0	1	1	0	0	4	0	1	5	80%
dairy	0	0	1	2	16	1	2	16	2	20	90%
beef	0	0	1	3	0	3	3	0	4	7	43%
hogs	0	0	1	3	1	2	3	1	3	7	57%
poultry	0	0	0	1	0	1	1	0	1	2	50%
organic	2	0	2	0	1	0	2	1	2	5	60%
Regional Characteristics:											
urban index	1	0	0	1	2	7	2	2	7	11	36%
urban areas	1	2	0	2	4	0	3	6	0	9	100%
Distance from town	0	0	0	1	1	3	1	1	3	5	40%
unemploym rate	0	0	0	0	1	0	0	1	0	1	100%
lagging behind Area	2	1	2	1	0	1	3	1	3	7	57%
% of primary sector in the economy	0	0	1	0	0	0	0	0	1	1	0%

(*continued on next page*)

Table 2 (*continued*)

Variable	On-Farm Models			Off-Farm Models			All			Total occurrences	% significance
	Positive	Negative	Non-significant	Positive	Negative	Non-significant	Positive	Negative	Non-significant		
Depopulated area	1	0	0	1	0	0	2	0	0	2	100%
hardiness	1	0	0	1	0	0	2	0	0	2	100%
mountain area	5	2	1	0	1	0	5	3	1	9	89%
hills	6	0	0	0	0	1	6	0	1	7	86%
flat planes	0	2	0	0	0	0	0	2	0	2	100%
soil quality	0	1	1	0	0	0	0	1	1	2	50%
protected area	2	0	0	0	0	0	2	0	0	2	100%
altitude	0	0	0	1	1	0	1	1	0	2	100%
climate risk	1	0	0	0	0	0	1	0	0	1	100%

these aspects separately in the next subsections.

5.1. Econometric determinants of diversification

This review found that several factors (in excess of 60) may influence diversification. However, not all these factors influence both on-farm and off-farm diversification in the same way, because the determinants behind the choice of one alternative over the other are rather different. The review confirmed that diversification determinants may be grouped in three broad categories: personal characteristics of the holder, farm's characteristics, and environmental or regional characteristics. While most applications include variables that capture all these aspects, overall the results of this study suggest that many models include a small number of determinants only. The most important personal, farm and environmental determinants are discussed in the following subsections.

5.1.1. Personal characteristics

Personal characteristics (i.e., socio-demographics features and/or individual behaviours) may influence both risk preferences (Hellerstein et al., 2013; Chang et al., 2004) and preferences for income stabilisation, in particular the decision to enter the off-farm labour market (Bai et al., 2022). The general positive association of diversification with respondents' age may be explained by the fact that younger individuals are in their initial stage of the farming activity and prefer to dedicate full-time in the farm, finding more profitable solutions in the set of agricultural activities. Similar to this, a farmer with a higher level of education (particularly in agricultural studies) was more likely to diversify on—farm, likely showing larger interest and competence in the farm business. The highest level of education attained by the owner of the farm influenced positively both on—farm and off—farm diversification activities. The composition of the household in terms of number of components and number of children was difficult to assess. On the one hand, the household size variable was almost equally split between models with a positive impact and models with a non-significant impact. On the other hand, the number of children had a comparable number of models with positive and negative coefficients. While these two variables are very similar and possibly highly correlated, they are not identical. In fact, the household size variable may take larger values because it captures households of farmers that live with grandparents or other relatives in addition to their children. Conversely, the number of children might also act as a proxy of the bequest value that farmers attribute to their farm, eventually affecting their decisions in terms of on-farm and off-farm diversification strategies. One last comment on this set of determinants relates to the decisions taken at household level. Within the framework of a farm household model (Barnum and Squire, 1979), some authors highlighted that the decision of two spouses to diversify the income are correlated, in particular for what regards off-farm diversification. When a farm is owned by a couple, the decision of one spouse to find a job off-farm may depend on the decision of the other spouse (Benjamin and Kimhi, 2006; Chang and Mishra, 2008). The econometric solution available to model this behaviour is to adopt a seemingly unrelated regression or a bivariate probit, which take into account potential correlation across the error terms of two regression models (Benjamin and Guyomard, 1994). This behaviour is difficult to disentangle in this quantitative review, it is however important to measure in primary studies.

5.1.2. Farm's characteristics

With respect to farm's characteristics, the review of econometric models suggests that farm size is an important factor that influences diversification in both on-farm and off-farm activities. However, direction of the impact is likely the opposite. In fact, most on-farm models found that farm size (measured in terms of either utilised agricultural area or net worth of the assets) increased diversification patterns, whereas off-farm models returned more negative causal relationships. This result may indicate that larger farms require full-time attention by their owners, who in turn have no time to dedicate to additional off-farm activities, and prefer to implement on-farm diversification only. Usually, larger farms are mechanised to a larger extent compared to smaller farms and therefore may benefit of economies of scale (Cochrane, 1958), especially if the on-farm diversification involves additional and related agricultural activities. The results about the legal status of the farm were also difficult to interpret, largely because of lack of data. Apart from sole proprietorship, which was included 8 times, there is dearth of studies that consider other types of farm property. Ownership of the farm, especially when considered as sole property as opposed to widespread shareholding, might indicate how simple it is to take a decision within the company, including diversification decisions. This aspect might particularly influence on-farm diversification, as it is performed using the farm's own capital.

The prevailing activity of the farm (i.e. whether the farm engages in arable crops, permanent crops, or livestock husbandry) has an impact on diversification which is rather difficult to assess, because models returned comparable proportions of positive, negative, and non-significant coefficients. Conversely, the link between farms that engage in transformed products such as dairy and meat to diversification is clearer. In fact, most of these farms are less likely to undertake diversification, especially off-farm. A possible explanation for this result is that farms selling transformed food products are not greatly affected by uncertainty related to climate and weather conditions and do not seek additional income off-farm.

5.1.3. Environmental and regional characteristics

The variables that capture regional and environmental features were the least considered in the econometric models of the studies included in the literature review. The low frequency of appearance of environmental variable may be due to the inclusion of regional fixed effects, which capture most regional variability of other variables.

The impact of altitude on diversification is explained by the fact that farms located at higher altitudes are often placed in a disadvantaged position to conduct their business, due to the remoteness of their place, harsher weather and climate conditions, but also due to the lack of available public services (Nicita et al., 2024; MacDonald et al., 2000).

Therefore, these farms must seek alternative sources of income to survive. Many of the positive relationships between altitude and diversification occur in on-farm models. One of the possible reasons for this result is that consumers have positive attitudes towards mountain products and services. The literature suggests that people are willing to pay more food products with mountain geographical indications (Cei et al., 2023; Mazzocchi and Sali, 2016) and are potentially interested in other activities undertaken by mountain farms, in particular recreational activities. Therefore, larger on-farm diversification may reflect the attempt of mountain farms to meet (urban) consumers' demand. While the detail of the activities undertaken is not always available, a possible explanation for this finding is that mountain farms exploits the beauty of their surroundings to engage in tourist-related activities. This result partly complies with the frequency of positive relationship found between diversification and the variable that captures farms located in disadvantaged places, which is a broader class where farms in high altitudes fall.

Other variables in the regional and environmental group were rarely used (less than five times each) but many of them were significant. Therefore, future econometric studies should consider these types of variables. In several cases, regional dummies capture the overall impact of several regional variables and additional regional variables may be redundant. However, models with a series of actual local or regional characteristics might be more effective to capture their effects and reduce measurement errors.

Another comment relates to the impact of climate change on agriculture in general and agricultural diversification in particular. Climate change has a complex causal relationship with agriculture and may impact agricultural productions in several ways (Agovino et al., 2019). Some cold-region countries may take advantage of climate change thanks to the carbon fertilisation effect (Stokes and Howden, 2010). However, most countries suffer negative consequences (e.g. due to water stress and varying yields). Often, a combination of impacts exacerbate the total climate change impact (Adger, 2006). With a direct impact on yields and the associated income, climate change is an important factor that may explain farmers' choices to diversify activities and sources of income. Despite its importance, climate change variables are often absent in diversification models, possibly due to lack of data at farm or local scale. Some metrics related to climate change are available at regional levels, but their impact is captured by regional dummies, when included. Among other benefits, the availability of high–resolution climate data at local levels would facilitate the estimation of diversification patterns. Another explanation possibly lays in the causal relationship between climate and agriculture. In fact, climate change and agricultural output show a loop of causality that makes the inclusion of climatic change variables into agricultural models endogenous (Husnain et al., 2018; Nicita et al., 2020; Adger, 2006). Similarly, climate change is endogenous to diversification, because diversification of activities made by farmers as a response to climate change might lead to additional GHG emissions that fuel climate change. Nonetheless, this is a long-run issue, which is unlikely to influence farmers' decisions in the short run.

5.2. Endogeneity and causality

Farmers' choice to undertake diversification may be endogenous to some of the determinants. This review highlighted that little attention has been placed on endogeneity issues in the literature. The endogeneity between diversification and climate change has been discussed in the previous section, and it was concluded that climate change consequences may not affect diversification choices due to their long-term effects. While the endogeneity between diversification and climate change might be not so important in farmers' choices, another source of endogeneity may be relevant in the econometric modelling. This other source lays in measurement errors while collecting climate data, in particular with respect to precipitation. In this case, endogeneity arises because measurement errors would make the variable correlated with the error term (Hiebl and Frei, 2023). There is dearth of contribution that investigate suitable instruments for climate data. An example of instrument is offered by (Husnain et al., 2018), who propose geographical coordinates as an instrument for temperatures. In panel data models, endogeneity might be addressed in the context of Generalised Method of Moments (GMM) estimation (Blundell and Bond, 2023), using data of previous years to instrument current climate data. Examples of this approach are provided in Quddoos et al. (2023) and Zafeiriou et al. (2023). However, panel data are not easily available in farm-level analysis because often statistical agencies do not keep track of farms over time.

In the context of causal relationships, in addition to climate change, endogeneity probably affects other determinants of farms' diversification strategies. The solutions proposed by the literature on endogeneity bias typically involve 2-stage least squares regression models using instrumental variables (Gui et al., 2023). However, good instruments are always difficult to retrieve. One of the variables that potentially cause endogeneity is the ownership of an agricultural insurance. Weber et al. (2016) acknowledge that the vast majority of the contributions treat insurance as exogenous, but it is unlikely the case. In particular, agricultural insurance is endogenous to agricultural output in general and to diversification in particular due to a bidirectional causal relationship. To address the endogeneity of insurance ownership, (Zou et al., 2022) proposed a 2-stage least square approach with two instruments, namely the urban-rural income gap, and the amount of fiscal expenditure of local government. Another instrument is proposed by Cornaggia (2013), who uses the introduction of new insurance policies in some countries. A workaround solution proposed by O'Donoghue et al. (2009) is to use county-level instead of farm-level data, thus removing the link between farm's choices and agricultural output.

Another stream of the literature suggests that income is endogenous to diversification, due to farmers' decision to diversify with income expectations in mind. In an on-farm model, Ahmadzai (2020) acknowledges the endogeneity of off-farm income to explain on-farm diversification and proposes the use of two instruments: 1) the total sum of non-farm income at district level (suggested by Kilic et al. (2009)), and 2) lagged income collected in the previous round of survey (as indicated by the work of Diiro and Sam (2015)). As a further evidence of the bidirectional causality between income and diversification, a large amount of documents estimates the reverse model, in which diversification is used as an explanatory variable for income levels. For this reason, instruments are proposed for diversification and not for income. In particular, Salvioni et al. (2020) adopt the extension of forested area owned by farms and length of farmers' participation in diversification as instruments, whereas Zhao and Barry (2014) propose the average diversification level of the county of residence as an instrument for the diversification of the farm.

5.3. Policy implications

In the context of improving the resilience of the agricultural sector, enhancing farms' diversification is a relevant objective for policymakers (Barbieri and Mahoney, 2009). In fact, there is evidence that agricultural diversification not only provides agronomic and economic benefits, but it is also a driver of major social benefits in terms of year-round employment (Johnston et al., 1995). While both on-farm and off-farm activities are useful for farmers' income stability, on-farm diversification is a better solution to increase the efficiency of the agricultural sector. In fact, on-farm activities allows farm's resources to remain within the farm enterprise, whereas off-farm activities move capital and labour outside the agricultural sector. This study informs policy-making by highlighting some possible criteria to adopt when tailoring agricultural policies.

A first consideration can be made on farmers' direct payments and subsidies. In several countries worldwide, agricultural policies include direct payments to farmers to assure minimum returns even in times of harsh conditions. Among others, the United States and the European Union provide direct payments to their farmers. In the United States, agricultural payments are regulated by the 1996 Federal Agriculture Improvement and Reform (FAIR) Act. In the European Union, since the 1992 reform of the Common Agricultural Policy (CAP), direct payments have been assigned to farmers as payments either coupled or decoupled to production (Hill, 2023; De Castro et al., 2020). The results of this review suggest that larger support payments very often result in lower diversification. One could argue that farms with higher reliance on public subsidies are less likely to engage in diversification because the income provided by support payments is a substitute of risk abatement strategies, including diversification. The lower propensity to diversify by highly supported farms may arise from the nature of the support, in particular in the European Union. To comply with World Trade Organisation (WTO) rules, an increasing share of support payments have been decoupled to production, i.e. assigned on a per-hectare basis (Sinabell et al., 2013). This form of payment, which is based on land ownership and not any specific objective, tends to favour agricultural rent over profits, hence not encouraging farmers to increase farms' efficiency (Czyzewski and Matuszczak, 2018). Farmers' support payments are likely more effective when assigned to fulfil specific objectives of the agricultural policy, however rent-seeking behaviours might hamper any attempt of reforming direct payments. For example, most of the farmers' protests in the EU in early 2024 were fuelled by the EU announcement of more-stringent environmental criteria to receive CAP payments, as a part of the EU Green Deal (e.g., devoting at least 4 percent of arable land to non-productive features or reducing fertiliser use by 20 percent) (Farokhi et al., 2024).

Other policy actions may be tailored based on holder's characteristics. When considering respondents' age, it was noticed that younger holders likely seek diversification on-farm rather than off-farm, which may be due to high interest in their primary activity. This result gives support to fiscal policies that target young farmers. For example, the CAP in the European Union aims to support younger farmers through several schemes, including larger support payments and loans for purchasing land and other activities, which are useful to support young entrepreneurs in building resilient farms. Similarly, supporting farmers through education schemes is likely successful. This review suggests that propensity to diversify increases with education, both on-farm and off-farm, probably because increase education equip farmers with new skills for their enterprise.

Another way to (re-)orient farmers' policy is to tailor support actions based on farms' characteristics. In this regard, one of the most common grounds for policy support is to look at farm's size, with small and medium-sized farms that should be eligible for larger support. This work overall suggests that on-farm diversification increases for larger farms, whereas off-farm diversification reduces at increasing sizes of the farm. Therefore, supporting small and medium farms' growth likely reflects in larger diversification. A variable that is linked to farm size is farm's net worth. While on-farm studies are too few to draw conclusions, off-farm diversification studies indicate that larger net worth of a farm often results in lower off-farm diversification. This is another evidence that supporting smaller farms for diversification may be successful for the overall improvement of the agricultural sector. In terms of main agricultural productions (e.g. arable crops, permanent crops, husbandry), the balance of evidence is not large enough to draw conclusions on the overall diversification. The only exception is observed for dairy farms, which in the vast majority of occurrences proved to be less likely diversified off-farm and potentially indicates adequate on-farm profitability.

Lastly, another relevant way to tailor agricultural policies is to provide incentives for diversification on a geographical or regional basis. While diversification across farms is generally not influenced by the level of urbanisation of the place, the larger diversification entertained by farms in hilly and mountainous areas suggests that slope and soil roughness may lead farmers to seek income stabilisation through diversification. Therefore, specific policies may consider the geographical location of the farms to effectively encourage diversification.

6. Conclusions

Diversification of the activities in the primary sector is one of the strategies that improves the overall economic sustainability of businesses. For this reason, the scientific literature thoroughly investigated both on-farm and off-farm diversification patterns. This contribution offered a review of econometric studies on on-farm and off-farm diversification, with the threefold objectives of identifying relevant determinants, highlighting potential sources of endogeneity, and understanding the policy implications of diversification studies.

Econometric studies include personal characteristics of the holder, farm's characteristics, and environmental or geographical characteristics of the farm location as drivers of on-farm and off-farm diversification. While further research is desired to understand more precisely what matters in diversification, the overall indication of this review is that all three groups of characteristics that were considered are useful to model farmers' diversification choices. It is therefore recommended to include in future studies variables that capture sociodemographics as well as farm, and environmental characteristics. However, the relative importance of each variable within a group can largely vary. Age and education are the socio-demographics that are used the most, and the high share of significance across models suggest that they are good predictors of diversification choices. However, evidence suggests that gender and marital status are less important. What might be important in couples is the interrelated choice of working off-farm, which is difficult to capture with a single equation, and it is often address using seemingly unrelated models. With respect to farm characteristics, the level of support payments, the net worth of the farm, main productions, and farm size were significant in a large share of instances and included in a number of models large enough to suggest high explanatory power in diversification choices. Lastly, regional and environmental variables are often significant but with a limited use.

Overall, it was found that a number of determinants in excess of 60 were included in econometric models that aim to explain diversification. However, each single model includes only a fraction of these variables. While the sample of collected studies contained only 64 econometric specifications, some interesting indications can be drawn from the study. A first consideration is that about half of the models include less than 10 variables each. Considering the wide range of determinants under analysis in the studies that focus on high-income countries, models with such a low number of explanatory variables are likely incomplete and may be affected by omitted variable bias. The use of large models is encouraged, in particular when national-level secondary data are used because these datasets are large enough to assure an adequate number of degrees of freedom and contain most of the variables discussed in this review. Some of the variables were included less than 5 times in the primary studies, therefore the number of cases is very low. However, these infrequent variables returned significant results in several instances, thus suggesting some explanatory power in modelling diversification (e.g. farmer experience, ownership of tractors, unemployment rate in the region, location in protected areas).

Another consideration provided by the review of documents is that endogeneity is not considered in diversification models. However, several variables are potentially endogenous. In particular, a feedback loop may affect the relationship between diversification and farms that own an insurance, income, and on—farm and off—farm diversification. The obvious way to address endogeneity is the use of instrument variables, however the number of contributions that propose adequate instruments for such endogenous variables is relatively low. Another possibility to address endogeneity is to use data of previous years as an instrument for the last year of data, however this option is subject to panel data availability.

While this systematic review provided useful insights in the main topics of on-farm and off-farm diversification, there are some limitations of the study to consider. One limitation relates to the geographical dimension of the collected studies, which only include high-income countries. This restriction was motivated by the need to achieve a sample of comparable studies. In fact, farmers' choice might have totally different drivers, based on the country in which each farmer resides. However, in several instances farmers compete in global markets and therefore the behaviours of all farmers worldwide are informative for policy. Future studies may explore drivers of diversification in middle and low income countries to achieve a more comprehensive picture of the world agricultural sector.

Furthermore, the primary objective of the review, which was to assess the determinants of diversification, is behind the choice to restrict the review to quantitative studies. This selection is useful to capture general trends, but some specific motivations of farmers can be measured with larger accuracy with different approaches, e.g. qualitative analyses. It is therefore recommended to complement future research with studies that investigate qualitative approaches to diversification.

Lastly, one motivation for this study relates to the data quality and availability. This review highlighted that most of the analyses are performed using cross-sectional dataset. Cross-section data is the natural option for survey-based studies. Questionnaire-based surveys are flexible tools that allow collecting a large amount of information, but questions frequently capture one-year data, mostly because the questionnaire might be too long or because respondents may not recall precisely data from previous years. Multiple yearly observations might be available for studies using secondary data, which are useful sources even if they do not allow control in data collection. The use of panel data is important to highlight differences across individuals and to understand diversification choices based on income, yields, and other circumstances that occurred in previous years. The availability of panels would also be beneficial to address the endogeneity of several variables, e.g. by the use of system GMM models (Blundell and Bond, 2000). In some cases, statistical offices do not keep track of enterprises across years, which hampers the use of panels because the same farm cannot be identified across multiple years. However, a wider use of panel dataset should be encouraged to capture time dynamics and better model unobserved heterogeneity.

Declaration

Authors declare no conflict of interest.

CRediT authorship contribution statement

Gianluca Grilli: Writing – review & editing, Writing – original draft, Methodology, Formal analysis, Data curation, Conceptualization. **Francesco Pagliacci:** Writing – review & editing, Writing – original draft, Supervision, Software, Resources, Funding acquisition, Conceptualization. **Paola Gatto:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources.

Data availability

Data will be made available on request.

Acknowledgements

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This manuscript reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

Appendix A. Complete list of bibliographic sources

ID	Source	Anno	Country	Topic
1	Anosike and Coughenour (1990)	1990	USA	on-farm
2	Ahearn et al. (2006)	1996	USA	off-farm
3	Alasia et al. (2009)	2009	Canada	off-farm
4	Goodwin and Mishra (2004)	2001	USA	off-farm
5	Benjamin (1994)	1994	France	off-farm
6	Bjørnsen and Biørn (2010)	2010	Norway	off-farm
7	Bonfiglio et al. (2022)	2021	Italy	on-farm
8	Bartolini et al. (2014)	2014	Italy	Both
9	Boncinelli et al. (2017)	2017	Italy	on-farm
10	Butinya and Velazco (2014)	2014	Spain	on-farm
11	Damianos and Skuras (1996)	1996	Greece	off-farm
12	El Benni and Schmid (2022)	2022	Switzerland	off-farm
13	Finocchio and Esposti (2008)	2008	Italy	off-farm
14	Gillespie and Mishra (2011)	2011	USA	off-farm
15	Hennessy and Rehman (2008)	2002	Ireland	off-farm
16	Holland et al. (2022)	2022	USA	off-farm
17	Howley et al. (2014)	2014	Ireland	off-farm
18	Huffman (1980)	1980	USA	off-farm
19	Jetté-Nantel et al. (2011)′	2011	Canada	off-farm
20	Khanal and Mishra (2014)	2014	USA	off-farm
21	Kurdys-Kujawska et al. (2021)′	2021	Poland	on-farm
22	Lagerkvist et al. (2007)	2006	USA	off-farm
23	Lien et al. (2010)	2010	Norway	off-farm
24	Mann (2009)	2009	Switzerland	on-farm
25	Mazzocchi et al. (2020)	2020	Italy	on-farm
26	McNamara and Weiss (2005)	2005	Austria	on-farm
27	Meraner et al. (2015)	2015	Netherlands	off-farm
28	Meraner et al. (2018)	2018	Germany	on-farm
29	Mishra and Goodwin (1997)	1999	USA	off-farm
30	Mishra et al. (2004)	2004	USA	on-farm

(continued on next page)

(*continued*)

ID	Source	Anno	Country	Topic
31	Mishra et al. (2010)	1999	USA	off-farm
32	Pfeifer et al. (2009)	2009	Netherlands	on-farm
33	Polling and Mergenthaler (2017)	2017	Germany	on-farm
34	Rivaroli et al. (2017)	2017	Italy	on-farm
35	Serra et al. (2005)	2000	USA	off-farm
36	van Leeuwen and Dekkers (2013)	2013	Netherlands	off-farm
37	Vik and McElwee (2011)	2019	Norway	Both

References

Adger, W., 2006. Vulnerability. Global Environ. Change 16.
Adnan, K.M., Ying, L., Ayoub, Z., Sarker, S.A., Menhas, R., Chen, F., Yu, M., 2020. Risk management strategies to cope catastrophic risks in agriculture: the case of contract farming, diversification and precautionary savings. Agriculture 10 (8), 351.
Agovino, M., Casaccia, M., Ciommi, M., Ferrara, M., Marchesano, K., 2019. Agriculture, climate change and sustainability: the case of eu-28. Ecol. Indicat. 105, 525–543.
Ahearn, M.C., El-Osta, H., Dewbre, J., 2006. The impact of coupled and decoupled government subsidies on off-farm labor participation of us farm operators. Am. J. Agric. Econ. 88 (2), 393–408.
Ahmadzai, H., 2020. How is off-farm income linked to on-farm diversification? evidence from Afghanistan. Studies in Agricultural Economics 122 (1), 1–12.
Alasia, A., Weersink, A., Bollman, R.D., Cranfield, J., 2009. Off-farm labour decision of canadian farm operators: urbanization effects and rural labour market linkages. J. Rural Stud. 25 (1), 12–24.
Anosike, N., Coughenour, C.M., 1990. The socioeconomic basis of farm enterprise diversification decisions 1. Rural Sociol. 55 (1), 1–24.
Bai, Y., Wang, W., Zhang, L., 2022. Off-farm employment experience triggers heterogeneity of exiting part-time farming in rural China. China Agric. Econ. Rev. 14 (3), 567–582.
Barbieri, C., Mahoney, E., 2009. Why is diversification an attractive farm adjustment strategy? insights from Texas farmers and ranchers. J. Rural Stud. 25 (1), 58–66.
Barnum, H.N., Squire, L., 1979. An econometric application of the theory of the farm-household. J. Dev. Econ. 6 (1), 79–102.
Bartolini, F., Andreoli, M., Brunori, G., 2014. Explaining determinants of the on-farm diversification: empirical evidence from tuscany region. Bio base Appl. Econ. 3 (2), 137–157.
Benjamin, C., 1994. The growing importance of diversification activities for French farm households. J. Rural Stud. 10 (4), 331–342.
Benjamin, C., Guyomard, H., 1994. Off-farm work decisions of French agricultural households. Agricultural household modelling and family economics 10, 65–86.
Benjamin, C., Kimhi, A., 2006. Farm work, off-farm work, and hired farm labour: estimating a discrete-choice model of French farm couples' labour decisions. Eur. Rev. Agric. Econ. 33 (2), 149–171.
Bjørnsen, H.-M., Biørn, E., 2010. Interrelated labor decisions of farm couples: a censored response analysis of off-farm work. Agric. Econ. 41 (6), 595–610.
Blundell, R., Bond, S., 2000. Gmm estimation with persistent panel data: an application to production functions. Econom. Rev. 19 (3), 321–340.
Blundell, R., Bond, S., 2023. Initial conditions and blundell–bond estimators. J. Econom. 234, 101–110.
Boncinelli, F., Bartolini, F., Casini, L., Brunori, G., 2017. On farm non-agricultural activities: geographical determinants of diversification and intensification strategy. Letters in Spatial and Resource Sciences 10, 17–29.
Bonfiglio, A., Abitabile, C., Henke, R., 2022. A choice model-based analysis of diversification in organic and conventional farms. Bio base Appl. Econ. 11 (2), 131–146.
Butinya, L., Velazco, J., 2014. Determinants of on-farm diversification: the case of farmers in catalonia. Technical report.
Cei, L., Defrancesco, E., Gatto, P., Pagliacci, F., 2023. Pay more for me, i'm from the mountains! the role of the eu mountain product term and other credence attributes in consumers' valuation of lamb meat. Agricultural and Food Economics 11 (1), 12.
Chang, C.-C., DeVaney, S.A., Chiremba, S.T., 2004. Determinants of subjective and objective risk tolerance. Journal of Personal finance 3 (3), 53–67.
Chang, H.-H., Mishra, A., 2008. Impact of off-farm labor supply on food expenditures of the farm household. Food Pol. 33 (6), 657–664.
Cochrane, W.W., 1958. The agricultural treadmill. Farm Prices, Myth and Reality. University of Minnesota Press, Minneapolis, pp. 85–107.
Cornaggia, J., 2013. Does risk management matter? evidence from the us agricultural industry. J. Financ. Econ. 109 (2), 419–440.
Czyzewski, B., Matuszczak, A., 2018. Rent-seeking in agricultural policy revisited: a new look at the common agricultural policy consensus. Studies in Agricultural Economics 120 (1316–2018-3607), 69–79.
Damianos, D., Skuras, D., 1996. Farm business and the development of alternative farm enterprises: an empirical analysis in Greece. J. Rural Stud. 12 (3), 273–283.
Dary, S.K., Kuunibe, N., 2012. Participation in rural non-farm economic activities in Ghana. Am. Int. J. Contemp. Res. 2 (8), 154–161.
De Castro, P., Miglietta, P.P., Vecchio, Y., 2020. The common agricultural policy 2021-2027: a new history for european agriculture. Riv. Econ. Agrar. 75 (3).
Di Bene, C., Francaviglia, R., Farina, R., Alvaro-Fuentes, J., Zornoza, R., 2022. Agricultural diversification. Agriculture 12 (3), 369.
Diiro, G.M., Sam, A.G., 2015. Agricultural technology adoption and nonfarm earnings in Uganda: a semiparametric analysis. J. Develop. Area. 145–162.
El Benni, N., Schmid, D., 2022. Off-farm income and direct payments—an indispensable diversification strategy of swiss farmers. Q Open 2 (1), qoab019.
Farokhi, A.S., Harmanny, K.S., Schulp, C.J., 2024. Aligning agri-environmental-climate public good supply and desire in a sustainable Dutch agricultural sector. Ambio 1–17.
Finocchio, R., Esposti, R., 2008. Determinants of farm diversification and interaction with the cap. an application to fadn of marche region (italy).
Gillespie, J., Mishra, A., 2011. Off-farm employment and reasons for entering farming as determinants of production enterprise selection in us agriculture. Aust. J. Agric. Resour. Econ. 55 (3), 411–428.
Goodwin, B.K., Mishra, A.K., 2004. Farming efficiency and the determinants of multiple job holding by farm operators. Am. J. Agric. Econ. 86 (3), 722–729.
Gui, R., Meierer, M., Schilter, P., Algesheimer, R., 2023. Rendo: internal instrumental variables to address endogeneity. J. Stat. Software 107, 1–43.
Hellerstein, D., Higgins, N., Horowitz, J., 2013. The predictive power of risk preference measures for farming decisions. Eur. Rev. Agric. Econ. 40 (5), 807–833.
Hennessy, T.C., Rehman, T., 2008. Assessing the impact of the 'decoupling'reform of the common agricultural policy on Irish farmers' off-farm labour market participation decisions. J. Agric. Econ. 59 (1), 41–56.
Hiebl, J., Frei, C., 2023. Correction to: daily precipitation grids for Austria since 1961—development and evaluation of a spatial dataset for hydroclimatic monitoring and modelling. Theor. Appl. Climatol. 151 (1–2), 951–951.
Hill, B.E., 2023. The Common Agricultural Policy: Past, Present and Future, vol. 14. Taylor & Francis.
Holland, R., Khanal, A.R., Dhungana, P., 2022. Agritourism as an alternative on-farm enterprise for small us farms: examining factors influencing the agritourism decisions of small farms. Sustainability 14 (7), 4055.
Howley, P., Dillon, E., Hennessy, T., 2014. It's not all about the money: understanding farmers' labor allocation choices. Agric. Hum. Val. 31, 261–271.
Huffman, W.E., 1980. Farm and off-farm work decisions: the role of human capital. Rev. Econ. Stat. 14–23.
Husnain, M.I.U., Subramanian, A., Haider, A., 2018. Robustness of geography as an instrument to assess impact of climate change on agriculture. International journal of climate change strategies and management 10 (5), 654–669.
Iqbal, M.A., Rizwan, M., Abbas, A., Makhdum, M.S.A., Kousar, R., Nazam, M., Samie, A., Nadeem, N., 2021. A quest for livelihood sustainability? patterns, motives and determinants of non-farm income diversification among agricultural households in Punjab, Pakistan. Sustainability 13 (16), 9084.
Jack, C., Adenuga, A.H., Ashfield, A., Mullan, C., 2021. Understanding the drivers and motivations of farm diversification: evidence from northern Ireland using a mixed methods approach. Int. J. Enterpren. Innovat. 22 (3), 161–176.
Jetté-Nantel, S., Freshwater, D., Katchova, A.L., Beaulieu, M., 2011. Farm income variability and off-farm diversification among Canadian farm operators. Agric. Finance Rev. 71 (3), 329–346. https://doi.org/10.1108/00021461111177602.
Johnston, B.F., Mellor, J.W., 1961. The role of agriculture in economic development. Am. Econ. Rev. 51 (4), 566–593.
Johnston, G., Vaupel, S., Kegel, F., Cadet, M., et al., 1995. Crop and farm diversification provide social benefits. Calif. Agric. 49 (1), 10–16.
Kahrass, H., Borry, P., Gastmans, C., Ives, J., van der Graaf, R., Strech, D., Mertz, M., 2021. Prisma-ethics–reporting guideline for systematic reviews on ethics literature: development. explanations and examples.
Khanal, A.R., Mishra, A.K., 2014. Agritourism and off-farm work: survival strategies for small farms. Agric. Econ. 45 (S1), 65–76.
Kilic, T., Carletto, C., Miluka, J., Savastano, S., 2009. Rural nonfarm income and its impact on agriculture: evidence from Albania. Agric. Econ. 40 (2), 139–160.
Kurdys-Kujawska, A., Strzelecka, A., Zawadzka, D., 2021. The impact of crop diversification on the economic e' fficiency of small farms in poland. Agriculture 11 (3), 250.
Lagerkvist, C.J., Larsen, K., Olson, K.D., 2007. Off-farm income and farm capital accumulation: a farm-level analysis. Agric. Finance Rev. 67 (2), 241–257.
Lien, G., Kumbhakar, S.C., Hardaker, J.B., 2010. Determinants of off-farm work and its effects on farm performance: the case of Norwegian grain farmers. Agric. Econ. 41 (6), 577–586.
MacDonald, D., Crabtree, J., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Gutierrez Lazpita, J., Gibon, A., 2000. Agricultural abandonment in mountain areas of europe: environmental consequences and policy response. J. Environ. Manag. 59, 47–69.

Mann, S., 2009. The Nature of the Diversified Farm Household. Forschungsanstalt Agroscope ReckenholzTanikon ART.̈. Technical report.
Mazzocchi, C., Orsi, L., Ferrazzi, G., Corsi, S., 2020. The dimensions of agricultural diversification: a spatial analysis of Italian municipalities. Rural Sociol. 85 (2), 316–345.
Mazzocchi, C., Sali, G., 2016. Sustainability and competitiveness of agriculture in mountain areas: a willingness to pay (wtp) approach. Sustainability 8 (4), 343.
McNamara, K.T., Weiss, C., 2005. Farm household income and on-and off-farm diversification. J. Agric. Appl. Econ. 37 (1), 37–48.
Meraner, M., Heijman, W., Kuhlman, T., Finger, R., 2015. Determinants of farm diversification in The Netherlands. Land Use Pol. 42, 767–780.
Meraner, M., Polling, B., Finger, R., 2018. Diversification in peri-urban agriculture: a case study in the ruhr metropolitan̈ region. J. Land Use Sci. 13 (3), 284–300.
Mishra, A.K., El-Osta, H.S., Sandretto, C.L., 2004. Factors affecting farm enterprise diversification. Agric. Finance Rev. 64 (2), 151–166.
Mishra, A.K., Erickson, K.W., Harris, J.M., Hallahan, C.B., Uematsu, H., 2010. Determinants of farm household income diversification in the United States: evidence from farm-level data. Technical report.
Mishra, A.K., Goodwin, B.K., 1997. Farm income variability and the supply of off-farm labor. Am. J. Agric. Econ. 79 (3), 880–887.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., Group, P., et al., 2010. Preferred reporting items for systematic reviews and meta-analyses: the prisma statement. Int. J. Surg. 8 (5), 336–341.
Mulungu, K., Kimani, M.E., Sarr, M., 2023. Do farmers' risk preferences remain stable in the face of climatic shocks? evidence from smallholder farmers in Zambia. Appl. Econ. 1–17.
Nicita, L., Bosello, F., Standardi, G., Mendelsohn, R., 2024. An integrated assessment of the impact of agrobiodiversity on the economy of the euro-mediterranean region. Ecol. Econ. 218, 108125.
Nicita, L., Cucuzza, G., De Salvo, M., Prato, C., Signorello, G., 2020. Spatial effects and endogeneity in a ricardian model of climate change: an application to a mediterranean region. Spatial Econ. Anal. 15 (3), 219–237.
Ochieng, J., Kirimi, L., Ochieng, D.O., Njagi, T., Mathenge, M., Gitau, R., Ayieko, M., 2020. Managing climate risk through crop diversification in rural Kenya. Climatic Change 162, 1107–1125.
O'Donoghue, E.J., Roberts, M.J., Key, N., 2009. Did the federal crop insurance reform act alter farm enterprise diversification? J. Agric. Econ. 60 (1), 80–104.
Papaioannou, K.J., 2016. Climate shocks and conflict: evidence from colonial Nigeria. Polit. Geogr. 50, 33–47.
Pastusiak, R., Jasiniak, M., Soliwoda, M., Stawska, J., 2017. What may determine off-farm income? a review. Agric. Econ. 63 (8), 380–391.
Pfeifer, C., Jongeneel, R.A., Sonneveld, M.P., Stoorvogel, J.J., 2009. Landscape properties as drivers for farm diversification: a Dutch case study. Land Use Pol. 26 (4), 1106–1115.
Polling, B., Mergenthaler, M., 2017. The location matters: determinants for "deepening" and "broadening" diversification̈ strategies in ruhr metropolis' urban farming. Sustainability 9 (7), 1168.
Quddoos, A., Salhofer, K., Morawetz, U.B., 2023. Utilising farm-level panel data to estimate climate change impacts and adaptation potentials. J. Agric. Econ. 74 (1), 75–99.
Rivaroli, S., Ghelfi, R., Bertazzoli, A., Piorr, A., 2017. Diversification pathways and farming systems: insights from the emilia-romagna region, Italy. Outlook Agric. 46 (4), 239–247.
Salvioni, C., Henke, R., Vanni, F., 2020. The impact of non-agricultural diversification on financial performance: evidence from family farms in Italy. Sustainability 12 (2), 486.
Serra, T., Goodwin, B.K., Featherstone, A.M., 2005. Agricultural policy reform and off-farm labour decisions. J. Agric. Econ. 56 (2), 271–285.
Sinabell, F., Schmid, E., Hofreither, M.F., 2013. Exploring the distribution of direct payments of the common agricultural policy. Empirica 40, 325–341.
Stokes, C., Howden, M., 2010. Adapting Agriculture to Climate Change: Preparing Australian Agriculture, Forestry and Fisheries for the Future. CSIRO publishing.
Tamburini, G., Bommarco, R., Wanger, T.C., Kremen, C., Van Der Heijden, M.G., Liebman, M., Hallin, S., 2020. Agricultural diversification promotes multiple ecosystem services without compromising yield. Sci. Adv. 6 (45), eaba1715.
Tittonell, P., Muriuki, A., Shepherd, K.D., Mugendi, D., Kaizzi, K., Okeyo, J., Verchot, L., Coe, R., Vanlauwe, B., 2010. The diversity of rural livelihoods and their influence on soil fertility in agricultural systems of east africa–a typology of smallholder farms. Agric. Syst. 103 (2), 83–97.
Ullah, R., Shivakoti, G.P., 2014. Adoption of on-farm and off-farm diversification to manage agricultural risks: are these decisions correlated? Outlook Agric. 43 (4), 265–271.
Van der Ploeg, Roep, D., 2003. Multifunctionality and rural development: the actual situation in Europe. Multifunct. Agric.: New Paradigm Eur. Agric. Rural Dev. 1, 37–53.
van Leeuwen, E., Dekkers, J., 2013. Determinants of off-farm income and its local patterns: a spatial microsimulation of Dutch farmers. J. Rural Stud. 31, 55–66.
Vik, J., McElwee, G., 2011. Diversification and the entrepreneurial motivations of farmers in Norway. J. Small Bus. Manag. 49 (3), 390–410.
Weber, J.G., Key, N., O'Donoghue, E., 2016. Does federal crop insurance make environmental externalities from agriculture worse? Journal of the Association of Environmental and Resource Economists 3 (3), 707–742.
Yin, Y.-n., Wang, Y., Jiang, N.-j., Long, D.-r., 2020. Can case management improve cancer patients quality of life?: a systematic review following prisma. Medicine 99 (40).
Zafeiriou, E., Azam, M., Garefalakis, A., 2023. Exploring environmental–economic performance linkages in eu agriculture: evidence from a panel cointegration framework. Manag. Environ. Qual. Int. J. 34 (2), 469–491.
Zhao, J., Barry, P.J., 2014. Income diversification of rural households in China. Canadian Journal of Agricultural Economics/Revue canadienne d`agroeconomie 62 (3), 307–324.
Zou, B., Ren, Z., Mishra, A.K., Hirsch, S., 2022. The role of agricultural insurance in boosting agricultural output: an aggregate analysis from Chinese provinces. Agribusiness 38 (4), 923–945.