The dimensions of agricultural diversification: a spatial analysis of Italian municipalities

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Abstract

Diversification in agriculture could ensure the survival of farming by broadening the income base of farms and encouraging agricultural sustainability. The diversification of on-farm activities may depend on socio-economic and environmental characteristics. Although multifunctionality is a hotly debated topic, few papers have focused on the farm characteristics that influence diversification and none have focused on the influence of the spatial pattern. This paper examines the relationship between farm characteristics and the adoption of a specific type of diversification. An econometric model is presented that uses a spatial autoregressive lag model at the municipal scale. The results demonstrate that the activation of each diversification dimension is influenced by both internal and external factors, encompassing farmers' characteristics, the farm structure and territorial features, including regional and spatial patterns. Deepening is mainly influenced by the farmer's age, education, and the presence of small and labor-intensive farms. The key factors for broadening diversification are the presence of small farms and farms with mixed production (breeding and crop cultivation). Regrounding is most affected by the labor-intensive farms in the area and the farms with mixed production.

Keywords: agricultural diversification, agricultural multifunctionality, rural development, agricultural sustainability

1. Introduction

Multifunctionality is one of the interpretative keys used to analyze the evolution of agriculture in contemporary societies (Henke et al., 2014) all over the world. According to Van Der Ploeg et al. (2016), over the last thirty years, multifunctionality has developed enormously and has become significant in the agricultural sector in Western Countries. The concept of multifunctionality was initially conceived in European policy. Today it is also fundamental in the United States, although according to Jourdan and Douglass Warner (2010), the adoption of multifunctionality in the US is not yet extensive due to constraints in "*sociopolitical, economic, and ecologic factors that are interrelated and mutually reinforcing*" (pp.60).

Some scholars aim to apply multifunctionality to new geographical and agricultural contexts such as Australia, Japan, Thailand, and New Zealand (Brummel and Nelson, 2014, Caron-Flinterman et al., 2010; Hollander, 2004; Holmes, 2006). In addition, in developing countries multifunctionality is one of the most effective pathways for sustainable development as it combines food security, productivity and the economic performance of smallholders with environmental protection (Moon, 2015).

Multifunctional agriculture in developing countries is an emerging issue (Bresciani et al., 2004, Losch, 2004, Wilson, 2007, Wilson, 2009). The management of the landscape (Israel and Wynberg, 2018), sustainable meat production (Marandure et al., 2018), low impact biofuel (Manu, 2017), and ecosystem services (Thorn et al., 2015) are some of the most relevant issues discussed in the recent literature on multifunctionality in developing countries.

Multifunctionality is the process of producing goods and services other than those that are strictly agricultural and involves a reorganization of allocated inputs (Heringa et al., 2013; Henke et al., 2014). Nevertheless, due to the multidisciplinary nature of the concept, several definitions of multifunctionality exist (Fagioli et al., 2017). Our starting point is the OECD definition (2001, pp.13) "*The key elements of multi-functionality are: (i) the existence of multiple commodity and non-commodity outputs that are jointly produced by agriculture and (ii) the fact that some of the non-commodity outputs exhibit the characteristics of externalities or public goods, with the result that markets for these goods do not exist or function poorly*."

This definition shows the dual nature of multifunctional agriculture. On the one hand, agriculture is a producer of public goods which, voluntarily or involuntarily, are made available to the entire community without any remuneration from the market. On the other hand, agricultural multifunctionality is the ability to produce private goods through the diversification of production aimed at providing new sources of income for farmers. This dual nature of multifunctionality corresponds to the reaction of farms to the crisis of the agricultural productivist model leading to the standardization of the agricultural sector which, for some authors, has contributed to its global economic decline (Marsden and Sonnino, 2008, Henke and Salvioni, 2010). According to Garcia-Arias et al. (2015), the framework of post-productivism as an exceeding of productivism, is described by diversification both in terms of the production and the consumption with activity extensification. Nevertheless, the term "non-productivism" rather than "post-productivism" is better for defining those changes that are not in line with productivism logic and which have occurred in farming in the last thirty years (Wilson, 2007). In describing multifunctionality in terms of farm strategies, Wilson (2007) proposes a multifunctionality-intensity scale from a weak to a strong level of multifunctionality.

The increase in diversification in the European farming sector is also encouraged by the Common Agricultural Policy (CAP), which since the reform of the structural funds in 1988 has fostered farm diversification based on the multifunctional character of European Union agriculture (Garcia-Arias et al., 2015). Today, in the CAP 2014-2020 farmers can earn additional income by exploiting the agro-environmental measures of the Rural Development Programme (RDP) or the *greening* payment [1]. Alternatively, agricultural activities can be diversified through other economic sectors, such as tourism or products, which are aimed to ensure revenues by widening the farm's income base (Mazzocchi and Sali, 2018, Arzeni and Sotte, 2013, Zasada, 2011).

As for Non-Commodity Outputs (NCOs), these are goods and services provided by agriculture, which shape the environment, affect the social and cultural system, and contribute to economic growth (Fagioli et al., 2017). Several studies have focused on the definition of agriculture NCOs (Vandermeulen et al., 2006, Andersen et al., 2013, Fagioli et al., 2017), have analysed the NCOs of multifunctional farms (Andersen, 2013), and have assessed the NCO value of the whole agri-food system (Fagioli et al., 2017) with econometrics and statistical models. At the opposite, some studies have used a survey approach, for example, to identify societal preferences for agricultural externalities (Pérez y Pérez et al., 2019).

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[1] In Italy, the National Strategic Plan (NSP) has been approved by EU and drew the main Italian agriculture guidelines. Then, each Region presented its RDP that has been approved by EU and Italian State. Once the RDP of a Region has been approved, it is managed by the Region itself. Thus, each Region adapted the general framework of NSP to the needs of its agricultural sector, by implementing specific measures.

Although assessing the value of agriculture externalities is a hotly debated topic, diversification is fundamental for providing new sources of income. The diversification of farms' productive activities is key to innovation (Vázquez-Barquero and Rodríguez-Cohard, 2016) and is mainly focused on tourist activities (e.g. Di Bella et al., 2019, Romao et al., 2018). In fact, diversification could lead to the innovation of agricultural production, because its implementation has usually led to the reorganization of agricultural production factors and entrepreneurial skills (OECD, 2005; Wilson, 2008; Jackson-Smith and Jensen, 2009).

In fact, according to the results of the EU-funded research program IMPACT, which analyzed seven countries (Ireland, the UK, the Netherlands, Germany, France, Italy and Spain), the diversification of agricultural activities contributed to an income of 6.95 billion euros, which, in many cases, represented a decisive contribution to the farms’ viability in addition to the main agricultural income (Van Der Ploeg et al., 2016). As reported in Vogel (2012), also in the United States the contribution of diversification activities to the total value of US agricultural production has reached 40%.

This paper examines the relationship between farm characteristics and the adoption of a specific type of diversification on Italian farms. Our aim was to assess the determinants of agricultural diversification choices and test the influence of the spatial element on the diversification typologies, using a spatial autoregressive lag model, implemented at a municipal scale.

The paper aims to add to the knowledge of diversification patterns in European countries and identifies how farm, farmer and territorial and spatial characteristic should be integrated into the farm strategy in order to better benefit from RDPs. Furthermore, the goal of spatial approach is to define regional and local patterns of diversification.

Section 2 describes the data and methods and Section 3 shows the results by a macro-group of independent variables: *Farmer’s characteristics (FCs), Farm structure (FS)* and *Territorial features (TFs).* In Section 4 we present and discuss the results. Section 5 presents the conclusions, highlighting the main contributions and limitations of this work.

1.1 The drivers of farm diversification

Diversification is defined as the development of income-earning activities beyond conventional crops and livestock businesses associated with agriculture (McInerney et al. 1989, Ilbery et al., 1991, Dries et al., 2012). Diversification could be interpreted as an exit-strategy derived from a period of economic crisis or simply the logical development in the use of natural resources (McInerney et al. 1989). However, different strategies can be followed simultaneously (Dries et al., 2012). A farmer's decision to diversify the on-farm activities may depend on external socio-economic and environmental characteristics or on the characteristics of the farm (Mazzocchi et al., 2014, De Filippis and Henke, 2014). In the literature a number of studies have investigated the diversification determinants of farms.

According to Dries et al. (2012) one of the main external drivers of farm diversification is the location: including the proximity to urban centers and the landscape features. Urban centers can be a source of the consumer demand for diversification services, such as recreational activities or on-farm activities. Several studies have affirmed the demand-driven effects of space on diversification, with farms that are closer to tourist sites or urban areas being more likely to diversify their production (Boncinelli et al., 2018, Zasada, 2011) because of a higher demand for farming services.

Beautiful landscapes could foster consumer demand for some typologies of diversification such as as agro-tourism activities, however some specific landscape features such as the altitude of the farm could pose constraints (Sharpley and Vass, 2006). Boncinelli (2017) found that an important option for enterprises located in marginal areas with structural constraints is the possibility to diversify income.

For example, with regard to mainland Italy, Henke et al. (2014) showed that diversification regards a still limited number of farms. De Filippis and Henke (2014) reported that in southern Italy, the structural features of the agricultural sector explain the low degree of diversification, namely that geography tends to orient farms toward a specific agro-industrial chain. At the same time Dries et al. (2012) affirmed that the Italian heterogeneity of the agricultural sector described by geographical variety, economic differences between the north and south, and environment diversity have led to a strong differentiation between farm strategies.

Arzeni and Sotte (2013) believe that the main external driver of diversification is the economic support provided by the CAP. In the CAP 2007-2013 programme, diversification is included in the thematic axes of the Rural Development Program: Axis 3 is focused on improving the quality of life in rural areas and encouraging the diversification of agriculture (Jensen, 2018). In the 2014-2020 Rural Development Program, the thematic sub programs of the European Priorities include the development of short supply chains and of quality schemes for agricultural products and foodstuffs, both linked to the agricultural diversification of European farms.

Other studies have focused on internal drivers, which depend on how a farm is organized and the farmers themselves. Focusing on the intensity level of diversification in Emilia-Romagna, Rivaroli et al. (2011) reported how larger and better-equipped farms, located in hilly or mountain areas, frequently managed by younger and better-educated farmers, are characterized by the highest degree of diversification. Meraner et al. (2015) also found a positive relationship between younger farmers and diversification, and Bowman and Zilberman (2013) confirmed the fact that the higher the education level of farmers, the higher the degree of diversification.

Benjamin (1994) and Bateman & Ray (1992) assessed the influence of farm size on farm diversification. This was also highlighted by Pfeifer et al (2009) who found that the fact that a farm is large has a significantly negative impact on the degree of diversification, suggesting that diversification might be used as a survival strategy by small farms, since they do not have the opportunity to increase in size. Benjamin and Kimhi (2006) focused on labour allocation such as the number of employees on farms, which could impact on diversification, since less labour means fewer new labour-intensive activities.

In terms of crop choices, organic agriculture is still regarded by many in the farming industry as an example of farm diversification (Maye, 2009), because it is a useful production choice aimed at a specific niche market. In their analysis on the typologies of European diversified farms, Weltin et al. (2017) found a positive relationship between farms that diversify their business by implementing an organic production, and young farmers, i.e. young farmers choose organic agriculture as a strategy to increase their income. The authors also showed the importance of the mixed production approach, i.e. the production of both animal and vegetable goods on a farm, in less favourable mainly mountainous areas. On these farms, the diversification strategies are thus aimed at both crops and the animal agricultural sector. Specialization also plays an important role, with extensive livestock and seasonal production, such as horticultural crops, being found to be more suited to a combination with other agricultural activities, contrary to intensive livestock and dairy productions (Dries et al., 2012, Centre for Rural Policy Research, 2003, Meert et al., 2005).

Finally, gender seems to be another variable influencing diversification in agriculture. Villamor et al. (2014) argue that gender may influence the decision to promote landscape quality through the diversification of the agricultural landscape. In addition, in the literature, gender influences the implementation of diversification activities, with females seeming to diversify agricultural activities more than males (Joo et al., 2013), and the presence of female-farm workers where farm diversification activities exist (Benjamin and Kimhi, 2006).

Van Der Ploeg and Roep (2003) propose a helpful classification in understanding the concept of farm diversification by clustering the activities in three dimensions: deepening, broadening and regrounding. In their model, these three dimensions contribute to extending the farm business, represented by a triangle, consisting of the agro-food supply chain, rural area and mobilization of resources (Van Der Ploeg and Roep, 2003, pp.6). Deepening relates to the agricultural activities that transform, expand and/or relink to other actors in order to provide products that entail more value added per unit "*precisely because they fit better with the demands in society at large*" (Van Der Ploeg and Roep, 2003, pp.6). A typical example of deepening is organic farming[2]. Broadening is defined as the "*rural*" character of agriculture, and "*taken together, such activities enlarge the income flows of the farm enterprise*" (Van Der Ploeg and Roep, 2003, pp.6). Broadening includes complementary activities such as agritourism. Regrounding is characterized by the mobilization of farm resources, which is the ability of farmers to employ their own machinery in order to work for third parties (e.g. ploughing another farmer's field or working on the parks of the local council). Taken together, deepening, broadening and regrounding reshape the farm into a multifunctional enterprise that offers a broader range of products and services (OECD, 2000; Wiskerke 2001).

Although multifunctionality is a hotly debated topic, few papers have focused on the farm characteristics that influence diversification. Lange et al. (2013), Meraner et al. (2015) and Pölling and Mergenthaler (2017) investigated the internal and external influences on the implementation of the three dimensions. The latter two analyzed the farm characteristics underlying the general decision to diversify, and then defined the characteristics behind the specific forms of diversification. Meraner et al. (2015) focused on the socio-demographic, economic and geophysical features, and Pölling and Mergenthaler (2017) explored the characteristics of the farms, farmers and locations. Concentrating on deepening and broadening and using binomial logit models as well as the multinomial probit model at the farm level, these two papers examined which factors influence whether or not a farmer decides to diversify. Our approach extends the Van Der

[2] For a complete list of the activities included in deepening, broadening and regrounding dimensions, see par. 2.2

Ploeg and Roep model by analyzing which variables, grouped into *Farmer's characteristics (FCs), Farm structure (FS)* and *Territorial features (TFs)*, influence a specific type of diversification and how (Figure 1).

Figure 1. The drivers of diversification at the farm enterprise level. Our analysis of the Van Der Ploeg and Roep model (Van Der Ploeg and Roep, 2003, pp.7)

Our approach also analyzes the factors impacting the "intensity of diversification", intended as the number of Deepening, Broadening and/or Regrounding activities at the municipal level, by developing spatial simultaneous autoregressive lag models.

2. Methodology

The paper aims to assess the influence of various characteristics of farms on the implementation of a specific diversification dimension, in a specific geographical area. The paper uses an econometric model based on a spatial simultaneous autoregressive lag models, explained in detail in Section 2.3.

2.1. Case study and data sample

Data were downloaded from ISTAT digital databases[3] from the VI Census of Agriculture (2010), and the XV Census of Population and Habitat (2011), as shown in Table 1.

The database includes all Italian municipalities in which farms are involved in diversification activities. In Italy, there are 8,095 municipalities that "host" farms involved in diversification activities, with a total of 98,839 activities distributed into deepening, broadening and regrounding (Table 1). Note that each farm may implement more than one activity, as the Istat database refers to the number of activities and not the number of farms.

2.2. Conceptual framework

As with the dependent variables, the diversification activities implemented on Italian farms, at a municipal scale, were grouped as follows using the Van der Ploeg and Roep classifications:

- Deepening: geographical and process certification production, organic production;

[3] Italian National Institute of Statistics

- Broadening: agritourism, direct sales on farm, recreational and social activities, teaching, handicrafts, initial processing of agricultural products, processing of vegetable and animal products, renewable energy production, wood processing, aquaculture, forestry, production of complete and complementary feed;
- Regrounding: farmers use their own machinery in order to be able to work for third parties, for example providing livestock services, restoring parks and gardens, gardening services, managing and cleaning of municipal land.

In accordance with the literature, the conceptual framework was developed in order to include the variables that could influence diversification in Italian municipalities. The explanatory variables (Table 1) were divided into three groups: *Farmers' characteristics (FCs), Farm structure (FS)* and *Territorial features (TFs).*

Assuming that the farmer can choose their own diversification strategy of his/her farm, the *FCs*, namely gender, age, education may condition the orientation toward a specific dimension following a specific pathway. For instance, according to the literature, small farms are more likely to adopt broadening activities (Meraner et al., 2015). Finally, farmers can benefit from the features of the geographical area where the farms are located. Farms in urban and periurban areas could take advantage of the local demand for products and services, and conversely farms in marginal areas could develop tourist services in order to increase their income (Mazzocchi et al., 2014).

Table 1. Description of variables.

FCs include: FAGE, WOM, EDU.

The farmer's age (FAGE) was used to verify the influence of the generational turnover on the implementation different diversification dimensions. Young farmers are usually more interested in innovation and diversification, for example in recreational activities (Pfeifer et al., 2009). To assess the link between a high education level and the propensity towards diversification, the educational level was considered (EDU). The percentage of female farm managers (WOM) was selected to verify the potential connection between gender and the choice of different activities as highlighted by some authors (Villamor et al., 2014), especially with regard to care for the landscape and environmental management.

The *FS* includes: LAB, MIX, COMP, SMALL, HOURS.

The presence of employees (LAB) is useful to verify the connection between professional farms and diversification. This connection is not immediately obvious because it sometimes represents the expansion strategy of farms which requires the employment of further staff. For example, farms need an additional labour for agritourism or farmers' markets. A mixed farm (MIX) is a farm that produces both vegetable and animal products. This production strategy could influence a farmer's decision to implement some activities rather than others. For example, tourism could be positively influenced by a mixed production rather than an intensive monoculture due to the greater variety of landscapes and the didactic opportunities offered by this kind of farm organization (Pfeifer et al., 2009). Other kinds of diversification, for example subcontracting, could be linked to the strong specialization of a farm in a specific agricultural sector.

In this analysis, the farm surface was considered as influencing the decision to diversify. The aim was to estimate whether small farms[4] (SMALL) are more interested in diversifying their production in relation to broadening, because of their small area of agricultural land available. Regarding the Italian decrease in the number of farms in the past 40 years, the most affected farms are those with less than 5 ha. Thus, small enterprises, more than the big ones, need to find alternative sources of income. The variable expressing the digitalization of farms (COMP), includes farms using information technology in administrative services, farms with online access, a personal web page, and with e-commerce. This variable measures the connection between farm access to IT systems and the implementation of activities requiring advertisements. The number of farms with a high number of working hours per year (HOURS) indicates the labour-intensive farms or the farms with a high labour force.

Territorial features were introduced as explanatory variables. *TFs group (TFs)* is: MOUN, DENS, POP, FARMS, REGION.

MOUN was added as a proxy of the Less Favoured Areas (LFAs) in which farms lay. On the one hand, Pfeifer et al (2009) found that location plays a role in explaining the number of diversification activities taken up by farmers; for example, proximity to national parks and mountain landscapes seems to be one of

[4] with less than 5 ha of UAA

the drivers of diversification. On the other hand, in Italy, MOUN has been considered an important variable in terms of multifunctional activities since the farm location can lead to the receipt of CAP subsidies from regional RDPs. POP may represent the magnitude of the demand, and it is possible that where the demand is higher, the more diversification activities will be requested. DENS is a proxy of the level of urbanization in relation to population.

Finally, the FARMS variable represents the degree of rurality in the area, since this may influence the different type of diversification. Lastly, we included a dummy variable (REGION) for each region (Italy is made up of twenty regions), to test the significance of regional characteristics influencing the implementation of diversification dimension. We chose Abruzzo as the benchmark to compare the results of each region. Thus, in this case the result indicates the deviation of each region relative to the benchmark.

Some variables (FARMS, POP, DENS, HOURS) were selected as "*control variables*", in order to test the robustness of the models.

A correlation analysis was performed to assess the existence of a high correlation among the variables. A correlation higher than 0.7 was taken as a threshold to consider those variables in a further analysis. Finally, a negative binomial regression analysis was implemented separately for each type of diversification. Starting with the control variables, the other variables were added to evaluate the effect of each one on the regression.

2.3 Model Specification

A spatial simultaneous autoregressive lag model was developed to verify the relationship between various farm characteristics and the territory and the adoption of a specific type of diversification.

Thus, our dependent variables are: deepening (DEEP), broadening (BROAD), regrounding (REGR).

Each dimension was used as a dependent variable in the spatial simultaneous autoregressive lag model, testing farm factors as explanatory variables, to assess their influence on the diversification dimensions, and three models (DEEP model, BROAD model and REGR model), one for each dimension, were obtained.

Since our observation units are the Italian municipalities and the geographic data tend to be spatially dependent, we implemented a spatial simultaneous autoregressive lag model to estimate our results. The common ordinary least squares (OLS) estimates, though unbiased, are inefficient when spatial dependence is present (Anselin 1988). Spatial dependence is "the propensity for nearby locations to influence each other and to possess similar attributes" (Goodchild, 1992, p.33).

Spatial lag is indicative of a possible diffusion of knowledge, innovative processes and innovative activities because of the spatial dimension of territorial characteristics, social interactions and collaborations, which are typically considered as important drivers for development and knowledge spillovers (De Noni et al., 2017; De Noni et al., 2018; Apa et al., 2018).

In terms of social and rural activities, certain diversification choices could be characterized by a strong spatial dimension. Spatial econometrics enable us to incorporate these spatial effects using econometric models that take into account any spillover or interaction.

We conducted a number of statistical tests to verify our choice of model. The Moran I test (see Table 3) was applied to measure the spatial autocorrelation given a set of features and an associated attribute. The result confirms that geographical and process certification, the number of agri-touristic activities and the number of agricultural and non-agricultural activities at the municipal level are spatially clustered activities. The Lagrange Multiplier (LM-lag) and Robust Lagrange Multiplier (RLM-lag) tests also confirmed that our dependent variables are spatially lagged.

We used the R[5] package spdep (spatial dependence) to estimate the regressive models with a maximum likelihood estimation controlling for spatial lag dependence.

Thus, following Anselin (1988), we defined the expression of the spatial lag models as:

$$Y = \lambda Wy + X\beta + \varepsilon$$

where Y is a vector of the dependent variables, X is a matrix of the explanatory and control variables, β represents the vector of the coefficients, ε is the vector of the residuals, and W is the spatial weight row-standardized matrix, showing the strength of the interaction between two municipalities. To construct the W matrix, we used a distance-based neighbours algorithm. This enabled us to choose the k-nearest points as neighbours. We set the K-nearest point to 10[6].

Lastly, we tested the robustness of the results and the assumption of the spatial lag dependence against alternative model specifications. First, we compared our results with pooled linear models and spatial error linear models but found no significant differences. Second, because the dependent variables, deepening, broadening and regrounding, can take on non-negative over-dispersed integer values, a negative binomial

[5] R is an open source software environment for statistical computing and graphics.

[6] We tested different k-values (5, 15, 20), however the results were consistent with the default value.

specification was used to check the robustness of our results. However, we found no significant differences between the two econometric specifications. The results of the negative binomial model were also qualitatively consistent with those presented in Table 3.

3. Results and discussion

3.1 Model Results

The correlations between variables do not suggest multi-collinearity issues (Table 2), however we carried out additional tests to detect possible multi-collinearity. We checked for the existence of multi-collinearity by computing the Variance Inflation Factors (VIFs) for all the models and found multi-collinearity not to be a problem. The VIF values were always lower than the cut off point of 5 (Hair et al., 2010, p. 189).

Table 2. Correlation matrix.

Table 3 presents the coefficient estimates for the spatial simultaneous autoregressive lag models.

We operationalised the Akaike information criterion (AIC), the log likelihood and log likelihood ratio (LR) test to evaluate the goodness of fit of the models. As a base model to compare our results against, we first present the outcome with only the control variables (DEEP-base Model, BROAD-base Model, REGR-base Model).

The overall full models with all the explanatory variables (DEEP-full model, BROAD-full model, REGR-full model) increased compared to the baseline models. The LR test shows that all the full models improved significantly against any base model (Pr > LR tests are 0.001). In other words, the introduction of the explanatory terms is important in explaining our dependent variables. In addition, the coefficients and signs of the control variables remained stable across the different models, showing robust results and that multi-collinearity is not a particular problem in these regressions. In addition, the variables were mean-centred standardized to improve the readability of the regression coefficients.

Table 3. Regression models results.

Our discussion of the results focuses on the full models (DEEP-full model, BROAD-full model, REGR-full model), because we did not find significant differences compared to the baseline models.

Concerning the spatial lag variable (RHO) we found a spatial dependency. In fact, the RHO results showed the positive influence of the spatial term on DEEP, BROAD and REGR. This means that there is a propensity for nearby municipalities to influence each other and to possess similar characteristics, in all the three models. The results of the *Farmers' characteristics group (FCs)* were interesting in terms of the three dimensions of multifunctionality. A high farm education level (EDU) had a different influence on the decision regarding the multifunctional typology. In the DEEP and BROAD-full models, the higher the farmer's education level, the more deepening activities were implemented; in the REGR-full model, this variable was not significant.

The percentage of female farm managers (WOM) did not influence the implementation of a specific dimension of diversification in agriculture.

The farmer's age (FAGE) had a positive effect on the dependent variable in the DEEP and REGR-full models. The positive influence of FAGE is notable because it means that the greater the average age, the greater the development of deepening and regrounding activities. Concerning the latter activities, no relationship was found between propensity to diversification and youth. Thus, diversification in these two dimensions does not depend on the presence of young farmers.

As for the *Farm structure group (FS),* the presence of employees (LAB) showed a direct relationship with the implementation of regrounding and a negative relationship with the implementation of deepening. The presence of computerized farms (COMP) had a negative influence on the deepening activities and a positive influence on the regrounding activities.

Mixed farms (MIX) did not have a significant influence in the DEEP model but positively influenced the activation of the BROAD and REGR dimensions. The variables SMALL and HOURS had a positive influence on all the three dimensions.

Concerning the *Territorial features group (TFs)*, FARMS had a positive influence in relation to DEEP and BROAD, which means that diversification activities increase with a greater number of farms presence in the same geographical area. POP showed a positive influence in all models: the greater the number of people living in a particular geographical area, the greater the number of diversification activities. Conversely, the

DENS variable negatively influenced BROAD and REGR variables: with a higher population density, the broadening and regrounding activities decrease. MOUN showed a negative influence in the DEEP and REGR model: which could mean that in municipalities located in hills and mountains, the presence of deepening and regrounding activities is scarcer than in the plains, such as production of geographical indication goods, organic farms, or subcontracting activities (Darnhofer, 2005). Conversely, the higher the municipality is located, the greater number of the broadening activities. The variable REGION, controls for the possible characteristics of the regions that could influence the implementation of a specific diversification dimension. The results differed from region to region, and are discussed extensively in the next section, grouped by deepening, broadening and regrounding. The positive influence of spatial correlation on the three dimensions could be explained by the spill-over of knowledge related to the three typologies of diversification, which leads to greater diffusion of specific diversification activities. For example, a farm's specializing in organic farming (deepening), can promote the dissemination of knowhow to neighbouring companies, which can also be repeated for activities related to broadening and regrounding.

3.2 Deepening

The DEEP variable is influenced by several explanatory variables. MOUN negatively influenced the implementation of deepening activities, probably because in the plains, organic and GI productions are more feasible than in mountain areas, where rigid temperatures, the difficult accessibility of agricultural land, and slopes, make it difficult or impossible to grow some crops and thus limit possible deepening activities. As affirmed by Dries et al. (2012), specific landscape features such as high altitudes can pose constraints on traditional agricultural activities, i.e. crop cultivation. Conversely, the older the farmer’s age (FAGE), the greater the number of deepening activities. This is probably because deepening activities require a high economic investment, and often young farmers have insufficient funds for this. If we consider organic production as a deepening activity, this is in contrast with the results of Weltin et al. (2018), who found a positive relationship between young farmers and diversification in organic production. However deepening activities include all the agricultural activities that transform, expand and/or relink to other actors, for example POD productions, typically regarding traditional agriculture and farms, sometimes driven by old farmers. The number of farms with employees (LAB), had a positive influence on regrounding and a negative influence on deepening. This demonstrates that activities such as subcontracting require additional labour, whereas GI production and organic farming can be supported by the family labour usually employed on farms. This can also be explained by the fact that a large farm is more interested in sub-contracting (regrounding) because it has a larger work force available (Knanal and Mishra, 2015). At the same time, the variable HOURS positively affects all the dimensions, which means that diversification involves recourse to a larger workforce, but only regrounding requires extra family labour.

Concerning POP, the higher the number of inhabitants in a municipality, the higher was the diversification in all the three dimensions. In fact, several diversification activities take advantage of the significant demand for services. Various studies confirm that diversification is widespread in peri-urban areas, where it fosters the adhesion to short food chains and positively influences the farm income, which is one of the main leverages for the protection of farming activities against the pressure of urbanization (Mazzocchi et al., 2014; Tobin and Glenna, 2018). Nevertheless, the literature analyzing the benefits of proximity to urban areas in terms of diversification is controversial. Ilbery (1991) and Meraner et al., (2015) confirm the limited effect of the size of population on diversification, whereas, Pölling and Mergenthaler (2017) affirm that being located in a very urban environment considerably increases the implementation of deepening and broadening.

The presence of small farms (SMALL) always contributes to the development of all the three types of diversification. In fact, small farms cannot benefit from scale economies, are often excluded from the most profitable markets, run the risk of being marginalized and in the long term of having to stop their business. Diversification for these farms is a need more than a choice, as affirmed by several authors (Corsi and Mazzocchi, 2019, Weltin et al., 2017, Henke et al., 2014). Direct selling, which is included in the deepening group, was found to be positively influenced by the presence of small farms in a particular geographical location, as affirmed by Corsi and Mazzocchi (2019). The EDU variable positively affects the implementation of deepening activities, probably because a higher educational level implies a greater propensity and capacity to product innovation, such as organic and GI productions. In fact, according to Boncinelli et al. (2018), the decision to diversify requires a high level of expertise and knowledge. The influence of the REGI variable in the DEEP model is evident. The regions belonging to the north and centre of Italy, such as Trentino Alto-Adige, Emilia Romagna and Tuscany, are significantly above the benchmark average, in terms of deepening. In fact, regions below the average, such as Puglia, Calabria and Molise, are all located in the south. This is probably because the agriculture of the north is usually more industrialized and richer, and organic agriculture, for example, involves financial investments. Moreover, Emilia Romagna and Tuscany are particularly rich in geographical indication products[7], thus local agriculture is particularly aimed at producing GI goods.

3.3 Broadening

Unlike with deepening, broadening is positively influenced by the MOUN variable. In fact, different studies (Mazzocchi and Sali, 2018, Dries et al., 2012, Pfeifer et al, 2009) show that diversification in the mountains involves the broadening of farm productions, such as agritourism with restaurants, accommodation, and tourist attractions. Mountains present opportunities that facilitate diversification. On the one hand, the attractiveness of the landscape and ecosystem promote tourism and facilitate tourist accommodation businesses and other related activities such as didactic farming. On the other hand, various constraints of the mountain environment force the farms to differentiate their activities in order to find additional income. At the same time, the population density (DENS) acts negatively on the BROAD variable: in mountain municipalities the population density is lower than in the plains.

The presence of mixed farms (MIX) positively influences broadening. Mixed farms are normally less efficient than those that adopt a single crop and diversifying farming activities is their own strategy to guarantee sustainable incomes (Bertoni, 2015). Mixed farm farmers also probably have a broader range of skills due to the mixed nature of their farms, which could be useful in diversifying productions with broadening activities.

Concerning EDU, as occurs with deepening, the higher the farmer's education level, the higher the implementation of the Broadening dimension. This is the only variable included in the *Farmer's characteristics group* (FCs) that is significant in the BROAD model, in which the *Territorial Features group (TF)* and the *Farm structure group (FS)* are more relevant. In fact, both FARMS (*TF*) and POP (*TF*) act positively on the implementation of broadening activities. This means that Broadening is activated more where the density is high but at the same time, the area has a high number of farms per inhabitant. The variable REGI in the BROAD model highlights that the benchmark region, Abruzzo, shows a high quota of broadening activities, and most of the regions in the north and the south of Italy, showed significantly lower

[7] For example, in Emilia Romagna, the Parmigiano Reggiano POD, Prosciutto di Parma POD; in Tuscany, all the POD wines typologies, such as Chianti POD, Brunello di Montalcino POD and many others.

values than the average. At the same time, Tuscany, Umbria and Marche, showed values that do not significantly differ from the benchmark average. This means that the broadening activities are more activated in the the centre of Italy, probably because these activities are linked to agri-touristic activities, handicraft products, direct-sell on the farm, recreational and social activities and others, requiring skills and expertise that are typically developed in these regions, and which are historically linked to tourism.

3.4 Regrounding

Regrounding is influenced by several independent variables. For example, the municipalities in mountains or hill contexts (MOUN), act negatively on the implementation of regrounding activities. This is probably because livestock services or restoring parks and gardens usually take place in urban and plain areas, where the demand for these services is higher than in mountains or hills, where farms are smaller with less capital to employ in subcontracting than farms in the plains. As occurs with deepening, the older the farmer's age (FAGE), the higher the implementation of regrounding activities. Our results seem to contradict the findings that that young farmers are more willing to diversify and innovate (Barbieri and Mahony, 2009, Rivaroli et al., 2011, Meraner et al., 2015), but on the other hand every type of diversification requires investments and young farmers normally have fewer financial resources. Moreover, regrounding activities are often related to optimizing the agricultural machinery already present on a farm, thus, in this case, the farmer's age often has no influence. In any case, this factor needs further study. The number of farms with employees (LAB) is positive for regrounding and negative for deepening and broadening, which demonstrate that if a farm already has employees, it is more likely to opt for regrounding. In fact, regrounding activities such as subcontracting, require an additional labour force, which are typical of large farms (Dries et al., 2012). Computerized farms (COMP) are probably more technology oriented, thus they foster regrounding. Finally, as occurs with broadening, the presence of mixed farms (MIX) seems to positively influence the implementation of regrounding. This could be explained by the fact that if a farm already has expertise in terms of diversification, such as breeding and cultivation, it may be more inclined to also diversify through regrounding.

The location in mountains or hill contexts acts negatively on regrounding probably because services for livestock or fixing up parks and gardens are usually activated in urban and plain territories, where the demand for this dimension is higher than in mountains or hills, where farms have a smaller dimension with less capital to employ in subcontracting activities than farms in the plains and because high altitude could pose a number of constraints for agricultural activities (Dries et al., 2012). Finally, the REGION variable is significantly above the average of the benchmark in three regions, Trentino Alto Adige, Emilia Romagna and Tuscany, where agricultural cooperatives are widespread and economically strong, and could influence regrounding activities.

Therefore, all diversification dimensions, separately as well as altogether, are a strategic choice by farmer aimed at increasing income (Van Der Ploeg and Roep, 2003).

4. Conclusions

The present paper analyses diversification activities in Italian municipalities through a spatial model. The main results suggest that in Italy smaller farms are more likely than larger farms to diversify in the three diversification dimensions. Younger and higher-educated farmers together with the presence of farms with employees who live in the local area, in municipalities located on the plains, influence diversification in the broadening dimension, for example investments in organic agriculture. A higher farmers' education level and the presence of farms in mountain areas producing both animals and vegetable products ("mixed" farms) tend to foster the broadening dimension, including for example, agritourism and recreational activities. The regrounding dimension, which covers the mobilization of farm resources, for example restoring parks and gardens, is mainly affected by the presence of younger farmers, farms with employees, "mixed" farms in an area, and a higher digitalization of farms.

The most significant contribution to the literature in the field of multifunctionality and rural development concerns the combined influence of different factors both internal and external, encompassing farmers characteristics, farms structure and territorial features, including the regional and spatial patterns. Spatial econometric models are thus very useful tools to analyze the mutual dependence of people, local authorities and their actions within the neighborhood framework. They can thus be used to show how farmers' decisions are not only the result of individual thinking but are also influenced by the choices/actions of others within the neighboring systems. More specifically, this methodology represents a toolkit for a better understanding and modeling of contextual outcomes and aligned decision making in social and rural research.

Finally, the findings of the present study suggest that diversification is a multi-faced phenomenon which can contribute to rural development, and the three dimensions can be defined as alternative but also synergic strategies for increasing a farm's income. This could provide interesting recommendations for local and regional rural development programs that can foster specific policies by supporting and funding targeted measures.

The spatial analysis highlights some regional trends. Firstly, deepening and regrounding activities are widespread in northern and central regions, namely Trentino-Alto Adige, Emilia Romagna and Tuscany, due to the wide diffusion of PDO and organic productions, and activities related to the mobilization of farm resources. On the other hand, the regions of southern Italy, show a negative trend in terms of the implementation of deepening activities, probably because this dimension of diversification needs substantial economic investments and, generally, the agricultural sector of southern Italy is poorer than in northern Italy. Broadening activities have been mainly implemented by farms located in central regions (Abruzzo, Tuscany, Umbria, Marche), where handcraft activities and agritourism are widespread. The spatial trends for the three diversification activities at a local scale are justified by the spatial correlation, which is the propensity for nearby municipalities to influence each other and to have similar characteristics.

Knowledge of the key determinants of the diversification can stimulate administrative bodies at different scales (regions, municipalities, EU) to implement targeted RDPs to foster specific diversification activities strengthening current trends or encouraging other kinds of activities.

However, the model has the following limitations. Firstly, due to the lack of data, it was not possible to carry out the analysis at the farm scale, which would have enriched the analysis. For the same reason, it was not possible to geo-reference the data and then add further geographical variables. In fact, the data refer to the geographical unit of municipality, but the individual diversification activities are not georeferenced to a lower scale, which would be more precise. It was thus not possible to include some variables. Moreover, the analysis is based on data from the VI Census of Agriculture, dated 2010, applying a regression without the time dynamics.

Future research could consider the time dynamics, revealing new elements on terms of changes in diversification dimensions. Since diversification is a precise strategy to increase income (Van Der Ploeg and Roep, 2003), for future research it would be interesting to study the positive or negative influences of the different dimensions on farmers' income, in order to assess the effectiveness of farmers' choices and the assessment of the three dimensions.

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Table 1. Variables and descriptive statistics.

Variable name	**Group name**	**Indicator (measure unit)**	**Obs**	**Average**	**Dev.St**
FAGE *farmer's age*	FCs	=total farmers' age/ farmers in the municipality (*n*)	8,095	57.12	4.66
WOM *female farm managers*	FCs	=(number of female farm manager in the Municipality/number of farms in the municipality)*100 (%)	8,095	0.24	0.12
EDU *education level of farmers*	FCs	=(number of farm managers with high-school diploma or higher certificate/number of farms in the municipality)*100 (%)	8,095	0.27	0.14
LAB *labour force*	FS	number of farms with employees in the municipality (n)	8,095	8.60	27.54
MIX *farms with mixed production*	FS	=(number of farms with both vegetable and animal production / number of farms)*100 (%)	8,095	4.19	8.59
SMALL *small farms*	FS	=number of farms in the municipality with less than 5 ha of UAA (n)	8,095	238.18	516.44
COMP *computerized farms*	FS	=(number of computerized farms / number of farms)*100 (%)	8,095	0.12	0.10
HOURS *labor intensive farms or farms with high labor force*	FS	=number of farms with more than 500 hours per year (n)	8,095	9.71	25.63
MOUN *mountain municipalities*	TFs	0 = plain municipalities; 1 = hills and mountain municipalities (binary index 0-1)	8,095	0.44	0.50
POP *population of the municipality*	TFs	=number of inhabitants (n)	8,095	6,894.83	39,734.53

DENS *density population of the municipality*	TFs	=number of municipality inhabitants/mq of municipality (in/mq)	8,095	395.81	635.09
FARMS *farms per inhabitants of a municipality*	TFs	=number of farms/inhabitants of the municipality (n)	8,095	0.05	-
REGION *regional dummy*	TFs	=regional dummy for each Italian region. Abruzzo region is the reference level. (1=region; 0=other region)	8,095	-	-

Table 2. Correlation matrix.

	Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	DEEP	1														
2	BROAD	0.42***	1													
3	REGR	0.47***	0.40***	1												
4	FARMS	0.13***	0.22***	0.02	1											
5	POP	0.16***	0.23***	0.23***	-0.09***	1										
6	DENS	-0.06***	-0.05***	0.01	-0.27***	0.28***	1									
7	HOURS	0.53***	0.44***	0.55***	0.00	0.26***	-0.02	1								
8	ALT	-0.05***	0.05***	-0.10***	0.19***	-0.07***	-0.28***	-0.10***	1							
9	FAGE	0.11***	0.15***	0.09***	0.21***	0.05***	-0.01	0.00	-0.16***	1						
10	LAB	0.29***	0.36***	0.41***	0.08***	0.22***	0.00	0.44***	-0.16***	0.18***	1					
11	MIX	0.25***	0.52***	0.34***	0.14***	0.15***	-0.07***	0.32***	0.07***	0.16***	0.24***	1				
12	SMALL	0.47***	0.61***	0.44***	0.23***	0.18***	-0.01	0.41***	-0.06***	0.19***	0.51***	0.31***	1			
13	EDU	-0.05***	-0.05***	-0.05***	-0.15***	0.05***	0.09***	-0.07***	-0.16***	-0.18***	-0.06***	-0.11***	-0.07***	1		
14	WOM	0.00	0.17***	-0.01	0.29***	0.00	-0.09***	-0.05***	0.17***	0.15***	0.02*	0.14***	0.17***	-0.03*	1	
15	COMP	-0.06***	-0.17***	0.02*	-0.31***	0.02*	0.14***	0.04***	-0.22***	-0.36***	-0.09***	-0.15***	-0.22***	0.39***	-0.29***	1

Notes: Significance levels are *** p<0.001, ** p<0.01, * p<0.1

Table 3. Regression models results.

Dependent variables:	*Spatial simultaneous autoregressive lag models*					
	Deepening		*Broadening*		*Regrounding*	
	Deep-base Model	*Deep-full Model*	*Broad-base Model*	*Broad-full Model*	*Regr-base Model*	*Regr-full Model*
Intercept	0.109 (0.047)*	0.022 (0.045)	0.379 (0.046)***	0.199 (0.038)***	-0.167 (0.047)***	-0.233 (0.044)***
Rho (spatial lag)	0.124 (0.016)***	0.116 (0.015)***	0.065 (0.016)***	0.064 (0.014)***	0.055 (0.017)***	0.042 (0.016)***
Explanatory variables						
MOUN		-0.03 (0.011)**		0.031 (0.009)***		-0.018 (0.01)*
FAGE		0.047 (0.011)***		-0.012 (0.009)		0.03 (0.011)**
LAB		-0.092 (0.011)***		-0.005 (0.009)		0.119 (0.011)***
MIX		0.011 (0.01)		0.284 (0.008)***		0.169 (0.01)***
SMALL		0.369 (0.013)***		0.458 (0.011)***		0.219 (0.012)***
EDU		0.051 (0.01)***		0.014 (0.008)*		0.003 (0.01)
WOM		0.01 (0.011)		-0.002 (0.009)		0.009 (0.01)
COMP		-0.025 (0.011)*		-0.003 (0.01)		0.03 (0.011)**
Control variables						
FARMS	0.14 (0.011)***	0.117 (0.011)***	0.088 (0.011)***	0.043 (0.009)***	0.036 (0.011)**	0.005 (0.01)
POP	0.048 (0.01)***	0.026 (0.01)**	0.137 (0.01)***	0.078 (0.008)***	0.093 (0.01)***	0.049 (0.009)***
DENS	-0.007 (0.01)	-0.01 (0.01)	-0.057 (0.01)***	-0.026 (0.009)**	0.009 (0.01)	0.016 (0.01)
HOURS	0.463 (0.01)***	0.373 (0.011)***	0.394 (0.01)***	0.158 (0.009)***	0.484 (0.01)***	0.311 (0.011)***
REGION_BASILICATA	-0.236 (0.086)**	-0.232 (0.081)**	-0.408 (0.084)***	-0.494 (0.068)***	0.28 (0.085)**	0.225 (0.08)**
REGION_CALABRIA	-0.275 (0.062)***	-0.412 (0.059)***	0.588 (0.06)***	0.462 (0.05)***	0.015 (0.061)	-0.073 (0.058)
REGION_CAMPANIA	-0.222 (0.059)***	-0.245 (0.056)***	-0.048 (0.058)	-0.045 (0.047)	-0.072 (0.059)	-0.074 (0.055)
REGION_EMIL ROM	0.046 (0.066)	0.272 (0.063)***	-0.596 (0.064)***	-0.125 (0.054)*	0.609 (0.066)***	0.801 (0.063)***
REGION_FRI VEN GIU	-0.14	0.031	-0.564	-0.216	0.13	0.244

	(0.074)*	(0.07)	(0.072)***	(0.06)***	(0.073)*	(0.069)***
REGION_LAZIO	-0.213	-0.263	-0.332	-0.341	-0.028	-0.04
	(0.063)**	(0.059)***	(0.061)***	(0.05)***	(0.062)	(0.058)
REGION_LIGURIA	-0.228	-0.153	-0.494	-0.228	0.184	0.339
	(0.071)**	(0.068)*	(0.069)***	(0.057)***	(0.07)**	(0.066)***
REGION_LOMBARDIA	-0.227	-0.014	-0.594	-0.211	0.117	0.295
	(0.053)***	(0.053)	(0.052)***	(0.045)***	(0.052)*	(0.052)***
REGION_MARCHE	-0.061	0.054	-0.265	-0.108	0.446	0.466
	(0.074)	(0.071)	(0.073)***	(0.06)*	(0.074)***	(0.07)***
REGION_MOLISE	-0.488	-0.371	-0.596	-0.493	0.33	0.398
	(0.084)***	(0.08)***	(0.082)***	(0.067)***	(0.083)***	(0.078)***
REGION_PIEMONTE	-0.231	-0.03 (0.051)	-0.625	-0.257	0.148	0.336
	(0.053)***		(0.052)***	(0.044)***	(0.052)**	(0.05)***
REGION_PUGLIA	0.095	-0.626	-0.274	-1.016	0.754	0.302
	(0.071)	(0.072)***	(0.069)***	(0.061)***	(0.071)***	(0.072)***
REGION_SARDEGNA	-0.003	0.169	-0.514	-0.181	-0.098	0.103
	(0.063)	(0.061)**	(0.062)***	(0.051)***	(0.062)	(0.059)*
REGION_SICILIA	-0.139	-0.332	0.155	-0.034	0.049	-0.171
	(0.062)*	(0.061)***	(0.061)*	(0.051)	(0.062)	(0.059)**
REGION_TOSCANA	0.38	0.442	-0.092	0.016	0.455	0.476
	(0.068)***	(0.064)***	(0.066)	(0.054)	(0.068)***	(0.064)***
REGION_TRE ALT ADI	0.279	0.585	-0.718	-0.262	0.299	0.618
	(0.065)***	(0.065)***	(0.064)***	(0.056)***	(0.065)***	(0.064)***
REGION_UMBRIA	0.152	0.102	0.383	0.008	0.278	0.026
	(0.097)	(0.093)	(0.095)***	(0.078)	(0.096)**	(0.091)
REGION_VAL D'AOSTA	-0.074	0.141	-0.635	-0.294	0.03	0.232
	(0.106)	(0.101)	(0.104)***	(0.085)**	(0.105)	(0.099)*
REGION_VENETO	0.096	0.281	-0.641	-0.458	0.251	0.196
	(0.058)	(0.059)***	(0.058)***	(0.051)***	(0.058)***	(0.058)**
Obs.	8070	8067	8070	8067	8070	8065
Moran I	6.64***	7.12***	2.81**	6.20***	4.27***	3.85***
LM-lag	58.51***	54.73***	15.42***	19.09***	10.93***	12.87***
RLM-lag	18.09***	9.72**	11.11***	16.04***	5.18*	6.48*
Aic	19365	18441	18970	15734	19196	18119
Log-likelihood	-9656.4	-9186.7	-9459.1	-7832.8	-9572.1	-9025.5
LR test		939.33***		3252.6***		1093.2***
Max VIF	1.14	1.47	1.14	1.47	1.14	1.47

Notes: Coefficients are mean-centered standardized.
Standard errors are reported in parentheses.
"Abruzzo" is the reference level for Region.
Significance levels are *** p<0.001, ** p<0.01, * p<0.10.

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