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Keywords	Pluriactivity; Agricultural income diversification; Agricultural intensification; Risk management, Negative binomial hurdle model.
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Structural factors of labour allocation for farm diversification activities

Abstract

While the share of agriculture, forestry, and fisheries in rural economies has declined, the importance of diversification activities has increased. The aim of this study is to investigate how structural factors affect both the decision of diversification into on-farm non-agricultural activities and the total labour assigned to them, measured in terms of the workdays allocated to producing diversification activities. Using Tuscany, a region in central Italy, as a case study, a negative binomial hurdle model has been applied to represent the two steps involved in farmers' behaviour. Farmers first decide whether to diversify and then decide the amount of farm resources to devote to diversification. The results have revealed that farms located in regions more distant from urban areas are more likely to diversify, but that distance is an influential factor in predicting the number of workdays dedicated to diversification. In addition, small family farms are less likely to diversify than large farms, and those that do so dedicate fewer workdays to diversification activities. A possible explanation for this evidence is that structural and endowment constraints are entrance barriers for involvement in on-farm non-agricultural production.

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1 Introduction

On-farm non-agricultural diversification (hereafter only diversification) is a business strategy in which a farmer produces non-agricultural goods and services employing farm resources (capital, labour and land) with the aim to sell them in the market. These activities can be a continuation of agricultural production using the farm agricultural outputs for processing. Production of dairy products using farm milk or production of juices and alcoholic beverages are typical examples. Moreover, diversification activities can employ the farm's equipment, buildings, and workforce for the production of other goods and services rather than growing crops or rearing animals. Agro-tourism and services for third parties are illustrative cases (Van Der Ploeg and Roep, 2003).

The results of Eurostat's Farm Structure Survey (2008) revealed that 12% of European farmers have set up diversification activities on their farms. According to Eurostat (2013), while the share of agriculture, forestry, and fisheries in rural economies has declined, the importance of farms' secondary activities in rural economies has grown. In 28 European countries, between 2005 and 2015, production in secondary activities has increased by almost 5% per year, while agricultural production at basic value has grown by only 2.2%. An increasing share of farms' resources is, therefore, being allocated to producing non-agricultural goods and services. The same is evident in the United States, where the contribution of diversification activities to the total value of US agricultural production is roughly 40% (Vogel, 2012).

Diversification represents a viable strategy for increasing a farm's income and for using any otherwise unemployed household workforce (McNamara and Weiss, 2005). In addition, these activities help farms and agricultural households to reduce their risk exposure by enlarging their income portfolio (Mishra et al., 2004). Indeed, diversifying their income sources, either by purchasing assets or by engaging in other activities with payoffs unrelated to agricultural production, allows farmers to reduce the uncertainty linked to their primary production, that is, the uncertainties of prices, technology, and policies (Moschini and Hennessy, 2001). Moreover, since agricultural households have an average income lower than that of non-agricultural households (Boncinelli and Casini, 2014), farms must find new earning sources to support their economic sustainability. Therefore, diversification is vital, even in terms of rural development, since these activities represent an opportunity to support rural economies and to maintain viability in rural areas. For example, Hyytiä (2014) has found that diversification has a positive effect on regional income in areas where agriculture is a minor player. Moreover, diversification has a pivotal impact at a local level because it helps to maintain employment levels in areas with development concerns and where opportunities provided by other economic sectors are limited (Di Iacovo, 2014).

Diversification in new activities is furthermore perceived as central to the Common Agricultural Policy's (CAP) reform strategies, not only because it strengthens the territorial and social cohesion of rural areas (European Commission, 2010) but also because of the strong link between multifunctionality and diversification (Van Der Ploeg and Roep, 2003). Indeed, several diversification activities can derive advantages from externalities and other goods produced by agriculture. Consequently, diversification has brought about greater integration and interdependency between farm households and rural economies.

Due to the importance of diversification for the economic viability of farms and rural areas, both agricultural economics and rural development literature have focused on identifying the structural determinants of diversification. Despite such an emphasis, little attention has been paid to fully understanding farmers' decision-making regarding diversification. Indeed, the majority of articles simulate farmers' behaviour toward diversification as a discrete choice of whether or not to be involved in diversification. Boncinelli et al. (2017) and Knanal and Mishra (2015) have criticized the existing approach, as it does not properly explain the complexity and causality of decision-making. The latter authors stress that determinants regarding diversification remain controversial and this evidence can be explained by the fact that previous studies have considered each diversification activity separately, without considering diversification as a single behaviour (Knanal and Mishra, 2015). Instead, Boncinelli et al. (2017) point out that literature about diversification has focused solely on the decision to diversify or not, without considering the allocation choice of the farm resources for diversification. Indeed, the decision regarding diversification can be split into two different decisions: (*i*) a farmer decides in favour of diversity and then (*ii*) he/she will choose the amount of farm resources to allocate to producing diversification goods or services. If the diversification is a two-step process, in each step different determinants might play contrasting roles in terms of sign and burden.

Since the second decision concerning farm resources allocated to diversification has received less attention, the purpose of this article is to enrich the existing literature by expanding the perspective to include a more realistic decision-making structure, considering the fact that farmers decide the total resources, such as the labour force, to be devoted to diversification conditionally to the choice of being involved in diversification. Moreover, as the same factors can have different impacts on the two decisions (i.e., deciding to diversify and deciding the total resources devoted to diversification), there is room for investigating and discussing the existing empirical literature in the light of this two-step process.

Therefore, by applying an innovative procedure to model diversification strategies, this study aims to investigate how structural factors affect the choice to diversify and the total farm labour forces allocated to these activities, measured as the workdays allocated to diversification activities. To the best knowledge of the authors, this article presents one of the first theoretical and empirical analyses to enable description of the intensity of diversification by the means of a decision to allocate labour between diversification activities and the usual agricultural activities. The factors analysed in this study are the characteristics of both the farm and the farmer, in addition to spatial factors that affect decisions concerning diversification. The final goal is to better understand this increasingly important aspect of modern agriculture.

Altogether, the paper contributes to the existing literature by developing a theoretical model that helps understand the decision to diversify and the allocation of labour towards diversification activities, and by applying a negative binomial hurdle model to study diversification as a two-step process that is involved both in the entrance into diversification and the amount of farm resources dedicated to these activities. Hence, the determinants of both steps are integrated to provide a coherent set of motivations that affect diversification. The main contribution of the article to the existing debate on diversification is the ability to disentangle the determinants' diversification processes, offering a more reliable picture of farmers' behaviour towards diversification and support for the development of policy actions that enable the effective preservation of agricultural labour in rural areas.

The remaining parts of the article are structured as follows. Section 2 introduces the existing literature. This is followed by Section 3, which describes the data and results. Finally, discussions are provided in Section 4 and conclusions in Section 5.

2 The determinants of diversification

The theoretical basis of the diversification adoption process is rooted in the farm household model (Taylor and Adelman, 2003). Following the theoretical basis of this model, a generic farm maximizes household profit to satisfy household consumption. The decision-making process regards the allocation of household resources (labour, capital, etc.) to farm production intensification, to diversification, and to off-farm activities (Mishra et al., 2014; Andersson et al., 2003).

An extensive body of literature has dealt with understanding the phenomenon of farm diversification, considering the contributions of farms, farmers, and household characteristics (see, for example, Meraner et al., 2015 and Hansson et al., 2013), in addition to external drivers such as location, spatial interaction, and connections (see, for example, Lange et al., 2013).

Several scholars have stressed the relevance of spatial connections and location for explaining the diffusion of farm diversification. A growing body of literature focuses on how space and location may affect the diffusion and magnitude of diversification strategies. Several studies have discovered the demand-driven effects of space on diversification, whereby farmers closer to tourist sites or urban areas are more likely to diversify their production (Zasada, 2011) because of a higher demand for farming services. Other studies have found contrary results, pointing out that proximity to urban areas can increase off-farm opportunities (Mishra et al., 2014; Bartolini et al., 2014), reducing the availability of the workforce that would be employed in farm diversification. Boncinelli et al. (2017) have pointed out that diversification is a relevant option for farms located in marginal areas with exogenous structural constraints. In this context, diversification may be a viable strategy for overcoming fewer opportunities to allocate household labour to diversification activities. Pfeifer et al. (2009) have provided a similar explanation, arguing that low returns from agricultural production incentivise farmers to find new strategies other than cropping or rearing; thus, poor soil quality can be a determinant for diversification. The source of the ambiguous results related to the relationship between localization and diversification is not manifest. All the cited studies explained their results by stressing the role of exogenous factors. However, as mentioned above, these studies assumed diversification as a discrete choice (to diversify or not) and considered specific diversification activities. The difference in the findings in the literature might be context specific. Therefore, modelling diversification, as the current article has done, as a two-step decision-making process by farmers, not linked to a specific activity, will shed new light on this topic.

The influence of a farmer's age on the probability of engaging in diversification activities has been disputed. Some authors have noted that older farmers are more likely to participate in on-farm income diversification (Joo et al., 2013). Barbieri and Mahoney (2009) have stressed that younger farmers feel a bigger need to strengthen the existing farm business for future generations. Meraner et al. (2015) and García-Arias et al. (2015), however, have found empirical evidence that younger farmers seem to be more likely to be involved in diversification. McNamara and Weiss (2005), quoting rural sociology studies, have determined that both young and old farmers are less likely to diversify, due to lower risk aversion levels among young farmers and reduced workloads for older farmers.

Farmers' education level also contributes to explaining diversification strategies (Bowman and Zilberman, 2013). Boncinelli et al. (2017) have found that farmers with higher education levels have a greater likelihood of diversifying, although this is not the case when the farmer has an agricultural education. McElwee and Bosworth (2010) have stressed that the educated male farmer tends to diversify more often than do others. Gender issues have also been found to be determinants of diversification. For example, females are more likely to diversify than are males (Joo et al., 2013). Benjamin and Kimhi (2006) have established a positive correlation between the presence of female on-farm workers and diversification.

Farmland size, economic size, and other endowment factors are often used as diversification diffusion drivers (Bowman and Zilberman, 2013). Vulnerable farms, such as those lacking productive-factor endowments, can particularly take advantage of diversification (Knanal and Mishra, 2014). Indeed, Knanal and Mishra (2015) have stressed that farms with limited land, capital, managerial ability and skilled labour face a major barrier to finding opportunities within the new challenges of agricultural business. Small- and medium-sized farms are often unable to adopt improved technologies, new managerial practices, and intensive cultivation. In these cases, a viable option is to use the existing farm resource endowments in a more profitable manner. Farm size plays a crucial role in the likelihood of diversification. However, the question of whether small or larger farms tend to diversify more has yet to be fully understood. McNamara and Weiss (2005) have argued that as farm size increases, on-farm income diversification is more likely, since the reduction of marginal returns determines that farms' resource allocation is directed towards more profitable activities. IIbery (1991) and McNally (2001) have arrived at the same conclusion. García-Arias et al. (2015) point out that larger farms have more resources to devote to other activities than agriculture. Others have argued that smaller farms are more likely to diversify. Their hypothesis is that larger farmers, due to economies of scale, can generate more profit if they specialize in agriculture (Mishra et al., 2004; Vik and McElwee, 2011). There is a strong correlation between organic farming and diversification activities (Choo and Jamal, 2009; Bartolini et al., 2014). Moreover, McNally (2001) has stressed the role of the seasonality of different crops in encouraging diversification, pointing out that producers of arable crops have more time to dedicate to on-farm production. Therefore, a farm's system indirectly affects the probability of diversification that is, where the production cycle has a period with a low work demand, diversification can serve as a way to allocate a temporary abundant labour endowment. Jongeneel et al. (2008) have noted that diversification is less likely to occur in farms specializing in time-intensive production.

Moreover, the relevance of the diversification activities is not limited to structural factors but is also crucial from a social perspective. Indeed, a common objection to the importance of these activities is that they take farmers away from traditional farm culture. Brandth and Haugen (2011) have demonstrated that farmers' existing identity is both reinforced by and combined with these new activities, turning farmers into what may be conceptualized as 'neo-peasants'. Barbieri and Mahoney (2009) have pointed out that farms involved in diversification have a complex set of goals that are not limited to economic dimensions. The continuance of farming, the enhancement of farmers' quality of life, the economic maximization of their existing resources, and maintaining family connections that support agricultural activities are all important household goals that play a key role in farmers' diversification decision-making processes (Hansson et al., 2013). Specifically, having a potential successor for the farm within the household and having an increasing share of household labour allocated to agriculture activity both reduce the probability of dismissing agricultural production strategies in favour of adopting strategies aimed at increasing incomes through diversification (Barbieri and Mahoney, 2009; Bartolini et al., 2014).

There is no consensus across agricultural economic literature on the influence of the CAP and its payments to farmers. Maye et al. (2009) have highlighted the role of agricultural policy in terms of affecting farmers' behaviour towards diversification, explaining the impacts of both first- and second-pillar payments on diversification strategies. First-pillar payments increase the sector's overall profitability and therefore influence the allocation of on-farm household labour, while also promoting on-farm investments (Bartolini et al., 2014). Other authors have emphasized the negative effects of the first-pillar policy on diversification, due to the maintenance profitability of commodity crops by promoting intensification in agricultural activities (Bartolini and Viaggi, 2012). Existing literature highlights positive effects of the Rural Development Programme (RDP) on improving attitudes towards diversification, but with a different explanation (Uematsu and Mishra, 2014). Since a specific axis of RDP is devoted to co-funding investments for diversification (formerly Axis 3), thereby having a direct and positive correlation with diversification, the other two axes of RDP have no direct linkages (Zasada and Piorr, 2015). Zavalloni et al. (2015) have found second-order effects of environmental payments on the diffusion of diversification. The authors argue that payments can positively affect the provision of ecosystem services from agriculture, causing a higher demand for diversification activities, such as rural tourism and the production of local foods. Desyeux et al. (2015) and Smith et al. (2015) have demonstrated that co-funding investment measures within the RDP (Axis 1) are focused on improving sector competitiveness and labour productivity. Hence, the different priorities set out by policymakers may incentivize other investments in agricultural production (Bartolini and Viaggi, 2012), with the effect that investment measures do not have significant or negative correlations with diversification. However, since other authors (e.g., Bartolini et al., 2014) have argued that these measures promote mainly labour-saving technologies, the 'surplus' of labour could be allocated for diversification, thereby justifying a positive effect on the diversification of investment measures.

The above review indicates that the roles of several factors regarding diversification remain controversial. This evidence might be explained by the fact that previous studies have considered each activity separately,[1] without considering diversification as a single behaviour (Knanal and Mishra, 2015). Moreover, these studies have also focused solely on the first step of a farm's decision-making (to diversify or not), without considering decisions concerning the allocation of resources for diversification.

3 Materials and methods

3.1 Econometric model

We have selected labour as a proxy of the total farm resources dedicated to diversification activities; thus, the dependent variable in this analysis is the number of workdays dedicated to diversification activities (L_d). The assumption is that labour is correlated with other farm resources. The list of diversification activities corresponds to those diversification productions recognized as components of agricultural income. These activities are agro-tourism/farm holidays, recreational activities, school activities, handicrafts, food processing, energy production, woodworking, aquaculture, agricultural and non-agricultural services, gardening, and animal feed processing.

As mentioned above, we modelled the decision-making process involved in diversification as a two-step plan: (*i*) a discrete choice between undertaking or not undertaking diversification activities, and (*ii*) the choice of the total amount of labour allocated for producing

[1] Surely, several other reasons justify the different outcomes in different studies; it is a fact that empirical evidence comes from very different contexts, sectors, farm types and policy measures. However, part of the heterogeneity detected by these empirical results depends on different theoretical approaches to studying diversification.

diversification activities—that is, the extent of resources allocated to these activities (Amanor-Boadu, 2013). Our key idea is that the fixation of the number of the workdays dedicated to diversification is logically preceded by the decision to be involved in the diversification.

In this article, we apply a double-hurdle model for count dependent variables (Mullahy, 1986). The double-hurdle model is an econometric model that allows participation and the involved decisions to be motivated by separate sets of variables. This model deconstructs the decision-making process into the two steps described above. The first step is a hurdle, in which the *i*-th farm decides whether or not to diversify. The second step uses a count model, in which the number of workdays is only positive. Therefore, the first decision is modelled applying a binary choice model (e.g., logit regression), while the second decision is modelled by applying a count model with a truncated component. Quoting Greene (2005), the hurdle model consists of an equation for 'participation' and a model for the event count that is conditioned by the outcome of the first decision. Moreover, this model accommodates databases with a large number of observations with zero value by separating the process that generates the zero from the process that generates the level outcome (Mullahy, 1986). The first step explains the determinants of access to diversification activities as binary variables equal to one if $L_d > 0$. In the second step, the level of farm involvement in diversification activities is denoted using a positive count variable, that is, L_d. Increasing the degrees of farm diversification means more days dedicated to diversification production. The data-generating process is a count distribution; therefore, a count model seems to be feasible to be applied in the second step. Literature provides two alternatives to model count data: Poisson and Negative binomial models. The Poisson distribution of the dependent variable is graphically shown in Figure (1) and it is demonstrated by a positive skewness equal to 26.48. However, the Poisson regression requires a restrictive assumption about data in order to get reliable results when applying this model. The Poisson model requires equality of the variance and the mean. However, very often the variance exceeds the mean, causing overdispersion.

Hence, we applied an overdispersion test statistic (Cameron and Trivedi, 1990) and we rejected the null hypothesis of equidispersion of the data with a *p*-value equal to 0.00. The overdispersion can be due by an excess of zeros in the dependent variable (about 90% of our observations are zeros) and by unobserved heterogeneity. The overdispersion has the practical consequence of returning biased estimations of the parameters of the Poisson model (Cameron and Trivedi, 2005). This motivates the selection of an alternative model with less restrictive assumptions able to capture overdispersion and unobserved heterogeneity, namely, the negative binomial hurdle model. The negative binomial hurdle is an extension of the basic Poisson hurdle model (Mullahy, 1986). The general assumption of this model is that unobserved heterogeneity is gamma distributed (Gurmu, 1997).

Following Gurmu and Trivedi (1996), Gurmu (1997), Yen (1999) and Deb and Trivedi (2002), the negative binomial hurdle model can be constructed as follows. Let L_d be the number of the workdays dedicated to diversification production, that takes values 0, 1, 2, 3, etc. The probability of being a farmer with no diversification activity is:

$$\Pr(L_d = 0 \mid z_i) = (1 + \alpha\gamma_i)^{-1/\alpha_1} \quad (1)$$

The parameter α > 0 is an overdispersion parameter and is a measure of the unobserved heterogeneity. Equation (1) indicates the probability that the farm does not diversify. The count part of the model (denoting the truncated-at-zero distribution for the positives) is:

$$\Pr(L_{di} \mid x_i, L_{di} > 0) = \frac{\Gamma(L_{di} + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(L_{di} + 1)} \left(\frac{\lambda_i}{\lambda_i + \alpha^{-1}} \right)^{L_{di}} \left(\frac{1}{(1 + \alpha\lambda_i)^{1/\alpha} - 1} \right), L_{di} = 1, 2, ... \quad (2)$$

where:

$$\gamma_i = \exp(\zeta' \boldsymbol{z}_i) \quad (3)$$

$$\lambda_i = \exp(\beta' \boldsymbol{x}_i) \quad (4)$$

Equation (2) introduces the assumption of gamma heterogeneity that generates the negative binomial distribution. The workdays dedicated to diversification, conditional on the evidence that the farm is involved in this kind of production, is:

$$E(L_{di}) = [\Pr(L_{di} = 0 \mid z_i)]^{1-I_i} \times [(1 - \Pr(L_{di} = 0 \mid z_i)) \Pr(L_{di} \mid x_i, L_{di} > 0)]^{I_i} \quad (5)$$

Where I_i is an indicator function $I_i = 1$ if $L_{di} > 0$and $I_i = 0$ otherwise.

Here, β and ζ in Equations (3) and (4) are the vector parameters and $\boldsymbol{x}_i$ and $\boldsymbol{z}_i$ are the covariates in the two equations. The vector of unknown parameters, along with overdispersion parameter estimation, is obtained by entering the probabilities in the log-likelihood function and applying the maximum likelihood method (see Gurmu and Trivedi, 1996 for details). We modelled the two-step process using the two vectors of covariates $\boldsymbol{x}_i$ and $\boldsymbol{z}_i$ that contain the information on the specific features of the *i*-th farm—in our specification, $\boldsymbol{x}_i = \boldsymbol{z}_i$. In other words, we want to investigate the impact of each factor in terms of statistical significance, sign, and burden in influencing the two processes.

The count hurdle models are similar to the zero-inflated model, as both have been developed to cope with zero-inflated outcome data. The difference between these two models is the source of zero. For the zero-inflated model, the process generating the zero can be sampling, that is, the zero outcome partially depends on chance. In the hurdle model, 'a binomial probability model governs the binary outcome of whether a count variate has zero or a positive realization. If the realization is positive, the "hurdle" is crossed and the conditional distribution of the positives is governed by a truncated-at-zero count data model' (Mullahy, 1986, p. a345). This implies that zero outcomes depend on a 'structural' process, as opposed to chance. In other words, the hurdle model is applied when the hypothesis is that zero depends on the specific decision to not be involved in a specific activity. Two other econometric models involve a two-step process: the Heckman model (Heckman, 1979) and the Tobit model (Tobin, 1958). The count hurdle models, however, better fits the question of understanding the diversification choice and the number of workdays dedicated to such activities. Ricker-Gilbert et al. (2009), when reviewing the three typologies of the models, have pointed out that the Heckman model is designed to be used when the truncation to zero is unobserved and accidental. In this case, applying a 'global model' results in biased estimations. The Heckman model provides consistent estimates by calculating correction factors, due to the unobserved sample selection. In contrast, the Tobit model assumes that the processes underlying the choice to diversify are the same as those underlying the decision of how much to diversify. The hurdle model considers the fact that the processes underlying the two steps may be different. This seems to better fit this paper's focus, since certain factors, such as farm size, presumably have different impacts on the decision to diversify than they have on decisions about the resources dedicated to these activities.

3.2 Source of data and model variables

The dependent variables and covariates are selected from data of the 2010 Italian agricultural census in Tuscany, combined with administrative data about rural development payments. The census data are cross-sectional data and cover 72,686 farms.

Tuscany has been chosen for this article because it is a suitable case study for several reasons. Tuscany shows a very high variability of geographical, climatic, and altitude factors, in addition to socio-economic conditions in rural areas (Boncinelli et al., 2015; 2016). Moreover, this region exhibits strong heterogeneity in product specializations, from extensive commodity production, such as cereals, to high-value cultivation, such as wine grapes and plant nurseries. The combination of these elements may create a different propensity to diversification. Therefore, due to such high variability, the results of this study should be less bound by specific conditions or specialization, and this may facilitate the generalization of the research conclusions (Boncinelli et al., 2017).

The aforementioned list of diversification activities includes agro-tourism/farm holidays, recreational activities, school activities, handicrafts, food processing, energy production, woodworking, aquaculture, agricultural and non-agricultural services, gardening, and animal feed processing. The dependent variable measures the total labour, in terms of working days, allocated to diversification activities and can take values between 0 and 5,249. The variable assumes a value equal to zero when a farm produces only agricultural output. A growing number of workdays indicate, *ceteris paribus*, a growing involvement of the farm in non-agricultural diversification.

The number of farms with diversification activities was less than 8%, and the average value for the number of working days allocated to diversification activities was 11.97 for the whole sample. The data present very high heterogeneity, as indicated by a strong standard deviation equal to 93.79 workdays. These descriptive statistics seem to outline a portrait similar to that of the rest of Europe, where only a small share of farms is involved in non-agricultural diversification. With respect to the group of farms that dedicate at least one workday to non-agricultural production, data show that the average number of workdays dedicated to diversification is about 155 with a standard deviation of 303.

The list of covariates has been classified into the four groups of (*i*) spatial factors and location, (*ii*) farmers' characteristics, (*iii*) farm and household characteristics and (*iv*) policy. The choice of covariates was driven by two main criteria, which are the availability of data in the datasets and the link with the aforementioned literature. Table 1 presents the descriptive statistics of the variables used in the model.

The first group concerns spatial determinants with dummy variables to control for geographical zones corresponding to mountainous or hilly areas. Farms' Euclidean distances from the closest urban areas (defined as areas with more than 15,000 inhabitants) are included as proxies for the market opportunities supplied by urban areas.

The second group concerns the characteristics of farmers that emerged from the previous review as diversification determinants. Thus, we have inserted a gender variable to check if the person who manages the farm is a male or a female, operationalized as a dummy equal to one if the farmer is male. To model age, we have included both the age of the farmer and the square of age. Age is modelled using a quadratic term to test the non-linear effect of age, as it emerged in the literature review that younger and older farmers appeared to show an equal probability of diversifying, although their reasons for doing so differed. Education is modelled with two dummies. The first dummy is equal to one if the farmer received a secondary education. The second is equal to one if the farmer received education in agriculture, regardless of education level.

The variables composing the third group describe the farm and household structures and employ several dummies. A dummy equal to one is used if the farm is a family farm (according to Italian law), and a dummy equal to one is used if a potential successor worked on the farm alongside the current manager. The latter is defined as a family member, 40 years of age or older, who worked for more than 100 standard workdays. The other covariates are the number of permanent workers (i.e., the household members who work for the farm and other permanent hired persons), the utilized agricultural area (UAA), a variable determined by the ratio of UAA to total land, and the number of plots on the farm. Other variables include the farming system, and the model includes a dummy to check whether the farm is organic and if the farm has arable crops or permanent crops. A dummy measuring whether the farm featured animal husbandry has also been included. Finally, the last group is linked to policy and consists of one variable related to the payment obtained from the RDP in support of investments (Axis 1). The variables concerning the number of workers and the family farm have been included as control variables to avoid potential endogeneity due to the correlation between error terms and farm and farmer characteristics. Indeed, as the number of workdays dedicated to diversification activities can be linked to an 'abundance' of labour force, if we excluded this variable we would bias the parameters of the other variables.

4 Results

The data have revealed that few farms are involved in diversification activities. Almost 92% of Tuscany farms are involved exclusively in agricultural production, while only 8% of farmers have adopted at least one diversification activity. This latter group presents a fairly high median rate of revenues from on-farm income diversification, about 40% of the total farm income. The average number of workdays dedicated to these activities is quite low, with only 16.5% of the total workdays per year allocated to diversification. Despite this low average value, the high variability suggests the presence of heterogeneous situations among Tuscan farmers. Moreover, the high number of instances of zero in the dependent variable, that is, of farms without diversification production, confirms the overdispersion of the data. The results of the negative binomial model are reported in Table 2.

The first step, the decision to diversify, is modelled using the binary hurdle equation. While being located in mountainous or hilly areas does not affect the likelihood of diversification, the distance from urban areas is statistically significant and has positive effects. That is, farms located far from urban areas have a greater probability of diversifying than do those close to urban areas.

Farmers' characteristics indicate a statistically significant impact on their probability to be involved in diversification, with gender being an exception. Having at least a secondary education and an agricultural education have a statistically significant and positive influence, and show the requirement of a high level of expertise and knowledge in the decision to diversify. The two age variables are both statistically significant. The sign and the burden of coefficients show heterogeneous effects, indicating that the probability of diversification with respect to age is a non-linear relation. That is, younger and older people have the same likelihood of being involved in diversification. Figure 2 shows the marginal effects calculated for several ages in the sample by means of other variables. The probability of diversification decreases up to the age of 50; after this age, the probability begins to increase. Thus, an older farmer exhibits the same probability of diversification as does a younger farmer.

The results concerning the variables related to the farm features have revealed that the size of farms, the number of workers and the number of plots are all statistically significant, with a positive sign, while the variable concerning family farm status shows a negative sign. The variables accounting for the farm system indicate a statistically significant and positive impact on the probability of diversifying. However, farms involved in organic farming are more likely to diversify than other farms. As the diffusion of sustainability practices in rural areas represents one of the main goals of the CAP (Bartolini and Brunori, 2014), a substantial relationship between sustainable practices and diversification strategies is, therefore, a valuable result, with a high degree of relevance for policymakers. Moreover, the presence of a potential successor has a positive and statistically significant impact. On the other hand, the UAA ratio shows a negative sign. Finally, as policy is not statistically significant, this variable did not have any effect on the probability of diversification.

The second step, the decision regarding the workdays that farmers are willing to dedicate to diversification, has been modelled using the count model equation. In this case, the distance to urban areas along with a location in hilly or mountainous areas have no effect on the number of workdays earmarked for diversification, since the related variables are all not statistically significant. This implies that geographical factors, on average, do not play a role in the farmer's decision regarding the workdays dedicated to diversification production.

The results of the count model differ from the binary equation of statistical significance even for the education of the farmer and the size of the farm. Therefore, these two factors influence the probability of diversification but they do not impact the workdays dedicated to it.

The remaining variables show the same signs and significance as do those in the binary models. That is, these variables affect the probability of diversification and, in the same manner, the share of the labour endowment to diversification activities. Farmers with an agricultural education, therefore, dedicate an increasing part of their labour endowment to diversification activities, especially if they are younger or older farmers. Even for the count model, the policy variable is not statistically significant and carries a negative sign.

An overall assessment of the impact of these variables on diversification is performed by analysing the partial effects of the two parts of the model (Table 3). Between two average farms with the same characteristics, the farm with a successor dedicates about 24 more workdays to non-agricultural production than others. Conversely, family farms dedicate about 13 fewer days to these activities than do other farm typologies. The UAA ratio is another variable that has a large negative impact on the probability of diversification. This seems to indicate that farmers with resources not directly involved in agriculture find that diversification activities represent an income opportunity and a way to allocate resources profitably. Moreover, rearing animals and farming arable crops increase the average workdays allocated to diversification activities; on the other hand, farming permanent crops has no effect on diversification. Finally, policy has no impact.

5 Discussion

The results indicate that farms with a larger workforce and more land have a greater probability of diversifying and of having a larger amount of farm resources dedicated to diversification activities. This result confirms the conclusions of IIbery (1991), McNally (2001) and McNamara and Weiss (2005).

Spatial factors like distance from urban areas indicate that more distant farms opt for diversification strategies more often than farms situated closer to urban areas. This result appears to contradict those in the existing literature, which stress that diversification is driven by demand from urban areas (Zasada, 2011). Therefore, this suggests that the diversification process can be seen as a more 'endogenous' strategy of overcoming disadvantages arising from farm locations in more remote areas (i.e., high transportation costs, fewer off-farm opportunities, and less networking) that reduce agriculture profitability (Pfeifer et al., 2009). In peri-urban areas, off-farm opportunities probably encourage farmers to allocate labour to non-agriculture activities, rather than to diversification. However, we find no relationship between the distance from urban areas and the workdays dedicated to diversification activities. Therefore, farms with the same number of workdays are just as likely to be located closer to or father from urban areas. These results are partially in line with the findings of Boncinelli et al. (2017), who have concluded that diversification in peri-urban farms is less common than in farms located in other areas; however, they found that farms in closer proximity obtain a greater share of their revenues from diversification activities than more distant farms.

The results of this study highlight the non-linear effect of age on the probability of diversification. Younger and older farmers have the same behaviour in relation to diversification. This could be rooted in the evidence that younger and older groups exhibit the same risk behaviour, as found by de Mey (2016). Therefore, diversification for these two groups of farmers is a result of risk strategy, targeted at reducing risk exposure within agricultural production (Mishra, 2004). Our findings on the effect of farmer age are in line with Meraner et al. (2015) and Joo et al. (2013), but contrast with those of McNamara and Weiss (2005).

In relation to the other farmer characteristics, the results of the model in the present article confirm the positive impact of education on diversification probabilities that has been found in the previous literature (Bowman and Zilberman, 2013; Boncinelli et al., 2017; McElwee and Bosworth, 2010). On the other hand, farmer gender has no effect on farm diversification. This finding is in contrast with the literature that in general finds that the farmer gender influences diversification (Benjamin and Kimhi, 2006; McElwee and Bosworth, 2010; Joo et al., 2013).

The study results also highlight the absence of any relationship between RDP payments and diversification. This appears to confirm in part the hypothesis of Bartolini and Viaggi (2012), Maye et al. (2009) and Bartolini et al. (2014) that investment measures reduce risk exposure and increase agriculture profitability, resulting in an intensification of agricultural activities.

In terms of policy options, this study presents valuable findings, as policymakers who aim to promote diversification as a rural development strategy must deal with the evidence that this strategy is more likely to be pursued by larger farms, with regard to the labour force and land endowment. As demonstrated by the macro data, diversification can be a relevant source of extra income for farmers; thus, its diffusion can be a relevant strategy for policy addressed at improving the economic sustainability of agriculture or rural economies. In addition, policymakers can take advantage of the relevant relationship between diversification and organic production. Integrated diversification and sustainable agriculture measures can be more effective in terms of the diffusion and territorial impact of policies.

6 Conclusion

The current article applies an original model to improve the understanding of the on-farm diversification production. The diversification strategy represents a relevant option for increasing farm incomes or stabilizing income streams. Indeed, the macro data indicate that these activities generate a growing share of farm income, although only by a small number of the farms. This is a clue that structural constraints affect involvement in diversification.

An extensive body of literature has studied the factors that ease or hinder diversification (see, among others, Meraner et al., 2015). Previous studies, however, have focused on specific diversification activities, without considering diversification as a unique behaviour. In addition, the previous works focused only on the determinants of participation, while a second step, the total resources that farmers decide to allocate to diversification activities, has not been investigated. Therefore, an econometric model that considers both steps has been applied in this study to better understand farms' decision-making behaviour.

The results indicate that small farms and family farms encounter structural constraints when they become involved in diversification activities. 'Vulnerable' farms, therefore, exhibit a lower likelihood of expanding their portfolios towards diversification, and, once this decision has been made, the total number of workdays dedicated to diversification activities is limited.

This is a relevant issue since this farm typology could benefit noticeably from the income stabilization and earning opportunities of diversification (Knanal and Mishra, 2015).

On the other hand, larger farms, in terms of available land and workforce, have a greater probability of being involved in diversification activities and, *ceteris paribus*, dedicate more workdays to them. Indeed, the evidence that, in the hurdle part of the model, farm size and number of workers play a positive role in the likelihood of diversification means that land and labour are structural hurdles to engaging in these activities. In other words, diversification activities have entrance barriers and require a fairly high endowment of productive factors. Indeed, as considerable investments could be required for involvement in diversification, large farms, or those with larger capital endowments, may reduce transaction costs by collecting information for new investments and may be more likely to receive credit from banks. This is further confirmed by the less frequent involvement of family farms in diversification, although they represent the larger share of the farms. Moreover, larger farms are encouraged to diversify even by the need to maximize returns from farm resources. Indeed, the impact of the UAA ratio has been shown to be notable, in the same manner as is the number of plots and the number of people who work on the farms.

In general, the maintenance of labour in rural areas and the reduction of uneven territorial development represent two of the main core arguments of the ongoing debate regarding the CAP reform post-2020. Our article contributes to the existing debate by showing that diversification has a large potential to pursue both objectives. Rural viability is deeply connected with the services provided by farmers and with the ability to maintain sufficient levels of income to avoid farm-dismissing strategies (Bartolini et al., 2014). The diversification process can represent a win-win situation by providing a valuable service to the collective and a stable source of income to agriculture for maintaining rural area communities.

However, our results indicate that the current policy setting does not seem to adequately support both objectives, as its impact on diversification remains quite limited. This is an important consideration, as the current policy setting does not appear to pursue such long-term objectives due to a lack of self-reinforced effects across policy instruments and a lack of coherence among first- and second-pillar policy and within the measures of the latter. Altogether, our results support the need for a more coherent set of policy measures (Rogge and Reichardt, 2016) that can support long-term policy objectives, such as rural viability and the provision of private and public goods from agriculture.

One limitation of the current analysis is that the diversification activities included (agro-tourism/farm holidays, recreational activities, school activities, handicrafts, food processing, energy production, woodworking, aquaculture, agricultural and non-agricultural services, gardening, and animal feed processing) are extremely heterogeneous in terms of labour, capital needs, and returns per hour. For example, energy production is not labour intensive but requires know-how capital; on the other hand, agro-tourism requires many work hours. Our model, however, intentionally did not account for these differences. This approach was adopted in order to understand farmers' diversification behaviour when considering diversification as a single business strategy.

Moreover, the analysis may suffer from a lack of additional variables that explicitly encompass relevant decision-making dimensions, such as social capital or networking, that are used to explain farmers' attitudes towards adopting diversification. In this sense, further research should include these elements and try to improve the ability of the model to cope with diversification.

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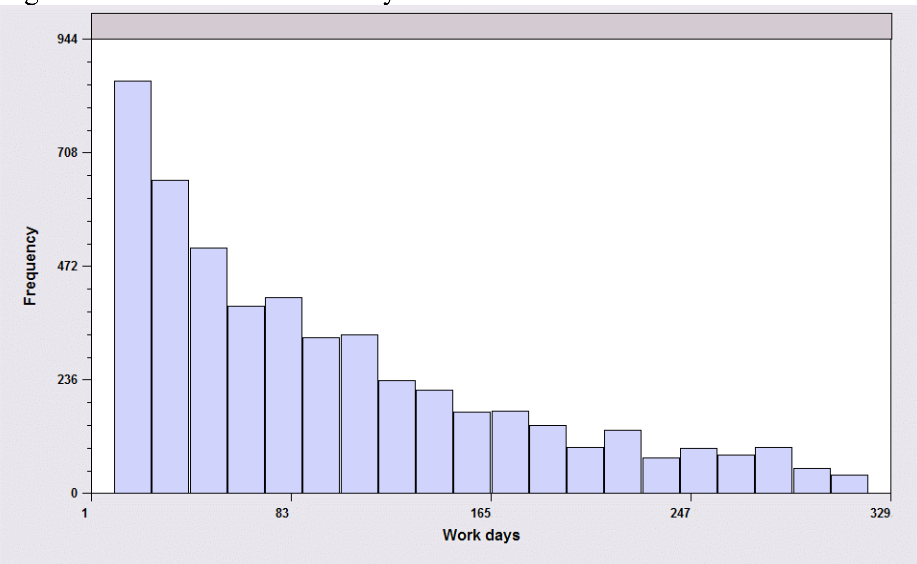
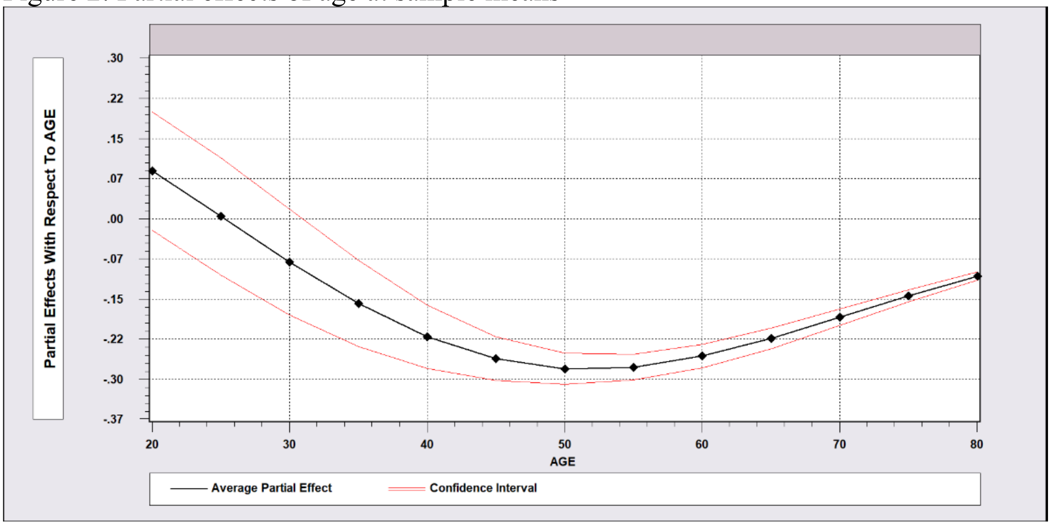
Figures

Figure 1: Distribution of workdays dedicated to diversification activities



Note: To improve clarity, the last decile of distribution is excluded.

Figure 2: Partial effects of age at sample means



Tables

Table 1: List of variables and descriptive statistics

Groups	Variables	Description and unit of measurement	Whole sample		Only farm with diversification	
			Mean	**St. dev.**	**Mean**	**St. dev.**
Dependent	Workdays	# of workdays dedicated to on-farm diversification activities	11.97	93.79	155.41	303.12
Spatial determinants	Hill	1=if the farm is located in a hilly area	0.69	0.45	0.69	0.46
Spatial determinants	Mountain	1=if the farm is located in a mountainous area	0.18	0.38	0.22	0.41
Spatial determinants	Distance	Distance to the closest urban area in kilometres	10.87	11.5	13.15	11.58
Farmer's features	Gender	1=if the farmer is male	0.69	0.46	0.69	0.46
Farmer's features	Age	Age of the farmer	60.50	14.96	51.96	14.17
Farmer's features	Age^2	Quadratic of age	-	-	-	-
Farmer's features	Higher education	1=if the farmer has at least a secondary education	0.33	0.47	0.54	0.50
Farmer's features	Agricultural education	1=if the farmer has an agricultural education	0.03	0.19	0.10	0.30
Farm's structure	Family farm	1=if the farm is a family farm	0.97	0.14	0.93	0.26
Farm's structure	UAA	Agricultural land in hectares	10.37	35.08	29.60	62.57
Farm's structure	UAA ratio	Ratio of agricultural and total land	0.74	0.27	0.65	0.29
Farm's structure	Workers	# of people who works on the farm	2.38	3.44	4.33	6.28
Farm's structure	Plots	# of plots	2.80	7.24	4.27	14.06
Farm's structure	Potential successor	1=if a potential successor of farm works in the farm	0.02	0.14	0.05	0.22
Farming system	Arable crops	1=if the farm has arable crops	0.54	0.49	0.73	0.45
Farming system	Permanent crops	1=if the farm has permanent crops	0.83	0.37	0.86	0.35
Farming system	Husbandry	1=if the farm breeds animals	0.13	0.34	0.32	0.47
Farming system	Organic	1=if the farm has organic production	0.03	0.17	0.15	0.36
Policy	Axis 1	Rural development support for Axis 1 (000)	1.22	15.05	5.36	33.42
Sample				N = 72,686		N = 5,602

Table 2: Results of the negative binomial hurdle model

Variables	Coefficient		Standard Error	z	Prob. |z|>Z*
Dependent: Work days dedicated to non-agricultural production					
Parameters of the binary hurdle equation					
Constant	-2.500	***	0.205	-12.220	0.000
Hill	-0.072		0.054	-1.330	0.185
Mountain	0.090		0.065	1.400	0.162
Distance	0.006	***	0.001	4.090	0.000
Gender	0.027		0.034	0.790	0.429
Age	0.016	**	0.007	2.360	0.018
Age^2	0.0004	***	0.0001	-7.160	0.000
Higher education	0.465	***	0.034	13.790	0.000
Agricultural education	0.241	***	0.057	4.250	0.000
Family farm	-0.153	**	0.066	-2.310	0.021
UAA	0.003	***	0.000	14.950	0.000
UAA ratio	-1.348	***	0.056	-24.000	0.000
Workers	0.067	***	0.002	38.810	0.000
Plots	0.008	***	0.001	8.250	0.000
Potential successor	1.135	***	0.076	15.000	0.000
Arable crops	0.859	***	0.034	24.940	0.000
Permanent crops	0.403	***	0.043	9.340	0.000
Husbandry	0.827	***	0.034	24.020	0.000
Organic	1.286	***	0.049	26.230	0.000
Axis one (000)	0.001		0.001	1.350	0.178
Parameters of the count model equation					
Constant	4.948	***	0.180	27.560	0.000
Hill	0.034		0.052	0.650	0.517
Mountain	0.007		0.061	0.110	0.915
Distance	-0.001		0.001	-1.160	0.247
Gender	-0.027		0.033	-0.810	0.417
Age	0.022	***	0.006	3.700	0.000
Age^2	0.0003	***	0.000	-6.110	0.000
Higher education	-0.029		0.033	-0.880	0.380
Agricultural education	0.102	**	0.049	2.090	0.037
Family farm	-0.564	***	0.054	-10.500	0.000
UAA	0.0004		0.000	1.540	0.123
UAA ratio	-0.227	***	0.048	-4.690	0.000
Workers	0.068	***	0.003	26.240	0.000
Plots	0.003	**	0.001	2.100	0.036
Potential successor	0.758	***	0.075	10.110	0.000
Arable crops	0.081	**	0.033	2.460	0.014
Permanent crops	-0.114	***	0.039	-2.950	0.003
Husbandry	0.194	***	0.032	6.000	0.000
Organic	0.108	**	0.045	2.430	0.015
Axis one (000)	0.023		0.000	0.060	0.954
Dispersion parameter for count data model					
Alpha	1.124	***	0.023	50.94	0.000

Note: ***, **, * equal to significance at 1%, 5% or 10% level, respectively.

Table 3: Partial Effects for Two Part Hurdle Model for Counts

Variable	Partial Effect	St. Error
Hill	0.128	1.183
Mountain	0.850	1.414
Distance	0.015	0.036
Gender	-0.339	0.728
Age	0.575***	0.264
Higher education	3.104	1.966
Agricultural education	4.007**	1.738
Family farm	-12.761***	2.805
UAA	0.032**	0.015
UAA ratio	-15.350**	6.577
Workers	1.931***	0.501
Plots	0.122**	0.051
Potential successor	24.522***	7.447
Arable crops	8.482**	3.997
Permanent crops	0.864	1.677
Husbandry	10.538**	4.196
Organic	12.418**	6.023
Axis 1	0.007	0.010

Note ***, **, * equal to significance at 1%, 5% or 10% level, respectively. Results are computed at the sample means of all variables. The effect is computed as the derivative = df(.)/dx