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Full Research Article

Explaining determinants of the on-farm diversification: empirical evidence from Tuscany region

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Abstract. On-farm diversification towards multifunctional activities is perceived as central in the Common Agricultural Policy (CAP) reform and in the Horizon 2020 strategies, because it strengthens territorial and social cohesion of rural areas.
While from a "macro" point of view relations between farm-household diversification and rural economies are central in the process of multi-functionality and in the provision of public goods through agricultural activities, from a "micro" point of view on-farm diversification activities can represent a relevant share of farm income.
Agricultural Economics and Rural Sociology have developed models aiming to explain the determinants of on-farm diversification thus providing a set of variables potentially influencing on-farm diversification. The paper applies a count model to explain the number of on-farm diversification activities that are implemented by farms in Tuscany. Since the high number of agricultural holdings that do not apply any diversification activity, we propose a two-step model where, firstly a simulation of adoption of diversified strategy as binary variable is considered and secondly, a model analysing the determinants of diversification intensity among the farms that have decided to diversify is implemented. Results confirm that location near main touristic areas and vicinity to urban markets are important determinants of on-farm diversification intensity. Results highlight a positive contribution of the Pillar 2 agricultural policies both in determining the diffusion of on-farm diversification activities and in influencing the intensity of adoption, while high per hectare Single Farm Payments have a negative influence on diversification intensity.

Keywords. On-farm diversification, multi-functionality, determinants, Tuscany.

JEL Codes. Q18, Q10

1. Introduction

On-farm diversification towards new activities is seen as central in the Common Agricultural Policy (CAP) reform and in the Horizon 2020 strategies, since it strengthens the territorial and social cohesion of rural areas (European Commission, 2010). In fact, in developed economies several available strategies provide means to differentiate income, while providing additional services and fulfilling functions that have a public

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utility. Thus, the increase of farm income through the allocation of household labour to on-farm diversified activities represents one of the main strategies to pursue viability of rural areas. Consequently, pluriactivity and diversification have brought about a greater integration and interdependency between farm households and rural economies. The relevance of diversification strategies is growing in rural economies. According to Knickel and Renting (2000), the relations between farm-household diversification and rural economies are central in the process of multi-functionality and in the provision of public goods through agricultural activities. In fact, based on 2007 Agricultural Resource Management Survey (ARMS) data, Vogel (2012) estimates that the contribution of on-farm diversification activities on the total value of US agricultural production is about 40%. Other authors (see e.g. Carter, 1999) have reported positive effects of diversification activities diffusion on rural development. The British Department of Environment, Food and Rural Affairs (DEFRA, 2012), estimates that since 2006, the share of UK farmer's income coming from diversification activities has continuously increased, while IRPET (2013), affirms that the share of farm income coming from diversification activity in Tuscany Region has increased by 20% during the last fifteen years. In 2010, according to Henke and Povellato (2012) about 5% of Italian farmers stated having diversified activities that accounted for 10 million of Full Time Equivalents, i.e. 4% of the total labour force in agriculture.

After the World War II, labour saving technologies have brought about a dualistic development among farms, which have either pursued concentration and specialisation in agriculture production or diversification strategies (see e.g. McNamara and Weiss 2005). Large amounts of literature deal with understanding the phenomena of farm diversification and pluriactivity, looking at the contribution of farm, farmer, and household characteristics (Hansson et al., 2013) as well as location and space in explaining farm household behaviours (Lange et al., 2013).

In this paper, determinants and motivations of on-farm income diversification towards activities other than crop and animal production are investigated. The paper addresses the activity classified as "Agricultural Secondary Activities" by Eurostat Statistics on Agriculture, Forestry and Fishery (see, e.g. Eurostat, 2013) and the Italian 2010 Agricultural Census.

The determinants of diversification strategies have been studied at micro level, focusing, on one hand, on the adoption of a specific activity (see Amanor-Boadu 2013) and of categories of activities (e.g. Vik and McElwee, 2011) and, on the other hand, on the adoption intensity by using indices measuring the degree of diversification (e.g. Barbieri and Mahoney 2009). This paper applies a count data model with the aim to explain the determinants of diversification intensity among farms in Tuscany. The level of intensity is measured as a count of available diversification activities. Furthermore, zero-inflated count models are applied in order to get an insight on the determinants of adoption of a diversification strategy by using a two step-model, where firstly, a simulation of adoption of a diversification strategy as a binary variable (adoption versus non-adoption) is considered and secondly, the determinants of intensity of on-farm diversification are analysed. The empirical analysis, which used micro-data collected from Agricultural Census 2010 and from the Tuscany Agency for Agricultural Payments (ARTEA), has highlighted heterogeneities among Tuscany farms in relation to explanatory variables between determinants of adoption of a diversification strategy and determinants of the intensity of adoption.

The paper contains five sections each focusing on one topic. In section 2 a review of literature is presented. Section 3 focuses on the theoretical model discussing the methodology underlying the econometric approach adopted. Section 4 gives a presentation of the data that has been used. The results and conclusions are given respectively in section 5 and 6.

2. Adoption of on-farm diversification strategy

The theoretical basis of the diversification strategy is rooted on a farm-household model, where a generic farm household chooses to allocate household labour between on-farm or off-farm activities, with the aim to increase income and to ensure a selected consumption level, while meantime ensuring a sufficient level of utility derived by the time allocated to leisure (Singh et al., 1986). Agricultural economics literature has investigated diversification adoption/diffusion under several perspectives focusing on the identification and definition of a diversification strategy and clarifying how this definition differs from the one of pluriactivity. Following the classification proposed by OECD, (2009) and by Salvioni et al., (2013), pluriactivity is a consequence of off-farm allocation of household labour while we have diversification when household labour is allocated on-farm. Authors highlight that diversification can be pursued by choosing one of the following pathways, a) agricultural output diversification (e.g. crops diversification), b) product diversification (e.g. Organic products, Protected Denomination of Origin products) and, c) non-agricultural output diversification (e.g. tourism activities). As Salvioni et al. (2013) point out the last two strategies can be grouped into a general category named on-farm income diversification.

On-farm income diversification strategy has been largely studied in agricultural economics. Since the seminal work of Johnson (1967), agricultural economics has identified the increase in returns of productive factors or the reduction of the risk of agricultural activities as main reasons to diversify farm activities. Andersson et al. (2003), applying a dynamic portfolio model, found that for risk adverse farmers a lower economic return was compensated by a reduction of the risk, when on-farm diversification is a risk-reduction activity. In this sense the differentiation of portfolio activities might reduce the exposure to several sources of uncertainty that affect farms, i.e. weather, pests and diseases, price and polices related to agricultural production, market and trade uncertainties. Thus, on-farm income diversification allows increasing utility for risk adverse farmers by reducing risk exposure due to specialisation (see McNamara and Weiss 2005). Mishra et al., (2010) and (2013), have found that on-farm diversification and off-farm labour allocation are less risky activities compared with agricultural production due to lower exposure to financial and physical risks (see Bowman and Zilberman, 2013).

Barbieri and Mahoney (2009) applying principal component analysis found that in addition to risk and uncertainty reduction (which remains the main goal of diversification) other five goals affect farmers' behaviour towards on-farm income diversification. These goals are the following, 1) retaining and expanding markets, 2) enhancing financial condition of the farm household, 3) individual aspiration and pursuit of personal interest/hobbies, 4) increasing revenues by means of additional income sources and 5) maintaining family connections keeping household labour on farm. Vik and McElwee (2011) applying a multinomial model to the adoption of diversification categories, found that motivations differ according with the categories of diversification activities. They point out that the search for additional income sources is the main motivation to diversify into tourism or other agricultural secondary activities while resource scarcity and availability as well as the desire to meet people are motivations to diversify into green care or social activities. McElwee and Bosworth (2010) individuated farm and household structures affecting the adoption of a diversification strategy and found that larger farms with young and high-educated male farmers are those that diversify. Furthermore they point out that farmers using internet on a regular basis show a higher probability to diversify while farmers with established business relations and involved in networking show lower statistical differences between those who diversify and those who do not diversify.

Other studies have shown how space and location influence the decision making towards on-farm income diversification strategies. The reason that increases the propensity to diversify is the demand and supply of diversified activities due to differences in the attractiveness of landscape, amenities and distance from urban areas and from main markets (Zasada, 2011). Recently, Lange et al. (2013) studied the spatial effect of rural attractiveness in explaining the diffusion of on-farm diversification activities, when this strategy aims to maintain farm viability. Mishra et al. (2010) have found that location in peri-urban areas influences the expectations regarding off-farm labour earnings and consequently, determines a higher allocation of household labour to off-farm activities due to the lower profitability of on-farm diversification strategies.

Both Pillar 1 and 2 payments affect the propensity to diversify production. Agricultural economics literature has highlighted that CAP strongly affects farm structures and types of production, and consequently directs farmers' behaviour towards on-farm diversification activities (Ilbery et al., 2006). Based on literature, income support payments affect the overall profitability of the entire agricultural sector and consequently the propensity to invest/innovate within the sector, as well as the propensity to diversify towards activities such as energy production or high value added production (Bartolini and Viaggi 2012). Furthermore, Pillar 1 payments reduce the propensity to exit from the agricultural sector by increasing the returns of on-farm activities and consequently reducing the willingness to allocate off-farm factors of production. Bowman and Zilberman (2013) have pointed out that the mechanism of payments based on eligible crops designed to produce commodities determine an increase in crop specialisation rather than in diversification. On the contrary, Pillar 2 payments affect positively on-farm diversification adoption in two ways, firstly via the co-funding mechanism, which reduces investment costs especially for first (Competitiveness) and third axes (Improving the quality of life in rural areas) payments (Bartolini and Viaggi, 2013) and secondly via the effects of payments for ecosystems services on rural viabilities and on the maintenance of valuable amenities within rural areas (Zanten et al., 2013).

3. Methodology

3.1 Theoretical model

This paper analyses the determinants of intensity of income diversification towards on-farm activities. Despite a large amount of literature, only a few empirical papers have studied the issue of diversification intensity. Barbieri and Mahoney (2009) deal with diversification intensity by using a diversification index based on the number of activities carried out on the farm. In this paper we use directly the count of diversified activities adopted that are included in a set of available diversification strategies. Such a count can be seen as a proxy of on-farm income diversification intensity. The portfolio of feasible on-farm income diversification strategies is created on the base of the agricultural secondary activities surveyed by the Italian 2010 Agricultural Census, which are mainly related to activities other than agricultural commodities production but that are connected with it. These activities belong to the following groups: a) agri-tourism, b) recreational and social activities, c) educational farms, d) processing farm products, e) aquaculture, f) contract work, g) processing of feed and services for breeding , h) forestry activities; i) renewable energy production; j) handicraft; k) "other" category.

As aforementioned, risk attitude and farm income stabilisation are used in economic literature to explain farm diversification strategies. This paragraph presents a theoretical formulation of the optimal intensity of on-farm income diversification, expressed as count of diversified on-farm activities. Several authors have stressed the simultaneity between decisions about diversification and household labour allocation between on-farm and off-farm activities. The paper adapts the model developed by McNamara and Weiss (2005) to the choice of diversification. The optimal diversification intensity could be modelled by the allocation of household labour l_i between a portfolio of n activities $\sum_{i=1}^{n} l_i + l_0 \leq L$ where l_0 measures the amount of household labour allocated off-farm and L is the total household labour endowment.

Assuming that a generic farm output/service i is produced by the production function[2] $f_i(l_i)$ and that farmer faces only uncertainty in output/service price, so that for a generic activity/service i p_i is the expected economic return of this diversifying activity, and considering two generic activities i and j whose variance and covariance are $\sigma_{ii} = \sigma_k^2$ and $\sigma_{ij} = \rho\sigma_k^2 \ \forall \ i \neq j = 1,\ldots,n$ with ρ as correlation coefficient such as $-1 \leq \rho \leq 1$

The expected profit for a generic farm household can be formalised as

$E(\pi) = \sum_{i=1}^{n} p_i f_i(l_i) + wl_o - cn$ that when substituting $l_i = L - l_0$ yields

$$E = npf\left(\frac{L - l_o}{n}\right) + wl_0 - cn$$

In w the expectation wage of off-farm labour allocation and c the fixed costs involved in undertaking a generic activity (investment costs, learning costs and transaction costs), with $l_0 \geq 0$.

The equation yields the optimal farm strategy as a function of choice of optimal count of diversified activities. Assuming risk aversion of farmers and a utility function that follows a negative exponential distribution $y(\pi) = 1 - e^{-r_a}$ with a constant absolute risk aversion r_a and a normal distribution of possible outcomes, it is possible to approximate the decision problem to a function of the first two moments (Freund, 1956), such as

[2] For simplicity, we assume equal production function among the portfolio of activities; productive factors and policy are omitted in the formal presentation of the model.

$CE(\pi) = E(\pi) - 0.5r_a V(\pi)$ where
$CE(\pi)$ is the certain equivalent;

$E(\pi)$ is the expected profit;

$V(\pi)$ is the variance.

As pointed out by Robinson and Berry (1987) the variance of the decision problem equals to

$$V = (L - l_0)^2 \left[\frac{1 + (n-1)\rho}{n} \right] \sigma_k^2$$

and then $CE(\pi)$ equals to

$$CE(\pi) = npf\left(\frac{L - l_o}{n} \right) + wl_0 - cn - \frac{r_a}{2}(L - l_0)^2 \left[\frac{1 + (n-1)\rho}{n} \right] \sigma_k^2$$

Maximising CE with respect to the decision count of diversified activities yields:

$\frac{CE}{n} = pf'\left(\frac{L - l_o}{n} \right) - c - \frac{r_a (L - l_0)^2 (1-\rho)\sigma_k^2}{2n^2} = 0$ that in a case of linear production function yields:

$$n^* = (L - l_o)\sigma_k \left[\frac{r_a}{2c}(1-\rho) \right]^{1/2}$$

The optimal count of diversification activities increases with a high-risk aversion coefficient r_a and with uncertainty in the diversified outcome, and consequently diversification determines a gain due to risk reduction strategies. This gain, as suggested by McNamara and Weiss (2005), is reduced by the amount of learning and transaction costs *c* needed to implement a new diversification strategy.

Thus, the farmers' choices are based on risk attitude, which measures their preferences as regards the set of alternatives and the variance of the expected profit this latter being determined by the expected return of the alternatives and by the productivity in the use of farm household's resources. Albeit purely income motivations might be at the base of farmers' choices and notwithstanding several papers point to that, nevertheless no explicit economic model has been presented so far; hence, this paper tries to explore empirically whether variables related to both motivations are affecting the intensity of diversification.

3.2 Econometrics specification

The intensity of the on-farm income diversification, measured as the count of activities adopted among a set of feasible portfolio, is the dependent variable. Many econometric models such as regression or quantile regressions are used in agricultural economics to estimate the degree or intensity of income diversification (McNamara and Weiss, 2005). Those models have been used to explain motivations and determinants by using, as a proxy of diversification intensity, a diversification index obtained either by the count of activities or by a weighted sum of portfolio of activities. McElwee and Bosworth (2010) have applied a categorical data model in explaining determinants of diversification, simulated as a binary variable or as a categorical variable. In this paper, applying a zero inflated count model we estimate diversification intensity *via* a two-step process, where in the first step the discrete decision about whether to diversify, or not, is explained, while the second step is used to explain determinants of diversification intensity. The use of a zero-inflated count model allows us to treat data with excess of zero value (Lambert, 1992; Green, 2003) by separating the decision process in these two steps.

The simulation of diversification adoption as a two-step process provides a better representation of farmers' behaviour. The first step allows coping with the boundary in pursuing at least one diversification alternative while the second step analyses the behaviour of farmers who have decided to diversify and who have access to the implementation of several alternatives (Amanor-Boadu, 2013).

Application of zero inflated count data are quite common in agricultural economics, e.g. Isgin et al. (2008) estimate the factors affecting the intensity of implementation of technological elements in Ohio farms, while Uematsu and Mishra (2011) estimate the determinants affecting the total number of direct marketing strategies adopted by farmers, and Bartolini et al., (2011) study the CAP impacts on the intensity of innovation.

Formally, the count of on-farm diversification activities is a function of a set of independent variables X_i so $\ln(\lambda_i) = \alpha_0 + \beta' X_i$ where λ_i is means of the on-farm differentiation activities, α_0 the constant term and β' is the coefficient of the set of explanatory variables. To analyse the variables, two distributions are considered, namely Poisson and Negative binomial models (Paxton et al., 2011).

Let Y_i be the observed event of count data, the parameter β' depends on the value of explanatory variables; consequently, it is possible to write:

$$E(Y_i \mid X_i) = \lambda_i = \exp(\beta' X_i) \quad i = 1,\ldots N$$

The probability density function for Poisson model is

$$P.\Pr\left(Y_i \mid X\right) = f\left(Y_i\right) = \frac{e^{-\lambda_i} \lambda_i^{Y_i}}{Y_i!}$$

The Poisson specification assumes that the first two moments are equal

$$E[(Y)] = \lambda$$

$$V[(Y)] = \lambda$$

To take into account overdispersion, a more flexible Negative Binomial Regression (NBR) model has been applied. The density function for the negative binomial model is

$$NB.\Pr\left(Y_i \mid X_i\right) = f\left(Y_i\right) = \frac{\Gamma\left(y+\alpha^{-1}\right)}{y!\,\Gamma\left(\alpha^{-1}\right)}\left(\frac{\alpha^{-1}}{\alpha^{-1}+\mu}\right)^{\alpha^{-1}}\left(\frac{\mu}{\alpha^{-1}+\mu}\right)^{y_i} \text{ where}$$

Γ is the gamma distribution function.

With $\alpha = 0$ a Negative Binomial model is equal to a Poisson model.

In this paper, we compare the results of a zero-inflated Poisson (ZIP) model with those of a zero-inflated Negative Binomial (ZINB) model. The mechanism underlying the models is related to how zero is generated, since zero value could be originated by two different regimes: a) the first one, where the outcome is always zero (the model explains the determinants affecting the non-adoption of a diversification strategy,) and b) the second one, using Poisson (or Negative Binomial) distribution to explain the outcome produced by a non-negative integer value (Green 2003). Zero inflated approaches estimate determinants by combining two steps models. The first model is a logit model analysing the discrete choice about the decision whether to diversify or not (first regime). The second model is a Poisson or Negative Binomial model generating a prediction of the count of the diversification activities (second regime). The main interest in applying such type of model is that the results of zero-inflated models return a correction to the estimation by separating the determinants of the count of diversified activities from the determinants of observed zero value that represents the non-adoption of a diversification strategy. In fact, the main assumption of the model is that two separate sets of covariates affect the decision to adopt diversification strategies.

Following Mullahy (1986) and Lambert (1992), it is possible to describe the choice as:

$Y_i = 0$ with ω_{it}

$Y_i \sim Poisson(\alpha_{it})$ probability $1 - \omega_{it}$ (in case of Poisson model)

$Y_i \sim NBR(\alpha_{it})$ with probability $1 - \omega_{it}$ (in case of Negative Binominal Regression model)

The probability of the zero positive outcomes can be expressed as:

$\Pr[Y_i = 0] = \{\omega_i + (1 - \omega_i)g(0)$

$\Pr[Y_i = k] = (1 - \omega_{it}) + (1 - \omega_{it})g(k)$, k=1, 2, 3... , where $g(\bullet)$ depends on the type of model considering the negative binomial probability function, as mentioned above.

4. Data Used

In this paper, we have used micro-data from the 2010 Italian Agricultural Census relating to on-farm differentiation activities undertaken by each farm and a set of variables that describe characteristics of farms, farmers and households. The census database has been merged with data relating to farm location, territorial description of the area, and with data on the amount of Single Farm Payments (SFP) received by farmers and their participation to some RDP measures. This latter information have been taken from ARTEA (the Tuscany Regional Agency for Agricultural Payments) database. The dependent variable represents the count of alternative diversification strategies applied at farm level. In the Census questionnaire, the adoption of on-farm diversification activities is analysed by using a list of 17 alternatives that we have classified into 11 categories taking into account their degree of similarity, e.g. putting together contract work provided to other agricultural or non-agricultural enterprises; handcraft and wood processing, etc. These categories include rural-tourism, recreation and social activities, contract work, renewable energy production (different from energy crops production), handicrafts, processing farm products, educational farm activities, aquaculture, production of feed and services for breeding and forestry. Table 1 shows the frequency of farms that have the considered activities in Tuscany.

Table 1. Tuscany – Absolute (#) and relative (%) frequency of implementation of on-farm diversification activities.

Diversification categories	Farms	
	(#)	(%)
Agri-tourism	3,487	4.80
Contract work	1,375	1.89
Processing farm products	1,314	1.81
Production of feed and services for breeding	1,004	1.38
Forestry activities	891	1.23
Handicraft activities	360	0.50
Recreational and social activities	244	0.34
Educational farms	204	0.28
Renewable Energy production	230	0.32
Aquaculture	25	0.03
Other activities	388	0.53

Source: Data from Istat, 6th Italian Agriculture Census (our processing).

Diversification activities are quite heterogeneous in terms of needed work and skills, provided services and as a source of income. Among the several groups of on-farm diversification activities, agri-tourism has the highest frequency among farmers in Tuscany. This activity counts ca. 3500 farmers, i.e. almost 5% of all farmers. Contract works and on farm processing of farm products come as second and third in importance as diversification activities. Both of these activities involve more than 1300 farmers in the Region, i.e. more than 1.80% of all farmers. Supply of services for livestock and forestry activity count ca. 1000 farmers each, i.e. around 1.3% of all farmers, while social and educational activities have a frequency of 0.5% or below.

Intensity of on-farm diversification is measured, for each farm, by the count of implemented diversification activities. Table 2 presents the number of farms in Tuscany according to their diversification activities count. This is the dependent variable in the econometric model and it measures the diversification intensity at farm level.

Table 2. Tuscany – Absolute (#) and relative (%) frequency of farms according to their count of on-farm differentiation activities.

Diversification intensity (# of activity	Farms	
	(#)	(%)
0	65,747	90.45
1	5,124	7.05
2	1,309	1.80
3	336	0.46
4	107	0.15
5	44	0.06
6	12	0.02
7	4	0.01
8	3	0.00

Source: Data from Istat, 6th Italian Agriculture Census (our processing).

The data illustrate that a vast majority (above 90%) of farmers in Tuscany have not applied any diversification strategy. Furthermore, data show that with respect to ca. 70,000 farms, some 5,000 (7.05%), implemented one diversified activity and ca. 1,300 farms (1.8%) implemented two diversified activities. The number of farms progressively reduces with the increase of the count of on-farm diversification activities and only some sixty farms apply five differentiation activities or more. The data used contain an excess of zero observations and consequently, zero-inflated models have been used in order to correct the estimation, when having such a large number of zero value observations (see methodology section).

As mentioned earlier the dependent variable is the count of the adopted diversified alternatives. As pointed out in theoretical model section, the determinants of diversification focus mainly on two dimensions: risk aversion and income (e.g. increasing profitable use of farm households' resources). Therefore, we have identified explanatory variables belonging to the following five categories, which can be related with those two dimensions: a) geography/location, b) farmer, c) household, d) farm characteristics, and e) policy. Descriptive statistics of the selected explanatory variables are presented in Annex 1.

The first category includes geographical variables such as altitude and Regional Development Programme (RDP) zoning. Location in urban or rural areas and the altitude are expected to be relevant as determinants of diversification patterns due to the priority mechanism defining eligibility to the measure 311, promoting diversification in rural areas, and as determinants of change in the demand of diversification related to services (Zasada 2011). According to literature, farm location affects expectations regarding off-farm wage and consequently differences in location modify the preferences of household labour allocation (McNamara and Weiss 2005). Thus, location variables are more related with the income dimension due to the effects in changing farm households labour revenue expectation between off-farm and on-farm activities and in changing the demand for diversified services provided by the farmers (Zasada, 2011; Lange et al., 2013)

Agricultural economics research has highlighted the influence of farmer and household characteristics (i.e. our second and third categories) on the risk attitude towards alternative farm strategies. However, while Vik and McElwee (2011) show that male educated young farmers have a higher probability to diversify, other studies show opposite effects due to the influence of the same characteristics on attitude and ability to obtain credit (see Bowman and Zilbermann 2013). The fourth category of explanatory variables includes farm characteristics that relate to farm structure, farm specialisation, and production technology. According to previous research, farm structure and farming systems influence the level of risk exposure while economies of scale on credit access influence the attitude towards farm specialisation (Chavas et al., 2001; Mishra et al., 2004; Bowman and Zilbermann 2013). The fifth category includes variables relating to payments received via agricultural policies. These variables may affect the decision to diversify in several ways, e.g. by preserving rural amenities, by producing changes on the productivity of farm structures or on the profitability and on the timing of adoption of new investments. Therefore, policy category affects mainly income dimension, due to the change of relative profitability between output diversification and on-farm income diversification.

5. Results and Discussion

As above mentioned the zero-inflated count model estimates the determinants of diversification intensity in two steps, firstly by identifying variables that affect the probability to observe a zero value and secondly by identifying variables affecting on-farm diversification intensity. Results of both Poisson and zero-inflated Negative Binomial models are shown in tables 3 and 4. Table 3 presents results in terms of determinants of the adoption of at least one diversification alternative versus non-adoption, while table 4 shows the determinants of diversification intensity.

The coefficients of the zero-inflated models can be interpreted in the same way than in standard binary choice models; therefore, coefficients describe the probability to observe a zero value of the count variable, i.e. non-diversification. Thus, a significant positive coefficient (table 3) means a high likelihood to observe a zero value (non-diversification), while a significant negative coefficient has opposite meaning. Vice versa, coefficients of table 4 describe changes in the expected count of the farmers adopting on-farm differentiation activities. Consequently, a positive value of the count outcome indicates that the variable determines an increase in expected outcome of the model and consequently has a positive effect on intensity of diversification, while a significant negative coefficient means that the variable reduces the expected count of diversification intensity.

Both tables show a comparison between zero-inflated Poisson (model 1) and zero-inflated Negative Binomial (model 2) models. Due to joint estimation of the determinants between zero-inflated and count outcome, the selection of estimation affects model results. However, both models (zero-inflated Poisson and zero-inflated Negative Binomial) have positively passed the Vuong test. This test compares respectively zero inflated Poisson versus standard Poisson model and zero-inflated negative binomial versus Negative Binomial model. Results suggest that, due to excess of zero values, zero-inflated Poisson and

Table 3. Determinants of the adoption of a diversification strategy, results of full Zero-inflated Poisson (ZIP) and Zero-inflated Negative Binomial (ZINB) models (logit).

Variable (Description)	Variable (Code)	ZERO INFLATED OUTCOME (Logit)			
		ZIP (Model 1)		ZINB (Model 2)	
Location in urban areas (dummy)	poli_urb	-0.053	*	-0.0364	*
Location in rural areas with developing problems (dummy)	rur_probsv	0.0807		0.1415	*
Fourth UAA percentile – very small (dummy)	uaa_vl	-0.5551	***	0.222	
First UAA percentile – very large (dummy)	uaa_vs	0.8244	***	0.5076	***
Amount of UAA (natural logarithm)	uaa1_ha	-0.0119	***	-0.08732	***
Farms with rented land (dummy)	uaarent_d	-0.7674	***	-0.7663	***
Farm specialization in horticulture (dummy)	spec_horticolture	0.8047	***	0.5235	***
Farm specialization in permanent crops (dummy)	spec_permanent	0.361	***	0.4114	***
Organic farming (dummy)	d_bio	-1.3439	***	-1.6665	***
Use of internet for farm activity (dummy)	inform_d	-2.3899	***	-3.5944	***
Square of farmers' age	age2	0.0018	***	0.0155	***
Farmers younger than 40 years (dummy)	d_young	-0.1712	*	-0.3036	***
Education lower than secondary school (dummy)	edu_low	0.2701	***	0.1771	***
Use of Paid labour (dummy)	cond_salecon	-1.1772	***	-1.1356	***
Participation at RDP first-axis measures (dummy)	part_axis1	-0.7710	***	-1.1975	***
Participation at RDP agri-environmental schemes (dummy)	part_axis2env	-0.3083	***	-0.2685	***
Participation at RDP forestry measures (dummy)	part_axis2for	-0.3102		-1.9128	*
Participation at RDP measure 311 - diversification (dummy)	part_311	-2.1450	***	-3.1291	***
SFP payments per ha (1000 €)	sfpr_ha_uaa	-0.1138	*	-0.2051	**
Constant	cons	1.6122	***	1.644	***
Number of observations		72686		72686	

*** significant at 0.01; ** significant at 0.05; *significant at 0.1; Not significant variables have been omitted.

zero-inflated Negative Binomial provide a better fit compared to standard count models[3].

The results of logit models show that geographical, farm, farmer, household and policy variables affect the probability to observe at least one diversification activity. Farmers' location in urban areas as identified for RDP purposes by inhabitant density is more likely to determine adoption of diversification strategies, while in locations in remote rural areas with development problems (defined by RPD zoning, as rural area where income are lower compared with other regions), one is less likely to observe diversified strategies; such

[3] Vuong test for model 1 Zero-inflated Poisson versus Standard Poisson has obtained a score of 25.25 and significance at 0.01, while Voung Test for model 2 Zero-inflated Negative Binomial versus Negative Binomial model has shown a score of 24.08 and significance at 0.01.

Table 4. Determinants of diversification intensity, results of full Zero-inflated Poisson and Zero-inflated Negative Binomial models (count variable).

Variable (Description)	Variable (Code)	COUNT OUTCOME			
		ZIP (Model 1)		ZINB (Model 2)	
Location in urban areas (dummy)	poli_urb	-0.2164	***	-0.1966	***
Location in intensive agricultural rural areas (dummy)	rur_int	-0.1119	*	-0.1097	
Location in rural areas with developing problems (dummy)	rur_probsv	0.4664	***	0.4095	***
First UAA percentile – very small (dummy)	uaa_vs	-0.1545	**	-0.1119	*
Amount of UAA (natural logarithm)	uaa1_ha	0.0006	***	0.0003	**
Farms with rented land (dummy)	uaarent_d	0.0851	***	0.005	
Farm specialization in arable crops (dummy)	spec_arable	-0.1719	***	-0.1705	***
Farm specialization in permanent crops (dummy)	spec_permanent	-0.0293		-0.0782	**
Farmers older than 65 years (dummy)	d_old	-0.1397	**	-0.1795	**
Farmers younger than 40 years (dummy)	d_young	-0.173	***	-0.1492	***
Agricultural education (dummy)	edu_agr	0.1026	**	0.0944	**
Education lower than secondary school (dummy)	edu_low	-0.256	***	-0.1735	***
Household lives on the farm (dummy)	live_on	0.219	***	0.1983	***
Farm that use mainly household labour (dummy)	cond_coltdir	-0.2106	***	-0.1458	***
Participation at RDP first axis measures (dummy)	part_axis1	0.1531	***	0.0923	**
Participation at RDP agri-environmental schemes (dummy)	part_axis2env	0.3481	***	0.2771	***
Participation to RDP measure 311 – diversification (dummy)	part_311	0.4867	***	0.3721	***
SFP payments per year (1000 €)	sfpr_year	-0.0039	***	-0.0051	***
Constant	Constant	-0.7281	***	-0.5664	***
	ln alpha			-0.932	***
	alpha			0.1914	***
Number of observations		72686		72686	

*** significant at 0.01; ** significant at 0.05; *significant at 0.1; Not significant variables have been omitted.

variable is significant only for zero-inflated Negative Binomial model. Our results confirm the hypothesis proposed by Lange et al. (2013) and Zasada (2011) about the demand-driven effects of diversification, due to closeness to potentially high demand for services provided by farm diversification. Results emphasise the effects of farmer's characteristics as a barrier against diversification adoption. In fact, as outlined by McNamara and Weiss (2005), age, education and attitude have a prominent role in explaining diversification due to their influence on risk aversion attitude, wealth and reduction of working load over time. In particular, young and high-educated farmers are more likely to diversify activities according to the life-cycle hypothesis in relation to the decision to allocate resources between on-farm and off-farm activities (Mishra et al., 2010). Results show that farmers who use internet in their business have a higher probability to diversify due to the possibility to reach spatially distant markets and to a higher probability to be involved in networks (McElwee and Bosworth 2010).

As pointed out by literature, farm structure strongly affects the likelihood of adopting diversification. According to our results farm specialisation, farm size and production system have a significant effect on adoption of diversification. There is no consensus in literature regarding the effect of farm size on diversification. In fact, while from one hand economies of scale push farms to become more specialised in agricultural production and consequently to diversify less (McNamara and Weiss 2005), on the other hand, the decrease in marginal return of specialisation determines a higher probability of allocating labour to diversified activities due to higher marginal value when allocating an additional household labour unit to diversified activities with respect the specialisation (Robinson and Barry, 1987). Our results seem to confirm the second hypothesis showing that for very small farms scarce land endowment represents a barrier to adopt any diversification strategy. Results show that farm specialisation, due to market structure and investment specificity, determine a higher level of risk exposure and consequently risk adverse farmers react by increasing diversification (Mishra et al., 2010). However, farm specialisations in horticulture and permanent crops show a low probability of diversification because of the specific market structure (vertical integration). In fact, this kind of market structure reduces price related risk and consequently determines higher investments and a more labour intensive production. According to research results, organic farming is more likely to be diversified because of synergies between diversification strategies (McElwee and Bosworth, 2010). Both CAP Pillars (Pillar 1 and Pillar 2) influence the probability to observe the implementation of at least one diversification activity. As expected, participation to RDP measures affects positively the probability to observe a diversification strategy. These results confirm the expectations that when participating to modernisation measures or agri-environmental schemes farmers renew and rethink their entire production system. Single Farm Payments (SFP) show same effects, in fact, increasing the amount of received SFP the probability to observe a diversification strategy on-farm increase.

The determinants of diversification intensity model are presented in table 4. Table 4 shows model results for farms whose dependent variable value is different from zero (farms with at least one implemented diversification activity). Positive coefficients mean an increase in the expected count of the dependent variable, while negative coefficients reduce the expected count of diversification intensity. As mentioned in the methodology section, zero-inflated Poisson and zero-inflated Negative Binomial models give different results due to the form of the used distribution function. As explained in the methodology part the main difference arises from the inclusion of α in the zero-inflated Negative Binomial model. Positive and significant observed value of α suggests the best fit for zero-inflated Negative Binomial compared to zero-inflated Poisson. Model results show that farm location has a strong effect to the expected count of diversification intensity. *Vice versa*, in the case of location in areas with development problems, due to lower off-farm opportunities compared to other areas, farmers who try to reduce risk exposure are pushed to increase their income diversification through on-farm activities (Mishra et al., 2014).

Results highlight that farm characteristics such as size and degree of specialisation affect diversification intensity. Farms with a large amount of UAA (Utilized Agricultural Area) and renting of land show an expected count increase towards diversification intensity, confirming the effect of decreasing marginal return of land in case of specialised activities (McNamara and Weiss, 2005). *Vice versa*, farms specialised in arable crops and farms specialised in permanent crops show a reduction in the expected count of diversification intensity due, in the latter case, to a lower flexibility of farm production, although this variable is significant only for zero-inflated Negative Binomial model. Age and education are variables that strongly affect the expected outcome of diversification intensity. Results show that both young and old farmers have low expected diversification intensity, and consequently, our work confirms the findings of McNamara and Weiss (2005) regarding the non-linearity of age effects on farm diversification intensity. They pointed out that young farmers are less risk adverse and show a lower propensity towards diversifying activities, while older farmers tend to reduce the amount of workload due to life cycle expectations. According to our study, families living on farm have a higher expected count of diversification. However, when the majority of on-farm labour is satisfied using household labour there are significant negative effects on diversification intensity, while variables related to policy context affect positively the expected outcome of diversification intensity. The results of ZIP and ZINB models stress the positive effects of RDP measures on diversification intensity. Results show that farmers are developing new business plans that focus more on the integration of farm income via diversification activities rather than just co-funding agro-tourism or production of renewable energy (the only available diversification activities eligible for measure 311). This allows us to consider participation at RDP measures as a driver to rethink the entire farm production system. Participation to any measure belonging to RDP second, environmental, axis positively affects the expected count of diversification intensity due to the improvement of provision of environmental quality, or the breeding or management of endangered species. At the same time, according to the research result the amount of SFP received reduces the diversification intensity due to the mechanism of promotion of specialisation in the production of commodities.

6. Conclusion

In this paper, determinants of diversification activities are analysed, using the Italian Census of Agriculture and ARTEA (Tuscany Regional Agency for Agricultural Payments) micro-data. The paper develops an econometric model that explains determinants firstly, of the discrete choice of adoption or non-adoption of a diversification activity and secondly, of the intensity of diversification, measured as a count of adopted alternative diversification categories. A relevant share (ca. 7%) of farmers in Tuscany has diversified their farm's activities mainly by implementing rural tourism, contract work or farm products processing activities. There is a large amount of literature explaining the determinants of adoption of categories of diversified activities, where categories are grouped according to provided services or the amount of efforts and of investments required. These models return interesting results, but in our case, synergies in adoptions and farm strategy show not-mutually exclusive alternatives. This represents a violation of independence of irrelevant alternatives and consequently does not make possible the application of multinomial models. In this sense, the paper's main novelty is represented by the choice to treat diversification as a count variable when trying to explain diversification intensity as a strategy that may be used to reduce on-farm risk exposure.

Model results show that farm, farmer, household and geographical characteristics strongly influence the attitude towards on-farm diversification activity. In particular, results confirm that diversification activity requires skills, competence and endowment of productive factors that represent a barrier to the adoption for many farms.

Results confirm previous literature findings in representing diversification strategy as a way to increase household income using on-farm resources and to reduce farm-household risk exposure. Results show a picture, where diversification is one of the strategies used by farms that a) are viable from an economic point of view for their structural characteristics, b) improve their income by expanding their size (rented land), c) search new ways for increasing farm income, through farm modernization, the research of new markets (organic farming) and the use of tools needed to compete on a global market (internet).

On the other hand, the group of farms, which are located in areas with development problems where involvement on agricultural activities is diminishing, are highly dependent on SFP and the activities that are carried out are mainly horticulture crops, olives and vineyards, likely using subcontractor services and/or family labour. In this case, it seems that farmers have a low interest in investing, modernising or improving farm capacity in order to provide an income other than the one coming from Pillar 1 subsidies.

Results confirm that location and geographical variables determine changes in the observed diversification activity. In particular, relations between demand for services provided by diversification (e.g. tourism, handicraft, or contract work) and expectation regarding income sources represented by off-farm activities are determinant for diversification adoption and intensity (Lange et al., 2013). Results show that these variables are relevant especially in urban areas (which are mainly in plain areas) and in marginal areas, such as rural areas with development problems. In fact, these areas have opposite direction as regards diversification adoption or diversification intensity. Urban and peri-urban areas show a low probability to observe diversification adoption and intensity of diversification. Location on rural areas with development problems represents a barrier to the adoption of diversification activities. However, at the same time in many areas diversification represents the main opportunity for income creation and risk reduction, due to scarcity or absence of other opportunities for off-farm labour and to the necessity to overcome territorial constraints, in the case of the farmers who internalise by providing social services. Consequently, farms, located in these areas, which have adopted a diversification strategy, show a high intensity of diversification.

Results confirm the effects of CAP in driving on-farm diversification intensity. Both Pillar 1 and 2 payments affect the attitude to diversify, although in opposite directions. Pillar 1 payments positively affect the decision to adopt diversification strategy by ensuring liquidity to invest on agriculture (Bartolini and Viaggi, 2012) and by contrasting exit from farming activities (or off-farm household labour allocation) due to an increase of the overall agricultural sector profitability (Raggi et al. 2013). Furthermore, RDP measures (Pillar 2) promote diversification activity in several ways, such as, a) co-funding investments on diversification (third axis) or on technology provision, such as new machinery or new energy plants (first axis), and b) by promoting a sustainable agricultural production (organic production), maintaining and preserving landscape elements and biodiversity.

In this paper, when trying to identify determinants of on-farm diversification as a framework of risk reducing behaviour, we have made an assumption that simplifies the definition of diversification intensity by counting the diversification activities provided by the Italian Agricultural Census data. This assumption influences the dependent variable that focuses on the count of activities rather than on income sources, and therefore determines an application of portfolio model based purely on a proxy of intensity.

Nevertheless, the use of census data for investigating diversification strategy is quite common in agricultural economics literature (see e.g. McNamara and Weiss 2010; Mishra et al., 2010) even if in the Census a set of relevant economic data (both on-farm and off-farm), networking and social capital dimension are missing. Therefore, future works need to be directed to the inclusion of those dimensions, that may have significant effects on the intensity of diversification, and that need ad hoc surveys due to the lack of official data. In the same way, the lack of data does not allow studying the trade-off between diversification and pluriactivity (allocation of household labour and investing in off-farm activities) that together with specialisation represent the main strategy of farmers in reducing risk exposure. Thus, further improvements through the identification of alternative farm strategies by understanding dynamics of off-farm labour pattern in other sectors would represent a viable strategy to understand risk aversion effects on agriculture.

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ANNEX 1. Descriptive statistics of data used

Category	Variable	Description	Observation	Mean	Standard Deviation	Min	Max
Geographical	plain	Location in plain areas	72686	0.1206	0.3257	0	1
	hill	Location in hill areas	72686	0.6984	0.4589	0	1
	mount	Location in mountain areas	72686	0.1809	0.3850	0	1
	poli_urb	Location in urban areas	72686	0.1737	0.3789	0	1
	rur_int	Location in rural areas with intensive agriculture	72686	0.1008	0.3011	0	1
	rur_trans	Location in rural areas in transition	72686	0.3408	0.4740	0	1
	rur_decl	Location in rural areas in declining	72686	0.2413	0.4279	0	1
	rur_probsv	Location in rural areas with developing problems	72686	0.1430	0.3501	0	1
Farm household	live_on	Famers' household livees on tha farm	72686	0.8402	0.3663	0	1
	selfcons	Self consumption of agricultural products (more than 50 % of productions)	72686	0.5026	0.4999	0	1
Farm	d_bio	Organic production	72686	0.0325	0.1775	0	1
	uaa_l	Small farm size	72686	0.2456	0.4304	0	1
	uaa_s	Medium-small farm size	72686	0.2344	0.4236	0	1
	uaa_vl	Medium-large farm size	72686	0.2489	0.4323	0	1
	uaa_vs	Large farm size	72686	0.2711	0.4445	0	1
	uaa_1n	Logarithm of Usable Agricultural Areas	72686	1037.81	3508.67	0	2292.1
	uaarent_d	Rented-in	72686	0.1552	0.3621	0	1
	spec_ livestock	Farm system specialised in livestock production	72686	0.0554	0.2289	0	1
	spec_arable	Farm system specialised in arable production	72686	0.1738	0.3790	0	1
	spec_ permanent	Farm system specialised in permanent crops	72686	0.5871	0.4923	0	1
	spec_ horticulture	Farm system specialised in vegetable crops	72686	0.0447	0.2068	0	1
	cond_ coltdir	Direct conduction by farmer	72686	0.9561	0.2047	0	1
	cond_ salecon	Conduction using paid labour	72686	0.0378	0.1908	0	1
	cond_oth	Other conduction	72686	0.0059	0.0770	0	1
Farmer	d_young	Farmers young than 40 years old	72686	0.1042	0.3056	0	1

Category	Variable	Description	Observation	Mean	Standard Deviation	Min	Max
	d_old	Farmers old than 65 years old	72686	0.4138	0.4925	0	1
	age2	Square of age	72686	3851.43	1740.82	256	9801
	inform_d	Use of internet for farming activities by the farmer	72686	0.0590	0.2351	0	1
	edu_agr	Farmer with agricultural education	72686	0.0388	0.1932	0	1
	edu_high	Farmer with education higher than secondary school	72686	0.3302	0.4703	0	1
	edu_low	Farmer with education lower than secondary school	72686	0.6697	0.4703	0	1
Policy	part_axis1	Participation in at least one measure of first RDP axis	72686	0.0270	0.1622	0	1
	part_axis2env	Participation in at least one measure of second RDP axis (environmental measures)	72686	0.1038	0.3050	0	1
	part_axis2for	Participation in at least one measure of second RDP axis (forestry measures)	72686	0.0013	0.0359	0	1
	rdp_311	Participation in measure 311 of RPD	72686	0.0021	0.0461	0	1
	Sfp_year	Amount of single farm payments received per years	72686	1411.35	5758.9	0	426822
	sfp_ha	Amount of single farm payments received per hectare	72686	152.33	1670.14	0	41130