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An analysis of the efficiency in a sample of small Italian farms part of the FADN dataset

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Abstract: Italian farms have an average surface lower than 10 hectares and they are predominately scattered in the upland rural areas. The most important aspect of small family farms is to protect the rural environment against the socio-economic marginalization of rural territories and reducing the out-migration from the countryside as well. Since the 1960s, the European Union has arranged a microeconomic survey on a sample of farms aimed at estimating the impact of the Common Agricultural Policy strategies on farmers called the Farm Accountancy Data Network or the FADN. The purpose of the analysis was to assess by a quantitative approach using the FADN dataset the technical, economic and allocative efficiency in Italian family farms over the time 2000–2012. In particular, the aim of the paper has been to investigate if the legal typology of property has influenced the efficiency of Italian farms. Some findings have pointed out that the co-operatives and family farms during the five year time 2008–2012 have had the same level of efficiency. Italian small farms smaller than 5 hectares need adequate financial supports allocated by the II. pillar of the Common Agricultural Policy and these subsides are pivotal in particular towards family farms located in the upland and hilly areas.

Keywords: allocative efficiency, Common Agricultural Policy, economic efficiency, rural areas, small family farms

The statistical data have pointed out that more than 90% of Italian farms have an average usable agricultural surface lower than 9 ha. In Europe, approximately 99% of farms have got a usable agricultural surface lower than 5 ha (Festuccia 2013; Istat 2013) what is far below the European average surface which is equal to 12.6 hectares (Greco and Cristofaro 2011). In general, 95% of Italian farms are owned by one entrepreneur, who has the property of the farm, on the contrary, the percentage of incidence of the limited companies farms and agricultural co-operatives in the total amount of Italian farms is lower than 5% (Istat 2013).

The small Italian farms, whose ownership is in the hands of a single person, who is the householder farmer, are manly scattered in upland rural areas and they are able to promote the multifunctionality and the rural development against environmental degradation in a perspective of the production of positive externalities.

The purpose of this paper is to assess the economic-financial impact of supports and subsides allocated by the II. pillar of the Common Agricultural Policy and also to estimate the technical, economic and allocative efficiency of Italian farms belonging to the Farm Accountancy Data Network (FADN) since 2000 to 2012.

The Farm Accountancy Data Network has been launched in 1965 and established by the Council Regulation number 79/65/EEC, aimed at evaluating the income of agricultural holdings and the impacts of the Common Agricultural Policy in a sample of European farms. The FADN is an annual survey carried out by each Member State belonging to the European Union (European Commission 2014) and in Italy, it is arranged annually by the INEA (Italian National Institute of Agrarian Economics). In general, the sample is made up by 80 000 European farms able to represent a population of five million farmers analysing more than 1000 microeconomic and structural variables such as income, crops areas, the usable surface and financial data (European Commission 2014).

As mentioned above, the agricultural property in Italy belongs predominantly to smallholder farmers, that have got tiny units of production, mostly fragmented but incorrectly considered, due to their dimension, inefficient, managed and owned by only one farmer and his/her family workers. A critical downside of the smallholder Italian farms is in-

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trinsic in their small size; hence, some studies have deemed that big farms should be considered more efficient than the small ones, in particular if the ownership in the hands of the limited companies or co-operatives, because the smallholders farms are not able to diversify their income compared to farms as agricultural limited companies or agrarian co-operatives with extensive agricultural surfaces. Therefore, among the variables such as the ownership of the farm, the dimension of usable agricultural surface and the economic and technical efficiency, there is a positive correlation and a direct nexus (Bravo-Ureta et al. 2007).

In the literature, few studies only have been addressed to investigate the connections among the typology of ownership and efficiency in the primary sector (Bravo-Ureta and Pinheiro 1997; Chavas and Aliber 1993); instead, many of the scholars have examined predominantly the role of the farm size on the efficiency (Carter 1984). The findings of researchers have underscored that there is an uncommon idea whereby a big- sized farm could be more efficient than a small one (van der Zyl et al. 1996), arguing that the farm size and productivity are tightly linked in the terms of return to scale productivity and efficiency in constant terms.

LITERATURE REVIEW

In order to assess the impact of the Common Agricultural Policy on farmers in different European Countries, the EU in the 1965 by the Council Regulation number 79 has established an analysis on a sample of farmers by the Farm Accountancy Data Network (FADN). This is an annual survey which covers approximately 80 000 farms and a population of about 5 000 000 farms located in the European Union equal to the 90% of the usable agricultural area (UAA) and it represents approximately 90% of the total European agricultural production (European Commission 2014).

In many European countries, numerous studies have investigated using the FADN dataset, or alternatively in few specific cases, a sample of farms located in different nations, the impact of the pillar two and the first pillar of the Common Agricultural Policy on farmers. The goal of these studies was to assess some relationships and quantitative connections among the variable farm size, cropping specialization and the technical-economic efficiency (Bojnec and Latruffe 2007; Bielik and Rajcaniova 2004; Latruffe et al. 2004).

In Italy, very few studies have investigated the main correlations, using the FADN dataset, between the farm dimension and the technical and economic efficiency (Galluzzo 2013), even if in the literature it is difficult to find studies aimed at assessing at the same time the role played by both the kind of ownership and also by the farm dimension on the efficiency. Findings in small farms managed by only one entrepreneur have pointed out that small family farmers are able to maximise the labour factor of production minimizing the economic and entrepreneurial risk by the diversification in the agrarian process of cultivation using the workforce in a more efficient way (Bielik and Rajcaniova 2004; Latruffe et al. 2004; Bojnec and Latruffe 2007), reducing the socio-economic marginalization in less favoured areas and in the upland territories at the risk of out-migration (Galluzzo 2013).

Small farms are considered unfit to guarantee a good level of efficiency due to a theoretical concept under which the economies of scale do not exist in the primary sector (Hall and LeVeen 1978; Garcia et al. 1982; Kumbhakar et al. 1991; Subal and Kumbhakar 1993); however, these units of agricultural production are more efficient than others because of a better organization of production factors in the terms of labour, capital and investments (van der Zyl et al. 1996; Hughes 2000), a decrease of marginal costs (Bielik and Rajcaniova 2004) and a drop of unemployment (Latruffe et al. 2004) with positive impacts on the technical and economic efficiency of farms. Kleinhanss et al. in 2007 have pointed out that some pivotal relationships exist between the efficiency and the farm size; in fact, these scholars have highlighted that there is a positive role of financial supports, allocated by the Common Agricultural Policy, towards the productive specialization and efficiency, corroborating the theoretical framework, in a sample of farms belonging to the FADN dataset, related to a specific nexus between the productive specialization or economic size and technical efficiency (Błażejczyk-Majka et al. 2011).

Theoretically, the main neoclassic approach has described that the farm performances are influenced by internal and external factor such as the legal type of the management and ownership and the level of human capital, hence, the small family farms are more efficient in the terms of costs, productivity, profitability than the big ones due to a different management abilities (Gorton and Davidova 2004).

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AIM OF THE RESEARCH AND THE THEORETICAL FRAMEWORK OF THE STUDY

In general, there is not a unique assumption about the role of family farms in improving the technical and economic efficiency. In fact, for some scholars a small family farm is more efficient than other kind of farms in which the property is in the hands of many people such as cooperatives or corporate farms (Schmitt 1991; Gorton and Davidova 2004); on the contrary, according to other studies, traditional small family farms are not efficient (Paul et al. 2004).

The reason of a good level of efficiency in small farms is due to a low level of transaction cost (Hagedorn 1994). Only a few authors argued that family farms have a high level of capital costs and they are not so well equipped in the terms of capital and investments than the co-operative and corporate farms (Allend and Lueck 1998). According to these two authors, family farms do not have a moral hazard to make efforts because their tasks are to maximize the income, spending in an optimal way the time and the invested capital such as machinery and other agricultural equipment. Limited liability farms and agricultural co-operatives have got a level of social capital and political decisions, in direct connection to the context of productive specialization, able to act positively on the level of the efficiency and maximization of output (Latruffe 2010).

The literature review has pointed out different studies about the relationships between the farm dimension and efficiency using as a variable the cropping specialization (Garcia et al. 1982) in a multi-output or in a multi-input methodology (Bojnec and Latruffe 2007). Focusing the attention on the spatial and geographical diffusion of studies about economic efficiency in farms, many of them have been carried out in developing countries (Bravo-Ureta and Pinheiro 1993) and in some European countries using a parametric approach (Curtiss 2000) with the purpose to investigate the role of crop specialization on the allocative and technical efficiency.

The aim of this analysis has been to assess the technical, economic and allocative efficiency in a sample of small Italian farms belonging to the Farm Accountancy Data Network (FADN), which is arranged annually by the INEA (Italian National Institute of Agrarian Economics), comparing the results to larger ones (the usable agricultural surface more than 50 hectares) in order to investigate if the size in the terms of agricultural surface and the typology of ownership have affected the efficiency.

In order to estimate the efficiency, there was used a sample of Italian farms stratified according to their usable agricultural surface lower than 5 hectares. Furthermore, in this research, the sample has been according to the type of ownership such as small family farms and other ordinary partnership agrarian societies in 2000 and in 2012. The next stage has been to compare in the five year time (2008–2012) the economic and allocative efficiency in 4 typologies of farms such as co-operatives, family farms, agricultural limited liability companies and ordinary agrarian partnership with a surface lower than 5 hectares.

To assess the impact of financial supports allocated by the II. pillar of the Common Agricultural Policy on family farms and the role of independent variables such as the farm net income, total costs and the usable agricultural area on the growth of Italian family farms, there was used a quantitative method by a multiple regression, over the time 2000–2012, stratifying the sample of the FADN dataset family farms according to altitude and the usable agricultural area.

METHODOLOGY

In order to study the efficiency, there are two ways: a parametric or deterministic approach, which needs a specific function of production and other parametric variables, and a non-parametric model or the DEA (Data Envelopment Analysis) aimed at defining in function the distance from the frontier of an hypothetical function of production an index of technical inefficiency (Bielik and Rajcaniova 2004).

In the non-parametric model, some deviations from the frontier of function are not efficient and they are not connected to the errors, thus the technical efficiency is described as the capabilities of farmers to maximize the output minimizing the used inputs or vice versa (Bojnec and Latruffe 2008). The efficiency has been estimated by a non-parametric model applied to specific assumptions in terms of the constant return to scale (CRS) in an input oriented model (Farrel 1957; Battese 1992; Coelli 1996) using the PIM-DEA software.

The goal of the DEA linear programming model is to minimize in a multiple-output model the multiple-input in each farm that is a ratio of efficiency and in a mathematical model, it can be written (Papadas 1991):

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$$\max h = \Sigma_r u_r y_{rjo} / \Sigma_i v_i x_{ijo} \quad (1)$$

s.t.

$$\Sigma_r u_r y_{rj} / \Sigma_i v_i x_{ij} \leq 1 \qquad j = 0, 1, ..., n \text{ (for all } j) \quad (2)$$

$u_r, v_i \geq 0$
u_r = the output price vector
y_{rjo} = the output level
v_i = the input price vector
x_{ijo} = the input level

In the term of productivity, if there are two DMUs such as *A* and *B* able to produce two levels of output such as y_a or y_b using a specific quantity of input x_a and $x_{b,}$ the productivity is a simple ratio y_a/x_a and y_b/x_b.

The non-parametric linear model throughout the Data Envelopment Analysis has been introduced for the first time in 1978 (Charnes et al. 1978) and it is useful to estimate the relative efficiency in each Decision Making Units based on a different level of input and output (Hadad et al. 2007) with the purpose to minimize the level of input (Doyle and Green 1994).

The goal of a non-parametric input oriented model, such as in our research, or DEA linear programming, is to minimize in a multiple-output model the multiple-input in each farm that is the ratio of efficiency. This model has many possible solutions and u_r^* and v_i^* are variables of the problem; hence, the value of efficiency should be greater than 0 or another small but positive quantity and any input and output can be ignored in estimating the efficiency (Papadas 1991; Bhagavath 2006). If h is 100, there are no issues about the efficiency because this unit ($DMUh_1$) is more efficient compared to other $DMUh_n$, but if h is above 100, there are many units more efficient than this unique and inefficient unit ($DMUh_1$), then, every unit is tightly linked to the level of input and output making each unit efficient (Bhagavath 2006). To solve this negative aspect, it is fundamental to transform the model into a linear function by a linear programming methodology called the CCR (Charnes and Cooper 1962; Bhagavath 2006) written in the following way:

$$\max h = \Sigma_r u_r y_{rjo} \quad (3)$$

s.t. dual variable

$$\Sigma_i v_i x_{ijo} = 100\% \, Z_o$$

$$\Sigma_r u_r y_{rjo} - \Sigma_i v_i x_{ijo} \leq 0 \text{ with } j = 0, 1, ..., n \text{ (for all } j) \quad \lambda_j$$

$$-v_i \leq -\varepsilon \qquad i = 0, 1,..., m \text{ and } \varepsilon \text{ is a positive value } s_i^+$$

$$u_r \leq -\varepsilon \qquad r = 0, 1, ..., t \text{ and } \varepsilon \text{ is a positive value } s_r^-$$

s_i^+ and s_r^- are the adjusted values able to increase the original level of input or output vector in order to reduce the inefficiency

In the dual problem, it is important to consider a dual variable in each constraint in the primary model (Charnes et al. 1978), but this paper did not take into account in the dual model a constraint able to classify and discriminate the DMUs using the super efficiency called the A&P model (Andersen and Petersen 1993). In mathematical terms, the solution of the dual model is written as:

$$\min 100 \, Z_o - \varepsilon \, \Sigma_i s_i^+ - \varepsilon \, \Sigma_r s_r^- \quad (4)$$

s.t.

$$\Sigma_j \lambda_j x_{ij} = x_{ijo} \, Zo - s_i^+ \quad i = 0, 1, ..., m$$

$$\Sigma_j \lambda_j x_{rj} = y_{rjo} + s_r^- \quad r = 0, 1, ..., t$$

$$\lambda_j, s_i^+, s_r^- \geq 0$$

λ_j are shadow prices able to reduce the efficiency in each unit lower than 1 or 100 and a positive value of λj is able to assess a peer group in some inefficient unit.

In this paper, we have investigated three typologies of efficiency: technical efficiency, cost efficiency and allocative efficiency. An enterprise is technically efficient if it operates on the frontier of production, producing the maximum output utilizing the input, and it is able also to satisfy the allocative efficiency, which implies a fixed and mixed level of inputs able to produce a level of output minimizing the cost (Coelli et al. 2005). In terms of cost efficiency, the farm should reduce costs of the production factors improving the level of financial supports allocated by the Common Agricultural Policy.

The next stage of the quantitative analysis has utilized a multiple regression model, estimating the parameters by the Ordinary Least Square, with the purpose to investigate if some independent variables such as total costs, subsides allocated by the EU and the total agricultural surface have acted on the dependent variable such as the number of Italian family farmers stratified according to the orography and the usable agricultural area.

The estimation of the parameters in the multiple regression model has used the open source software GRETL 1.8.6. In its algebraic form of matrix, the multiple regression models can be expressed as follows (Verbeek 2006; Andrei and Bourbonnais 2008):

$$\mathbf{y} = \mathbf{X}\beta + \varepsilon \quad (5)$$

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Table 1. Level of efficiency in Italian farms regarding the usable agricultural area (UAA) and type of ownership in 2000 and in 2012

Type of farm	Class of UAS	Technical efficiency		Cost efficiency		Allocative efficiency	
		2012	2000	2012	2000	2012	2000
Limited companies	> 40	100.00	100.00	100.00	96.17	100.00	96.17
	15–40	100.00	100.00	100.00	100.00	100.00	100.00
	10–20	100.00	100.00	100.00	100.00	100.00	100.00
	5–10	100.00	100.00	100.00	100.00	100.00	100.00
	< 5	100.00	100.00	100.00	100.00	100.00	100.00
Average		**100.00**	**100.00**	**100.00**	**99.62**	**100.00**	**99.62**
Family farm	> 40	100.00	100.00	66.41	70.65	66.41	100.00
	15–40	100.00	100.00	69.42	100.00	69.42	92.90
	10–20	100.00	87.62	69.42	92.90	69.42	84.75
	5–10	100.00	76.08	73.04	74.26	73.04	70.20
	< 5	100.00	69.81	77.96	53.41	77.96	56.80
Average		**100.00**	**86.70**	**70.65**	**80.93**	**71.25**	**72.04**

Source: our elaboration on data INEA retrieved from the website www.inea.it

y = a dependent variable
X = a vector of independent variables which have dimension $n \times k$
ε = the error but both are the vectors with n-dimensions

In the analytical terms, the model of multiple regression can be written in the following way (Asteriou and Hall 2011; Baltagi 2011):

$$y = \alpha_0 + \beta x_1 + \gamma x_2 + \delta x_3 + \zeta x_4 + \varepsilon_{jt} \quad (6)$$

y = the number of family farms
α_0 = the constant term
x_1, x_2, x_3, x_4 = independent variables such as net income, usable agricultural area, total costs, funds allocated in order to promote the rural development by the II pillar of the Common Agricultural Policy
β, γ, δ, ζ = the estimated parameters of the model
ε_{jt} = the term of statistic error

Basis assumptions, to use a multiple regression model, are:

the statistic error *ui* has conditional average zero that is $E(ui|Xi) = 0$;

(Xi, Yi), $i = 1, \ldots, n$ are extracted as distributed independently and identically from their combined distribution;

Xi, *ui* have no fourth moment equal to zero.

Other assumption in the model of multiple regression are: no correlation among the regressors and random noise so that the value between β expected and β estimated is the same. Furthermore, with the White's Test on the error terms has been analysed the heteroscedasticity on standard errors.

RESULTS OF THE ANALYSIS

The small farms belonging to the FADN dataset, stratified in the cluster of limited liability companies, have recorded in 2012 a level of cost efficiency lower than in 2000 with a value of the cost and allocative efficiency not efficient in Italian farms with the usable agricultural area higher than 40 ha (Table 1). The findings about the efficiency in family farms have registered both in 2000 and also in 2012 a level of the cost and allocative efficiency lower than 100%, even if in 2000 family farms in the cluster with the usable agricultural area lower than 5 hectares have had the worst performances, while the family farms with the area above 40 ha have registered the best results. Comparing the average values between Italian family farms and limited liability companies, the

Table 2. Main results in average of the efficiency analysis over the years 2008–2012 stratified with regard to the ownership with the area lower 5 hectares

Typology of Property	Efficiency	Cost efficiency	Allocative efficiency
Co-ops	100.00	90.22	90.21
Family farm	100.00	38.84	38.84
Limited company	98.54	75.89	76.91
Ordinary partnership	100.00	78.77	78.77

Source: our elaboration on data INEA, retrieved from the website www.inea.it

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Table 3. Main results of the multiple regression model: dependent variable the number of family farms

	Upland areas		Hilly areas		Plane areas	
	coefficient	*t* ratio	coefficient	*t* ratio	coefficient	*t* ratio
Constant	59.04	2.11*	697.70	9.46***	143.77	5.60***
Funds II pillar CAP	0.0094	8.78***	0.041	2.001*	–0.0013	–0.17
Total costs	–0.0007	–0.750	–0.013	–2.38*	–0.0003	–0.50
Net Income	0.0008	2.75**	–0.0033	–0.40	0.0010	2.460*
Usable Surface	–1.554	–4.69***	0.358	0.068	0.197	0.0807
R^2	0.626		0.687		0.557	

*denotes significance at a 10% level; **denotes significance at 5 % level; ***denotes significance at 1%

Source: our elaboration on data INEA retrieved from the website www.inea.it

main results have stressed a higher level of the cost and allocative efficiency in the latter (Table 1). At this stage of the analysis, we did not investigate the agricultural co-operatives because the data was not homogeneous over the time of the study and the dataset was unbalanced due to a lack of data.

Focusing the attention only on the Italian farms in the FADN dataset with an usable agricultural area lower than 5 hectares, which is a typical farm size in several rural areas, stratified according the different typology of ownership, over the time 2008–2012, the findings have pointed out a level of the allocative and cost efficiency lower than 100% (Table 2) even if the agricultural co-ops have been more efficient than the other types of ownership in Italian farms.

The multiple regression model has been used to discriminate the different orography where the family Italian farms are located, such as in the mountain, hilly and lowland areas. The further stage has been to estimate if the size of the farms in terms of the usable agricultural area has acted on the increase of the farms over the time of investigation.

The Italian family farms have been influenced in a positive way by the funds and financial supports allocated by the European Union in order to promote the rural development (Table 3). The net income has been correlated directly with the dependent the number of family farms, the proxy variable of the growth of family farms; in contrast, the usable agricultural area has been indirectly correlated to the number of family owned Italian farms (Table 3). The multiple regression model in the upland rural areas has pointed out that the family farmers have been very sensitive to the funds disbursed by the Rural Development Program in the seven year time 2000–2006 and 2007–2013. In the lowland areas, family farms have shown a direct correlation with the independent variable net income, but in this case, some findings have underlined that the funds and subsides allocated by the European Union did not act on the growth of the farmers.

The subsequent phase of the analysis has stratified the Italian family farms, belonging to the FADN dataset, in only three classes of the usable agricul-

Table 4. Main results of the multiple regression model: dependent variable the number of family farms according to size

	Less than 5 ha		5–10 ha		More than 50 ha	
	coefficient	*t* ratio	coefficient	*t* ratio	coefficient	*t* ratio
Constant	491.7	7.60***	1 149.78	3.77***	–22.80	–22.77
Funds II pillar CAP	0.039	4.62***	0.005	0.942	0.003	0.003
Total costs	–0.0021	–2.97**	–0.006	–5.02***	0.0002	0.0002
Net income	0.003	2.84**	0.0061	2.66**	–5.99e–05	–6.00e–05
Usable surface	–124.5	–8.23***	–132.551	–3.01**	–0.42	–0.423
R^2	0.720		0.908		0.256	

*denotes significance at a 10% level; **denotes significance at 5 % level; ***denotes significance at 1%

Source: our elaboration on data INEA retrieved from the website www.inea.it

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tural area aimed at simplifying the study focusing it in the comparison among small, medium and big sized farms. The family farms in Italy with the usable agricultural area above the average value of 5 ha have been more sensitive and directly correlated to the independent variables of funds and subsides allocated by the European Union in order to promote the rural development and the variable net income; in contrast, the independent variables of the usable agricultural area and the total costs have acted in an indirect way on the number of farms (Table 4). The role of funds with a specific destination in promoting and incentivizing the rural development do not have any effects on the growth of the Italian family farms with the size of 5–10 ha. The family farms with the size above 50 ha have been completely independent on the variables of funds allocated by the EU, costs and the usable agricultural area. This implies that the size of the farm is a variable able to influence the growth of farms giving them an opportunity to become self-sufficient in economic terms with impacts on their level of efficiency.

CONCLUSIONS

The outcomes have pointed out that the family farms are the best units of agricultural production, protecting rural areas from the risk of the socio-economic marginalization and environmental degradation with a significant level of efficiency compared to other types of farms. Nevertheless, the usable agricultural area should be considered the first and foremost variable and factor of production in order to implement the economic efficiency in small Italian farms scattered in particular in the upland and in less favoured rural areas. This has corroborated the theoretical hypothesis, proposed during the European Cork Conference on Rural Development in Cork during 1996, about the function of farms in protecting rural areas from the risk of out-migration as a consequence of the irreplaceable role of multifunctionality in the rural territories, which need financial subsides allocated by the European Union in order to stimulate the generational turnover in the countryside and in supporting farms in the backwards rural areas.

Small family farms are able to face the socio-economic and environmental challenges of the modern agricultural model focused and deeply rooted in rural territories and in their specificities, becoming as efficient as big farms, in consequence of an optimal organization of production factors, refuting the idea according to which the economies of scale in the primary sector do not exist.

Summing up, small family farms are able to face up the economic and allocative efficiency better than the co-operatives, even if it is important to stimulate the growth of the socio-economic network among different stakeholders in rural areas with specific subsides, allocated by the local authorities and predominately by the European Union in the Rural Development Plan, towards rural districts. These latter in fact are a cluster of farms, agro-food enterprises, rural cultural heritage and tourist facilities, able to promote the certified quality food and an integrated rurality in its own different kaleidoscopic aspect.

The pluriactivity in small farms and the diversification of agricultural activities such as rural tourism and agritourism can be useful to implementing the farmer's income; therefore, the European Union should improve financial resources in favour of family farms with an area lower than 5 ha in order to promote the pluriactivity by a productive diversification. In fact, the small farms are one of the most pivotal tool in order to protect the rural space against environmental degradation, reducing the socio-economic marginalization in rural territories because of the out-migration from the countryside, without compromising their technical and economic efficiency compared to other types of farms.

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