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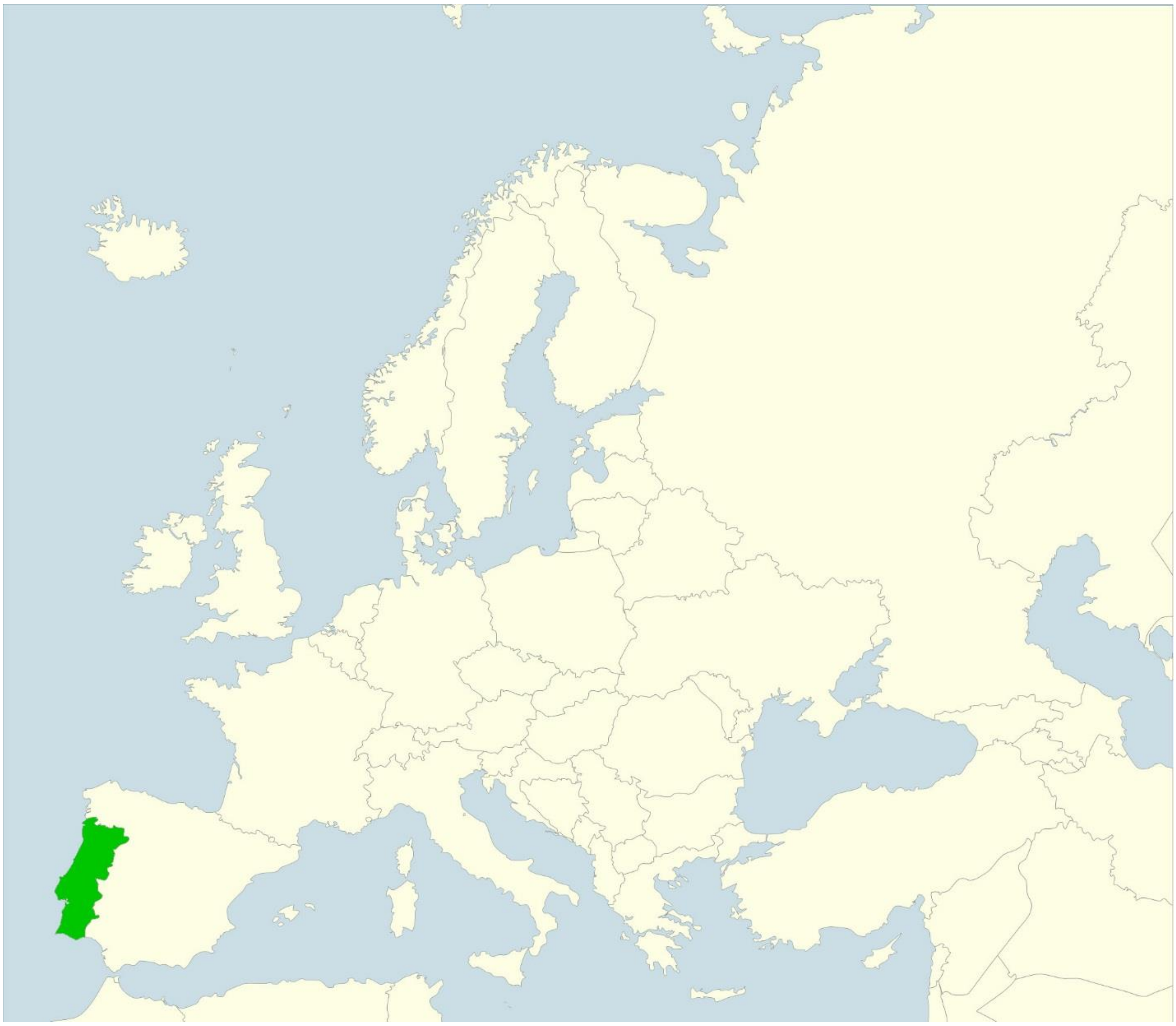
EFFICIENCY OF THE DAIRY FARMS: A STUDY FROM AZORES (PORTUGAL)

Emiliana Silva[1], Bruno Almeida[2], Ana Alexandra Marta-Costa[3]



[1] Assistant Professor with habilitation, Emiliana Silva, Centre of Applied Economics Studies of the Atlantic (CEEAPlA), Azores University, Ponta Delgada; e-mail: emiliana.ld.silva@uac.pt

[2] Bruno Almeida, Agricultural Association of S. Miguel, Ponta Delgada, e-mail: bruno_almeida45@hotmail.com

[3] Assistant Professor Ana Alexandra Marta-Costa, Centre for Transdisciplinary Development Studies (CETRAD), University of Trás-os-Montes e Alto Douro (UTAD), Vila Ciudad Real, e-mail: amarta@utad.pt

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Abstract: Azores dairy represents 30% of Portuguese production. The farms are dominated by family nature and a relevant part of them are an exclusive source of the producer's income. Nowadays, the milk production has some problems due to the falling prices of milk on the producer and the European milk quotes abolishment. This situation requires the assessment of the Azorean dairy farms efficiency as a way to rationalize the use of the factors of production for the milk production. The aim of this research is to estimate the Technical Efficiency (TE) in two different groups of farms, of which the used criteria were to earn incomes exclusively from farm (Full-Time Farmer, FTF) or to have another complementary source of income (Partial-Time Farmer, PTF). The farms database was provided by a farmers' association and the Data Envelopment Analysis (DEA) was chosen for modelling TE estimation. The main findings show the inexistence of substantial differences in the farms performance with or without complementary sources of income (0.679 for PTF and 0.689 for FTF). However, the most efficient farms are related with the main source of income.

Keywords: Azores, efficiency, milk, productivity

1. Introduction

Azores is a Portuguese archipelago located in the middle of North Atlantic, between the European and American Continent. Its surface area is 2,322 km^2 and, in 2012, there were 247,440 residents (SREA, 2013). The weather, soil distribution and steep slopes have conditioned all the activities of the Azorean people. Also, it is a consequence of a deep humanization of five centuries. Most residences and agricultural fields are below 150 meters of altitude. Above 350 meters, there are grasslands and few forests and above 1,200 meters, only forest (Cruz et al., 2005).

The main economic activity of Azores has always been agriculture and its developing models are designed to take livestock production as the base, particularly dairy farming for milk production (Silva, 1994), which has a big impact on the landscape and territory conservation. In 2013, there were 11,806 farms (SREA, 2013), with an average size of 10 hectares. Almost 97% of the Utilised Agricultural Area (UAA) was used by animal production, through 49% farms, and the milk production affects 37% of the Azorean farms, which occupy 57% of the UAA of the region (INE, 2011, Sebastião et al., 2012).

The rearing of cattle for milk is also the most important activity for the Azores regional economy that has had a growing increase since Portugal joined the European Union. Milk production (536,016,473 litres) represents 29.86% of the Portuguese production (SREA, 2013). Therefore, cheese, butter and fresh milk are the most representative dairy products.

In terms of population occupation, this activity also has repercussions. The family farming population of the Azores represents 17% of its resident population (data for 2009), with more than one half (52%) being below 45 years old and 16% are over 65 years old (Sebastião et al., 2012). Only one third of the family farm population has a gainful activity outside the farm that complement their income, mainly producers (37%) and their spouses (36%), than the other elements of family (27%). This population corresponds to 11,532 Annual Work Units (AWU) and is in charge of 80% of the agricultural work needed, according to data of 2009 (Sebastião et al., 2012). These authors pointed out that Azorean farms also have temporary (64%) or permanent labour (11%).

Concerning agricultural sustainability, there are 13,360 sole producers, in 2009, from which 24% are a full time and 96% want to carry on the agricultural activity in order to complement the family income, due to the affective value and due to the lack of professional alternative (Sebastião et al., 2012). In addition, the farming activity is the main source of income for 99% of sole producers.

Given the importance of dairy farming for Azores, any exogenous variable could be risky for the milk production affecting its equilibrium and having serious consequences for the region, as the end of the European milk quotes system. Silva et al. (2016) showed that this policy issue will decrease the milk price and consequently can affect the establishment of Azorean young farmers.

The situation was emphasised for British farmers in the Guardian Journal, where Doward (2015) referred that the end of quotes could lead them to be desperate, adding to the milk glut and hundreds are opting to leave the industry. The low milk prices prevailing since the abolishment of the milk quota was also detached from Dutch farmers, in the LTO document (2017) and was the reason why in 2016, the European Commission launched a voluntary milk production reduction scheme.

As a consequence, it is urgent to identify the most efficient production systems in order to outline a regional agricultural policy that could overpass the recent handicaps (Silva et al., 2016). As the development of other or complementary activities to the dairy farming can be a solution for the Azorean farmer instead of the abandonment of the activity, this research aims to compare the dairy farms efficiency according to the farmers' income source typology (FTF and PTF), as a way to rationalize the use of production factors for the milk production.

The article is divided in four sections. The first section presents the importance of the theme and the objective under study. A brief literature review regarding the efficiency of dairy farming is exposed in section 2. Section 3 introduces the available data and describes the chosen methodology, supported by relevant references and mathematical formulations. In the subsequent section, the results are presented and discussed. Finally, section 5 summarizes the main conclusions and makes suggestions for further improvement.

2. Efficiency of dairy farming: brief review

Previous studies showed the efficiency scores that were estimated using partial index. For example, Arzubi and Berbel (2001) used the amount of milk (litres) per cows in a year (or day) as dairy farm productivity or the amount of milk per hectare as land productivity. These indexes are partial and the milk production in a grazing system depends on various factors. In this sense, Barnes et al. (2011) argued for a whole-farm, rather than a partial indicator, approach to assessing efficiency should be accounted for. The efficiency models play an important role in the field of dairy production as it allows a more complete and adequate reproduction of the real context to reach high levels of performance.

Two different types of efficiency models has been used; (1) the Data Envelopment Analysis (DEA, no parametric models) (e.g., Weersink et al., 1990; Cloutier and Rowley, 1993; Fare and Whitakker, 1995; Gonzalez et al., 1996; Fraser and Cordina, 1999; Arzubi and Berbel, 2001; Silva, 2001; Almeida and Silva, 2015; Candemir and Koyubeube, 2006; Luik et al., 2011; Silva and Marote, 2013; Terin et al., 2017; Parlakay et al., 2015) and (2) the Stochastic Frontier Production (SFA, parametric models) (e.g., Mehmood et al., 2018; Parlakay et al.; 2017; Atzori, et al., 2013). These models have the concept of efficiency in common, which has been decomposed by Farrell (1957) into Technical Efficiency (TE) and Allocative Efficiency (AE).

The TE measures the maximum equiproportion reduction in all inputs that still allows continued production of given outputs. The AE reflects the ability of a firm to use the inputs in optimal proportions, given their respective price. These two concepts, forms the concept of economic efficiency (Coelli, 1996). Both are very useful to support decision-making because they give an indication of the main characteristics for an efficient farm and how some of the problems identified may be solved (Silva and Marote, 2013).

The farms efficiency on dairy sector has been extensively researched in Azores by Silva (2001); Silva and Marote (2013); and Almeida and Silva (2015). Similar studies have been developed in other geographical areas, as Estonia (Luik et al., 2011); Turkey (Candemir and Koyubeube, 2006; Parlakay et al., 2015; Parlakay et al.; 2017; Bozoglu et al., 2017; Terin et al., 2017); Argentina (Arzubi and Berbel, 2001; 2002; Angon et al., 2013); New Zealand (Jaforullah and Whiteman, 1999); Australia (Fraser and Cordina, 1999); Canada (Weersink et al., 1990; Cloutier and Rowley, 1993); Spain (Gonzalez et al., 1996); Pakistan (Mehmood et al., 2018); and Brazil (Ferrazza et al., 2017). These studies used from 21 (Arzubi and Berbel, 2002) to 264 (Jaforullah and Whiteman, 1999) dairy farms, and the majority an input – output oriented model from a combination of two (Luik et al., 2014) or three (Candemir and Koyubeube, 2006) outputs and to six (Luik et al., 2014) or seven (Candemir and Koyubeube, 2006) inputs, with DEA as the most used technique. However, we ought to realize that some factors constrain the efficiency scores, such us, the farms number, the input and output number of variables, the benchmarking firms, the homogeneity of farms, the animal grazing system efficiency (Mendes et al., 2013) and then, the comparisons should be done carefully.

Generally, the results indicate that dairy farms could maintain the current output with decreasing current inputs. The major drivers of the dairy systems efficiency were identified as the education level of the household head, herd size, farm size and farmers' experience (Fare and Whitakker, 1995; Angon et al., 2013; Ferrazza et al., 2017; Parlakay et al., 2017; and Mehmood et al., 2018). In addition, Lopes et al. (2016) found that the managerial and technical indexes differed according to the stages of production under study, and these authors categorized three production levels: small, medium or large units.

Efficiencies are also positively correlated with concentrate feed ratio (Parlakay et al., 2015; and Angon et al., 2013) and Fare and Whitakker (1995) showed that using intermediate products increase the efficiency of dairy farms.

Besides the referred variables, in a very recent survey of Mehmood et al. (2018), cross-breed and imported cattle had significant positive impacts on efficiency, followed by the diversified sources of income.

3. Data and Methodology

Agricultural Association of S. Miguel (AASM, n.p.) were the used database for this research, which integrated 91 dairy farms, in 2010. The sample selection criteria were: (1) to be a representative dairy farms typology of Azores; (2) to have organized accountancy methods; and (3) to pursue the milk recording.

The dairy farms efficiency was assessed according to the income source of the farm that was organized in two groups: farms whose owner has complementary (Group I – PTF) or exclusive (Group II – FTF) sources of income from agriculture. According to Sebastião et al. (2012), the complementary activities of dairy farms in Azores are forest (0.2%) and other activities (1.3%), such as the third sector activities, mainly in the Regional Public Administration.

From the 91 dairy farms, 9.8% (9 farms) belong to Group I, and 90.2% (83 farms) have income that comes exclusively from agriculture (Group II). These values are similar to Sebastião et al. (2012) data, which found a 99% of sole producers from the Azorean dairy farms. Also, Lopes et al. (2016) categorized the production system under study into three production levels: small (nine units), medium (nine units) or large (two units).

The structural characteristics obtained by the average scores of these farms are shown in Table 1, which analysis shows little divergence between the two groups of farms, in terms of farms size (40.4 hectares) and livestock density (2.4 and 2.5). However, there was a slight increase in the average values of the total number of animals (90.6) and of dairy cows (67.3) from Group II.

The largest discrepancy between the groups under analysis is the number of employees on farms. While the production units of Group I always employ agricultural workers and the producer does not work in agriculture, the average figure is 1.8 workers, Group II has 0.7 workers and only a few of their farms use wage-labour.

In Table 1, it is possible to identify milk production and its Entrepreneur and Family Income per hectare. Farms whose income comes exclusively from farming (8104.8 litres of milk per cow and 1032.8 €/Ha, respectively) are slightly higher as compared to farms with complementary incomes of the agricultural activity (7666.6 litres of milk per cow and 730.9 €/Ha). This may be due to the struggle effort of the farmer who relies exclusively on agriculture to ensure the maximum yield.

Tab 1. Average structure and economic performance of dairy farms under analysis, in 2010. Source: Data from AASM (n.p.).

	GROUP I	GROUP II	TOTAL GROUP
Number of farms	9	83	91
Utilised Agricultural Area (Ha)	40.4	40.4	40.4
Livestock (Normal Heads, NH)	79.4	90.6	89.5
Livestock density by UAA (NH/Ha)	2.4	2.5	2.49
Number of dairy cows	60.7	67.3	66.7
Number of Wage-earning agricultural workers	1.8	0.7	0.8
Milk production by cow (L/year)	7666.6	8104.8	8061.4
Milk sale (€/Ha)	3973.4	3774.3	3794.0
Meat sale (€/Ha)	206.0	213.6	212.9
Subsidies (€/Ha)	830.5	1118.6	1090.1
Entrepreneur and Family Income (€/Ha)(1)	730.9	1032.8	1002.9

(1) Difference between revenues and real charges, according to Avillez et al. (1988).

The total costs structure of the majority of the observed Azorean farms reveals the high weight of food (38.1%), and as result its reduction is one of the main goals of milk producers (Silva et al., 2016). In general terms, the average annual costs per hectare of these dairy farms were 2620.8 Euros (Silva et al., 2016), corresponding to about 70% of the obtained value from the sale of milk (3794 €/ha). Since they are specialized milk production units, the average value of beef sold is very low (212.9 €/ha). However, there are farms that do not sell beef and neither do they receive subsidies, but for others, 22% of the income comes from those supports (Silva et al., 2016).

The dairy farms efficiency was estimated by DEA. This no-parametric technique is able to estimate the dairy farms efficiency using the relationship between dairy farms outputs and inputs (Coelli et al., 2005 and Mendes et al., 2013). The DEA model efficiency is input-oriented, that is, how much can input quantities be proportionally reduced without changing the outputs quantities produced (Coelli, 1996).

The dairy farmers' TE was found using the DEA Computer Program (DEAP) developed by Coelli (1996). This program is based on the follow model, that consist of optimization model used by Charnes et al. (1978), but considering the input components V_iX_{ij} as a constant (K).

$$MaxE_j = \sum_1^m U_i Y_{ij}$$

$$s.a.$$

$$\sum_1^m V_i X_{ij} = K$$

$$\sum_1^m U_i Y_{ij} - \sum_1^m V_i X_{ij} \leq 0$$

$$U_i, V_i \geq 0$$

Y_{ij} is the level of output *i* used by decision making unit *j; X_{ij}* is the level of input *i* used by decision making unit *j*; and U_i and V_i are the non-negative variable weights associated to the solution of decision making unit *j*, of output and inputs, respectively.

The results of DEA use three models: Constant Returns-to-Scale (CRS) model, the Variable Returns-to-Scale (VRS) model and Scale efficiency (SCA) model. The CRS assumption is only appropriate when all decision making units are operating at an optimal scale. Coelli (1996) refers the study of Banker et al. (1984), that suggest an extension of the CRS DEA model to the CRS specification when not all decision making units are operating at the optimal scale, which will result in the measure of TE that are confounded by SCA. The use of the VRS specification will permit the calculation of TE devoid of these SCA effects.

In the current research, it were taken three outputs: milk sales, subsidies and others sales, in Euros; and three inputs: cows number, farm size (hectares) and total costs (Euros). These costs included land rent; paid insurance and taxes; equipment and building depreciation; concentrate feeding; fertilizers; medicines and veterinary; electricity; and other costs.

4. Results and discussion

The analysis of TE, through the DEA method, showed the scores presented in Table 2 regarding TE from CRS, VRS and SCA. The first one indicates that the values of the inputs and outputs are proportional, whereas the VRS shows that the increases of the outputs can be higher or lower than the increases of inputs. Also, the SCA reveals the amount of productivity that can be increased if a change of points occurred for the optimal scale of technical production, which can be achieved by the CRS/VRS ratio (Coelli et al., 2005).

Tab 2. Average scores of TE and number of efficient farms at technical level. Source: Own elaboration

	TE			**Number of efficient farms**		
	GROUP I	GROUP II	TOTAL	GROUP I	GROUP II	TOTAL
CRS	0.679	0.689	0.688	1	6	7
VRS	0.787	0.818	0.815	1	13	14
SCA	0.855	0.845	0.846	1	6	7

The results show that there are no significant differences in the mean values of efficiency between farms with exclusively agricultural incomes (0.689 to CRS) and those with complementary activities (0.679 to CRS) (Table 2). The differences are greater in the number of efficient farms (only one farm with a supplementary income to agriculture).

Regarding the VRS, there were higher efficiency values (0.818) for Group II compared to Group I (0.787), and 13 efficient farms in the first case while only one was identified in Group I. However, the SCA is slightly higher in Group I (0.855) than Group II (0.845).

These figures are quite different from those found by Silva (2001) in dairy farming of Azores, who found seven efficient farms over a sample of 122 Azorean farms, with an average TE of 66.4%. More recently, Almeida and Silva (2015) found seven efficient dairy farms (7.69%) to CRS over 91 farms. The gathered average level of technical inefficiency may draw a conclusion on the possibility of reducing up to 31.2% of consumption expenditures without decreasing the output.

Similar values of those gathered in this research were obtained by Luik et al. (2014) with DEA technique (input – output oriented model, with two outputs and six inputs). They found three different groups of efficiency: 1) low TE (0.549-0.8369; medium TE (0.840-0.968) and high TE (0.970-1). Also in a previous study of Luik et al. (2011), the TE in Estonian dairy farms ranges from 0.861 to 0.835 (CRS: 2001-2009) and 0.918-0.908 (VRS: 2001-2009), and finally, 0.938 to 0.919 (SCA: 2001-2009).

Arzubi and Berbel (2002) show the increasing of TE from 83 (1997) to 87% (2000) in 21 dairy farms of Buenos Aires (Argentina). Previously, Arzubi and Berbel (2001) had used the DEA and found 11.4% of farms efficient and CRS and its efficiency value were 0.782; 17.1% of efficient farms at VRS; and finally, 14.3% farms were efficient at SCA. In New Zealand, Jaforullah and Whiteman (1999) found an average TE of 89% for increasing dairy farms and only 19% of 264 dairy farms were efficient.

Higher figures were found in Turkey by Candemir and Koyubeube (2006) with DEA technique in 80 dairy farms and considering three outputs and seven inputs. They found 41% CRS and 58% VRS of dairy farms. The efficiency values were 0.934 (CRS) and 0.954.

Similar values were obtained by Fraser and Cordina (1999), when they applied DEA to assess TE of 50 dairy farmers of Australia. The average TE was 90.5% and 90.8% for 1994/95 and 1995/96 periods, respectively. However, 24% of the dairy farms were efficient for the first period, but decrease for 20% in the subsequent period.

For Cloutier and Rowley (1993), when they applied DEA to 187 dairy farms in Canada, for the years 1988 (88%) and 1989 (91%), they gathered 15 and 21% of dairy farms, respectively efficient. Also for Canada, Weersink et al. (1990) found a TE of 91.8% in 105 dairy farms and 43% of that farms were efficient.

Lower values of TE were found by Gonzalez et al. (1996) in 133 dairy farmers in Spain. The average global TE was around 78%, but only few (5%) were efficient. Similar situation was found with SFA, by Parlakay et al. (2017), with a score of 79% of TE to estimate the effects of socio-economic variables on TE.

Bozoglu et al. (2017) in 150 dairy farms of Turkey and using the DEA for estimating TE achieved an average of 0.80 for inefficient farms, which indicates those farms could reduce their average input by 20%. For the same country, but with 43 dairy farms, Terin et al. (2017), and using DEA, found the technical, allocative and economical efficiencies as 0.66, 0.43 and 0.23, respectively. The results showed that only 23.26% of the farms were efficient (CRS). Still in Turkey, Parlakay et al. (2015), according to the results of the DEA model, estimated the TE for CRS and VRS of 0.64 and 0.69, respectively.

In Argentina, through parametric techniques, an average TE of 35% was estimated and three levels of efficiency were established (Angon et al., 2013).

5. Conclusions

This research allowed us to verify that there are no relevant differences in the productive characteristics of different Azorean farms according to the type of income obtained by their owners (exclusively from the farm or from several complementary sources). However, dairy farms appear to be more technically efficient when the activity has exclusively agricultural incomes than when it has supplementary incomes to the agricultural activity. In the same way, it is confirmed that there are more efficient farms when agriculture is the only source of income.

The VRS and CRS value found in the Azorean research is quite similar to other researches around the world. For example, the average TE found by Arzubi and Berbel (2002) in Argentina was 0.782; by Cloutier and Rawley (1993) in Canada had ranged from 0.88 to 0.91; and by Jaforullah and Whiteman (1999) in New Zealand was 83%. More recent studies, as Parlakay et al. (2017) and Bozoglu et al. (2017) gathered analogous scores of 79% and 80% of TE, respectively. That is, generally, dairy farms could maintain the current output with decreasing current inputs. The increase of the score of milk sector efficiency calls for a better understanding of the key factors driving the performance of dairy systems, which could be a difficult task due to the heterogeneous characteristics of the production systems. However, focusing on the objective of this research, it can be noticed that the fact of having exclusively agricultural incomes can lead to a greater rationalization of the production factors.

Also the situation can be reflected in a productivity logic that benefit the maximizing of the production or raising the community funds that support the development of milk activity, and, therefore, reflected in future regional policies to be implemented.

The inefficient farms could sustain their economic viabilities with the government's livestock supports. As argued by Bozoglu et al. (2017), the government should facilitate the farmers in achieving efficient use of resources in dairy farming and the link between efficiency and economic sustainability should be recognized as a matter of policy priority. In fact, if the farmers have a complementary income source, they will not depend exclusively on the farm income for family economical survival and well-being. That is, they will be “more independent” of the income and more economically sustainable because they will not exclusively depend on the market prices.

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