Efficiency analysis of agricultural cooperatives in Trentino-Alto Adige

Darina Zaimova[1], George Zheliazkov[2], Julia Doitchinova[3]

Trakia University, Faculty of Economics, Department "Industrial business and entrepreneurship"

Abstract

Collective organization of agricultural production is assumed to be a sufficient choice taking into a consideration a several reasons why mergers of existing farms promote efficiency, such as: *increase in optimal scale* from reduced duplication; *reduced transaction costs; synergies* from complementary activities; and i*mproved management and coordination*.

Data envelopment approach (DEA) is applied to the input and output variables to reveal the efficiency levels of cooperatives in Trentino-Alto Adige in Italy. The analysis is also developed to estimate input utilization and changes that might occur in terms of their optimizations and higher level output.

JEL: D61, P32, Q13, P13, C14

Резюме

Колективната форма се възприема като успешен избор за организация на производството в аграрния сектор, предвид редица фактори благоприятстващи нивото на ефективност: оптимален мащаб на производство, намаляване на транзакционните разходи, синергия посредством взаимодопълващи се дейности, и подобрени управленски и координационни дейности.

Използваме Data envelopment approach (DEA) спрямо променливите на входа и на изхода на производството за да определим нивото на ефективност на кооперативите в региона Трентино Алто-Адидже в Италия. Анализът е също така разработен в посока оценка ефективното използване на производствените ресурси и възможността за оптимизация на нивото на краен резултат.

JEL: D61, P32, Q13, P13, C14

[1] *Address:* Trakia University, Student Campus, 6000 Stara Zagora; Faculty of Economics, Department "Industrial business and entrepreneurship", *Email:* dzaimova@gmail.com; *Tel.:* +359 899 807008
[2] *Address:* Trakia University, Student Campus, 6000 Stara Zagora; Faculty of Economics, Department "Industrial business and entrepreneurship"; *Email:* george-zh@mbox.digsys.bg; *Tel.:* +359 888 202663
[3] *Address:* Trakia University, Student Campus, 6000 Stara Zagora; Faculty of Economics, Department "Industrial business and entrepreneurship", *Email:* juliadoj@abv.bg; *Tel.:* +359 888 711815

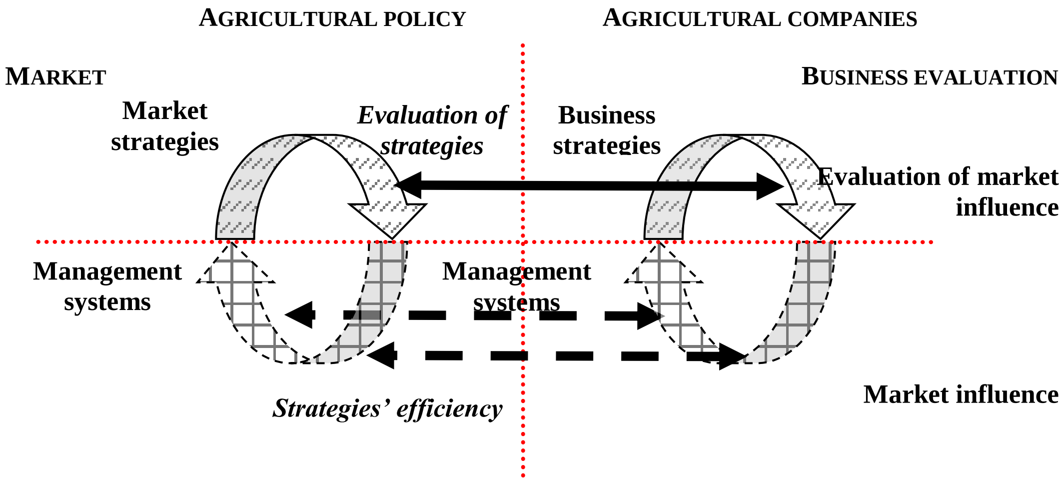
Introduction

Common Agricultural policy (CAP) is a classic example of intervention policy – product support, production quotas, aid schemes and direct payments. Early retirement schemes, grants for setting young farmers and diversification initiatives promote intra-sector structural change and assist for reduction of the low mobility of production resources. Indeed these measures are often assumed also as an impediment for efficient allocation of resources as they are aimed at intervention in a primary production sectors. Even direct transfer payments are not qualified as efficient instrument for employment promotion as they have short-term effect. Defining the impact of the agricultural market policy reveals as highly problematic and controversial not only considering the expected results. The main argument supporting this statement is that the policy hardly suited and is less efficient in supporting structurally weak rural areas. Therefore characteristics of the CAP objectives have received considerable attention and discussion due to their broad impact and influence.

Rural areas and agricultural policy in Italy

Cluster policy at sub-national level in Italy is enhanced by the support of strong regional governance and active society awareness. In the context of agricultural policy implementation, the term *"cluster policy"* refers to provision of institutional incentives for companies in the sector to act as a competitive industrial framework (Figure 1).

Figure 1 Competitive agro-industrial framework



Source: Own resources

Considering the presence of high concentration of small agricultural companies it is interesting how they appear to be competitive in terms of quality, production costs and price? The answer is in their ability to behave as part of a group, binding together on the base of produced product or geographical region and benefiting from their common competitive advantage in terms of specialization, cooperation and flexibility. Still this characteristic of the Italian agricultural sector does not provide for equal development and adaptation of all regions. Regional economic policy is complicated and varies because of the heterogeneity of the regions. On one side they fall into different European funding categories. From the other, not all Italian regions possess the same institutional power and autonomy[4] - there are five regions with special statute and extended legislative power – Sicily, Sardinia, Friuli–Venezia Giulia, Trentino-Alto Adige and Valle d'Aosta.

Due to diversity of characteristics and dynamics' level of its rural regions, in Italy the Common Agricultural policy has different impact and implementation results. The most important aspect for the better accumulation of policy resources – both institutional and financial, is the degree of technological innovation, capital investment opportunity, intensification of production process, level of competitiveness and environmental undertakings. The common finding about the entire development of the European agricultural sector is applicable to the development of the Italian agricultural sector: large-scale farmers and big food companies play significant role in the agri-food chain. From one point this fact could be observed as rather beneficial, since the concentration of production and distribution process has initiated new production technologies and imposed high quality standards for the final product. At the same time the process, acknowledged as the *"modernization"* of the agricultural sector caused its restructuring in a manner less favourable for the small-scale producers and enterprises. Their position has been even worsened when the large companies acquired some specific niche products (in respect to their quality and regional characteristics). Hence, the quality that once was found only in small-scale farms' products now could be guaranteed by the quality brands of competitive enterprises. Many traditional productions that failed to adjust to the new institutional circumstances and to apply new technological strategies just ceased their existence.

While developing their quality and improving their production technology, milk and beef production have experienced a process of de-territorialization and standardization. Strong regional identity was preserved in wine and cheese production, where local production systems have emerged, based on small-scale production. This was an opportunity to preserve small-scale and semi-subsistence farming by exploring the opportunity for part-time farming and integration through a large set of cooperative arrangements.

Beside production restructuring there was also observed a change in the consumption behaviour and attitude. The focus has been shifted towards environmental policy and quality of production. The diversification process in the agri-food chain was associated with several different aspects like: health, quality, innovation, technological progress and preservation of traditions (Table 1).

Table 1 Perspectives of participants in the agri-food chain

Food companies	▪ Environmental measures; ▪ Market segmentation; ▪ Product innovation; ▪ Exploiting competitive advantage of the regions.
Retailers	▪ Quality standards; ▪ Extension of after-sell services.
Consumers	▪ Quality of consumption

[4] Constitution of the Italian Republic, Art.116, "Friuili-Venezia Giulia, Sardinia, Sicily, Trentino-Alto Adige/ Südtirol and Valle d'Aosta/ Vallee d'Aoste have special forms and conditions of autonomy pursuant to the special statutes adopted by constitutional law.

Specificity of the agricultural production has influenced the institutional measures and initiatives taken in respect to the Common Agricultural Policy framework. This influence could be characterized in the light of *"both localization and broadening of agricultural scope"*. *"(...) Localization through intensified interaction and cooperation is perceived as a viable strategy of defence"*[5]. Drivers of the change in the agricultural sector in Italy could be summarized in four groups: political, economic, social and technical. Political factors are associated with the large consensus between public authorities and private sector representatives; high influence of farmers' unions and consumers' organizations; promotion of high quality and origin of production; and focus on the environmental policy. The economic factors are mainly related to the long-standing tradition resulting from a large number of family farms; concentration of retail system; and the competitive advantage of local production. As social factors, significantly contribute the level of food culture, the new trends in consumers' attitude towards smaller quantities and higher quality of food and the efficient communication between farmers and consumers. Last but not least is the importance of the technical factors and the increasing levels of the technological innovation.

Italian national reference framework *Programmi di sviluppo rurale* (2007-2013) established the basis for the regional programing in a way to allow continued progress both towards the convergence of the Italian economy with the Community average and the convergence of the economies of Italian regions amongst themselves.[6] Furthermore, even within the Italian regions with a higher level of development, particular attention is given to certain specific areas. For the entire programming period available amount was close to 8,3 million euro of which 90 % come from EAFRD and the rest from the debits of EAGGF (2000-2006) and from the CMO tobacco reform (Council Regulations (EC) 1782/2003 and 864/2004)[7]. According to the classification scheme of the policy interventions, there are four basic types of interventions: diffusion of innovation; promotion and reinforcement of the relationships among firms; diffusion of information and training to improve the internal functioning of the agricultural structures; and promotion of economic growth.

Nevertheless there are some weak aspects in characteristics of regional development that should be mentioned, such as: lack of coordination among undertaken incentives, low level of monitoring and evaluation control, policy implementation is efficient only in regions with already established efficient regional structures, and difficulty in identifying appropriate level of policy making regarding different production sectors.

[5]Brunori, G., R. Cerutti, S. Medeot, A. Rossi, F. Valini (2002) Marketing sustainable agriculture: an analysis of the potential role of the new food supply chains insustainable rural development. Macro-level analysis of food supply chain dynamics and diversity, National report - Italy

[6]State aid N 324/2007 – Italy, Regional aid map 2007-2013

[7] In April 2004, the Council of EU Agricultural Ministers decided to reform the raw-tobacco sector in two phases: a transition phase (2006-2009) a second phase (2010 and after). At the first phase, Member States may either completely break the link between production and the financial aid provided to the tobacco sector. After 2010, all Member States will be required to completely decouple production and the aid. 50% of aid to the tobacco sector will be incorporated into the Single Payment Scheme. The other 50% will go towards strengthening rural development programmes, particularly in tobacco-growing regions.

Table 2 Strategic and Specific objectives in the RDP (2007-2013)

Strategic objectives	Specific objectives
Promotion of modernisation of businesses and integration of industries	- Increase and maintenance of the competitiveness in the agro-forestry sector is prioritised by investing in human capital through increasing training opportunities and valuing young farmers
Develop the quality of agricultural and forestry production	- Developing and modernising local infrastructures, and supply mountainous areas with it
Improvement of infrastructure	- Developing product/ process innovation
Encourage entrepreneurship	- Improving the quality of local agricultural and forestry produce through improved commercialisation services and promoting local products and tourism

Rural development programme for the next period (2014-2020) found its place in the Operational programme of the Province in Trento, which included the following three priorities:

- stimulate the competitiveness of the agricultural and forestry sector;
- ensure the sustainable management of natural resources and climate action;
- achieve balanced territorial development of rural economies and communities, including the creation and retention of jobs.

The Province proposed 12 measures with a total amount of 301 million euro of public expenditure co-financed by the European Union, the State and the Province. (Sforzi J. et. al, 2015).

Efficiency analysis

The literature on total factor productivity (TFP) growth can be broadly categorized in two main streams: frontier (parametric and non-parametric approaches) and non-frontier approach. Frontier approach, represented by Stochastic and Bayesian approach requires structuring a functional form (production, cost, profit functions or regression equations). The non-parametric estimates are conducted by data envelopment analysis, which is characterized as a linear-programming methodology. Before proceeding to the implementation of stochastic frontier (SFA) and data envelopment analysis (DEA) to the cooperative data set, it is necessary to define the term "frontier" which appears as the key element in the analysis.

According to the definition provided by Mahadevan (2002) *"(...) a production frontier traces the set of maximum outputs obtainable from a given set of inputs and technology, and a cost frontier traces the minimum achievable cost given input prices and output. The production frontier is an unobservable function that is said to represent the 'best practice' function as it is a function bounding or enveloping the sample data."* Data envelopment analysis (DEA) is a non-parametric approach that could be both input and output oriented. The methodology optimizes on each observation unit with the objective to calculate a discrete piecewise frontier determined by the set of Pareto efficient decision-making units. As DEA does not produce standard errors it could not be applied in testing hypothesis. When the analysis is oriented towards inputs, it defines the frontier by seeking the possible proportionate reduction in input usage, with the output levels hold constant. If DEA is output-oriented – it defines the maximum proportional increase of output level with input levels held fixed. The two measures provide the same results within testing constant returns to scale, but different in case of variable returns to scale.

Charnes, Cooper and Rhodes (1978) used the optimization method of mathematical programming, to generalize Farrell's (1957) single-output to single-input technical efficiency measure, to calculate multiple outputs to multiple inputs cases by construction a single "virtual" output to a single "virtual" input relative efficiency measure. The proposed CCR model estimates the overall efficiency and identifies the sources of inefficiency in the model.

It is reasonable to assume constant returns to scale (CRS) in cases when all studied decision-making units operate at the optimal scale. Nevertheless, dynamics related to market operations and the influence of other external factors suggest for more reliable assumption - variable returns to scale (VRS). Afriat (1972); Färe, Grosskopf, Logan (1983) and Banker, Charnes and Cooper (1984) adjusted the CRS DEA model to account for variable returns to scale situations. The model BCC accounts for pure efficiency and differentiates among constant, increasing and decreasing returns to scale.

One of the advantages of DEA is that the approach not only rates efficiency, but also estimates sources and amounts of the inefficiency components. The meaning of inefficiency score is calculated by slack analysis of inefficient decision-making units, so that the result would be an operating surplus on the revenue and expense statement. DEA provides methods for estimating production frontiers and measurement of productivity that require a minimal set of assumptions regarding technology and minimum extrapolation from observed data.

There are two important properties of the efficient frontier that need to be specified (Zhu, 1996):

Property 1: Convexity $\sum_{j=1}^{n}\lambda_j x_{ij}$ (i= 1, 2, …m) and $\sum_{j=1}^{n}\lambda_j y_{rj}$ (r= 1, 2, …s) is the possible set of outputs and inputs achievable by the DMU_j, where λ_j (j= 1,2, …n) are non-negative scalars such that $\sum_{j=1}^{n}\lambda_j = 1$.

Property 2: Inefficiency: it is expected that the same level of output y_{rj} could be Achieved by using $\hat{x}_{ij}$, considering that $\hat{x}_{ij} < x_{ij}$, or that the higher level of $\hat{y}_{rj}$ could be produced using the same quantities of input x_{ij}, satisfying the $\hat{y}_{rj} > y_{rj}$.

The input oriented DEA determines the minimization of the level of used inputs in order to produce the same level of output (Banker, Charnes, Cooper, 1984). The model is represented by:

$\theta^* = \min \theta$, subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{i0} \qquad (i = 1, 2, \ldots m)$$

$$\sum_{j=1}^{n} \lambda_j y_{rj} > y_{r0} \qquad (r = 1, 2, \ldots s)$$

$$\sum_{j=1}^{n} \lambda_j = 1$$

$$\lambda_j \geq 0 \qquad (j = 1, 2, \ldots n)$$

, where decision-making unit (DMU) represents one of the n DMUs under evaluation, x_{i0} and y_{r0} are the i-th input and r-th output of the DMU.

The value of θ represents the efficiency score of the evaluated DMU. If it is estimated that $\theta = 1$ then this is feasible solution for the evaluated unit. This means that the current inputs cannot be reduced proportionally and that DMU has already achieved its position on the efficient frontier. In cases when $\theta \leq 1$, the DMU under evaluation is dominated by the frontier.

Important specification is given by Cooper et. al (2007) with definition of the production possibility set P,

$$\mathbf{L \leq e \lambda \leq U}$$

, where $e = (1 \ldots 1) \in R^n$ and, $L \leq 1$ and $U \geq 1$ are respectfully the lower and upper bounds to the intensity of λ.

In the input oriented model the estimates of L = 1 and U = 1 signifies that the DMU operate under constant returns to scale (CRS), the values of L =0 and U = 1 correspond to increasing returns to scale and finally if L = 1 and U = ∞ then the calculations show decreasing rate of return.

Scale efficiency determines how close the estimated DMU is to the optimal scale size. Førsund and Hjalmarsson (1979) have defined three measures of scale efficiency. The first measure "*shows the distance from the observed plant to the optimal scale on the frontier function by the ratio of an input coefficient evaluated at the technically optimal scale for the observed input ratios and the corresponding observed input coefficient*"[8]. The measure signifies for the possibility to achieve optimal scale of production by relative reduction of inputs. This first measure leads to the following two measures that correspond of how the evaluated units could be moved closer to the optimal production frontier - in horizontal or vertical direction and show the distance from the transformed isoquant corresponding to the unit's position towards the optimal scale.

Scale efficiency is calculated as the ratio of the technical efficiency (TE) estimates under the assumption of constant returns to scale (CRS) to the values of technical efficiency under the assumption of variable returns to scale (VRS) (Banker, Charnes

[8]Førsund, F., L Hjalmarsson (1979) Generalized Farrell measures of efficiency: An application to milk processing in Swedish dairy plants, The Economic Journal, vol. 89, No.354 (Jun. 1979), pp.294-315

and Cooper, 1984; Färe, Grosskopf and Lowell, 1985). The scale efficiency is given by the ratio:

$$\mathbf{SE\ (X,\ Y) = \theta^*_{CRS} / \theta^*_{VRS}}$$

A decision-making unit appears to be scale inefficient if it exceeds the most productive scale size (thus experiencing decreasing returns to scale), or if it is smaller than the most productive scale size and failing to take advantage of the production capacity (experiencing increasing returns to scale) (Charnes, Cooper, Lewin, Seiford, 1994). Traditional DEA does not include uncontrollable inputs in the sensitivity analysis, because by definition management cannot manipulate in terms of improvement or change these variables.

Descriptive analysis - financial ratios

During the last few decades, financial statements in the agricultural sector have been standardized, which allowed for ratios and measures commonly used in the other industrial sectors for estimating economic efficiency to be successfully applied to data sets of agricultural producers and their organizations. In the present analysis are included 69 cooperatives with location Trentino Alto-Adige, which have developed their production in three sectors – fruit and vegetables, dairy and wine. Additionally is included a forth category of cooperatives which provide services for the agricultural sector.

Relying on the available financial information, estimated financial ratios represent their liquidity and solvency for the period 2014-2015 (Table 3).

Table 3 Average value of the calculated financial ratios, 2014/ 2015

Finacial ratios	2014	2015	Mean	Median	Standard deviation
			Solvency ratios		
Long term debt/ Equity - leverage	1,15	1,36	1,25	1,25	0,15
Long term debt/ Total assets	0,19	0,19	0,19	0,19	0,00
Total liabilities/ Total asset	0,67	0,69	0,68	0,68	0,01
Equity/Asset	0,28	0,26	0,27	0,27	0,01
Cash/Sales	0,10	0,08	0,09	0,09	0,01
Current liabilities/ Total liabilities	0,73	0,73	0,73	0,73	0,00
			Liquidity ratios		
Tobin Q	0,95	0,95	0,95	0,95	0,00
Current ratio	1,32	1,40	1,36	1,36	0,05
Quick ratio	1,48	1,15	1,30	1,31	0,23
Depreciation/ Total sales ratio	0,04	0,04	0,04	0,04	0,00

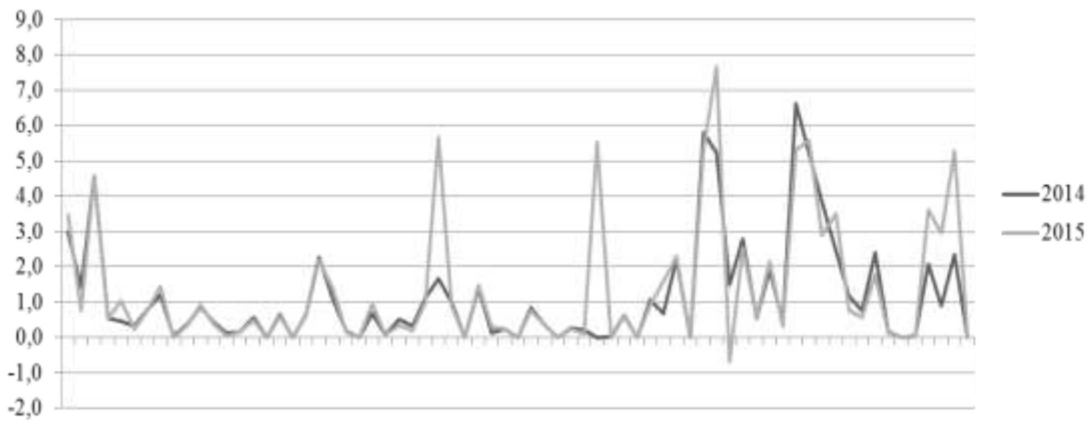
Source: Own calculations

Solvency by definition is the ability to pay off all debts if the business were to be liquidated. Solvency ratios deal with the relationship among total assets, total liabilities and net worth. The three standard solvency ratios are as follows: debt to asset ratio; equity to asset ratio and debt to equity ratio. *Liquidity* measurements are concerned with the cooperative ability to generate sufficient cash flow and to maintain balanced proportion between current assets and liabilities. These ratios are represented in the analysis by Tobin Q, current ratio, acid test. The current liabilities or the obligations that cooperatives are expected to cover during the normal operating cycle include as a general rule the information about: trade accounts, short-term notes payable, payroll liabilities, sales and taxes. The current assets should be easily converted to cash and concern the cash level, short-term investments, accounts receivables, prepaid expenses and inventory. The current ratio is calculated to signify the amount of assets available to pay current obligations. Another way to define cooperative ability to meet current obligations is simply to calculate the working capital, which is represented by the remainder of the current assets after the current liabilities are paid.

The first calculated ratio represents the relation between the *long-term debt* and the *equity* (Graph 1). The long-term debt stands for amounts owed after more than one year for goods and services purchased on credit terms. The equity represents the value of shareholders' interest in the cooperative and is calculated by decreasing total assets by total liabilities. It is composed by share capital, reserves and retained profit. As equity is derived residually any change in the value of assets and liabilities would cause a proportionately larger change in the value of equity. The long-term debt to equity ratio measures cooperatives' financial leverage. The ratio looks at how the equity of the cooperatives is leveraged by using debt capital. It compares the relationship of the amount of debt to the amount of equity for the two year period.

There are no firmly established rules for acceptable debt-to-equity ratio. Generally speaking companies with debt exceeding 60 – 65 % of capital (that is leverage of 1,8 : 1 or above) are less viable over long-term period. The common rule is that if the ratio is greater than 1, the majority of assets are financed through debt. If the coefficient is smaller than 1, assets are primarily financed through equity. In the data set 61 % of cooperatives achieved debt-to-equity ratio smaller than 1. For the rest of cooperatives the primary conclusion is that a lot of debt has been used to finance increased operations in cooperatives. These cooperatives do not possess the capacity to generate more earnings without outside financing. In the optimal case this outside financing could increase earnings by greater amount than the debt cost (interest) and consequently more earnings would be spread among the same amount of members. Nevertheless the opposite situation when the cost of this debt financing might outweigh the return that the cooperatives generate on the debt through investment and business activities should not be underestimated. This could lead to lower financial results and in cases of unfavorable economic conditions even to bankruptcy.

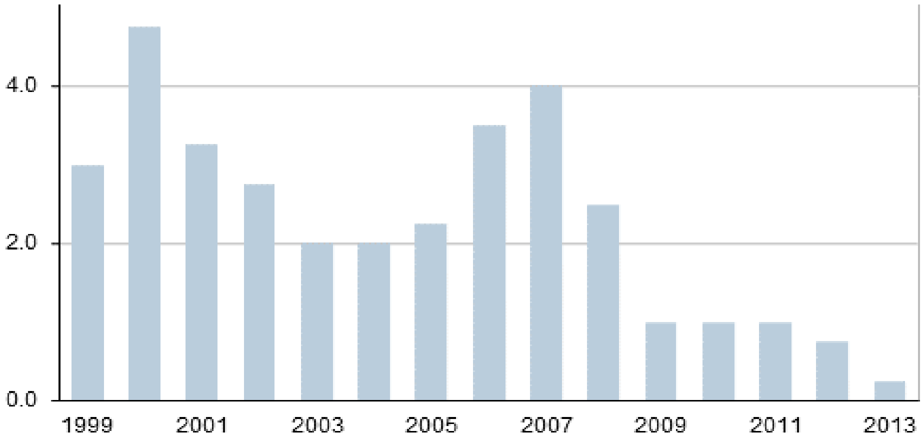
Graph 1 Long-term debt to Equity ratio estimates (2014-2015)



Source: Own calculations

Investing in a company with a higher debt-to-equity ratio might be riskier, especially in times of rising interest rates, due to the additional burdening of the debt. The general information about the interest rates shows their relative decrease in the rate charged by banks on loans to prime customers (Graph 2):

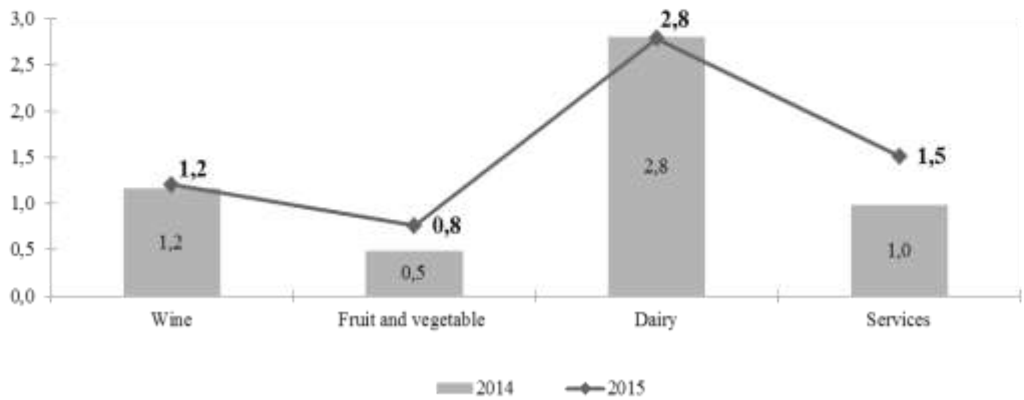
Graph 2 Interest rate (%)



Source: Forecast economics

The interest rate is not the only factor when assessing the financial status of the organizations. The results of the debt-to-equity ratio also depend on the sector in which the cooperatives operate and could be interpreted regarding the type of production (Graph 3).

Graph 3 Debt-to-equity ratios by sectors

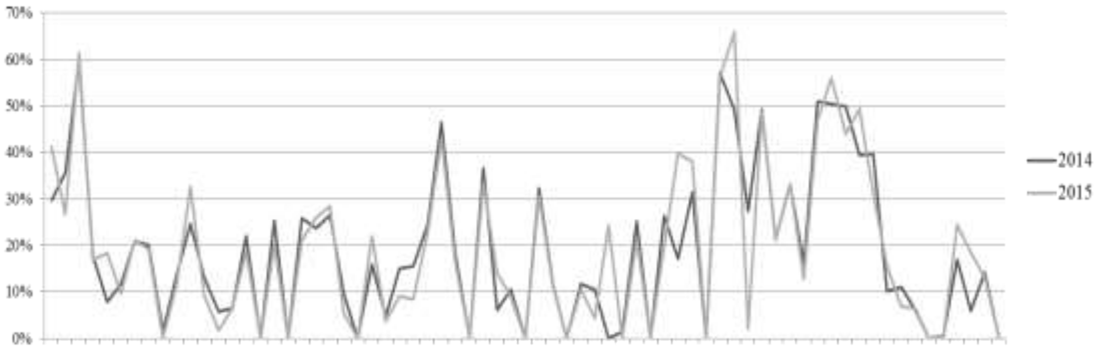


Source: Own calculations

Capital-intensive sectors tend to have a debt-to-equity ratio above 2, while other type of industries have a debt-to-equity ratio under 0,5, which has been confirmed by the calculated ratio results per sectors. Higher coefficients' value is calculated for dairy cooperatives (average 2,8 for the two years), followed by the wine producing cooperatives (average 1,2). The debt-to-equity ratio for cooperatives in the fruit and vegetable production is estimated to 0,5 for the first year and 0,8 for 2015; while the average values of the service cooperatives is 1,25 for the entire period.

The simplest way to calculate what portion of the cooperatives' total assets is financed from long-term debt is by the ratio *long-term debt to total assets* (Graph 4) According to theoretical formulations when cooperatives have less than 25 % of their assets financed by loans or any kind of debt mechanisms they maintain their position stable. This position becomes more vulnerable if this percentage increases to 50 % and above. In the present data set 68 % of cooperatives have less than 25 % of their assets financed by loans, and only 4 cooperatives have above 50 % of their assets financed by loans. The long-term debt to asset ratio should not be separated from the loan terms and structure of financing. In some cases the lower interest rates and extended loan repayment could lower the cost of borrowed funds and therefore the cooperative's business could support a higher debt-to-asset ratio.

Graph 4 Long-term debt to assets ratio (%)



Source: Own calculations

The ratio *total liabilities to total asset*, reveals another aspect of cooperatives' ability to pay their total obligations. The average ratio for 2014 is 0,67 and for 2015 0,68. This indicates that for every 1 euro of assets 0,67 to 0,68 euro cents are owned to total liabilities. The *equity-to-asset ratio* signifies the percentage of total assets that are owned by cooperative. The average ratio of 0,27 for the two years indicates that for every 1 euro assets 0,27 euro cents are owned equity.

Financial strength of the cooperatives is further represented by the *total cash-to-total sales* ratio. This ratio looks at the effectiveness of cooperatives to collect cash payments from debtors. The higher the value of this ratio, the stronger the cooperative is. In other words this percentage measures the cooperative ability to convert released sales into cash. The high percentage indicates that there is sufficient cash flow to finance additional production, and the low number indicates for the opposite. The calculated percentage of the cash-to-sales ratio is relatively low – 9 %. This result could be related to the seasonal character of agricultural and the contract arrangements with the wholesalers and the final customer. Producers expect to receive their payments upon the immediate sale of their production or to receive down payments. However most of the contracts specify that cooperative receives its payments after the released sale of the production. In some cases the crop is stored for certain period before it is sold. All these factors contain possible reasons for clash of interests between producers and the cooperatives. Therefore it is necessary to consider efficient payment scheme that is consistent with cooperatives' contracts with clients and members' payment expectations. One working scheme is to organize payments to the members five times per year. Cooperative allocates the revenues in the proportion to the quantities delivered, reduced with the costs related to processing and marketing of production. Another possibility is to retain a certain percentage (up to 10 %) from the revenue that would be used for the next year. This way the payments to the producers are secured no matter that the actual sale of production is still not released.

The *debt-structure ratio* measures proportion of current liabilities to total liabilities and in general its high value indicates for solvency problems. Regarding cooperatives included in the present data set - their average estimated value is 0,72 and infers for relatively solvency stability. Nevertheless calculations of this ratio do not consider the value of long-term liabilities that are included in total liabilities. In cases when their value is low, the higher values of debt structure ratio do not necessarily predict some solvency problems for cooperatives.

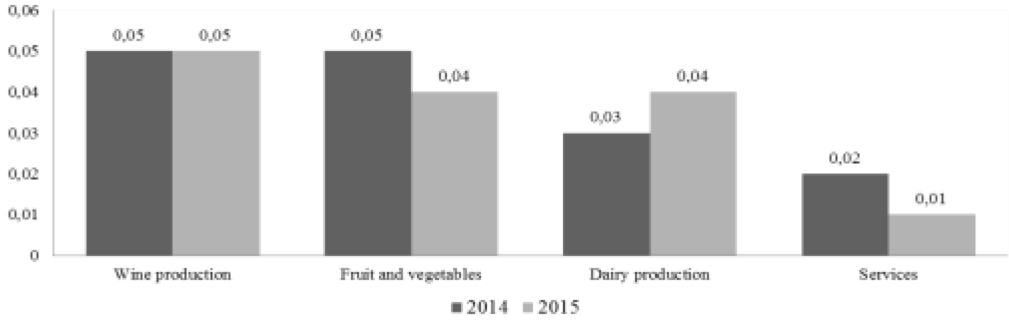
An appropriate way to compare the market value of the cooperatives and the value of cooperatives' assets is calculating *Tobin Q*. The ratio represents the sum of equity, liquidation value and total liabilities, divided to the value of total assets. A ratio of 1 indicates that the market value of cooperative is based solely on its assets. When the ratio is less than 1 - market value of cooperative is less than the value of its total assets. The most efficient situation is achieved when the value of Tobin Q ratio is greater than 1. This result usually characterizes companies that operate and invest in assets that are expected to create value added. Performed calculations show that the average ratio for the data set is close to unity – 0,95. By using Tobin Q as a variable the question whether cooperative management optimizes cooperatives' value is addressed. In other words: does cooperatives trade at Tobin Q that is as high as it could be possible in the given input set? And whether investment decisions are optimally taken? There are two necessary characteristics to be fulfilled in order to answer these questions. The first one is that the ratio should hold constant the output level and to optimize utilization of the inputs. The second characteristic implies that it is stochastic or allows errors in the estimations. These assumptions are based on the empirical results of Land et al (1994), who estimated a strong negative relation between leverage and subsequent investment, but only for firms with weak growth opportunities or with Tobin Q less than 1. For firms with higher expectations towards cash flows and net worth, leverage is less a constraint on investment since the firms have strong growth prospective.

Quick ratio or the acid-test in the analysis is calculated as the sum of cash, medium-term investments and receivables (trade debtors) divided to current liabilities. Exclusion of inventories in the calculation allows for an assessment of the medium-term liquidity position of cooperatives. The ratio of 1 indicates that there are enough assets of liquid nature to cover current liabilities. The optimal value of the quick ratio varies accordingly to the type of farming activity. In general the ratio of 1 to 1 is acceptable. However it should be considered that the quick ratio does not predict the timing or the adequacy of the future cash flows.

The *current ratio* (working capital ratio or real ratio) is a standard measure of business' financial health. In the present data set it is calculated to define whether cooperatives are able to meet their current obligations by measuring if they have enough assets to cover their liabilities. The generally accepted ratio is 2:1, while the minimum acceptable ratio is 1:1. A ratio under 1:1 indicates that cooperative's current liabilities exceed its current assets and the ability to pay its obligations when they become due might be impaired. Calculations of the current ratio show that its average value is 1,35. This infers that debt of cooperatives is covered over 1,35 times in short term aspect. It is calculated that only 6 cooperative in the data set have achieved the optimal current ratio of 2:1. Only 10 % of cooperatives have current ratio under 1. It could be assumed that they have difficulties in converting account receivables to cash or have long inventory turnover cycles.

Depreciation expense to sales ratio defines the cost of depreciation of annual sales (Graph 5).

Graph 5 Average values of depreciation to sales ratio



Source: Own calculations

By definition the greater the ratio, the more equipment and building on farms has per sales, therefore for higher profitability of cooperatives this ratio is expected to be kept low. However the low values of the coefficient might also indicate for insufficient investment in machinery, building and storage capacity.

Data envelopment analysis (DEA) – empirical results and discussions

The calculated ratios are based on the historical information in cooperatives' financial statements. Therefore they account for the cooperatives' financial position for the past two year period and provide for general perspective of how cooperatives have maintained their business activity. Nevertheless there are other important relationships that could be derived from the balance sheet information that should be considered as significant in studying cooperative economic efficiency. Further analysis is focused on efficiency calculation by implementation of the data envelopment analysis.

I. Efficiency coefficients calculations

Cooperatives included in the data set represent three sectors of agricultural production – fruit and vegetables, wine and dairy products as well as provision of services for the agricultural production.

Table 5 DEA efficiency coefficients

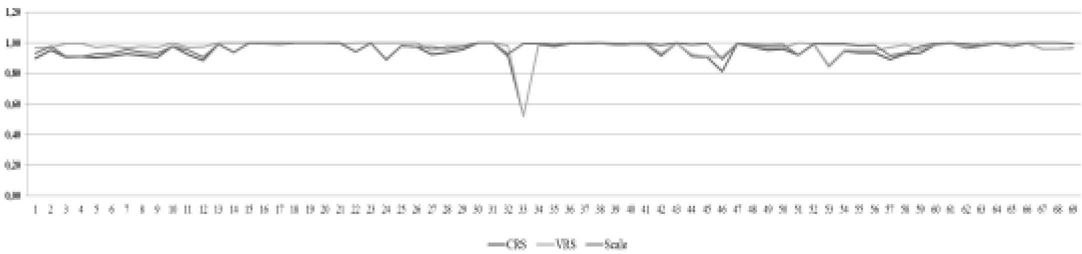
	2014			**2015**		
	Efficiency $_{CRS}$	Efficiency $_{VRS}$	Scale efficiency	Efficiency $_{CRS}$	Efficiency $_{VRS}$	Scale efficiency
Wine	0,919	0,979	0,938	0,958	0,982	0,975
Fruit and vegetables	0,958	0,974	0,985	0,966	0,979	0,986
Dairy products	0,930	0,961	0,968	0,956	0,967	0,988
Services	0,980	0,986	0,994	0,982	0,987	0,995

Source: Own calculation

The highest efficiency scores are achieved by the cooperatives in the service sector. Results signify for their stable position under constant and variable returns to scale for the entire period. In 2014 cooperatives in the service sector, which represent 14 % of the total decision-making units, operate under the highest average efficiency coefficients. Their average efficiency value is 0,98 both under constant and variable returns to scale. A more intensive increase in the efficiency levels is observed among the cooperatives in wine and dairy sector, which have managed in one year to improve their productivity by 3,92 % and 2,57 % respectfully. The average efficiency scores for the wine and fruit and vegetables cooperatives does not differ significantly – 0,97.

The estimated efficiency scores of the cooperative included in our data set are represented on Graph 6.

Graph 6 Efficiency coefficients (2014)



Source: Own calculation

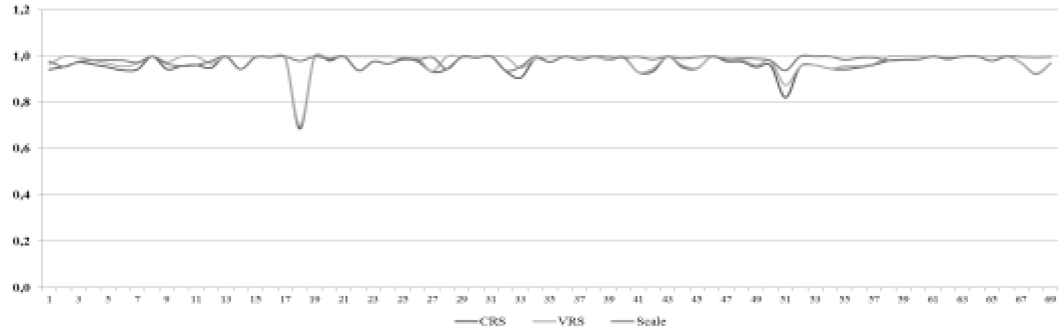
In 2014 under constant returns to scale (CRS) 18,9 % of the cooperatives in the data set operate on the optimal production frontier - they have achieved efficiency coefficient equal to unity. The rest decision-making units’ efficiency coefficients range between 0,63 and 0,99. This implies that 81,2 % of the less efficient cooperatives achieves on average 0,94 of their optimal efficiency level. Calculations for variable returns to scale (VRS) show that relatively higher percentage of cooperatives – 27,5% has achieved production at the optimal production frontier. The average efficiency score for the rest of cooperatives is estimated to 0,98. Calculated average scale efficiency is 97 %, which represents how close cooperatives are from the efficient production size.

In terms of their scale economies results show that 71 % of cooperatives exceed their efficient productive scale and thus operate under decreasing rate of return. Percentage that characterizes this exceeding ranges between 9,1 and 27,3 for all included in the analysis inputs. In general this implies that on average 24,03 % input increase will result in less than 24,03 % output increase.

Cooperatives, whose actual production scale is smaller than their potential efficient scale represent 10,1 % of the total number studied cooperatives. These cooperatives operate under increasing returns to scale and on average they have input capacity of 44,9 % that is not utilized properly in the production process.

In 2015 the least efficient sector is the dairy sector. Cooperatives that represent this type of production have achieved 96 % of their optimal efficiency levels. Regarding other three cooperative type – there is insignificant difference among their efficiency results. Their average efficiency score is 0,98 (Graph 7).

Graph 7 Efficiency coefficients (2015)



Source: Own calculations

The average efficiency coefficient of the cooperatives for 2015 under constant returns to scale (CRS) is 0,96. Of their total number 20,29 % perform under increasing returns to scale with average efficiency coefficient of 0,94. Cooperatives that are estimated to belong on the efficient frontier represent 18,84 % - these results do not differ substantially from the previous year. Nevertheless the majority of cooperatives in data set – 60,87 % still continue to operate under decreasing returns to scale with average efficiency coefficient of 0,96. Under estimations for variable returns to scale (VRS), 42 % of cooperatives belong to the efficient frontier. The rest less efficient units have the average coefficient of technical efficiency of 0,96.

Efficiency coefficients derived from variable returns to scale model are higher than the ones estimated by constant returns to scale model. Results give a broad picture of achieved productivity of cooperatives, as well as prove for a satisfactory efficiency level. One of the main problems that appear during studied period is that most of cooperatives operate under decreasing returns to scale. As the scale economies are the flip side of returns to scale, it is reasonable to assume that considerable part of cooperatives operates under diseconomies of scale or that their long-term average costs increase with the increase of their production.

Furthermore data envelopment analysis is developed in terms of sensitivity analysis in order to provide more detailed information about input utilization and opportunity to increase efficiency through their more appropriate re-distribution in the production process.

II. Sensitivity analysis

The calculations of this model applied to the present data set under the assumption for both CRS and VRS provide the following results:

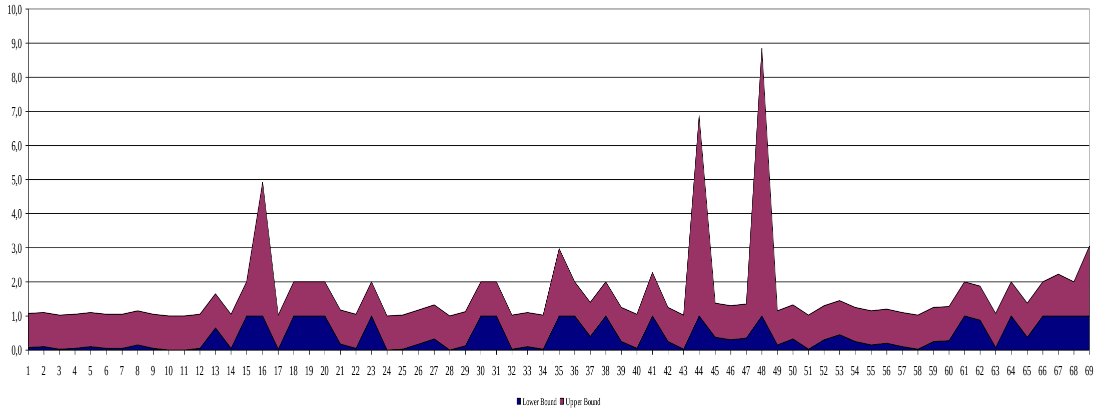
Table 6 Calculations on possible input optimization

Number of cooperatives on the efficient frontier	CRS	13/ 69
	VRS	21/ 69
Number of cooperatives with less than 10% request to decrease their inputs		26/ 69
Number of cooperatives with more than 10% request to decrease their inputs		43/ 69

Source: Own calculations

The estimates of the lower and the upper bound of stability regions under variable returns to scale are calculated for each evaluated cooperative in the data set and represented on the following Graph 8. Estimated percentages reveal by how much inputs in each cooperative could be changed (decreased or increased) without influencing its efficiency levels. For those cooperatives that have no input slacks, any input change or decrease of the output would worsen their efficiency level. In any other case the value of β^0_k gives maximum possible optimization of the inputs (considering IRS or DRS), while preserving the efficiency level of cooperatives. Represented hypothetical frontier points of the minimum and maximum points of this increase are given in the percentage values of the lower and upper bounds.

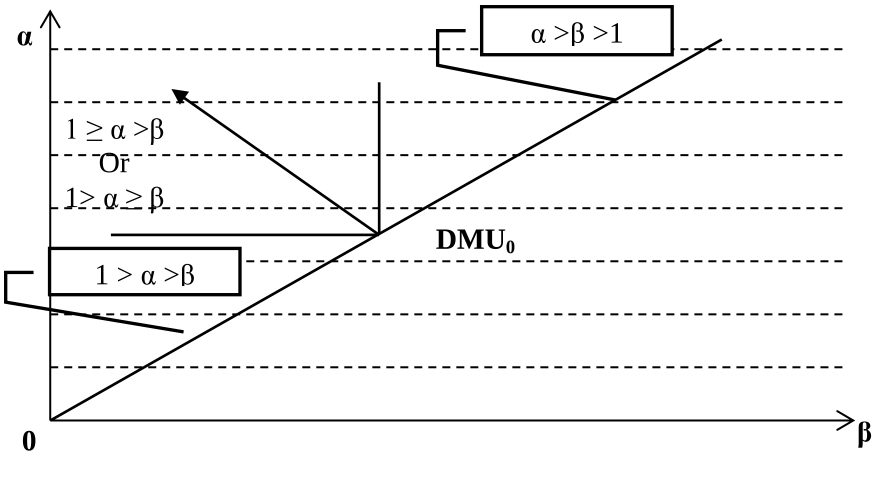
Graph 8 Stability regions (%)



Source: Own calculations

Calculated bounds define the input stability region only for these cooperatives that remain efficient even after they increase their inputs within these bounds. Defined regions are associated with the directions of the returns to scale – constant, increasing or decreasing (Graph 9). According to the variables – α represents proportional change in the outputs of cooperatives, while β stands for the proportional change of all inputs utilized in production process. Increasing returns to scale occur when $\alpha > \beta > 1$ for each decision-making unit, $1 > \alpha > \beta$ indicates for decreasing returns to scale. The cooperatives that fall in between $1 \geq \alpha > \beta$ or $1 > \alpha \geq \beta$ means that they are technically inefficient.

Graph 9 Regions by returns to scale



Further analysis reveals three sensitivity regions, accordingly to the performed returns to scales in cooperatives. In 2014 for the Region I are included 7 cooperatives that operate under increasing returns to scale – they do not explore their optimal production capacity and still have the opportunity to increase it (Table 7).

Table 7 Stability regions (2014)

	Region I		Region II		Region III	
No	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**
1	1,00	1,00	1	1	0,90	0,97
2	0,98	0,99	1	1	0,95	0,97
3	0,99	0,99	1	1	0,91	1,00
4	0,91	0,92	1	1	0,91	1,00
5	0,98	0,99	1	1	0,90	0,97
6	0,96	0,96	1	1	0,91	0,98
7	0,96	0,96	1	1	0,93	0,97
8			1	1	0,92	0,98
9			1	1	0,91	0,98
10			1	1	0,98	1,00
11			1	1	0,92	0,97
12			1	1	0,89	0,99
13			1	1	0,99	1,00
14					0,94	1,00
15					0,99	0,99
16					0,99	1,00
17					0,94	1,00
18					0,89	1,00
19					0,98	0,99
20					0,97	1,00
21					0,93	0,95
22					0,94	1,00
23					0,96	0,98
24					0,91	0,98
25					0,64	1,00
26					0,99	0,99
27					0,99	1,00
28					0,98	0,98
29					0,99	0,99
30					0,92	0,93
31					1,00	1,00
32					0,91	0,91
33					0,81	0,91
34					0,99	1,00
35					0,95	0,97
36					0,96	0,97
37					0,92	1,00
38					0,99	1,00
39					0,85	0,85
40					0,95	0,95
41					0,93	0,95
42					0,94	0,95
43					0,89	0,97
44					0,93	0,99
45					0,93	0,96
46					0,99	0,99
47					0,98	0,98
48					0,98	1,00
49					0,98	1,00

Source: Own calculations

In the Region II belong 13 cooperatives that operate on the optimal production frontier under constant returns to scale. As it was expected the calculations under VRS have placed more cooperatives on the efficient production frontier. At the same time there is a considerable excess of inputs being used to produce less output– the rest 49 cooperatives included in Region III operate under decreasing returns to scale.

An interesting result reveals the sensitivity analysis for 2015 estimating six sensitivity regions (Table 8). The Region I is represented by 12 cooperatives that operate under increasing return to scale. Their average efficiency under constant returns to scale is 0,94, while calculations assuming variable returns to scale estimate efficiency coefficient of 0,95. Under constant returns to scale perform 13 of the cooperatives (Region II). Their technical efficiency is estimated to be 1 and thus they are defined as the benchmark in the data set, belonging to the best-practice frontier. The majority of the cooperatives that fall in the third region (Region III) operate under decreasing rate of return. 40 cooperatives are estimated on average with 0,961 (CRS) and 0,982 (VRS) technical efficiency coefficients.

Table 8 Stability regions (2015)

	Region I*		Region II**		Region III***		Region IV****		Region V*****		Region VI******	
No	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**	**CRS**	**VRS**
1	0,996	0,998	1,000	1,000	0,943	0,964	0,978	1,000	0,956	0,956	0,962	0,962
2	0,994	0,994	1,000	1,000	0,955	1,000	-	-	0,947	0,947	-	-
3	0,686	0,700	1,000	1,000	0,974	0,997	-	-	-	-	-	-
4	0,908	0,950	1,000	1,000	0,965	0,982	-	-	-	-	-	-
5	0,990	0,990	1,000	1,000	0,954	0,969	-	-	-	-	-	-
6	0,976	1,000	1,000	1,000	0,940	0,956	-	-	-	-	-	-
7	0,931	0,933	1,000	1,000	0,944	0,969	-	-	-	-	-	-
8	0,953	0,962	1,000	1,000	0,945	0,976	-	-	-	-	-	-
9	0,978	0,986	1,000	1,000	0,959	1,000	-	-	-	-	-	-
10	0,972	0,973	1,000	1,000	0,963	1,000	-	-	-	-	-	-
11	0,923	0,926	1,000	1,000	0,951	0,970	-	-	-	-	-	-
12	0,970	0,972	1,000	1,000	0,945	1,000	-	-	-	-	-	-
13	-	-	1,000	1,000	0,996	1,000	-	-	-	-	-	-
14	-	-	-	-	0,982	0,991	-	-	-	-	-	-
15	-	-	-	-	0,939	1,000	-	-	-	-	-	-
16	-	-	-	-	0,968	1,000	-	-	-	-	-	-
17	-	-	-	-	0,987	0,995	-	-	-	-	-	-
18	-	-	-	-	0,979	0,993	-	-	-	-	-	-
19	-	-	-	-	0,933	0,936	-	-	-	-	-	-
20	-	-	-	-	0,946	1,000	-	-	-	-	-	-
21	-	-	-	-	0,997	0,998	-	-	-	-	-	-
22	-	-	-	-	0,995	0,999	-	-	-	-	-	-
23	-	-	-	-	0,936	0,998	-	-	-	-	-	-
24	-	-	-	-	0,987	1,000	-	-	-	-	-	-
25	-	-	-	-	0,984	0,986	-	-	-	-	-	-
26	-	-	-	-	0,995	1,000	-	-	-	-	-	-
27	-	-	-	-	0,935	0,947	-	-	-	-	-	-
28	-	-	-	-	0,948	0,950	-	-	-	-	-	-
29	-	-	-	-	0,979	0,990	-	-	-	-	-	-
30	-	-	-	-	0,953	0,963	-	-	-	-	-	-
31	-	-	-	-	0,960	0,979	-	-	-	-	-	-
32	-	-	-	-	0,821	0,875	-	-	-	-	-	-
33	-	-	-	-	0,944	0,958	-	-	-	-	-	-
34	-	-	-	-	0,953	0,958	-	-	-	-	-	-
35	-	-	-	-	0,964	0,969	-	-	-	-	-	-
36	-	-	-	-	0,982	1,000	-	-	-	-	-	-
37	-	-	-	-	0,985	1,000	-	-	-	-	-	-
38	-	-	-	-	0,987	1,000	-	-	-	-	-	-
39	-	-	-	-	0,989	0,996	-	-	-	-	-	-
40	-	-	-	-	0,981	1,000	-	-	-	-	-	-

* Increasing returns to scale
** Constant returns to scale
*** Decreasing returns to scale
**** Increasing returns to scale in input-oriented DEA calculations, constant returns to scale in output-oriented DEA calculations
***** Constant returns to scale in input-oriented DEA calculations, decreasing returns to scale in output-oriented DEA calculations
****** Increasing returns to scale in input-oriented DEA calculations, decreasing returns to scale in output-oriented DEA calculations

Source: Own calculations

To the region IV belongs only one cooperative with technical efficiency coefficient of 0,978 (CRS) and 1 (VRS). This unit appears to operate under increasing returns to scale when input-oriented DEA is performed, but under constant returns to scale when output-oriented DEA is calculated. A possible conclusion is that this cooperative operates on the edges of the production frontier and could not be easily associated with particular type of returns to scale.

For the two cooperatives that fall into Region V the average efficiency estimates are 0,951 both under CRS and VRS. When input-oriented DEA is calculated it appears that these cooperatives perform under constant returns to scale, while according to output-oriented DEA they operate under decreasing rate of returns. The last Region VI is represented only by one cooperative that operate under increasing returns to scale when input-oriented DEA is calculated, but under decreasing returns to scale when output-oriented DEA is performed. For the case of the last two regions it is difficult to specify the type of returns to scale. Golany (1997) suggests that: *"(...) no feasible solution exists in the region (i) since the existence of a convex combination of other DMUs in region (ii), established in the current solution, indicates that DMU_0 lies on a decreasing RTS piece of the frontier and the piece-wise concavity assumption precludes the possibility of an increasing RTS piece to the 'right' of a decreasing RTS piece"*[9].

Identification of returns to scale for each cooperative in the data set is incomplete unless an additional sensitivity analysis is executed. Therefore the maximum possible optimization of each one of the inputs is calculated, by holding the rest inputs and outputs unchanged. Subject to the condition that only the evaluated input is changed, results separately show the possible percentage increase of production costs, salaries, total fixed assets, depreciation and investments. Efficiency coefficients of the cooperatives that initially are estimated to belong on the production frontier decrease, while the efficiency of the remaining cooperatives improves.

In the sensitivity analysis of production costs, 10 cooperatives are estimated as the most efficient – achieving technical efficiency coefficient of 1. Their production costs are proportionally increased, in the way that their output decreases and these units become the infeasible solution in the data set. At the same time production costs in the remaining cooperatives are optimized so that the efficiency of these units improves. The change appears only in the production costs – the rest inputs are held constant. The results show that production costs in the less efficient cooperatives have been decreased by 24,1 % and individual technical efficiency on average has increased by 2,57 %.

The same calculations are performed for the rest inputs. The results are presented on the following Table 9:

Table 9 Sensitivity analysis (2014)

	Average change in the data set (%)	Optimal λ (%)	Increase of the efficiency coefficients (%)
Production costs	98,03	24,1	2,57
Salaries	26,7	18,5	8,7
TFA	36,7	2,16	3,43
Depreciation	33,7	30,6	24,69
Investments	75,6	32,7	25,08

Source: Own calculation

Redistribution of production and investment cost further significant influence over improvement of technical efficiency of cooperatives. Average redistribution of salary costs equal to 18,5 %, which reflects on 8,7 % increase of efficiency levels achieved by cooperatives in data set. Sensitivity analysis of total assets reveals that while increasing this category in the most efficient cooperatives (17 units), the rest of the cooperatives have improved the average level of their efficiency coefficient with 3,43%. Percentage change in re-allocation of this input equals to 36,7 %. Therefore depreciation costs are also added in the analysis, which initially is difficult to measure, considering difference that sometimes may occur in terms of their economic

[9] Golany, B.; Gang Yu (1997) Estimating returns to scale in DEA; European Journal of Operational Research 103, pp. 28-37

and accounting value. Changes in depreciation costs are on average 33,7 % and they have managed to increase the average efficiency level by 24,7 %.

These conclusions are confirmed in the following 2015 year (Table 10). The fixed assets and depreciation costs remain the main source for improvement of the efficiency levels.

Table 10 Sensitivity analysis (2015)

	Average change in the data set (%)	Optimal λ (%)	Increase of the efficiency coefficients (%)
Production costs	97,9	18,11	8,29
Salaries	8,7	31,68	11,8
TFA	34,4	40,0	2,21
Depreciation	32,8	33,7	20,2
Investments	99,7	39,8	30,13

Source: Own calculations

The most considerable contribution for improvement of efficiency is provided by optimized utilization of investment costs, which on average results in 30 % increase in the total generated efficiency results. Another cost category, which needs to be optimized in order to increase efficiency levels by 11,8 % are the salary expenditures.

As previously estimated, results suggest for necessity in optimization in costs related to maintaining production process, as well as the payment of the employees. There is also another conclusion that draws attention. Results point to the importance of fixed costs, which in the agricultural sector is not isolated case[10] and in the present analysis corroborates to the calculations of depreciation to sales ratio for the period.

III. Slack-based model

As already described DEA calculates input and output slacks for each cooperative that is under evaluation. Input slacks indicate for proportionate reduction of inputs and at the same time preserving the same level of output. Under constant returns to scale estimated results show that there is a possibility to reduce on average up to 33,55 % of the costs related to salaries. Costs related to fixed assets consumption during production period could be reduced up to 23,19 %. The contribution of medium-term investments could be optimized by 39,13 %.

The same calculations are conducted under condition of variable returns to scale. Results indicate that cooperatives could reduce their salary costs by 14,70 %. The share of costs related to fixed assets utilization could be optimized up to 19,70 %, while medium-term investments that contribute to the final output could be redistributed to more profitable areas in cooperatives by 34,19 %.

Output slacks calculated under assumption for constant and variable returns to scale are insignificant. The opportunity to increase production value and sales is less than 1%. Increase of the production value under variable returns to scale is less than 1 percent, while sale could be increased with 2 %.

For 2015 under variable returns to scale is calculated that 32,23 % of salary costs could be redistributed or utilized for other production purposes. Percentages of total

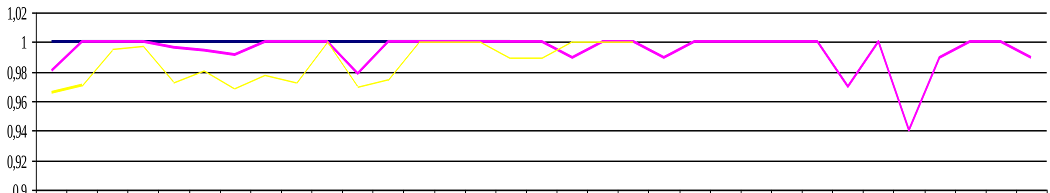
[10] "(…)Silva (2001) found the animal feeding and equipment depreciation in the Azorean dairy farms of great importance, about 27% and 13% of total costs, respectfully", In "An application of data envelopment analysis (DEA) in Azores dairy farms"; Silva, E., A. Azrubi, J. Berbel (2004) New MEDIT, A Mediterranean Journal of Economics, Agriculture and Environment, vol.3, 3, pp.39-43

fixed assets' and investments' slacks amount to 40,6 % and 42,43 % respectfully. Calculated outputs slacks in terms of achieved production value do not differ from the previous year – the percentage amount to 1,40. An unexpected increase of sales' slack occurs – 11,10 %.

IV. Context dependent DEA

Context-dependent DEA applied to our data set for 2014 introduced three levels best-practice frontiers (Graph 10). The range of the efficiency coefficients on the Level 1 range between 0,97 - 1 and includes 20 cooperatives. The second-level frontier allows improving the efficiency of the remaining cooperatives. Estimated efficiency scores vary in between 0,94 - 1 and includes 33 cooperatives. The third-level frontier includes the remaining 16 cooperatives with efficiency of 1.

Graph 10 Context-dependent DEA (2014)

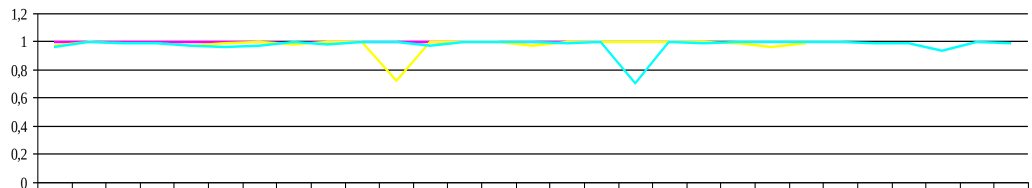


	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
Level 3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1																	
Level2	0,98	1	1	1	1,00	0,99	0,99	1	1	1	0,98	1	1	1	1	1	1	0,99	1	1	0,99	1	1	1	1	1	0,97	1	0,94	0,99	1	1	0,99
Level 1	0,97	0,97	1	1	0,97	0,98	0,97	0,98	0,97	1	0,97	0,97	1	1	1	0,99	0,99	1	1	1													

Source: Own calculations

Results for 2015 are presented on Graph 11. The first-level best-practice frontier is represented by 29 cooperatives with efficiency coefficients ranging between 0,70 - 1. Consequently algorithm introduces the second best-practice frontier, which includes 23 from the remaining cooperatives in the data set with efficiency coefficients between 0,72 - 1. The third-level best-practice frontier includes 17 cooperatives with higher efficiency estimates 0,99 - 1. Apparently the Level 4 is represented only by one cooperative with technical efficiency of 1.

Graph 11 Context-dependent DEA (2015)



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Level 4	1																												
Level 3	1	1	1	1	1	1	1	0,99	1	1	1	1	1	1	1	1	1												
Level 2	0,97	1	0,99	0,99	0,97	0,99	1	0,98	1	1	0,72	1	1	1	0,97	1	1	1	1	1	0,99	0,96	0,99						
Level 1	0,96	1	0,99	0,98	0,97	0,96	0,97	1	0,98	1	1	0,97	1	1	1	0,99	0,99	0,70	1	0,99	1	1	1	1	0,99	0,99	0,93	1	0,99

Source: Own calculations

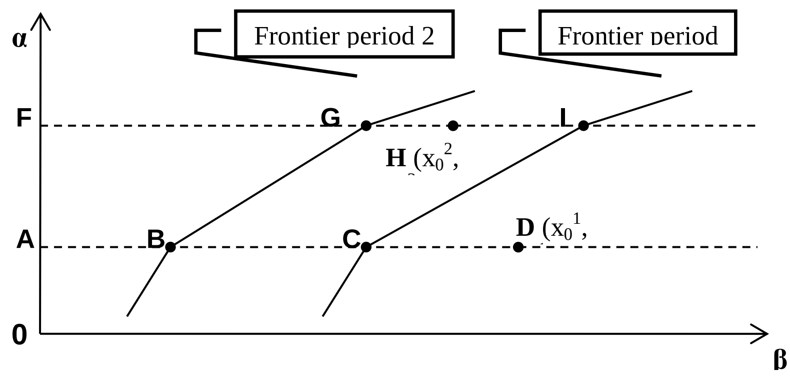
V. Malmquist Index

One of the advantages of the DEA is the possibility to measure the change of the efficiency over time, as well as the change in the efficient frontier. This is provided by a methodology which as an example of comparative statistics allows for estimating the dynamics in the data set. The *"catch up"* effect calculates the degree to which the decision-making unit improves or worsens over time. The progress or regress of the frontier technology between two periods of time under the multiple inputs and outputs is addressed by the *"frontier shift"* effect. The so called Malmquist index represents the Total Factor Productivity (TFP) and is computed as a product of the "catch up" and the "frontier effect".

The Graph 9 is transformed in Graph 10 to represent these effects in terms of their calculations in our analysis. The production possibility set is defined by:

$$(X, Y)^t = \{ (x, y) | \ x \geq \sum_{j=1}^{n} \lambda_j x_j^t, \ 0 \leq y \leq \sum_{j=1}^{n} \lambda_j y_j^t, \ L \leq e\lambda \leq U, \ \lambda \geq 0 \}$$

Graph 10 Malmquist index



The catch up effect is represented by the ratio of efficiency estimates for the second period to the efficiency estimates for the first period, or:

Catch up effect = $\dfrac{\text{Efficiency of } (x_0^2, y_0^2) \text{ with respect to period 2 frontier}}{\text{Efficiency of } (x_0^1, y_0^1) \text{ with respect to period 1 frontier}}$

Progress in the relative estimated efficiency is proven when the coefficient of representing the catch up effect is higher than 1. In the cases when this coefficient is equal to or less than 1 the conclusion points out no change or regress in the efficiency frontier.

Furthermore to evaluate fully productivity change the frontier-shift effect is calculated. According to Cooper et. al. (2007) this effect is addressed also as an innovation effect. Considering Graph 17 the frontier-shift effect is represented by:

$\varphi_1 = AC/AD : AB/AD$

$\varphi_2 = FI/FH : FG/FH$

Respectfully *frontier shift effect* for the two periods is defined by $\varphi = \sqrt{\varphi_1 \varphi_2}$. In the cases when $\varphi > 1$, there is a progress in the frontier technology, while $\varphi = 1$ or $\varphi < 1$ indicate for status quo and regress in the frontier technology.

Table 11 Malmquist productivity index – results

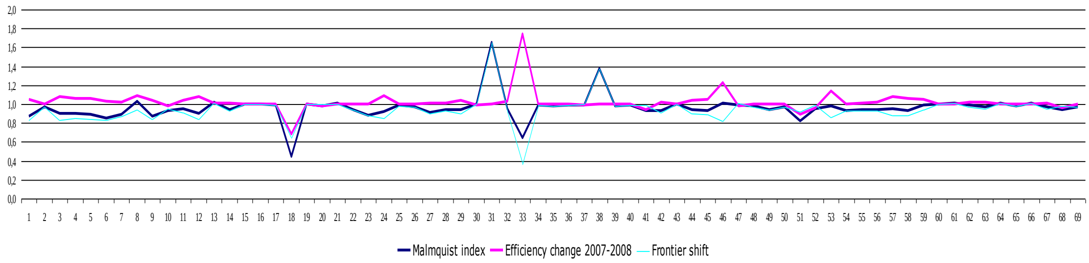
No.	Technical efficiency change: Total	Pure efficiency	Scale efficiency	Malmquist index	Efficiency change 2014-2015	Frontier shift
1	0,9006	0,9664	0,9319	0,8747	1,0476	0,8349
2	0,9514	0,9709	0,9800	0,9735	1,0041	0,9696
3	0,9070	0,9959	0,9107	0,8972	1,0745	0,8350
4	0,9087	0,9977	0,9108	0,9011	1,0623	0,8483
5	0,9036	0,9727	0,9289	0,8932	1,0556	0,8461
6	0,9135	0,9804	0,9318	0,8506	1,0288	0,8268
7	0,9285	0,9688	0,9583	0,8869	1,0167	0,8723
8	0,9167	0,9780	0,9373	1,0283	1,0908	0,9426
9	0,9062	0,9725	0,9319	0,8746	1,0428	0,8387
10	0,9790	1	0,9790	0,9344	0,9791	0,9543
11	0,9227	0,9699	0,9513	0,9500	1,0433	0,9106
12	0,8845	0,9746	0,9075	0,9023	1,0747	0,8396
13	0,9933	1	0,9933	1,0164	1,0067	1,0096
14	0,9387	1	0,9387	0,9387	1,0065	0,9327
15	1	1	1	0,9981	0,9962	1,0019
16	0,9956	0,9971	0,9984	0,9956	1,0004	0,9951
17	0,9939	0,9952	0,9987	0,9933	1,0005	0,9928
18	1	1	1	0,4423	0,6863	0,6445
19	1	1	1	1,0031	1	1,0031
20	1	1	1	0,9847	0,9816	1,0032
21	0,9953	0,9968	0,9985	1,0052	1,0048	1,0004
22	0,9410	0,9995	0,9415	0,9420	0,9974	0,9444
23	1	1	1	0,8780	1	0,8780
24	0,8897	0,9984	0,8911	0,9240	1,0884	0,8489
25	0,9825	1	0,9825	0,9877	1,0045	0,9832
26	0,9751	0,9989	0,9762	0,9700	1,0038	0,9664
27	0,9257	0,9489	0,9755	0,9119	1,0079	0,9048
28	0,9402	0,9797	0,9597	0,9375	1,0057	0,9322
29	0,9582	0,9797	0,9780	0,9406	1,0406	0,9039
30	1	1	1	0,9964	0,9949	1,0015
31	1	1	1	1,6584	1	1,6584
32	0,9127	0,9835	0,9280	0,9488	1,0255	0,9252
33	0,5204	0,5232	0,9946	0,6463	1,7440	0,3706
34	0,9876	0,9911	0,9965	0,9898	1,0021	0,9877
35	0,9790	0,9892	0,9897	0,9777	0,9971	0,9805
36	0,9976	1	0,9976	0,9882	1,0024	0,9858
37	0,9955	1	0,9955	0,9884	0,9911	0,9973
38	1	1	1	1,3798	1	1,3798
39	0,9849	0,9870	0,9978	0,9840	0,9996	0,9844
40	0,9932	1	0,9932	0,9950	1,0020	0,9930
41	0,9933	0,9987	0,9946	0,9316	0,9375	0,9937
42	0,9175	0,9311	0,9854	0,9298	1,0195	0,9120
43	0,9989	1	0,9989	1,0032	1,0011	1,0020
44	0,9135	0,9238	0,9889	0,9442	1,0433	0,9050
45	0,9057	0,9086	0,9968	0,9294	1,0465	0,8881
46	0,8119	0,9095	0,8927	1,0116	1,2317	0,8213
47	0,9945	0,9968	0,9978	0,9919	0,9845	1,0075
48	0,9732	0,9843	0,9887	0,9772	1,0047	0,9727
49	0,9544	0,9679	0,9860	0,9430	0,9991	0,9439
50	0,9606	0,9713	0,9890	0,9656	0,9999	0,9658
51	0,9204	0,9985	0,9218	0,8220	0,8924	0,9211
52	0,9934	0,9958	0,9976	0,9551	0,9620	0,9929
53	0,8459	0,8535	0,9912	0,9754	1,1367	0,8580
54	0,9462	0,9533	0,9925	0,9305	1,0010	0,9296
55	0,9340	0,9504	0,9828	0,9386	1,0108	0,9285
56	0,9360	0,9500	0,9852	0,9451	1,0176	0,9288
57	0,8922	0,9716	0,9183	0,9480	1,0805	0,8773

Source: Own calculations

Table 11 represents calculated Malmquist indices, as well as the decomposition into indices of efficiency change and frontier shift over the period 2014-2015. As already mentioned, the values of Malmquist index which are higher than 1 signify for improvement, while in contrary when these values are less than 1 there is regress in productivity observed. Efficiency coefficients and their change are decomposed into pure and scale efficiency. Calculated results show increase in productivity, but do not favour innovation effect. The catch up effect signifies that there is an increase in the relative efficiency, proven by the average coefficient of efficiency change – 1,023. Results show that the percentage of cooperatives that have managed to improve their relative efficiency is significantly high - 65,2 %. Among all decision-making units in the data set 24,6 % have shown regress in efficiency, while 10,2 % have kept their relatively stable position and signify for no change in the efficiency. The rest 24,6 % have registered regress in their efficiency.

Analysis by sectors show that the biggest improvement is in the winery sector where the productivity increases by 1,04 %, followed by the dairy sector 1,03 %, fruit and vegetable sector (1,01 %) and services (1 %).

Graph 12 Total factor productivity (2014-2015)



Source: Own calculations

The answer to the question whether the progress in efficiency is due to improvement in production technology is negative. The calculated frontier-shift effect signifies for regress in frontier technology, as its value is 0,945. Only 18,84 % from the total number of cooperatives have indicated for progress in the production technology. Cooperatives in the wine sectors are mostly acknowledged as market stable with more advanced technology although the results show an interesting turn. Only in the fruit and vegetable sector the increase of the productivity is due to the positive change in their pure efficiency. Of their total number 43,8 % have registered increase in pure efficiency coefficient.

The average value of the Malmquist index is 0,98 that is close to unity, but still according to the theoretical explanations signifies for the deterioration in the total factor productivity. This result is mostly justified by the regress in the frontier technology.

Conclusion

Data envelopment approach is applied to the input and output variables to reveal the efficiency levels of cooperatives included in the data set. Besides these results, the analysis is developed in sensitivity analysis and slack-based model, which aim at estimating input utilization and changes that might occur in terms of their optimizations toward achieving higher level output. The context-dependent DEA reveals an algorithm that structures new frontiers by allowing for the inefficient decision-making units to become relatively efficient by gradually removing the efficient ones. Calculated Malmquist index measures the total factor productivity of the cooperatives for the period 2014-2015.

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