1. Introduction

Wine is made traditionally in the southern regions of Europe (Italy, Spain, France etc.), but today wine is produced on all the continents and even in cold countries such as Canada.

The world production and consumption of wine are increasing: the growth rate of wine production in 2011-2014 was 6.4% and for wine consumption – 0.1% (Wine Institute, 2016). Italy, France and Spain remain the leaders of wine production: their total share in the world production in 2014 was 45.9% (Wine Institute, 2016).

Focus in our research will be on the countries that have not yet reached a high level of development in the global wine market. These Eastern European countries are trying to integrate into the EU and attempting to gain a foothold in new markets. For the study we have considered one country from the middle of the list of world’s wine producers in 2014 (Wine Institute, 2016) – Ukraine (20th place), and one country from the bottom of this list – Bosnia&Herzegovina (54th place of 57 countries).

Ukraine

In the period 2006-2013, the volume of grape processing was quite high (Figure 1) and ranged from 300 to 450 thousand tons per year (2014), and after the annexation of Crimea (229 thousand tons). The dynamics of wine production in Ukraine for the past nine years is presented in Figure 1.

Odessa, Mykolaiv, Kherson regions and Crimea are the largest wine-producing regions in Ukraine. The shares of these regions in total grape processing (during the period 2010-2013) have been relatively stable and changed between 3-7% per year. However, in 2014 the structure of grape processing has changed significantly: over 61% of grapes are now processed in the Odessa region, about 20% – in Mykolaiv, about 16% – in Kherson, and only 3.7% in other regions of the country.

Changes were also in the structure of wine production, more than 97% of wine industry is concentrated in three regions: the Odessa area – more than 60%, Nikolayev – 21.4% and Kherson – 15.6%.

The biggest share in the total volume of grape processing in Ukraine is held by seven varieties: Aligote, Rkatsiteli, Cabernet Sauvignon, Muscat, Chardonnay, Sauvignon and Riesling. Their total share in the total volume of grape processing in 2011-2014 was 59-62%. Among the leading seven varieties for the whole period (2010-2014) the share of Chardonnay (from 5% to 11%), Cabernet Sauvignon (from 6% to more than 9%), Riesling (from 3.6% to nearly 6 %) and Sauvignon (from 4.2% to 7%) significantly increased due to reduction of Rkatsiteli share (from 11% to 5.5%) and other varieties. The traditional leader – Aligote remains the highest share (12-13%).

Despite some difficulties of doing business and the impact of other negative factors that take place in the country,
accompanying varieties Bena, Krkošija, Smederevka, Vranac, Plavka, Merlot and Cabernet. The wine sector in B&H is relatively small, but the wine sector is significant in several municipalities in western and southern part of the country - in Herzegovina and areas around Trebinje.

The division between registered and unregistered grape production and wine reflects the dual structure of the sector in B&H; on the one hand, 40% of the sector is under a professional organization and management, while 60% of the sector is organized in the form of permanent or semi-permanent production for personal use and sell in the local market. The total vineyard area of Herzegovina is divided into more than 14,200 parcels with an average area of 0.25 ha.

Wine production in B&H has increased slightly last years. Analysing the period 2006-2014, the volume of wine production has increased from 2.6 mil. lit. in 2006 to 4.5 mil. lit. in 2014 (Agency for Statistics of Bosnia& Herzegovina, ASBH, 2015b). Based on the FAO (2012), it can be estimated that the value of wine production in B&H amounts to 66 million KM (33.8 mil. €) in 2011, while the value in 2005 amounted to 48.5 million (24.7 mil. €) on the basis of constant prices on the market, and confirms the progress in this sector.

A value of 66 mln KM from 2011 represented 3.7% of GDP of agriculture and related services in B&H, and 0.27% of total GDP of B&H.

2. Literature Review

Many studies are devoted to different aspects of winemaking: consumption properties of wine, e.g. tastes and aromas (Rinaldo et al., 2014; Hanf, 2014), quantitative and qualitative changes in consumption and production of wine in different countries, e.g. Italy (Barisan et al., 2015), Germany (Hanf et al., 2013), Spain (Gil et al., 2015) or Australia (Orr, 1997).
Some studies are devoted to the efficiency of wine production. Conradie et al. (2006) estimated the relationship between technical efficiency and vineyard size and have shown that efficiency is affected by labour quality, age and education of the farmer, location, the percentage of non-bearing vines and expenditure on electricity for irrigation.

Sellers-Rubio et al. (2016) estimated productivity and efficiency at a winery level through a dynamic approach from two of the main wine-producing countries in the world (Italy and Spain). According to their results, in order to improve efficiency, firms should be able to identify the sources of poor performance and the alternatives available to make better use of their resources.

Galluzzo (2014) identified that producers of Protected Designation of Origin (PDO) wine have the poorest level of technical efficiency, because of the level of agrarian capital and labour force compared to conventional ones. In their research, Toth and Gal (2014) used a two stage model on a panel of most of the major wine producing countries over the period 1995-2007 identifying factors of the inefficiency (development of the financial system, the quality of human capital and per capita wine consumption). Output-oriented version of the weighted additive model can be used to properly identify revenue, technical, and allocative inefficiencies in Spanish designation of origin (Aparicio et al., 2013).

The efficiency of wine production is also searched by Henriques et al. (2009) using several parametric techniques and Bojnec and Latruffe (2008, 2009) using non-parametric techniques. Lazareva (2015) identified the level of efficiency of 11 wineries in Ukraine using three-criteria approach (relative, dynamic and structural) and detected ineffectiveness of small business in the Ukrainian wine industry.

The system of partial indicators of economic efficiency of grapes and wine in the dynamics of the years 2005-2011 was researched by Timofti (2013). He developed a methodology for calculating the synthetic (integral) indicator of efficiency which can take into consideration the basic indicators of grape production and the results of their processing. Vázquez-Rowe et al. (2012) used LCA (Life Cycle Assessment) and DEA in their research which confirmed that improving the operational performance of inefficient vine-growing farms is not only worthwhile from an environmental perspective, but also regarding economic profits. Strategic evolution towards more specialisation could be more profitable for their growers than further integration towards packaged wine sales (Coudere and Marchini, 2011).

Thus, a literature review revealed a weakness of studies of the efficiency of winemaking in the developing countries and the absence of comparative studies for these countries.

The purpose of this study is to evaluate and compare the efficiency of winemaking in two developing countries (Ukraine and Bosnia&Herzegovina) from the perspective of their development.

### 3. Methods

The following methods are being often applied for winemaking: corrected ordinary least squares (COLS), production functions, stochastic frontier analysis (SFA), data envelopment analysis (DEA) etc. In SFA, inefficiency is assumed to have asymmetrical distribution, usually a half normal distribution and random error is expected to have standard symmetrical distribution. SFA deals with the problem that not all deviations from criteria are due to a lack of efficiency and they may also occur as a result of misfortune (fortune) or measurement errors (Vincová, 2005).

Jozsef and Peter (2014) used SFA and Cobb-Douglas production function to explore macroeconomic factors influencing the technical efficiency of 16 major wine producing countries. Moreira et al. (2011) use a Cobb-Douglas model to estimate a stochastic production frontier (SPF) and to obtain efficiency scores both at the individual block and at the farm level for a sample of wine grape producers in Chile.

Today researchers constantly seek for new and innovative ways to improve performance and competitive advantage in winemaking and wine grape growing. In the microeconomic aspect among the other methods, DEA must be the most expedient tool for analysis of efficiency of the winemaking industry providing us with answers to the following two basic questions:

- what are the most efficient subjects in the group of subjects? and b) how inefficient is each particular subject compared to the rest of the group and how can it improve its performance?

Besides, DEA method supposes simultaneous use both cost and physical units that allows to generalize heterogeneous input and output parameters.

DEA is a non-parametric frontier method, first offered by Charnes et al. (1978) that has received wide theoretical development and practical application over the last decade in

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**Diagram 1 - Advantages of using DEA.**

- "DEA is a non-parametric frontier method, first offered by Charnes et al. (1978) that has received wide theoretical development and practical application over the last decade in"
a management of various fields of human activity, for example, in water utilities (Lo Storto, 2014), banking and investments, postal service (Çakır et al., 2015), healthcare and pharmaceuticals (Goncharuk and Getman, 2014), education (De Witte, 2015), manufacturing (Monat, 2009), energetics (Goncharuk, 2013), etc. Its essence consists in the use of methods of linear programming for construction of a piecewise linear convex surface (frontier) for enterprises sample, and estimation of efficiency concerning this surface.

Bouzdine-Chameeva (2012) made research with a focus on measuring performance through an efficiency value of wine chateaux in Bordeaux region in France and the use of the DEA methodology for estimating potential resources of performance for 58 wine producing companies in Bordeaux regions. The performance was measured against best-practice firms taking into consideration multiple input and output data, complex by their nature.

Sellers and Alampi-Sottini (2016) used several parametric and non-parametric tests to analyse the influence of firm size on these performance indicators. Their results obtained with a sample of 723 Italian wineries (limited companies and cooperatives) in 2013 showed that size has a positive influence on the economic performance of wineries.

Townsenda et al. (1998) found that the most of wine grape producers operate under constant returns to scale. Comparing the efficiency of private companies and cooperatives, Barros and Santos (2007) found that Portuguese wine cooperatives are more efficient than their private counterparts. Using DEA, Aparicio et al. (2013) estimated revenue inefficiency decomposed to technical and allocative inefficiencies. They showed that revenue efficiency was higher in the case of PDOs with specific wine products serving niche markets and without clear competition.

Among existing DEA models in the context of given research, it is expedient to use the following:

(a) to estimate an efficiency score for each wine company, the common input-oriented model with a constant return of scale (CRS) (see Charnes et al., 1978) and input-oriented model with a variable return of scale (VRS) (see Banker et al., 1984) will be used;

(b) to estimate an influence of production scale on the winery efficiency and to define returns to scale (RTS) for each winery, the parameter of scale efficiency will be defined on the following ratio:

\[ L = \frac{TE_{CRS}}{TE_{VRS}} \]  \hspace{1cm} (1)

where \( TE_{CRS} \) is technical efficiency score for CRS model and \( TE_{VRS} \) is technical efficiency score for variable return of scale (VRS) model (Goncharuk, 2009);

(c) to make full ranking for wine companies, the DEA model of super-efficiency, offered by Anderson and Petersen (1993), will be used. Mathematically the input-oriented DEA model of super-efficiency for \( m \) inputs, \( r \) outputs and \( n \) DMUs can be formalized in the following way:

\[ \sum_{i=1}^{n} \lambda_i x_{ij} - \sum_{m=1}^{m} \mu_m s_{i} - \sum_{r=1}^{r} \nu_r y_{ri} - \sum_{j=1}^{n} \theta_{j} z_{j} = 0, \quad \sum_{j=1}^{n} \theta_{j} = 1, \quad \lambda_i, \mu_m, \nu_r, \theta_{j} \geq 0 \]  \hspace{1cm} (2)

where \( \theta^{sup} \) is a scalar; \( \lambda_i \) is a weight of DMUj; \( x_{ij}, y_{ri} \) are inputs and outputs of DMUj; \( s_{i}^{n}, s_{i}^{d} \) are input and output slacks (Goncharuk, 2011);

(d) to estimate the reserves of inputs reduction for companies and industry the slack-based model (SBM) advanced by Tone (2001) will be used. SBM has the following mathematical form:

\[ \sum_{m=1}^{m} \lambda_i x_{ij} + \sum_{m=1}^{m} \mu_m s_{i} - \sum_{r=1}^{r} \nu_r y_{ri} - \sum_{j=1}^{n} \theta_{j} z_{j} = 0, \quad \sum_{j=1}^{n} \theta_{j} = 1, \quad \lambda_i, \mu_m, \nu_r, \theta_{j} \geq 0 \]  \hspace{1cm} (3)

where \( s_{i}^{n} \) and \( y_{ri}^{d} \) are inputs and outputs for company j; \( s_{i}^{n} \) and \( y_{ri}^{d} \) are the slacks variables that reflect input excess and output shortage correspondingly; \( \lambda_i \) are the weights of companies; \( w_{j}^{n} \) and \( w_{j}^{d} \) are user-specified weights obtained through value judgement.

4. The Data

The sample in this research includes 33 wine companies (17 - Ukrainian and 16 - Bosnian). We used material costs, number of employees and fixed assets as inputs and net sales as output. Input variables reflect the basic factors of production (materials, labour and fixed capital) and net sales represent companies’ output – volumes of product sold. Small number of variables and significant volume of sample provide rigorous results of the analysis and narrows number of the companies that lie on industry frontier of efficiency.

Considering that results of DEA are sensitive to errors in initial data, the annual reports of wine companies for 2013, reliability of which is confirmed by the auditor conclusions, were used as a source of information. The descriptive statistics of a sample of the companies is framed in Table 1.

Total annual net sales of 33 wineries included in a sample in 2013 were 251.6 mln EUR. Total number of employees was above 3.2 thousand people.

5. The Results

DEA CRS model allowed us finding the efficient and inefficient wineries in each country. The relative efficiency for Ukrainian and Bosnian wineries was evaluated separately: 35% Ukrainian wineries are effective and the other have efficiency score less than 1; 37% Bosnian wineries are
effective and the other have efficiency score less than 1. The average efficiency score in both samples are very similar: it is 0.71 for Ukraine and 0.72 for Bosnia&Herzegovina. Ukrainian and Bosnian wineries have similar distribution of efficiency scores and average relative efficiency.

In order to find country leaders on efficiency we used DEA-super-efficiency model that allowed ranking the relative efficiency of the wine companies within an international sample. In table 2, there are results of super-efficiency estimation with return to scale (RTS) for the wine companies.

Wine industry leaders on efficiency are Shabo – in Ukraine and AG Međugorje – Bosnia&Herzegovina. Shabo has relatively a big scale with above 200 employees and over 60 mln EUR net sales per year, and AG Međugorje is a small winery with 7 employees and only 66 ths EUR net sales per year.

Analysing data, we found that all Ukrainian leading wineries are medium or big businesses with multi-million EUR annual sales. Among inefficient Ukrainian wineries 10 have increasing RTS. Those wineries are not large enough to achieve a high efficiency. We can conclude that small businesses in Ukrainian wine industry are characterized by inefficiency.

The largest wineries in Ukraine (Artemivsk Winery and Koblevo) have decreasing RTS and they have a medium efficiency. The reason of that can be overproduction and there is a need to reduce the scale of wine production to improve an efficiency of their business.

Two largest wineries in Bosnian sample (Hepok and Vinarija Čitluk) are inefficient and they are characterized by the decreasing RTS. Inefficiency of big wine business in Bosnia&Herzegovina causes the need to reduce the scale of wine production in order to improve an efficiency of their business. Feature of Bosnian leading wineries is their small size with less than one-million EUR annual net sales. These results give a picture about Bosnian wine industry with the conclusion that small business is efficient.

Summarizing the above mentioned results, there is the same average efficiency and number of leaders in both country. Medium and large wineries in Ukraine are developing more efficiently than small wineries; in Bosnia&Herzegovina, on the contrary, a small wine business is more efficient. Positive correlation coefficient between the efficiency scores and the number of employees (at the Ukrainian wineries (0.39) and negative one for the Bosnian wineries (-0.28)) also supported mentioned conclusion.

In our research, we have applied the slack-based DEA model (SBM) on two samples of wine companies in order to identify the reserves for cost reduction and increase of an efficiency potential. With the purpose of revealing potential growth of efficiency of Ukrainian and Bosnian wine industry, we applied Computer program DEAFrontier™. Reserves of inputs reduction for each company have been estimated, and total results are presented in Table 3.

Our calculations showed the existence of significant reserves of input reduction and potential growth of output. The highest reserve on fixed assets reduction specifies a presence of excessive fixed capital or a share of their unproductive part (39.3% in Ukrainian and 79.1% in Bosnian wine industry), of which the wineries can escape on reaching a benchmark level of capital productivity.

There is a significant gap in a labour productivity level of benchmark wineries in Ukraine (efficient) and other wineries because of the high reserve of reduction in number of employees in (13% – 388 workers).
In Bosnia&Herzegovina, low reserve of reduction of a number of employees (0.1% – only 2 workers) indicates the small difference in the level of labour productivity.

Zero reserve of material inputs reduction testifies the insignificant gap in a level of material capacity of production between the efficient and inefficient wineries in Ukraine. High reserve of material costs reduction are characterized by the Bosnian wineries (total reserve is about 2 mln EUR or 26.4%).

Identifying reserves in wine industry, we found that the high potential growth of efficiency in Ukrainian wineries (till 28.9%) can be realized due to staff reduction and reduction of excessive fixed assets (improving and optimizing the facilities and equipment). These problems can be decided by implementing new technologies that would increase labour productivity in inefficient Ukrainian wineries. In Bosnian wineries, reduction of specific consumption of raw materials and excessive fixed assets would affect the potential growth of efficiency (till 28.3%).

Reserve of material inputs reduction equal to zero prevented us from seeing how much effectively raw materials are used in the Ukrainian wineries. That is why our next research assignment was to conduct cross-country efficiency analysis.

**Cross-country efficiency analysis**

In the next steps, we have tried to reveal the features of individual wine businesses and to find opportunities for their effective development. The following tools are used:
- CRS and VRS DEA models to estimate scale efficiency and RTS for each winery;
- DEA model of super-efficiency to make a full ranking for wineries and finding cross-country leaders in wine industry;
- SBM to define the reserves of inputs reduction for inefficient wineries.

On the cross-country efficiency frontier are 8 out of 33 wineries. Six medium and big Ukrainian wine companies are in a leaders’ group. All of them have constant RTS, but only four have positive net profit (Shabo, Tsjurupinske, Feodosiya and Kyiv Factory of Sparkling Wines). Two Bosnian wineries are in the leaders’ group: (AG Medugorje and Proto). AG Medugorje has the highest super-efficiency and also high profitability (above 30%).

Other wineries are inefficient and can be divided into three groups.

The most numerous group presents the middle-efficient wineries with increasing RTS and the prospects for efficient development. This group includes 13 wineries (7 Ukrainian and 6 Bosnian). All they need to improve operational technologies and increase sales and output to reach efficiency frontier.

The second numerous group includes low-efficient wineries. This group includes 10 wineries (2 Ukrainian and 8 Bosnian), small and medium wineries and have no chance in the near future to achieve efficiency frontier. Each of them has own problems, but all have an increasing RTS, hence if their business grows then efficiency will increase.

The third group is relatively small and includes two wineries - the big Ukrainian wine companies that have accelerated growth in inputs when increasing output. To improve their efficiency companies’ management should decrease output or implement a significant change in operational technologies.

The scale inefficiency for observed sample is about 12% and total potential growth of efficiency

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**Table 4. The results of cross-country efficiency analysis of wineries.**

<table>
<thead>
<tr>
<th>Country Code</th>
<th>Company name</th>
<th>Number in a total rating</th>
<th>Super-efficiency score</th>
<th>Returns to Scale (RTS)</th>
<th>Scale efficiency score</th>
</tr>
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<tr>
<td>B&amp;H</td>
<td>AG Medugorje</td>
<td>1</td>
<td>2.7604</td>
<td></td>
<td>1</td>
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<td>UA</td>
<td>Shabo</td>
<td>2</td>
<td>1.9198</td>
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<td>1</td>
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<td>Bakchisaray</td>
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<td>1</td>
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<td>Ugursynske</td>
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<td>1.3770</td>
<td></td>
<td>1</td>
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<td>UA</td>
<td>Odesa Factory of Sparkling Wines</td>
<td>5</td>
<td>1.2736</td>
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<td>1</td>
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<tr>
<td>UA</td>
<td>Feodosiya</td>
<td>6</td>
<td>1.2636</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>UA</td>
<td>Kyiv Factory of Sparkling Wines</td>
<td>7</td>
<td>1.1261</td>
<td></td>
<td>1</td>
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<td>Pusta</td>
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<td>1.0690</td>
<td></td>
<td>1</td>
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<td>0.9999</td>
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<td>Vynogradar</td>
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<tr>
<td>B&amp;H</td>
<td>Podrum Vukoje 1982</td>
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<td>B&amp;H</td>
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<td>Beregovo Tov</td>
<td>33</td>
<td>0.2171</td>
<td></td>
<td>0.9805</td>
</tr>
</tbody>
</table>

**Average on a total sample:** 0.6978 0.8153

Source: Authors’ calculations.

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**Diagram 2 - Classification of Ukrainian and Bosnian wineries in three groups according to the cross-country efficiency analysis.**
is above 30%. Those results present good prospects for effective development of the wine industry in both countries. In order to realize this potential of the inefficient wineries, there is necessity of learning the best practices from industry leaders and enhance the activity in the field of sales promotion.

In the next phase, we have used SBM in order to define the potential to reduce inputs to achieve the efficiency frontier (Figure 5).

Analyzing the inputs of Ukraine and Bosnia&Herzegovina wineries and their potential to reduce them, we concluded that there is a high reserve of reduction in number of employees (about 14% – 450 workers). This indicates the significant gap in a labour productivity level of benchmarks (efficient) and other wineries. There is insignificant gap in a level of material capacity of production between the efficient and inefficient wineries in Ukraine and Bosnia&Herzegovina, because the reserve of material inputs reduction is close to zero. The highest reserve on fixed assets shows a share of their unproductive part (over 50%), of which the wineries can escape reaching a benchmark level of capital productivity.

6. Discussion and conclusions

Cross-country efficiency analysis enabled us to find inter-country leaders in wine industry – small Bosnian wineries and large Ukrainian wine companies; to group inefficient wineries and find main directions to improve efficiency for each group; to define a potential growth of efficiency (above 30%) and scale inefficiency (about 12%) for a total sample; to calculate the potential to reduce inputs in wine industry and potential growth of output at constant inputs for total sample. The high potential growth of efficiency in Ukrainian wineries (till 28.9%) can be realized due to reduction of excessive fixed assets (improving and optimizing the facilities and equipment) and staff reduction. Together these problems can be decided by implementing new technologies that increase labour productivity in inefficient Ukrainian wineries. In accordance with the results of this study we can recommend for the government of Ukraine to remove the barriers for development of small business in the wine industry. One of the major barriers in this country is the high license fee for the right to sell a wine, which amounts to about 20000 EUR per year. This amount is very difficult for a small business and significantly decreases its effectiveness. As a result, none of the small wineries in Ukraine today is effective or profitable.

The high potential growth of efficiency in Bosnian wineries (till 28.3%) can be realized due to a reduction of specific consumption of the raw materials and excessive fixed assets. The development of the wine sector in B&H will, to a large extent, depend on the measures of market-price policy, structural policy measures and measures of financial support. The research system is also an important actor in this respect. One significant development issue for the B&H wineries is the situation regarding the payment (90 days) terms of the clients and the associated delays. Furthermore, next challenges must be met with the education and training of wine producers and processors in B&H, but also of the sector down the value chain in general, where emphasis is on the processes of a small-scale wine making.

The characteristic of wine production in B&H is the fact that it deals with a large number of small producers who produce the same products in different ways which makes them difficult to harmonize and consolidate the joint bid. Often such production can be described as extensive, and a way of producing traditional and typical for the area. On the other hand, it can be an advantage if such products are supplied in the market as products with protected designation of origin or traditional products.

In support of the objective pertaining to the improvement of efficiency in this sector, generally raising the technological level of production must also be ensured by increasing the volume and sources of investment financing.

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