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PATTERNS OF EFFICIENCY AND PRODUCTIVITY IN THE LITHUANIAN AGRICULTURE: A NON-PARAMETRIC ANALYSIS

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SUMMARY

It is efficiency that provides a momentum for a non–inflatory economic development and increase in competitiveness. Indeed, firm– and sector–specific efficiencies do also influence national competitiveness. This study aims at discussing efficiency and total factor productivity patterns in the Lithuanian agricultural sector as well as their implications on policy making. The efficiency analysis is carried out at various levels: First, the agricultural sector is compared to the remaining economic sectors of the Lithuanian economy. Second, the performance of the Lithuanian family farms is compared to that of the EU Member States. Third, the farming efficiency is analysed across farming types in Lithuania. The analysis, therefore, covers both national and international levels. The study is organized in the following way: Section 1 describes the general idea of the research and contains the literature survey. Section 2 presents the research methods, namely DEA, Malmquist TFP index, and MULTIMOORA. Section 3 focuses on the Lithuanian agricultural sector and treats the data provided by Statistics Lithuania. The Lithuanian agricultural sector is analysed by the means of index decomposition analysis and financial ratio analysis. The inter–sectoral comparison proceeds by employing Malmquist TFP index for analysis of the productive efficiency. Section 4 is solely devoted to family farm sector and relies on FADN data. Specifically, an international comparison of family farming is facilitated by the means of DEA, whereas the Lithuanian family farm performance is analysed by both DEA and Malmquist TFP index. The managerial implications of the findings on the agricultural policy are discussed.

The DEA enabled to identify the prospective ways for efficiency improvement. More specifically, land productivity should be increased in the Baltic States. Moreover, the increased crop output would enable to achieve the efficiency frontier. The future challenges for the agricultural development of the Baltic States are discussed in the study. The analysis showed that efficiency of an average Lithuanian farm had been somehow subdued during 2005–2007. Mixed crop and mixed livestock (mainly grazing) farming was peculiar with the highest technical efficiency estimate throughout the research period. Slack analysis revealed that low land productivity, returns on assets, and intermediate consumption productivity are the most important sources of the inefficiency.

Keywords: family farms, efficiency, total factor productivity, data envelopment analysis.

SANTRAUKA

EFEKTYVUMO IR PRODUKTYVUMO DĖSNINGUMAI LIETUVOS ŽEMĖS ŪKYJE: NEPARAMETRINĖ ANALIZĖ

T. Baležentis, I. Kriščiukaitienė

Efektyvumo didinimas yra infliacijos nesukeliančio, tvaraus ekonominio augimo šaltinis ir vienas svarbiausių konkurencingumo veiksnių. Įmonių ir sektorių gamybos efektyvumas bei konkurencingumas lemia ir bendrąjį valstybės konkurencingumą. Studijos tikslas – atlikti efektyvumo ir bendrojo produktyvumo pokyčių Lietuvos žemės ūkio sektoriuje analizę ir pasiūlyti žemės ūkio politikos formavimo sprendimus. Efektyvumo analizė atlikta įvairiais lygmenimis. Pirma, žemės ūkio sektorius palygintas su kitais šalies ūkio sektoriais. Antra, Lietuvos ūkininkų ūkių veikla įvertinta Europos Sąjungos kontekste. Trečia, ūkininkų ūkių veiklos rezultatai analizuojami nacionaliniu lygmeniu. Taigi, studiją sudaro keturi skyriai. Pirmajame pristatoma tyrimo idėja ir pateikiama literatūros apžvalga. Antrajame skyriuje pristatomi tyrime naudoti metodai, t. y. duomenų apgaubties analizė, Malmkvisto bendrojo produktyvumo indeksas ir daugiakriterinio vertinimo metodas MULTIMOORA. Trečiajame skyriuje Lietuvos žemės ūkio sektoriaus veiklos efektyvumas lyginamas su kitais ūkio sektoriais taikant indeksinę analizę ir ribinius metodus. Ketvirtajame skyriuje, remiantis Ūkių apskaitos duomenų tinklo duomenimis, analizuojama Lietuvos ūkininkų ūkių veikla. Tarptautinis palyginimas atliktas taikant duomenų apgaubties analizę. Lietuvos ūkininkų ūkių veikla nacionaliniu lygmeniu įvertinta taikant minėtus ribinius metodus. Studijoje aptariama gautų rezultatų įtaka formuojant žemės ūkio politiką.

Duomenų apgaubties analizė leido nustatyti potencialius efektyvumo didinimo būdus. Baltijos valstybėms svarbiausia padidinti augalininkystės produkcijos apimtis ir žemės ūkio produktyvumą. Studijoje aptariami žemės ūkio plėtros ateities iššūkiai Baltijos valstybėse. 2005–2007 m. Lietuvos ūkininkų ūkių gamybinis efektyvumas buvo sumažėjęs. Tyrimo metu efektyviausi buvo mišrūs ūkiai vyraujant augalininkystei ir galvijininkystei (žolėdžiams). Išanalizavus rezervus įvertinta nagrinėtų veiksnių svarba veiklos neefektyvumui (didžiausią neigiamą įtaką darė žemas žemės našumas, turto grąža). Taigi, svarbu diegti technologines inovacijas, kurios leistų padidinti gamybos veiksnių produktyvumą ir gamybos efektyvumą. Tam turėtų būti inicijuojamos atitinkamos paramos ir mokslinių tyrimų programos, derinamos prie efektyvumo bei produktyvumo rodiklių pokyčių.

Raktiniai žodžiai: ūkininkų ūkiai, efektyvumas, bendrasis produktyvumas, duomenų apgaubties analizė.

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ABBREVIATIONS

CAP –	Common Agricultural Policy
CRS –	Constant Returns to Scale
DEA –	Data Envelopment Analysis
DMU –	Decision Making Unit
EC –	Efficiency Change
EU –	European Union
FADN –	Farm Accountancy Data Network
IDA –	Index Decomposition Analysis
TC –	Technical Change
TE –	Technical Efficiency
TFP –	Total Factor Productivity
VRS –	Variable Returns to Scale

1. INTRODUCTION

1. 1. Research Methodology

This study aims at discussing efficiency and total factor productivity patterns in the Lithuanian agricultural sector as well as their implications on policy making. The efficiency analysis is carried out at various levels: First, the agricultural sector is compared to the remaining economic sectors of the Lithuanian economy. Second, the performance of the Lithuanian family farms is compared to that of the EU Member States. Third, the farming efficiency is analysed across farming types in Lithuania. The analysis, therefore, covers both national and international levels.

In order to achieve the aforementioned objectives, the following tasks are set: 1) to carry out a literature survey; 2) to discuss the main methods and techniques commonly employed for the efficiency analysis; 3) to assess the performance of the Lithuanian agricultural sector; and 4) to assess the Lithuanian family farm performance both in local and the EU terms.

In this study we apply the non-parametric frontier methods. Specifically, Data Envelopment Analysis is employed for efficiency score estimation, whereas Malmquist TFP index is utilized to measure TFP change. Index decomposition analysis is applied to measure the performance of the Lithuanian agricultural sector in terms of financial ratios. The multi-criteria decision making method MULTIMOORA is applied to facilitate integrated assessments. The *FEAR* package (Wilson, 2010) was employed for the analysis.

The research covers the period of 2003–2010. The latter time span, however, was expanded when enough data were available. The aggregate data provided by Statistics Lithuania and FADN survey are used for the analysis.

The study is, therefore, organized in the following way: Section 2 presents the research methods, namely DEA, Malmquist TFP index, and MULTIMOORA. Section 3 focuses on the Lithuanian agricultural sector and treats the data provided by Statistics Lithuania. Section 4 is solely devoted to family farm economics and relies on FADN data.

1. 2. Motivation for Productivity Analysis

Henningsen (2009) argued that efficiency of the agribusiness is related to labour intensity, farm structure, technology and investment, managerial skills, and profitability. One thus needs to develop appropriate measures of efficiency and productivity. Furthermore, it is efficiency that provides a momentum for a non–inflatory economic development and increase in competitiveness. As Latruffe (2010) pointed out firm– and sector–specific efficiency does also influence national competitiveness. Accordingly, the European Commission (2011a) launched a flagship initiative under the Europe 2020 Strategy called *A resource-efficient Europe*

In order to perform the appropriate benchmarking it is necessary to fathom the terms of effectiveness, efficiency, and productivity. One can evaluate effectiveness when certain utility or objective function is defined (Bogetoft, Otto, 2011). In the real life, however, this is not the case and the ideal behaviour can be described only by analysing the actual data, i. e. by the means of benchmarking. Productivity means the ability to convert inputs to outputs. There can be a distinction made between total factor productivity (Solow, 1957) and partial (single factor) productivity. The productivity growth is a source of a non-inflatory growth and thus should be encouraged by the means of benchmarking and efficiency management. Efficiency can be perceived as a ratio of the observed productivity level to the yardstick productivity level.

Nauges et al. (2011) presented the following factors stressing the need for research into agricultural efficiency. First, agricultural producers typically own land and live on their farms, therefore the standard assumption that only efficient producers are to maintain their market activity usually does not hold in agriculture; moreover, suchlike adjustments would result in various social problems. Second, it is policy interventions—education, training, and extension programmes—that should increase the efficiency. Third, policy issues relating to farm structure are of high importance across many regions.

The efficiency measures can be grouped into parametric and non-parametric ones as well as into deterministic and stochastic ones (Murillo-Zamorano, 2004; Coelli et al., 2005; Vinciūnienė, Rauluškevičienė, 2009). The Lithuanian agricultural sector was analysed by the means of regression analysis (Kriščiukaitienė et al., 2010c), multi-criteria decision making methods (Baležentis, Baležentis, 2011a). Savickienė and Slavickienė (2012) employed the correlation analysis and discussed some methodological issues regarding the viability of farming business. The frontier measures were also employed (Vinciūnienė, Rauluškevičienė, 2009; Rimkuvienė et al., 2010; Baležentis, Baležentis, 2011c; Baležentis, 2012; Baležentis, Kriščiukaitienė, 2012; Baležentis et al., 2012). However, the productivity indices were not utilized to measure the dynamics of the total factor productivity in the Lithuanian agricultural sector up to date. The three types of indices are commonly utilized to estimate the dynamics of the total factor productivity viz. (i) Malmquist index, (ii) Hicks–

Moorsteen index, and (iii) Luenberger index (Färe et al., 2008). The Malmquist productivity index relies on multiplicative relations and usually is either input- or output-oriented. The Hicks–Moosteen index is a generalization of the Malmquist productivity index. The Luenberger productivity index (Chambers et al., 1996) is based on additive decomposition and directional distance function.

1. 3. Literature Survey

Central and East European countries are specific with agricultural sectors contributing to relatively high share of GDP in those countries. Therefore a number of studies have attempted to research into the farming efficiency by employing frontier techniques (Gorton, Davidova, 2004). The Lithuanian agricultural sector, though, received less attention in the latter scientific area. Moreover, those few examples employed non-parametric methods, whereas parametric methods (e. g. stochastic frontier analysis) remain underused. This section overviews the earlier papers which analysed the efficiency of the Lithuanian agricultural sector by the means of frontier measures, namely DEA.

The pioneering paper in the discussed field is that of Vinciūnienė and Rauluškevičienė (2009). The latter study attempted to research into technical and scale efficiency and its relations to farm size. The research relied on FADN aggregates (74 observations in total). The authors employed the following procedure to estimate the technical efficiency: 1) input variables were selected on the basis of correlation analysis (output vs. respective input indicators); 2) the selected variables were divided by output thus defining respective ratios; 3) DEA models were established for each pair of ratios and efficiency scores were obtained; 4) Cobb-Douglas production function was employed for computation of weights for efficiency scores obtained by different DEA models; 5) efficiency scores were aggregated with respect to the weights. Thus the analysis suggested that larger farms were operating more efficiently. Baležentis (2012) employed the graph DEA model to estimate the efficiency scores, whereas the rank–sum test was employed to test the relationships between efficiency and expansion variables. Farm expansion was analysed by considering multiple criteria. The rank–sum test indicated that the farms expanded in terms of ESU and UAA were specific with lower efficiency during the preceding periods. Meanwhile, labour input and assets were not related to different populations of efficiency scores.

The paper by Rimkuvienė et al. (2010) also addressed the farming efficiency by performing an international comparison on a basis of DEA and free disposal hull—the two non-parametric methods. This study also discussed the differences between terms *efficiency* and *effectiveness* which are often misused in the Lithuanian scientific works. The research covered years 2004–2008 and some 174 observations (aggregates) for the EU and non-EU states. Input- and output-oriented DEA models yielded efficiency scores of 43.2 and 41.4%, respectively. In addition the effectiveness of capital and intermediate consumption were observed in Lithuania.

It was Douarin and Latruffe (2011) who offered the single foreign contribution to the DEA-based efficiency analysis of the Lithuanian agriculture. The aim of that study was to estimate the farming efficiency and possible outcomes of the incentives provided by the EU Single Area Payments. Moreover, this study was based on micro- rather than aggregate data. Thus, the farm efficiency estimation was followed by questionnaire survey which tried to identify the farmers' behaviour, namely decisions to expand their farms or stay in the farming sector, as a result of public support distribution. The research showed that 1) larger farms operated more efficiently, 2) subsidies were related to lower efficiency scores. The Heckman model was employed to quantify the impact of various factors on farmers' decisions to stay in farming or expand the farms. It was concluded that the overall farming efficiency should decrease, for lower efficiency farms were about to expand and thus increase competition in the land market.

The carried out literature survey indicates that both Lithuanian and foreign scientists are involved in the productivity analysis of the Lithuanian agricultural sector. As for the Lithuanian part, the two main centres for suchlike research are found here viz. Aleksandras Stulginskis University (formerly Lithuanian University of Agriculture) and the Lithuanian Institute of Agrarian Economics. To conclude, the productive efficiency is still promising area for further researches in Lithuania. Micro data analysis is especially underemployed. Furthermore, the parametric methods should be employed to fit the production functions.

2. RESEARCH METHODS

This section presents the three main methods employed for the research. DEA is employed to measure technical efficiency of the agricultural sector (Section 3) as well as farming efficiency (Section 4). The Malmquist TFP index is utilized to quantify productivity gains and losses (Sub-section 3. 2 and Sub-section 4. 2. 2). Finally, the multi-criteria decision making method, MULTIMOORA, is applied to perform integrated assessments in Sub-section 3. 2 and Sub-section 4. 1. 1.

2. 1. DEA

DEA is a nonparametric method of measuring the efficiency of a decision–making unit (DMU) such as a firm or a public–sector agency (Ray, 2004). The very term of efficiency was initially defined by Debreu (1951) and then by Koopmans (1951). Debreu discussed the question of resource utilization at the aggregate level, whereas Koopmans offered the following definition of an efficient DMU: *A DMU is fully efficient if and only if it is not possible to improve any input or output without worsening some other input or output*. Due to similarity to the definition of Pareto efficiency, the former is called Pareto–Koopmans Efficiency. Finally, Farrell (1957) summarized works of Debreu and Koopmans thus offering frontier analysis of efficiency and describing two types of *economic efficiency*, namely *technical efficiency* and *allocative efficiency* (indeed, a different terminology was used at that time). The concept of technical efficiency is defined as the capacity and willingness to produce the maximum possible output from a given bundle of inputs and technology, whereas the allocative efficiency reflects the ability of a DMU to use the inputs in optimal proportions, considering respective marginal costs (Kalirajan, Shand, 2002). However, Farrell (1957) did not succeed in handling Pareto–Koopmans Efficiency with proper mathematical framework.

The modern version of DEA originated in studies of A. Charnes, W. W. Cooper and E. Rhodes (Charnes et al., 1978, 1981). Hence, these DEA models are called CCR models. Initially, the fractional form of DEA was offered. However, this model was transformed into input– and output–oriented multiplier models, which could be solved by means of the linear programming (LP). In addition, the dual CCR model (i. e. envelopment program) can be described for each of the primal programs (Cooper et al., 2007; Ramanathan, 2003).

Unlike many traditional analysis tools, DEA does not require to gather information about prices of materials or produced goods, thus making it suitable for evaluating both private– and public–sector efficiency. Suppose that there are $j = 1, 2, \ldots, t, \ldots, N$ DMUs, each producing $r = 1, 2, \ldots, m$ outputs from $i = 1, 2, \ldots, n$ inputs. Hence, the DMU *t* exhibits input–oriented technical efficiency θ_t, which may be obtained by solving the following multiplier DEA program:

$$\max_{\phi_t,\lambda_j} \phi_t$$
s. t.
$$\sum_{j=1}^{N} \lambda_j x_i^j \le x_i^t, \quad i = 1,2,\ldots,n;$$
$$\sum_{j=1}^{N} \lambda_j y_r^j \ge \phi y_r^t, \quad r = 1,2,\ldots,m; \tag{1}$$
$$\lambda_j \ge 0, \quad j = 1,2,\ldots,N;$$
ϕ_t unrestricted.

In Eq. 1, coefficients λ_j are weights of peer DMUs. Noteworthy, this model presumes existing constant returns to scale (CRS), which is rather arbitrary condition. CRS indicates that the manufacturer is able to scale the inputs and outputs linearly without increasing or decreasing efficiency (Ramanathan, 2003).

Whereas the CRS constraint was considered over–restrictive, the BCC (Banker, Charnes, and Cooper) model was introduced (Banker et al., 1984). The CRS presumption was overridden by introducing a convexity constraint $\sum_{j=1}^{N} \lambda_j = 1$, which enabled to tackle the variable returns to scale (VRS). The BBC model, hence, can be written by supplementing Eq. 1 with a convexity constraint $\sum_{j=1}^{N} \lambda_j = 1$.

The best achievable input can therefore be calculated by dividing actual input by technical efficiency of a certain DMU. On the other hand, the best achievable output is obtained by multiplying the actual output by the same technical efficiency, ϕ_t, where ϕ_t is obtained from Eq. 1. The difference between actual output and the potential one is called slack. In addition it is possible to ascertain whether a DMU operates under increasing returns to scale (IRS), CRS, or decreasing returns to scale (DRS). CCR measures gross technical efficiency (TE) and hence resembles both TE and scale efficiency (SE); whereas BCC represents pure TE. As a result, pure SE can be obtained by dividing CCR TE by BCC TE. Noteworthy, technical efficiency describes the efficiency in converting inputs to outputs, while scale efficiency recognizes that economy of scale cannot be attained at all scales of production (Ramanathan, 2003).

A two-output example of an output-oriented DEA could be represented by a piece-wise linear production possibility frontier, such as that depicted in Fig. 1. Note that the observations lie below this curve, and that the sections of the curve that are at right angles to the axes result in an output slack calculated when a production point is projected onto these parts of the curve by a radial expansion in outputs. The constructed production frontier is an empirical one, for at least one of the observations does always lie on it.

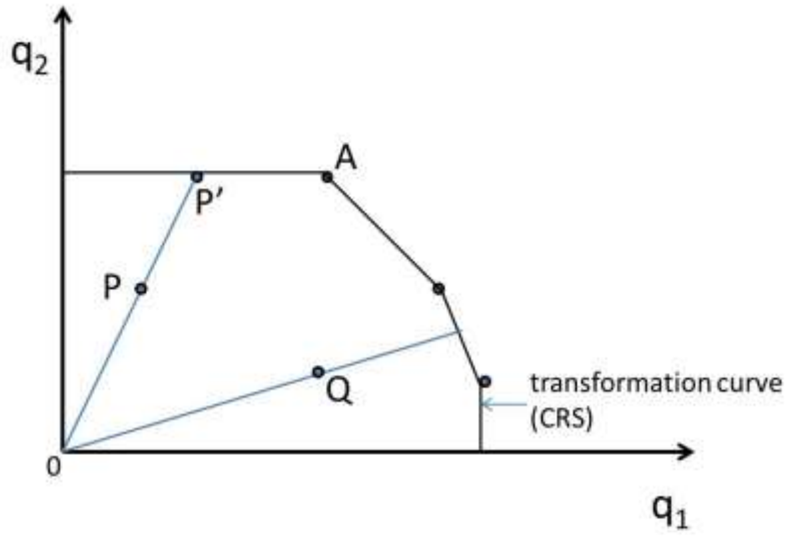

Fig. 1. An output-oriented DEA model

For example, by the virtue of a radial movement point *P* is projected to point *P*' which is on the frontier but not on the efficient frontier. The radial slack is zero at the point *P'*, however this is not the case for the total slack. This is because the production of q_1 could be increased by the amount *AP'* without using any more inputs. Thus, there is an output slack in this case of *AP*' in output q_1 (Coelli et al., 2005). The VRS (BCC) TE can be estimated as the ratio *0P* / *0P*' (Shepard measure).

2. 2. Malmquist TFP Index

Measurement of the total factor productivity (TFP) of certain DMU involves measures for both technological and firm-specific developments. As Bogetoft and Otto (2011) put it, firm behaviour changes over time should be explained in terms of special initiatives as well as technological progress. The benchmarking literature (Coelli et al., 2005; Bogetoft and Otto, 2011; Ramanathan, 2003) suggests Malmquist productivity index being the most celebrated TFP measure. Hence this section is describing the preliminaries of Malmquist index.

Färe et al. (2008) firstly describe productivity as the ratio of output *y* over input *x*. Thereafter, the productivity can be measured by employing the output distance function of Shepard (1970):

$$D_o^t(x,y) = \min\{\theta : (x, y/\theta) \in T^t\}, \tag{2}$$

where T^t stands for the technology set (production possibility set) of the period *t*. This function is equal to unity if and only if certain input and output set belongs to production possibility frontier.

The Malmquist productivity index (Malmquist, 1953) can be employed to estimate TFP changes of single firm over two periods (or *vice versa*), across two production modes, strategies, locations etc. In this study we shall focus on output–oriented Malmquist productivity index and apply it to measure period–wise changes in TFP. The output–oriented Malmquist productivity index due to Caves et al. (1982) is defined as

$$M_o = \left(M_o^0 \cdot M_o^1\right)^{1/2} = \left(\frac{D_o^0\left(x^1, y^1\right)}{D_o^0\left(x^0, y^0\right)} \frac{D_o^1\left(x^1, y^1\right)}{D_o^1\left(x^0, y^0\right)}\right)^{1/2}, \tag{3}$$

with indexes 0 and 1 representing respective periods. The two terms in brackets follows the structure of Fisher's index. Consequently a number of studies (Färe et al., 1992, 1994; Ray and Desli, 1997; Simar and Wilson, 1998; Wheelock and Wilson, 1999) attempted to decompose the latter index into different terms each explaining certain factors of productivity shifts. Specifically, Färe et al. (1992) decomposed productivity change into efficiency change (EC or catching up) and technical change (TC or shifts in the frontier):

$$M_o = EC \cdot TC, \tag{4}$$

where

$$EC = D_o^1\left(x^1, y^1\right) / D_o^0\left(x^0, y^0\right), \tag{5}$$

and

$$TC = \left(\frac{D_o^0\left(x^1, y^1\right)}{D_o^1\left(x^1, y^1\right)} \frac{D_o^0\left(x^0, y^0\right)}{D_o^1\left(x^0, y^0\right)}\right)^{1/2}. \tag{6}$$

EC measures the relative technical efficiency change. The index becomes greater than unity in case the firm approaches frontier of the current technology.

TC indicates whether the technology has progressed and thus moved further away from the observed point. In case of technological progress, the TC becomes greater than unity; and that virtually means that more can be produced using fewer resources.

Given the Malmquist productivity index measures TFP growth, improvement in productivity will be indicated by values greater than unity, whereas regress – by that below unity. Distance function estimated for Eqs. 3–6 may be obtained by solving the following multiplier DEA program:

$$\begin{aligned}
&\left(D_O(x, y)\right)^{-1} = \max_{\phi_t, \lambda_k} \phi_t \\
&\text{s. t.} \\
&\sum_{j=1}^{N} \lambda_j x_i^j \le x_i^t, \quad i = 1,2,\ldots,n; \\
&\sum_{j=1}^{N} \lambda_j y_r^j \ge \phi y_r^t, \quad r = 1,2,\ldots,m; \\
&\lambda_j \ge 0, \quad j = 1,2,\ldots,N; \\
&\phi_t \text{ unrestricted.}
\end{aligned} \tag{7}$$

An important issue associated with the decomposition a la Färe et al. (1992) is that of returns to scale. In this case Eqs. 3–7 represent distance functions relying on the assumption of the constant returns to scale (CRS) rather than variable returns to scale (VRS). As a result the efficiency change component, *EC*, catches both the pure technical efficiency change and scale change. The latter two terms were defined by Färe et al. (1994) who offered the decomposition of the Malmquist productivity index under assumption of VRS. Indeed, macro-level studies do often assume the underlying production technology as a CRS technology.

2. 3. MULTIMOORA

Belton and Stewart (2002) defined the three broad categories of MCDM methods: 1) value measurement models; 2) goal, aspiration, and reference level models; 3) outranking models (the French school). A more detailed overview of MCDM methods is presented by Zavadskas and Turskis (2011). In this study, we applied the MULTIMOORA method which encompasses the value measurement and reference level methods. The Multi-Objective Optimization by Ratio Analysis (MOORA) method was introduced by Brauers and Zavadskas (2006). This method was enhanced (Brauers, Zavadskas 2010a) and became a more robust method, namely MULTIMOORA (MOORA plus the full multiplicative form). These methods have been applied in numerous studies (Brauers, Zavadskas, 2010b, 2011; Baležentis, Baležentis, 2010, 2011b) focused on regional studies, international comparisons and investment management.

The MOORA method was proposed by Brauers and Zavadskas (2006). This method begins with the matrix *X* where its elements x_{ij} denote the *i*-th alternative of a *j*-th objective ($i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$). The MOORA method consists of two parts – the Ratio System and the Reference Point approach.

The Ratio System of MOORA (RS). The ratio system defines data normalization by comparing the alternative of an objective to all values of the objective:

$$x_{ij}^{*} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^{2}}}, \qquad (8)$$

where x^{*}_{ij} denotes the *i*-th alternative of the *j*-th objective (in this case the *j*-th structural indicator of the *i*-th state). Usually these numbers belong to the interval [–1; 1]. These indicators are added (if desirable value of an indicator is its maximum) or subtracted (if the desirable value is minimum), and the summary index of state is derived in the following way:

$$y_i^{*} = \sum_{j=1}^{g} x_{ij}^{*} - \sum_{j=g+1}^{n} x_{ij}^{*}, \qquad (9)$$

where $g = 1, 2, \ldots, n$ and n denotes the number of objectives to be maximized. Then, every ratio is given the rank: the higher the index, the higher the rank.

The Reference Point of MOORA (RP). The reference point approach is based on the ratio system. The Maximal Objective Reference Point (vector) is found according to ratios found in formula (8). The *j*-th coordinate of the reference point can be described as $r_j = \max_i x_{ij}^*$ in case of maximization. Every coordinate of this vector represents the maximum or minimum of a certain objective (indicator). Then, each element of the normalized response matrix is recalculated, and the final rank is given according to deviation from the reference point and the Min–Max Metric of Tchebycheff:

$$\min_i \left(\max_j | r_j - x_{ij}^* | \right). \tag{10}$$

The Full Multiplicative form (MF) and MULTIMOORA. Brauers and Zavadskas (2010a) proposed MOORA to be updated by the Full Multiplicative Form method embodying maximization as well as minimization of the purely multiplicative utility function. The overall utility of the *i*-th alternative can be expressed as a dimensionless number:

$$U_i^{'} = \frac{A_i}{B_i}, \tag{11}$$

where $A_i = \prod_{j=1}^{g} x_{ij}$, $i = 1, 2, \ldots, m$ denotes the product of objectives of the *i*-th alternative to be maximized with $g = 1, \ldots, n$ being the number of objectives (indicators) to be maximized and $B_i = \prod_{j=g+1}^{n} x_{ij}$ denotes the product of objectives of the *i*-th alternative to be minimized, with $n–g$ being the number of objectives (indicators) to be minimized. Thus, MULTIMOORA summarizes MOORA (i. e. the Ratio System and Reference point) and the Full Multiplicative Form. The three ranks provided by different parts of MULTIMOORA are summarized by applying the theory of dominance (Brauers, Zavadskas, 2011).

As one can see, the Reference Point prevents the MULTIMOORA from becoming a fully compensatory technique. Whereas the Ratio System and the Full Multiplicative Form are fully compensatory methods, the Reference Point is not. Indeed, the latter method is based on the Min–Max metric of Tchebycheff, which identifies certain alternatives peculiar by a relative backwardness in either of criteria. Hence, the MULTIMOORA is quite an effective tool for assessing the sustainability of various phenomena resulting in unbiased ranking of alternatives.

3. EFFCIENCY AND PRODUCTIVITY OF THE AGRICULTURAL SECTOR

This section analyses the Lithuanian agricultural sector as the one operating amid the remaining sectors of the Lithuanian economy. The first sub-section employs accounting approach and thus focuses on financial ratio analysis. The second sub-section, though, is based on frontier measures, viz. DEA and Malmquist TFP index. Accordingly the term *efficiency* differs across these two sub-sections: we treat efficiency ratio as a ratio of the value added to the intermediate consumption in the first sub-section, whereas for the rest of the study we follow the frontier methodology by considering efficiency as a distance from the production possibility frontier.

3. 1. Sectoral Performance and Index Decomposition Analysis

Efficiency as well as competitiveness can be assessed at the three levels, namely at those of state, sector, and enterprise (Navickas, Malakauskaitė, 2010; Misiūnas, 2010). Our study is hence focussed on the Lithuanian agricultural sector which currently operates under both competition and support of the European Union (EU) and its Member States.

Since becoming a Member State of the EU in 2004, Lithuania faces an increasing need to provide the competitive production to the Single Market. According to Eurostat (2010), the share of intermediate consumption in crop production (output) amounted to 37.2 per cent and 68.7 per cent in animal production for Lithuania, whereas the EU average values were 22.1 and 59.5 per cent, respectively (as of 2009). In addition, Kazakevičius (2011) reported the declined efficiency of the Lithuanian farming. Hence, the Lithuanian agriculture is peculiar with relatively high level of intermediate consumption and thus less competitive production. Therefore it is important to investigate into the recent trends of main indicators describing productivity and competitiveness of the Lithuanian agricultural sector.

Although efficiency and competitiveness of the Lithuanian agricultural and food sector has been analyzed in many studies at various levels (Kriščiukaitienė et al., 2007; Paunksnienė, Stalgienė, 2009; Vinciūnienė, RaulUškevičienė, 2009; Tamošaitienė et al., 2010; Baležentis, Baležentis, 2011a), the relations between returns on fixed assets, output, and value added remain rather vague. This study, thus, attempts to reveal the main trends in aforementioned indicators identifying efficiency of the agricultural sector.

This sub-section seeks to quantify changes in gross value added generated in agriculture by considering the underlying factors. The following tasks are therefore set: 1) to describe the main trends of efficiency indicators of agricultural sector; 2) to estimate the impact of different factors on changes in gross value added; and 3) to compare efficiency of the Lithuanian agricultural sector with that of the whole economy. The enumerated methods were employed for the research: statistical analysis, ratio analysis, index decomposition analysis. The research covers the period of 1995–2009.

Indicators for measurement of efficiency and productivity are of crucial importance for benchmarking. The following paragraphs will thus briefly describe the main indicators identifying productivity of certain sector or economy as a whole. Further, the dynamics of these indicators will be presented.

As defined in the European System of Accounts methodology (Council of the European Union, 1996), *output* consists of the products created during the accounting period. The output indicator, hence, identifies the overall production level of sector or economy. *Intermediate consumption* consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. The goods and services may be either transformed or used up by the production process (Council ..., 1996). Thus, output less intermediate consumption constitute *gross value added*, which basically is remuneration for owners of factors of production. Finally, *fixed assets* are tangible or intangible assets produced as outputs from processes of production that are themselves used repeatedly, or continuously, in processes of production for more than one year.

The efficiency of economic sector or economy, therefore, can be assessed by considering the following ratios. The return on fixed assets (ROFA) ratio is computed by dividing total output from fixed assets (Mackevičius, 2008). The efficiency ratio of a certain sector or economy as a whole can be measured as a quotient of the gross value added over the total output. The following equation, hence, holds:

$$FA_t \cdot \frac{Q_t}{FA_t} \cdot \frac{VA_t}{Q_t} = FA_t \cdot ROFA_t \cdot E_t = VA_t , \qquad (12)$$

where FA_t denotes fixed assets, Q_t – total output, VA_t – value added, $ROFA_t$ – return on fixed assets, and E_t – efficiency ratio during period *t*.

According to data of Statistics Lithuania (2012), gross stocks of fixed capital in the whole Lithuanian economy amounted to 232 059.8 million Lt in 1995 and grew up to 514 161.1 million Lt in 2009, i. e. they grew by some 122 per cent with mean annual growth rate of 5.8 per cent. Meanwhile, the gross stocks of fixed capital in agricultural sector (NACE 1.1 sectors A and B) went up by 90 per cent from 22 917 million Lt to 43 634.9 million Lt with annual growth rate of 4.7 per cent. Thus one can note that stocks of fixed assets increased at a slower pace in agricultural sector if compared to the economy as a whole.

During the investigated period of 1995–2009 the total output of the Lithuanian economy increased by 204 per cent (mean annual growth of 8.2 per cent), namely from 52 052 million Lt up to 157 978 million Lt. The agricultural output, however, grew by 19 per cent (annual rate of 1.2 per cent) from 6 584.9 million Lt up to 7 842 million Lt. Since the total output is available in current prices only, we use all other indicators expressed in current prices as well. As it was described above, the ROFA ratio (Fig. 1) resembles the level of fixed assets productivity.

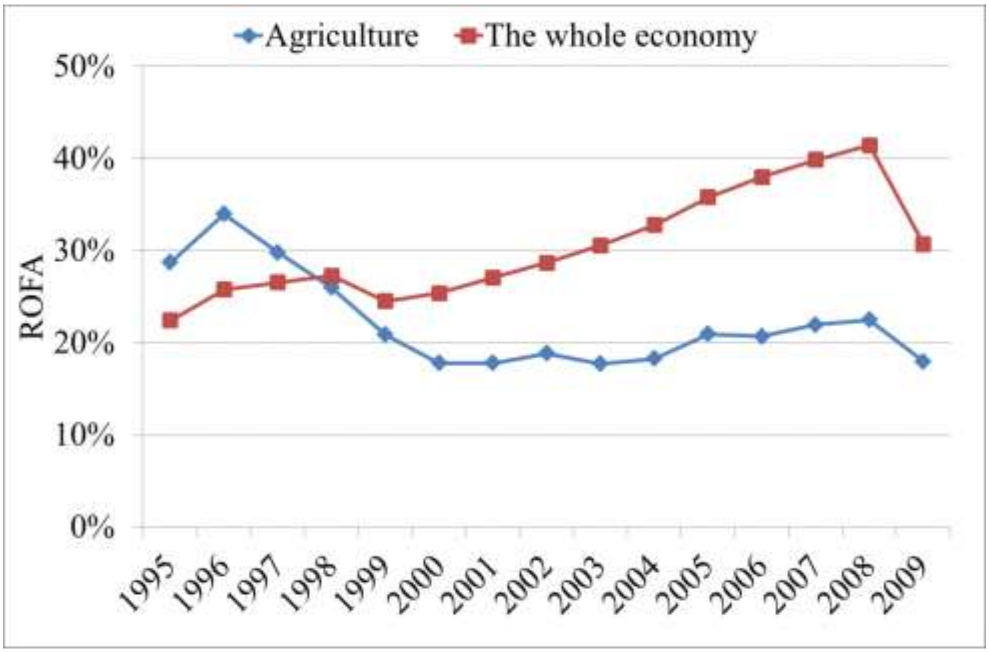

Fig. 2. Return on fixed assets in the agriculture and the whole Lithuanian economy, 1995–2009

As shown in Fig. 2, the agricultural fixed assets provided higher rates of return until 1998. However they had been decreasing during the period of 1996–2000. Afterwards ROFA in the agricultural sector fluctuated around the value of 18 per cent and gained momentum in 2004 consequently reaching its peak in 2008 (22 per cent). Meanwhile, ROFA for the whole economy reached 41 per cent in 2008. Both of these indices, however, shrunk in year 2009 due to economic downturn. To conclude, ROFA in the agricultural sector was lower if compared to that for the whole economy during 1998–2009 even though it had been increasing in 2004–2008 possibly due to the Lithuania's accession into the EU. For acquired investments into the agriculture might have enabled to expand more competitive production. Noteworthy, the stability of ROFA in the agriculture exhibited throughout 2000–2004 might also be partially attributed to non–increasing amount of fixed assets.

The value added generated in the Lithuanian economy increased from 24 063 million Lt to 82 428 million Lt (at current prices), whereas in the agriculture it grew from 2 642 million Lt up to 2 770 million Lt (concerning 1995–2009). Specifically, growth of 4.8 per cent and 243 per cent was observed for the agriculture and total economy, respectively, though the corresponding deflated figures are 27 per cent and 88 per cent. Prices of agricultural output, hence, were relatively less inflated (or even deflated) during the analysed period. Consequently, efficiency ratio was always lower in the agriculture if compared to that for the whole economy (Fig. 3). More specifically, prices of agricultural production were not increasing as robustly as those of imported machinery and raw materials and thus fuelled growth of intermediate consumption share in total output as well as decrease in efficiency ratio. As the following Fig. 3 depicts, the efficiency ratio in the agricultural sector had been decreasing ever since 2003.

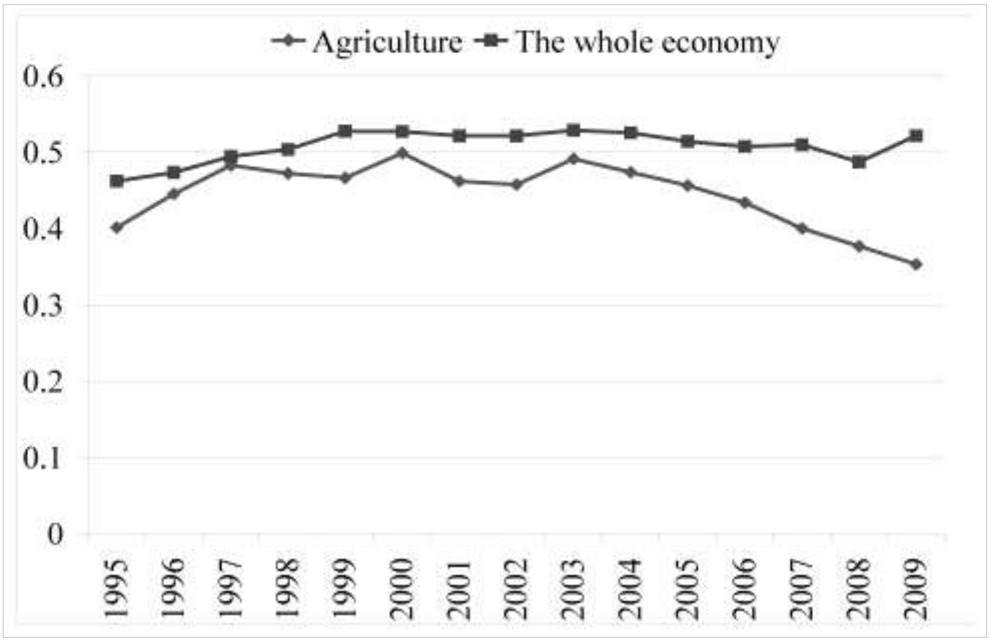

Fig. 3. Efficiency ratio for the Lithuanian economy and agriculture sector, 1995–2009

Index decomposition of changes in gross value added. The Logarithmic Mean Divisia Index (Ang, 2005) will be applied for index analysis. By employing respective index decomposition analysis (IDA) models, we can decompose changes in gross value added (Eq. 12) either in additive or in multiplicative form. The additive IDA enables to decompose the difference $\Delta VA = VA_T - VA_0 = \Delta VA_{FA} + \Delta VA_{ROFA} + \Delta VA_E$ with sub-indexes *T* and *0* meaning current and base periods, respectively, and:

$$\Delta VA_{FA} = \frac{VA_T - VA_0}{\ln VA_T - \ln VA_0} \ln\left(\frac{FA_T}{FA_0}\right), \quad (13)$$

$$\Delta VA_{ROFA} = \frac{VA_T - VA_0}{\ln VA_T - \ln VA_0} \ln\left(\frac{ROFA_T}{ROFA_0}\right), \quad (14)$$

$$\Delta VA_{FA} = \frac{VA_T - VA_0}{\ln VA_T - \ln VA_0} \ln\left(\frac{E_T}{E_0}\right). \quad (15)$$

Similarly, the multiplicative IDA decomposes the ratio $D = VA_T / VA_0 = D_{FA} \cdot D_{ROFA} \cdot D_E$ where:

$$D_{FA} = FA_T / FA_0 , \quad (16)$$

$$D_{ROFA} = ROFA_T / ROFA_0 , \quad (17)$$

$$D_E = E_T / E_0 . \quad (18)$$

By employing Eqs. 13–15 we managed to decompose changes in gross value added generated in the agriculture (Fig. 4a and Fig. 5a).

a

b

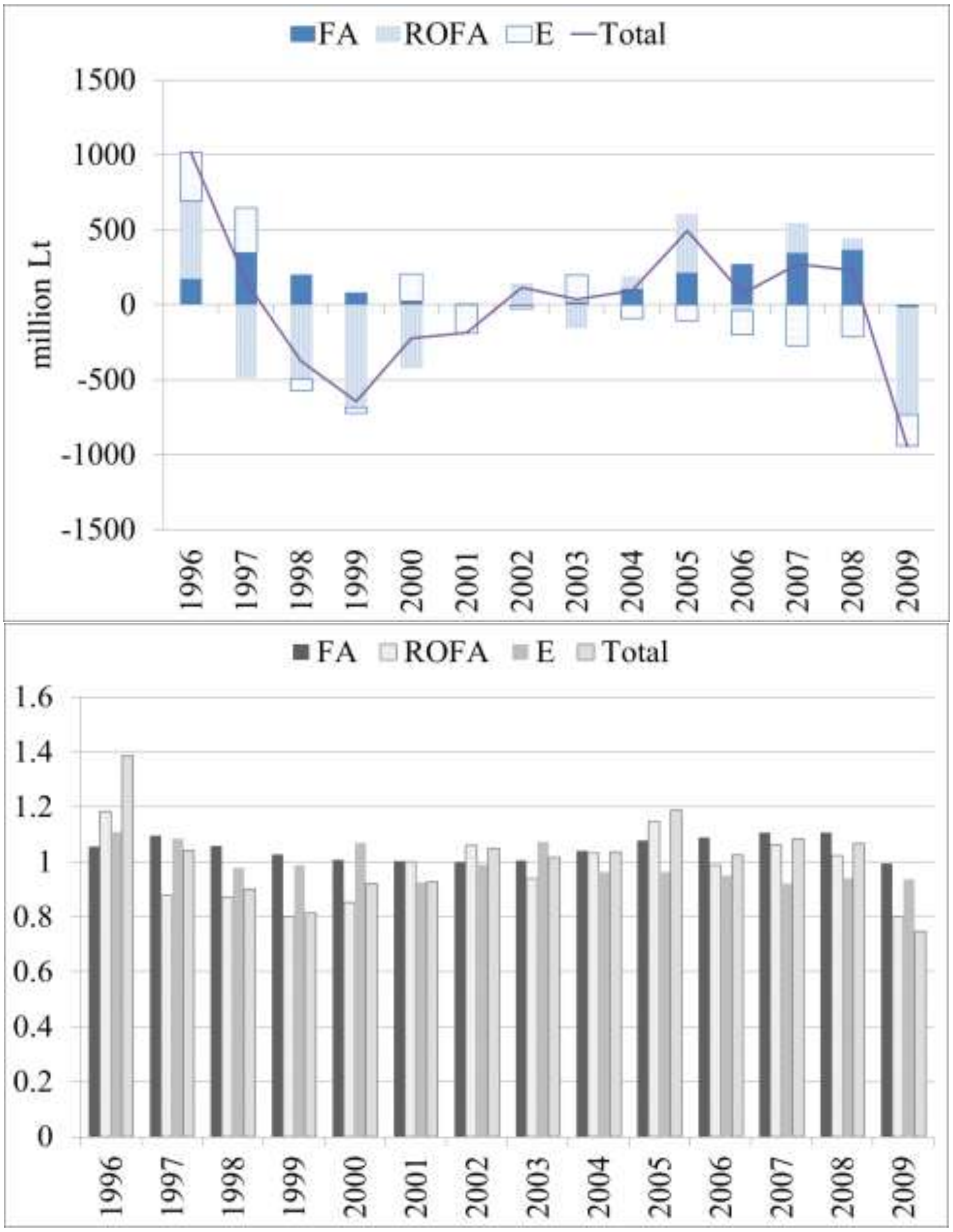

Fig. 4. Additive (a) and multiplicative (b) IDA for changes in gross value added generated in the agriculture: fixed assets (FA), return on fixed assets (ROFA), and efficiency ratio (E) effects

Subsequently, Eqs. 16–18 were applied to perform multiplicative IDA (Fig. 4b and Fig. 5b). As one can note, the most serious declines was experienced during crises of 1998–1999 and 2009. The shifts in gross value added were mainly driven by declined ROFA, what might be attributed to shrunk output. Falling efficiency ratio, in turn, deepened the decline of value added in 1998–1999 and since 2004. As for effect of fixed assets employed in the agriculture, their positive effect on generation of value added had been falling since 1997 and began to recover in 2003. The latter phenomenon might be interrelated with the EU support under the scheme of SAPARD and Rural Development Programme. Nevertheless, the economic crisis of 2009 caused decline in fixed assets formation.

a

b

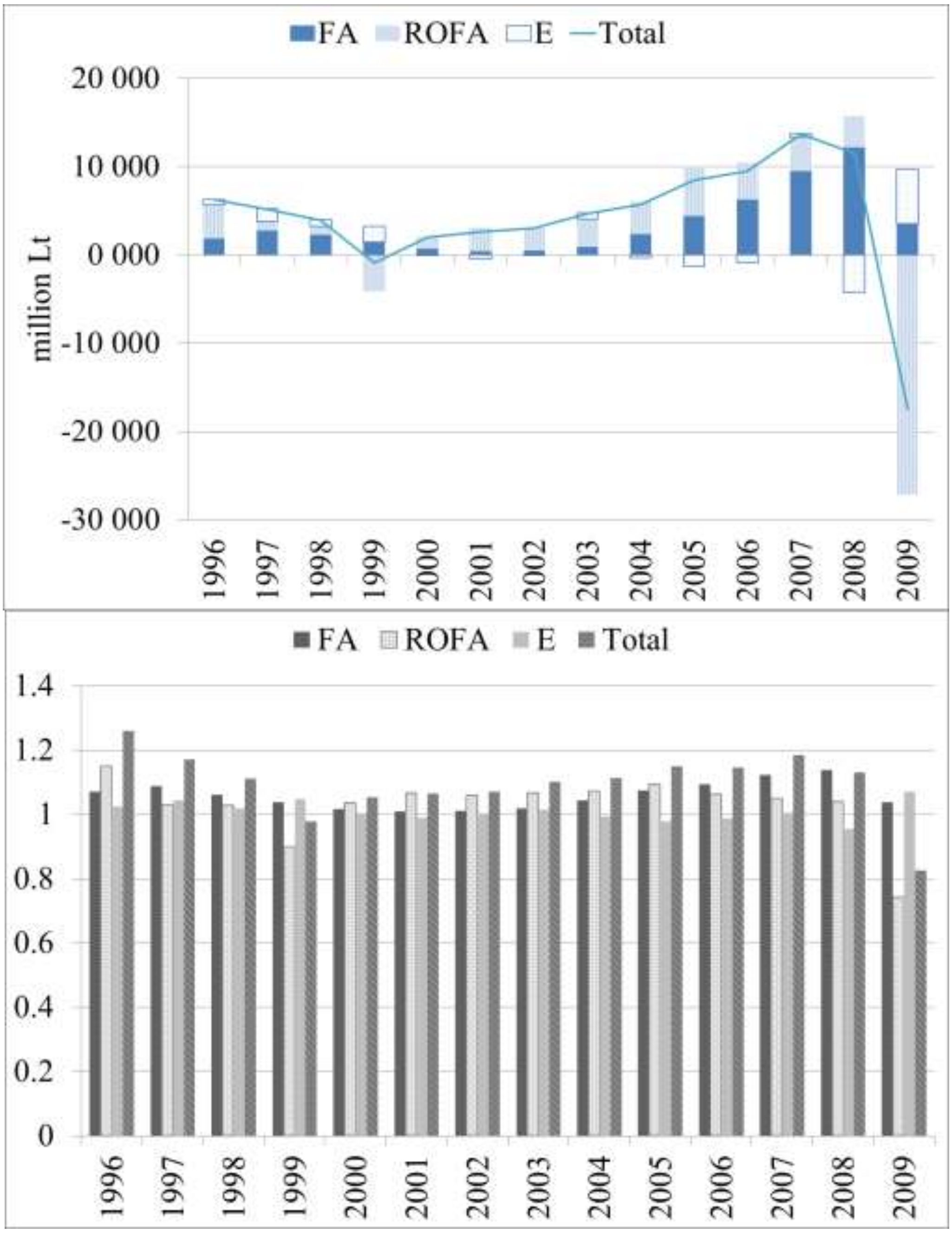

Fig. 5. Additive (a) and multiplicative (b) IDA for changes in gross value added generated in the whole economy: fixed assets (FA), return on fixed assets (ROFA), and efficiency ratio (E) effects

Comparison of Fig. 4 and Fig. 5 reveals that the increasing efficiency ratio had a positive effect on the gross value added in the whole economy during the recent crisis of 2009, whereas the same effect was negative in the agriculture. Hence, the agricultural sector is peculiar with certain inertia leading to relative inefficiency. The following Table 1 summarizes results from additive and multiplicative IDA. As we can see, changes in fixed assets had similar impact on gross value added in the agriculture and the whole economy, indexes of 1.9 and 2.2, respectively. ROFA and efficiency ratio, however, caused decrease of 36 and 12 per cent, in that order, in nominal gross value added. Meanwhile, these effects were positive for the whole economy.

Table 1. Results from additive and multiplicative IDA of changes in gross value added (GVA)

	Agricultural sector		The whole economy	
	Additive	Multiplicative	Additive	Multiplicative
GVA (1995)	2642.50	1.00	24063.18	1.00
FA	2123.71	1.90	48885.46	2.22
ROFA	–1593.28	0.63	4963.74	1.37
E	–403.12	0.88	4515.81	1.13
GVA (2009)	2769.81	1.05	82428.18	3.43

Given the results of our analysis, it can be concluded that the Lithuanian agricultural sector managed to accumulate fixed assets due to the EU support through programmes like SAPARD, structural support, Rural Development Programme etc. These assets, nevertheless, were used relatively inefficiently. Hence, it is important to improve productivity of the agricultural sector by introducing innovative technologies and thus providing more competitive production. For instance, improvements of crop structure, crop rotation as well as rational use of agricultural machinery could increase the productivity. The current situation when intermediate consumption relies on goods imported from the EU states, whereas output export is oriented towards the CIS states creates unfavourable terms of trade. Furthermore, increased competitiveness would enable to opt for Western markets and thus increase value added. These changes would lead to somehow increased efficiency of the agricultural sector.

The efficiency of the Lithuanian agricultural sector as well as the whole economy was assessed by considering the two ratios, namely return on fixed assets (ROFA) and efficiency ratio. The former one was computed by dividing total output from fixed assets, whereas the latter one was measured by dividing gross value added from total output.

Agricultural fixed assets provided higher rates of return until 1998. However they were decreasing during the period of 1996-2000. Afterwards ROFA in agricultural sector fluctuated around the value of 18 per cent and gained momentum in 2004 consequently reaching its peak in 2008 (22 per cent). Meanwhile, ROFA for the whole economy reached 41 per cent in 2008. Both of these indices, however, shrunk in year 2009 due to economic downturn. To conclude, ROFA in the agricultural sector was lower if compared to that for the whole economy during 1998–2009 even though it had been increasing in 2004–2008 possibly due to the Lithuania's accession into the EU.

More specifically, prices of agricultural production were not increasing as robustly as those of inputs (imported machinery and raw materials) and thus fuelled growth of intermediate consumption share in total output as well as decrease in efficiency ratio. Indeed, the efficiency ratio in the agricultural sector had been decreasing ever since 2003. As of 2009, efficiency ratio of agricultural sector was 35 per cent, whereas the same figure for the whole economy amounted to 52 per cent.

Changes in fixed assets had similar impact on gross value added (indexes of 1.9 and 2.2 for the agriculture and the whole economy, respectively). ROFA and efficiency ratio, however, caused decrease of 36 and 12 per cent, respectively, in nominal gross value added. Meanwhile, these effects were positive for the whole economy.

Given the results of our analysis, it can be concluded that fixed assets in the Lithuanian agricultural sector could be used more efficiently. Hence, it is important to improve productivity of the agricultural sector by introducing innovative technologies and thus providing more competitive production. For instance, improvements of crop structure, crop rotation as well as ration use of agricultural machinery could increase productivity. Furthermore, increased diversification of international trade partners would results in improved terms of trade. Moreover, the increased competitiveness would enable to opt for Western markets and thus increase value added. These changes would lead to somehow increased efficiency of the agricultural sector.

3. 2. Dynamics of the Total Factor Productivity

The research relies on National Accounting data provided by Statistics Lithuania (2012). We have used the aggregates for 35 economic activities (NACE 2 classification). The data cover the period of 2000–2010.

The gross value added generated in certain sector was chosen as the output variable, whereas intermediate consumption, remuneration, and fixed capital consumption were treated as inputs. The latter three indicators enable to tackle the total factor productivity and thus are usually employed for productivity analysis (Piesse, Thirtle, 2000). The FEAR package (Wilson, 2010) was employed for the analysis.

Firstly, the VRS technical efficiency scores[1] were estimated by employing the output oriented DEA model (cf. Eq. 7). The following Fig. 6 presents these estimates for years 2000 to 2010. The weighted average for the whole economy was obtained by weighting the efficiency scores by the value added generated in the respective sector during the base year. As the results suggest, the mean efficiency increased from 0.79 in 2000 up to 0.85 in 2010. These efficiency scores imply that there was a 21% gap in output for 2000 which decreased to 15% in 2010 given technological frontier of those periods. Note that the contemporaneous technological frontier is defined by the efficient DMUs viz. economic sectors, and these gaps are therefore incomparable in absolute terms. The application of Malmquist index will enable to identify the shifts of the efficiency frontier. The analysis showed that the four sectors remained operating on the efficiency frontier during 2000–2010: pharmaceutical products (C21), wholesale and retail trade (G), real estate activities (L), and education (P).

[1] Please note that the VRS assumption is relaxed for the Malmquist productivity index.

The following Fig. 6 exhibits a steep decrease in efficiency of the agricultural sector during 2005–2009. Meanwhile, the weighted average for the whole economy fluctuated around 0.85. The efficiency of the agricultural sector fell to somewhere below 0.5 in 2009 and thus reaching its minimum. However, this indicator did increase in 2010 up to 0.6. The decrease of 2005–2009 can mainly be related to an increased capital consumption which, in turn, gained momentum after Lithuania acceded to the EU and the Lithuanian agricultural sector received significant financial support under various schemes. Nevertheless, the economic crisis of 2008–2009 had a relatively lower impact upon the agricultural sector if compared to the remaining ones. Given the TE score for the agricultural sector approached 0.6 (Shepard measure) in 2010, it should increase its output by a factor of 1/0.6=1.66 (Farrel measure) in order to approach the efficiency frontier.

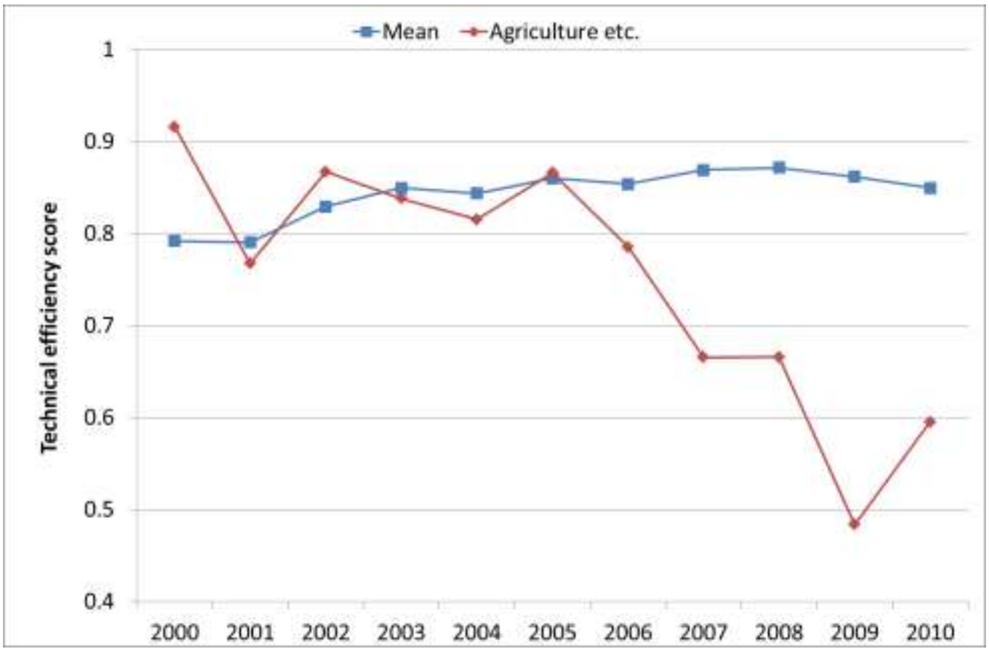

Fig. 6. Technical efficiency scores for the whole economy (Mean) and agricultural sector (Agriculture etc.), 2000–2010

TFP can increase not only because of increasing efficiency, but also due to movements of the production frontier. The total change in TFP is presented in Fig. 7. As one can note, it follows the similar pattern as Fig. 7. Although the TFP used to move upwards during certain periods, the cumulative TDFP change remained negative for the agricultural sector and indicated that TFP had decreased by some 40% during 2000–2010. Meanwhile, the weighted average TFP change for the whole economy indicated TFP increase of some 4%.

The changes in TFP can be decomposed in the spirit of Eq. 4 into the two terms, TC and EC. Fig. 8 exhibits the results of this decomposition for the whole economy (as the weighted average) and the agricultural sector. It is obvious, that a negative TC—an inward movement of the production frontier—was observed for both the agricultural sector and the whole economy until 2004. Ever since, TC has been positive indicating technological progress.

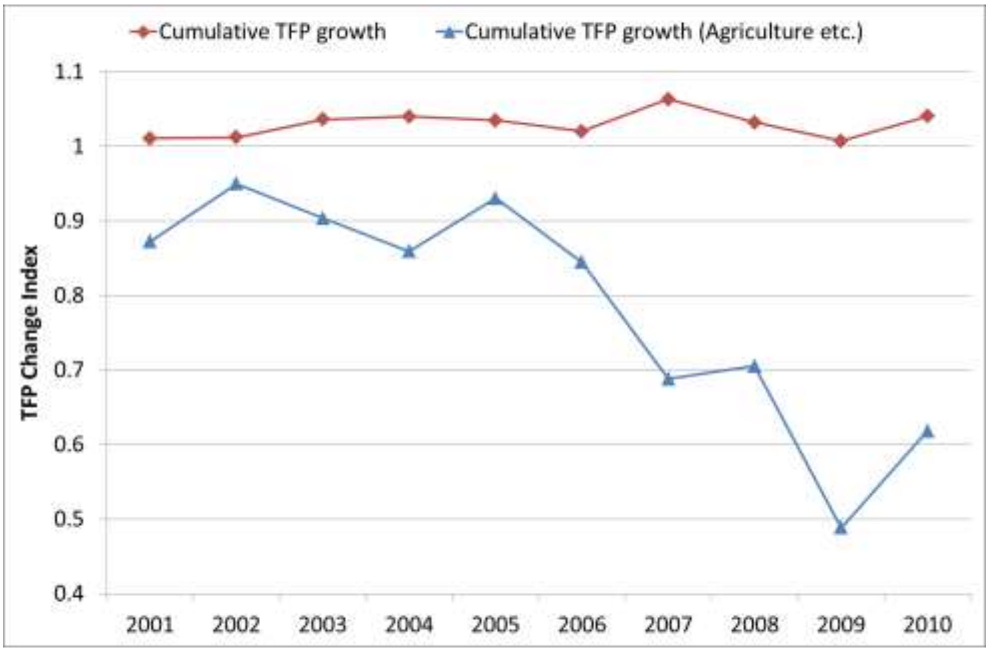

Fig. 7. TFP change in the whole economy (Mean) and agricultural sector (Agriculture etc.), 2000–2010

Once again, it might the integration with the EU that encouraged technological and market developments. The agricultural sector, though, has not gained much from these processes yet in terms of efficiency and productivity. On the other hand, the high-technology and trade services cannot be directly compared to the agricultural sector due to different value added chains and technologies.

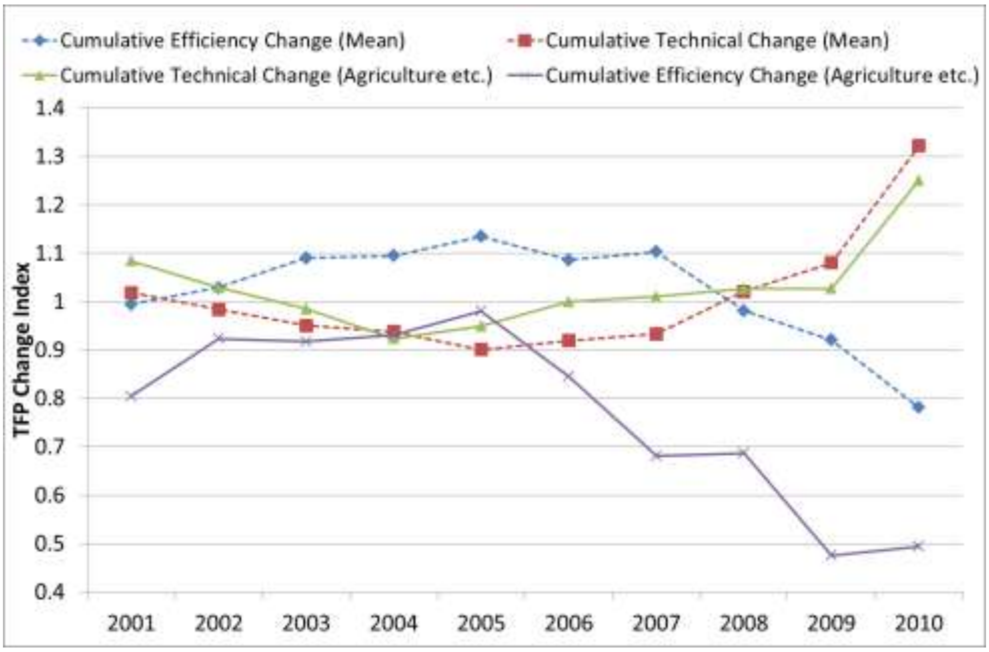

Fig. 8. Decomposition of the TFP change in the whole economy (Mean) and agricultural sector (Agriculture etc.), 2000–2010

In order to facilitate an integrated assessment of sector performance one needs to employ a multi–criteria technique. The multi-criteria decision making method MULTIMOORA (Brauers, Zavadskas, 2010) was therefore employed to simultaneously consider these criteria identifying different objectives:

- the mean technical efficiency score for 2000–2010 (to be maximized);
- coefficient of variation of the technical efficiency scores (to be minimized);
- the mean change in total factor productivity for 2000–2010 (to be maximized);
- coefficient of variation of change in total factor productivity (to be minimized).

The presented set of indicators has the following implications. First, a sector specific with high values of technical efficiency might be experiencing decreasing total factor productivity and thus require certain managerial and institutional measures to be taken. Second, a sector exhibiting increasing total factor productivity might still remain an inefficient one. Third, a high variance in these indicators indicates high volatility of performance and should also attract certain attention. The analysis showed that the agricultural sector was the 30th among the 35 economic sectors under analysis. This finding implies that the agricultural sector might not be attractive for investors and entrepreneurs.

To conclude, the agricultural sector should expand its output by some 60% in order to approach the efficiency frontier defined by the remaining economic sectors in Lithuania. The EU support has certainly decreased the technical efficiency thanks to increased capital consumption. It is, therefore, important to further develop the EU support policies and provide farmers and agricultural companies with appropriate decision support tools, which could lead to increasing efficiency in the long run. Anyway, the agricultural sector managed to improve its relative efficiency during 2009–2010 in spite of the economic crisis.

4. EFFCIENCY AND PRODUCTIVITY OF FAMILY FARMS

This section analyses the family farm performance in terms of the FADN aggregates. Specifically, the first sub-section presents EU–wide comparisons, whereas the second one focuses on the Lithuanian family farms.

4. 1. Lithuanian Family Farms in the EU Context

4. 1. 1. General Assessment of Efficiency

Assessment of the efficiency of a certain economic sector is of high importance when making strategic decisions at any management level. Furthermore, the increase in efficiency leads to an increase in the competitiveness of production. It is the Common Agricultural Policy and Single Area Payments of the European Union (EU) that involve the EU Member States and their agricultural sectors into the processes of competition, convergence and cohesion. The competitiveness of the Lithuanian agricultural sector, hence, becomes an even more actual issue. Moreover, given the relatively high share of the gross value-added generated in the primary sector, peculiar to the Central and Eastern European states, agricultural efficiency is of crucial importance here (Gorton, Davidova, 2004).

Hence, a number of studies have attempted to investigate the issues of efficiency and competitiveness. Indeed, data envelopment analysis (DEA) is a method widely applied to assess the efficiency (Odeck, 2009; Vinciūnienė, Rauluškevičienė, 2009). Gorton and Davidova (2004) provided an overview of papers on farm productivity and efficiency. Kriščiukaitienė et al. (2007) and Tamošaitienė et al. (2010) analysed the efficiency of the Lithuanian farms. A multi-dimensional comparison of Lithuanian farm efficiency was performed by Baležentis and Baležentis (2011a). Although Baležentis and Baležentis (2010) performed an international comparison of the EU Member States' achievements in rural development, there is a lack of such comparison in the farming efficiency area. The study of Rimkuvienė et al. (2010) is the sole Lithuanian contribution to the area under discussion.

The aim of this section is to identify the prospective development directions of the Lithuanian agricultural sector by proposing a new framework for multi-criteria assessment and comparison of farming efficiency. Consequently, such an assessment can constitute a basis for strategic decision support. The efficiency of farming will be evaluated by applying the multi-criteria decision-making (MCDM) method MULTIMOORA (Multi-Objective Optimization plus the Full Multiplicative Form) as well as DEA.

Noteworthy, there are some innovative features in this study. The derived economic indicators, namely ratios, are used as the variables to evaluate farming efficiency, instead of the typically used input–output variables. Another important feature is the absence of inputs in the DEA model which, while not innovative, is relatively underutilized. In this study, performance is measured with an output vector consisting of three ratios and no inputs. Such a modelling constitutes an interesting alternative for evaluating the efficiency and a complement to the simple ratio analysis employed by agricultural economists. Finally, the application of the MCMD method MULTIMOORA enables to validate the results obtained by DEA.

It is the complex nature of contemporary socio-economic phenomena that makes MCDM methods more and more actual nowadays (Kahraman, 2008; Zavadskas, Turskis, 2011). The expanding spectrum of multi-criteria problems encompasses both business and public sector decision-making and benchmarking. Indeed, Roy (1996) offered the following classification of MCDM problems: 1) *choosing* problem – choosing the best alternative; 2) *sorting* problem – classifying the alternatives into relatively homogeneous groups; 3) *ranking* problem – ranking the alternatives from the best one to the worst one; 4) *describing* problem – describing the alternatives in terms of their peculiarities and features. In our study, we will apply the MULTIMOORA method for the multi-criteria assessment of farming efficiency in the EU Member States. This method was introduced and developed by Brauers and Zavadskas (2006, 2010a). MULTIMOORA was applied in regional development studies (Brauers, Zavadskas, 2010b; Baležentis, Baležentis, 2011b). However, the MCDM method provides ranking without any additional information. The use of additional methods, therefore, becomes an actual issue.

The DEA method, however, is characterised by opposite characteristics. It is a nonparametric method for measuring the relative efficiency of a decision-making unit such as a firm or a public sector agency, which results in estimating their actual as well as potential efficiency. The ranking based on this efficiency is usually not very robust (Jaržemskienė, 2009). Nevertheless, DEA offers some additional information which soundly supports the multi-criteria optimization. DEA was first introduced by Charnes et al. (1978). It is a relative technical efficiency measurement tool which uses operation research techniques to automatically calculate the weight assigned to the input and output of the production units (Kahraman, 2008). Thus, neither market prices nor disaggregation of inputs and outputs are mandatory. Indeed, DEA was applied in studies of agriculture (Alvarez, Arias, 2004; Gorton, Davidova, 2004; Vinciūnienė, Rauluškevičienė, 2009). The DEA ISYDS / SIAD package (Angulo Meza et al., 2005) will be applied in this study to evaluate the technical efficiency of farming.

The following tasks, therefore, are set: 1) to define an indicator set for estimating the farming efficiency across the EU Member States; 2) to apply MULTIMOORA and DEA when estimating farming efficiency; 3) to check the consistency of results; and 4) to provide summarized guidelines for the future development.

The research was based on data provided by the Farm Accountancy Data Network (FADN). More specifically, the data cover the year 2008. The following methods were employed for the research: statistical analysis, MCDM method MULTIMOORA, and DEA.

The farming efficiency was evaluated across the EU Member States on the basis of data from FADN[2]. Noteworthy, FADN is an instrument for evaluating the income of agricultural holdings and might be used to study the impacts of the Common Agricultural Policy (CAP).

Accordingly, we established the indicator system identifying the main aspects of farming efficiency. The three ratios under consideration were derived by comparing the other six indicators identifying both inputs and outputs. A dimension reduction, thus, was achieved. The three ratios identify the productivity of the respective production factors and therefore should be maximized. As for the MCDM and DEA methods, the inputs should be minimized, whereas the outputs should be maximized. Table 2 summarizes initial data for 27 EU Member States.

The input indicators identify a bundle of material and financial resources – factors of production – employed in the production process. The total labour input expressed in AWU (annual work unit, i. e. full-time person equivalent) quantifies the labour input. The total Utilised Agricultural Area (UAA) in hectares resembles the land input. Total livestock units are converted into the so-called livestock units (LSU).

The output indicators describe the results of farming activities. Total outputs in Euro are estimated for crops and crop products, livestock and livestock products, etc. More specifically, we assess three derived ratios: the total crop output per ha, total livestock output per LSU, and net value added expressed per agricultural work unit. The two former indicators enable to evaluate the productivity of land and husbandry. The indicator of farm net value-added (in Euro) quantifies remuneration to the fixed factors of production (work, land and capital), whether they be external or family factors. In addition, labour productivity is assessed by considering farm net value-added expressed per agricultural work unit. The pair-wise correlation coefficients among these three variables varied in the range 0.19 and 0.36. Therefore, no serious multicollinearity existed in the data set.

Table 2. Initial data for assessment of farming efficiency in the EU, 2008

Indicator	Total crop output per UAA	Total livestock output per LSU	Farm Net Value Added per AWU
Dimension	EUR / ha	EUR / LSU	EUR / AWU
Belgium	1 722	1 026	34 262
Bulgaria	593	721	4 307
Cyprus	1706	1 774	9 370
Czech Republic	742	1 034	14 229
Denmark	1 278	1 281	49 973
Germany	1 076	1 155	30 171
Greece	1 979	996	11 480
Spain	937	764	22 127
Estonia	281	981	10 485

[2] *FADN Public Database*. Accessible on–line http://ec.europa.eu/agriculture/rica/database/database_en.cfm.

Indicator	Total crop output per UAA	Total livestock output per LSU	Farm Net Value Added per AWU
France	1 043	928	29 086
Hungary	910	1 192	15 427
Ireland	180	728	20 646
Italy	2 414	1 072	24 389
Lithuania	454	870	9 904
Luxembourg	539	1 063	35 361
Latvia	343	937	7 293
Malta	7 205	1 072	13 966
Netherlands	6 132	1 432	41 762
Austria	681	1 382	26 323
Poland	791	1 026	5 661
Portugal	521	771	8 428
Romania	687	654	8 465
Finland	616	1 557	23 127
Sweden	687	1 161	39 629
Slovakia	512	899	7 872
Slovenia	1 014	767	3 967
United Kingdom	637	860	37 366
EU-27	1 050	994	17 202

As mentioned above, the efficiency of farming was assessed by applying the MCDM method MULTIMOORA and DEA. This section presents the results of these evaluations. Specifically, we will pay a particular attention on the three Baltic States, namely Estonia, Latvia, and Lithuania, as well as to Poland and Germany.

The application of MULTIMOORA begins with normalization of initial data (Table 2) by employing Eq. 8. Consequently, each Member State was attributed a respective ratio (Eq. 9) and thereafter ranked with respect to RS. Furthermore, Eq. 10 was applied in order to rank EU Member States according to RP. Finally, the considered states were ranked with respect to the MF approach (Eq. 11). These three ranks were summarized by applying the theory of dominance (Brauers, Zavadskas, 2011). The discussed data are provided in Table 3.

Initially, the EU Member States had been conditionally grouped into three groups, each of them encompassing high-, medium-, and low-performing states, respectively. As one can see, the high-performance group consists of the Netherlands, Malta, Denmark, Italy, Belgium, Cyprus, Germany, Sweden, and France. Thus, the enumerated states can be considered as those characterized by the most relatively efficient farming practices. The underlying factors causing success of these states might be higher rates of CAP payments, a higher quality of agricultural land, and higher prices of agricultural production (Kriščiukaitienė et al., 2010a, 2010b).

Table 3. Ranking of the EU Member States by farming efficiency according to MULTIMOORA, 2008

	Ratios			Ranks			
	RS	RP	MF	RS	RP	MF	Final
The Netherlands	3.7E + 11	1.150	0.099	1	1	1	1
Malta	1.1E + 11	0.964	0.286	2	2	2	2
Denmark	8.2E + 10	0.741	0.546	3	3	7	3
Italy	6.3E + 10	0.606	0.441	4	5	3	4
Belgium	6.1E + 10	0.612	0.505	5	4	5	5
Cyprus	2.8E + 10	0.545	0.507	8	7	6	6
Germany	3.7E + 10	0.543	0.565	6	8	8	7
Sweden	3.2E + 10	0.583	0.600	7	6	17	8
France	2.8E + 10	0.491	0.568	9	13	10	9
Austria	2.5E + 10	0.516	0.601	10	10	18	10
Greece	2.3E + 10	0.449	0.481	11	14	4	11
Finland	2.2E + 10	0.515	0.607	12	11	20	12
United Kingdom	2E + 10	0.508	0.605	13	12	19	13
Luxembourg	2E + 10	0.518	0.614	14	9	22	14
EU-27	1.8E + 10	0.409	0.567	15	16	9	15
Hungary	1.7E + 10	0.417	0.580	16	15	13	16
Spain	1.6E + 10	0.397	0.577	17	17	12	17
Czech Republic	1.1E + 10	0.364	0.595	18	18	15	18
Poland	4.6E + 09	0.299	0.591	19	20	14	19
Lithuania	3.9E + 09	0.274	0.622	20	22	25	20
Romania	3.8E + 09	0.246	0.600	21	27	16	21
Slovakia	3.6E + 09	0.268	0.617	22	23	24	22
Slovenia	3.1E + 09	0.260	0.570	24	24	11	23
Portugal	3.4E + 09	0.251	0.616	23	26	23	24
Estonia	2.9E + 09	0.282	0.638	25	21	27	25
Ireland	2.7E + 09	0.309	0.647	26	19	28	26
Latvia	2.3E + 09	0.255	0.632	27	25	26	27
Bulgaria	1.8E + 09	0.216	0.609	28	28	21	28

The second group of states covers the EU average. More specifically, Austria, Greece, Finland, United Kingdom, and Luxembourg are characterized by a higher farming efficiency as compared to the EU average, whereas Hungary, Spain, Czech Republic, and Poland fall behind it.

The third group consists of Lithuania, Romania, Slovakia, Slovenia, Portugal, Estonia, Ireland, Latvia, and Bulgaria. With exceptions of Portugal and Ireland, this group encompasses the new EU Member States which are still undergoing transformations caused by the fall of the centrally planned economy. More specifically, the shortage of funds required for the modernization and labour-intensive mode of production prevents these states from gaining the competitive advantage.

Indeed, the old EU Member States (excluding Spain, Portugal, and Ireland) that acceded the EU before 2004 were ranked above the EU average. The two small economies of Malta and Cyprus exhibited a relatively high efficiency. This phenomenon might be explained by a dynamic adjustment to market peculiar to such small-scale economies.

As one can see, Poland holds the rank of 19, whereas the Baltic States remain beneath. Lithuania (ranked 20th) is the first among the remaining Baltic neighbours, since Estonia and Latvia were attributed with ranks 25 and 27, respectively. Meanwhile, Latvia and Bulgaria were the last two states according to farming efficiency. The further analysis, namely the application of DEA, will explain the underlying reasons for inefficiency as well as prospective challenges to agricultural development in these states.

In order to efficiently apply DEA to ratio data, an output-oriented DEA model without inputs (Halkos, Salamouris, 2004) was employed. Consequently, the three ratios, namely net value-added per AWU, crop output per hectare, and livestock output per LSU, were considered as outputs for DEA. Furthermore, the hypothetic inputs of 1 were defined for each DMU (i. e. Member State). The employed ISYDS / SIAD package (Angulo Meza et al., 2005) solved the CCR and BCC models. Given the nature and variation of the analysed data set, both models yielded the same results. The scale efficiency, therefore, was not estimated. TE is depicted in Fig. 9.

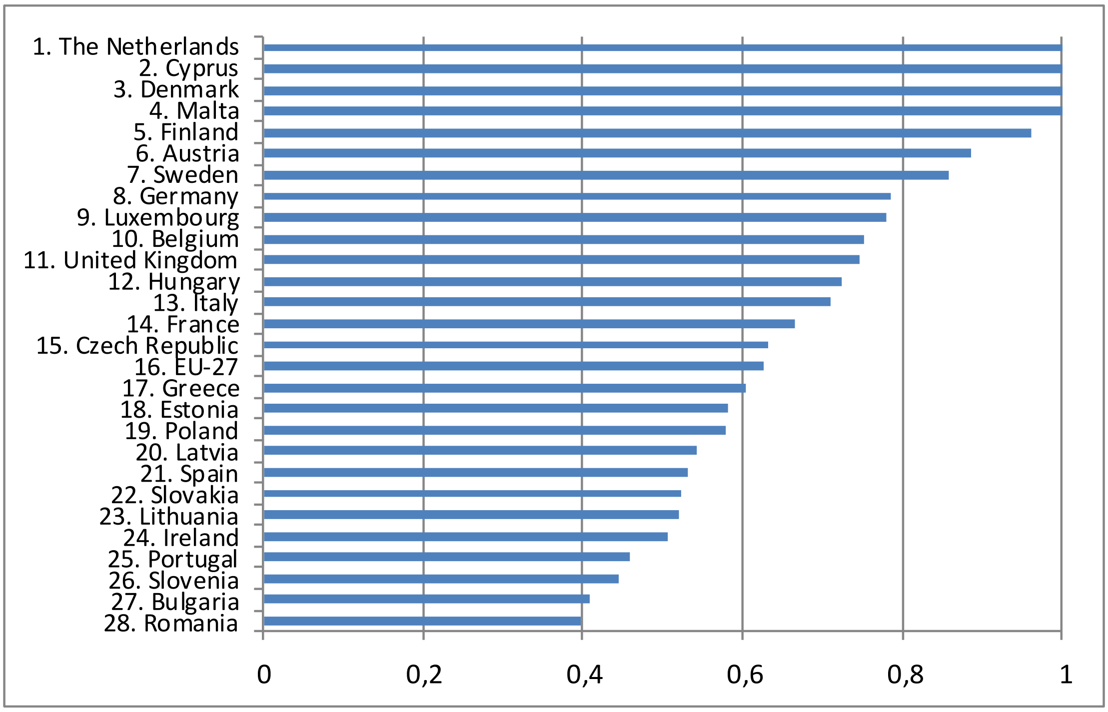

Fig. 9. Technical efficiency of farming in the EU Member States, 2008

As Fig. 9 suggests, there were four cases of efficient farming in 2008 among the EU Member States – in the Netherlands, Malta, Denmark, and Cyprus. Noteworthy, Rimkuvienė et al. (2010) also reported Malta and the Netherlands as states characterised by efficient farming. Indeed, only the Netherlands, Cyprus, and Denmark became peer DMUs for another 23, 19, and 5 states, respectively. The Netherlands were ranked as the most efficent state. Therefore, these states could be considered as examples of successful agricultural policy in the EU. The peer weights are lambda coefficients in Eqs. 5 and 6. By analysing these coefficients one can reveal the theoretical prospective development path for a certain DMU. As for Lithuania, these peer states would be Cyprus and the Netherlands. Obviously, some managerial aspects of the Cyprian agricultural policy could be implemented in Lithuania. On the other hand, modernization of the Lithuanian agricultural sector could be mainly based on the Netherlandish experience. According to the efficiency scores, Lithuania and Latvia reached the efficiency of 52 and 54 per cent, whereas Estonia and Poland – that of 58 per cent. Hence, the output indicators should be increased by respective margins in order to erradicate the radial inefficiency.

According to the results of DEA, Finland, Austria, Sweden, Germany, Luxembourg, Belgium, the United Kingdom, Hungary, Italy, France, and Czech Republic follow the aforementioned four states in the above order. The remaining states – Greece, Estonia, Poland, Latvia, Spain, Slovakia, Lithuania, Ireland, Portugal, Slovenia, Bulgaria, and Romania – were placed below the EU average. The mean TE for the old EU Member States (EU-15) was 75 per cent, whereas that for the new Member States (EU-12) accounted for 61.3 per cent, and the EU-27 average was 62.8 per cent. In this case, Estonia is attributed a higher rank as compared with Latvia and Estonia. Figure 3 shows the variation of ranks provided to certain EU Member States according to MULTIMOORA and DEA.

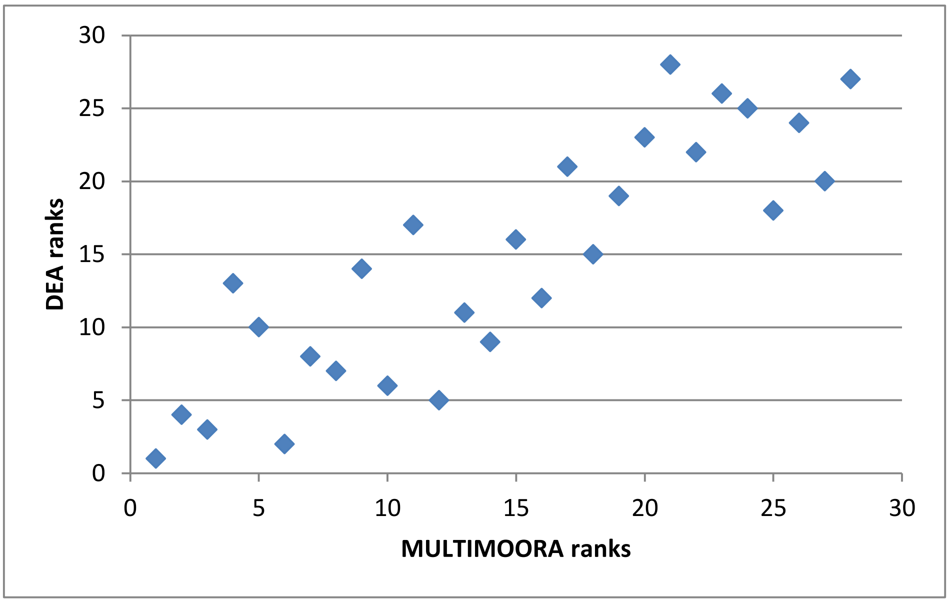

Fig. 10. The variation of ranks provided by DEA and MULTIMOORA for the EU Member States

As Fig. 10 suggests, the ranks provided by both means of analysis are distributed along the diagonal line meaning an indentical rating. Moreover, the correlation coefficient (R = 0.86) confirms these findings. Thus, it might be concluded that DEA and MULTIMOORA provide us with consistent rankings of the EU Member States with respect to their farming efficiency.

As mentioned before, the DEA enables to estimate the potential values of the variables under consideration. In case of output-oriented DEA model, one can obtain respective output targets for each DMU. Achieving these targets would place the respective DMU on the efficiency frontier. Figures 11–13 present these results.

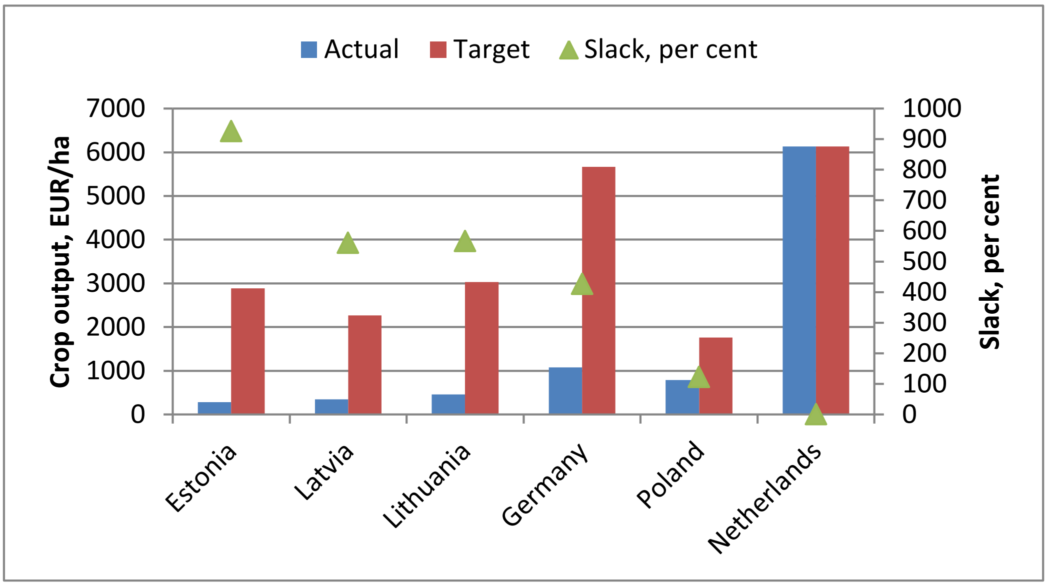

Fig. 11. Crop output targets and slacks for the selected EU Member States, 2008

Considering the selected countries, the largest absolute slack in crop production per ha was estimated for Germany (Fig. 11): in order to reach the efficiency frontier, the German crop output should increase from 1.2 thousand EUR/ha up to 5.7 thousand EUR/ha, i. e. by the margin of five times (growth of over 420 per cent). Latvia, however, should achieve the largest increase in relative terms, i. e. crop output here should increase tenfold. As Fig. 11 suggests, the three Baltic States should reach a similar level of crop output, whereas Germany should seek for much higher values. At the other end of the spectrum, a lower level of crop output was estimated for Poland, albeit it should still meet the increase of some 120 per cent. Noteworthy, the Netherlands were depicted in Fig. 11 since this is a peer country. These differences were caused by respective bundles of outputs peculiar to each states. In our case, they are related to differences in agricultural production structures and productivity across the EU Member States.

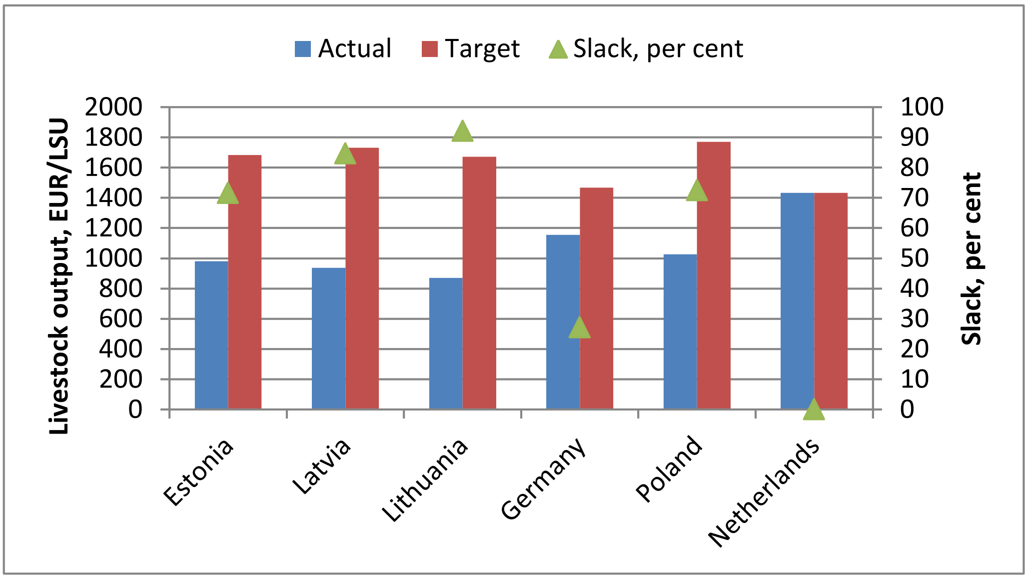

Fig. 12. Livestock output targets and slacks for selected EU Member States, 2008

Livestock output slacks are much lower for the selected states (Fig. 12). For instance, a target of 1761 EUR / LSU was estimated for Lithuania. However, Lithuania was attributed with the relatively highest slack. Given the Netherlands is not the sole peer country influencing lisvestock output targets for the selected states, the three Baltic States were attributed with output targets higher than those of the former country. These findings suggest that the Baltic States have some competitive advantage in husbandry. However, the relatively low livestock intensity in these states prevents them from approaching the efficiency frontier.

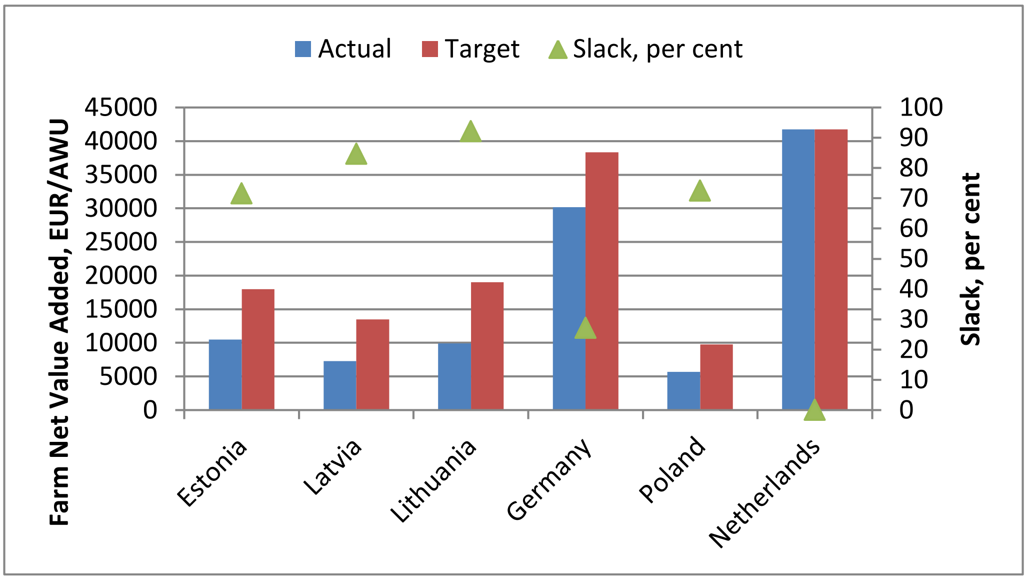

Fig. 13. Farm net value-added targets and slacks for selected EU Member States, 2008

The Baltic States and Poland are characterised by a relatively low labour productivity (Fig. 13). The slacks of net value-added per AWU account for 72–92 per cent. Indeed, these states have relatively high numbers of persons employed in agriculture. Thus, the labour-intensive agriculture should be transformed into the capital-intensive one there.

The high value of slacks in crop output (land productivity) and net value-added per AWU (labour productivity) in the three Baltic States indicate the necessity of qualitative and quantitative changes to be implemented here. More specifically, agricultural modernization should transform the current labour-intensive agricultural business into a more sophisticated one. Indeed, the value-added generated in agriculture mainly relies on productivity which, in turn, could be fostered by employing of state-of-the-art scientific knowledge and implementing innovative projects (Paunksnienė, Stalgienė, 2009).

Husbandry, nevertheless, remains the most efficient agricultural activity for these states. As Skurdenienė and Ribikauskas (2009) argued, milk production and pig farming are the activities suitable for Lithuanian climatic conditions. The low value of the livestock density index in Lithuania, Latvia, and Estonia exhibits the possible intensification to be achieved.

It is the EU financial support that indirectly shapes business decisions taken by farmers. The EU support, such as CAP payments and structural funds, should be distributed with respect to the objectives defined by such scientific methods as DEA. For instance, analysis of output slacks suggests that investment support could be mainly directed towards the new EU Member States, thus promoting the modernization of their agrucultural sectors.

Farming efficiency was evaluated across the EU Member States on the basis of data from FADN by the MCDM method MULTIMOORA and DEA. The derived economic indicators, namely the ratios (the total crop output per ha, total livestock output per LSU, and net value-added per AWU), were used as variables to evaluate farming efficiency instead of the typically used input–output variables. This choice led to the dimension reduction, which is an important feature of DEA. An output-oriented DEA model without inputs was therefore applied.

The EU Member States were ranked according to the indicator system by applying the MULTIMOORA method. The EU Member States were conditionally grouped into three groups, each of them encompassing high-, medium-, and low-performing states. The high-performance group the Netherlands, Malta, Denmark, Italy, Belgium, Cyprus, Germany, Sweden, and France. The third group consisted of Lithuania, Romania, Slovakia, Slovenia, Portugal, Estonia, Ireland, Latvia, and Bulgaria.

The application of DEA enabled to identify the main factors of inefficiency as well as the way of prospective development. As Fig. 9 suggests, there were four cases of efficient farming in 2008 among the EU Member States, i. e. in the Netherlands, Malta, Denmark, and Cyprus. Noteworthy, Rimkuvienė et al. (2010) also reported Malta and the Netherlands as states characterised by efficient farming. Considering the number of cases when a certain state is a peer DMU for another state, the Netherlands were ranked as the most efficent state. According to the results of DEA, Finland, Austria, Sweden, Germany, Luxembourg, Belgium, the United Kingdom, Hungary, Italy, France, and Czech Republic followed the aforementioned four states exactly in this order.

The research, though, was focused on the single period, namely year 2008. Therefore, further researches based on the longitudinal data are needed. For instance, Malta and Cyprus descended by at least several positions in terms of the investigated variables describing the productivity of different production factors, whereas Hungary and the Czech Republic improved their postitions.

According to the DEA efficiency scores, Lithuania and Latvia reached the efficiency of 52 and 54 per cent, whereas Estonia and Poland that of 58 per cent. Hence, the output indicators should be increased by respective margins in order to eradicate the radial inefficiency. A purely mathematical analysis suggests the Netherlands and Cyprus being the prospective examples for the Baltic States in the area of agricultural development.

The high value of slacks in crop output (land productivity) and the net value added per AWU (labour productivity) for the three Baltic States indicates the necessity of qualitative and quantitative changes to be implemented here. More specifically, agricultural modernization should transform the current labour-intensive agricultural business into a more sophisticated one. Husbandry, nevertheless, remain the prospective activity for the Baltic States. However, livestock intensity there should approach the sustainable level. The EU support in the form of CAP payments and structural funds should be distributed with respect to the objectives defined by such scientific methods as DEA.

4. 1. 2. Efficiency Across Farming Types

The effective decision making aimed at sustainable change requires appropriate benchmarking practices. More specifically, the sustainable change can be fostered through benchmarking-based comparative analysis which enables to identify the best practices and thus improve the situation. As Jack and Boone (2009) reported with reference to Bogan and English (1994), benchmarking can (i) create motivation for change; (ii) provide a vision for what an organization can look like after change; (iii) provide data, evidence, and success stories for inspiring change; (iv) identify best practices for how to manage change; and (v) create a baseline or yardstick by which to evaluate the impact of earlier changes. Moreover, steady growth in productivity and efficiency leads to non-inflationary economic growth, which, in turn, results in reduced unemployment rate and increased earnings.

The issue is of the particular importance in the area of the agricultural policy. As for the European Union (EU) Member States, it is important to streamline the structural and income support policies so that they lead to increase in efficiency as well as competitiveness of the agricultural sector (OECD, FAO, 2011). Therefore, the appropriate benchmarking system would improve the quality of decisions taken by farmers, farmer advisors, and policy makers.

Moreover, the Central and East European countries are specific with relatively high importance of the agriculture in the total economy. The latter finding makes agricultural policy especially important here. Usually, the benchmarking processes are based on Key Performance Indicators. Indeed, the multi–criteria assessment should be employed for the analysis, for these indicators are usually conflicting ones and should be considered simultaneously. There is, however, a lack of international comparison of farming efficiency across different farming types. Hence, this study focuses on farming efficiency of the different farming types across the EU Member States.

Data envelopment analysis (DEA) is suitable for the latter purpose. A number of studies have attempted to investigate the issues of efficiency and competitiveness (Kriščiukaitienė et al., 2010). Indeed, DEA is a method widely applied for efficiency assessment in agriculture (Van Zyl et al., 1996; Odeck, 2009; Vinciūnienė, Rauluškevičienė, 2009; Bojnec and Latruffe, 2008; Van Passel et al., 2009). Gorton and Davidova (2004) provided an overview of papers on farm productivity and efficiency. Rimkuvienė et al. (2010) and Baležentis and Baležentis (2011) have performed an international comparison of the EU Member States' achievements in rural development. Nevertheless, there is a lack of such comparison across different farming types.

The aim of this sub-section is to apply the benchmarking method and thus reveal the competitive advantages of the Lithuanian agricultural sector by comparing efficiency of different farming types. More specifically, this paper focuses at the three Baltic States given the fact that they are specific with similar geo-political environment as well as production structure. However, the farming efficiency in these states is estimated in relative terms with respect to the EU-27 states. The following tasks are set: 1) to describe the DEA method; 2) to define variables identifying farming efficiency; and 3) to apply the DEA model when analyzing efficiency of different farming types. The research is based on Farm Accountancy Data Network (FADN) data covering the period of 2009 (European Commission, 2011b). The DEA model was implemented by employing *R* language, namely package *Benchmarking* (Bogetoft, Otto, 2011).

As it was mentioned before, our analysis was based on FADN data. More specifically, the TF8 farming type classification was employed for the analysis. The latter classification defines the following eight farming types: Fieldcrops; Horticulture; Wine; Other permanent crops; Milk; Other grazing livestock; Granivores; Mixed. In addition, the aggregate category (Total) is defined for each Member State. Given the fact that wine is not produced in the Baltic States we did not take into account the latter farming type. Thus the total number of observations accounted for 170 (8 farming types x 27 Member States minus 46 missing observations).

The farming efficiency was estimated in terms of input and output indicators. The following input indicators covered the land, labour, and capital factors employed in agricultural production: utilised agricultural area (UAA) in hectares (ha), total labour in Annual Working Units (AWU), total assets in EUR, and intermediate consumption in EUR. The output indicators identify crop, livestock, and other output (in EUR). The applied output decomposition enabled to distinguish between different production structures specific to certain farming types. The DEA minimizes input and maximizes output indicators when calculating efficiency scores.

The *R* package *Benchmarking* (Bogetoft, Otto, 2011) was employed for DEA computations described in the antecedent section. More specifically, the output-oriented DEA model was applied, for agricultural producers can increase outputs by means of modernization, whereas inputs are less likely to be altered.

The main findings are presented in Fig. 14 which depicts VRS technical efficiency across the three Baltic States and Poland. In this case Poland was chosen as the most proximate state peculiar with similar geo-political environment. The last group of columns in Fig. 14 describes the overall technical efficiency of farming in the enumerated states. More specifically, Latvia was ranked the first (TE=0.7), whereas Estonia (TE=0.67), Lithuania (TE=0.62), and Poland (TE=0.6) remained behind. As for Lithuania, the most efficient farming types were horticulture (TE=0.81), other permanent crops (fruits and permanent crops combined; TE=0.79), milk (TE=0.74), and mixed farming (TE=0.7), in that order. Meanwhile other permanent crop farming and granivore farming appeared to be fully efficient in Estonia, whereas the same types plus dairying were fully efficient in Latvia. However, FADN did not provide data for granivore farming in Lithuania and horticulture in Latvia.

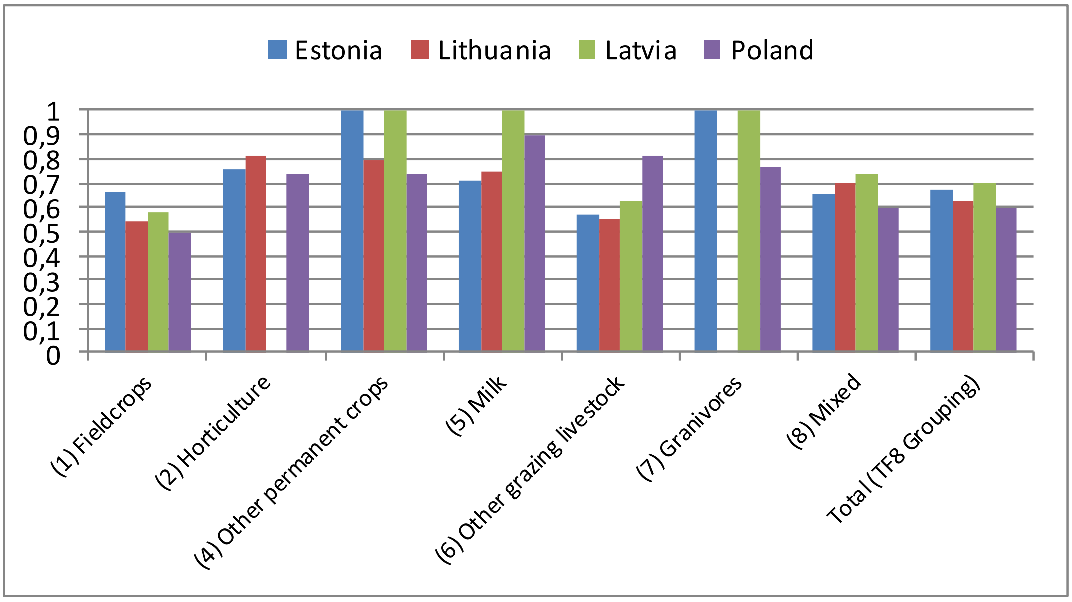

Fig. 14. Technical efficiency of various farming types across the selected states, 2009

These differences in TE, however, are impacted by the nature of different farming types. Hence further analysis is needed for each particular farming type. For instance, the mean efficiency of granivore farming was 0.86, horticulture – 0.85, other permanent crops – 0.81, dairying – 0.71 (as of 2009). The competitive advantages in this case can be revealed by comparing, for instance, Lithuanian TE and EU-27 TE for specific farming type. The latter ratio and technical efficiency for each farming type are depicted in Fig. 15. As one can note, the highest competitive advantage was observed for mixed farming and dairying. These farming types were more efficient than the average EU farm specialised in respective area (ratios 1.12 and 1.04, respectively). The previously mentioned farming types—horticulture and other permanent crops (fruits and permanent crops combined—were also approaching the mean EU efficiency for certain farming type (ratios 0.95 and 0.97, respectively).

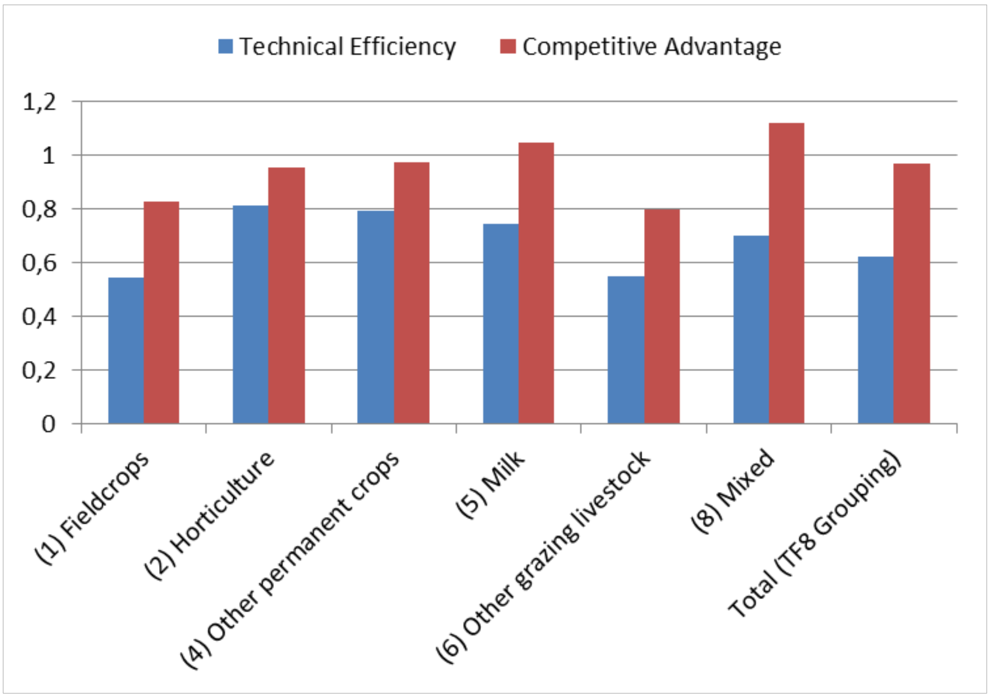

Fig. 15. Technical efficiency and competitive advantage of various farming types in Lithuania, 2009

For Lithuania, the most prospective farming types in terms of international competitiveness are those related to cattle production, namely dairying (milk) and mixed farming. Indeed, Lithuania is specific with high availability of feed. Furthermore, the dairying sector underwent some kind of modernization even before Lithuania acceded to the EU. Hence, milk products are being exported to both the EU and third countries thus constituting a stable source of income. The enumerated advantages, however, are likely to shrink in the future, mainly because of growing wages and other expenditures. In addition, the current absolute level of intermediate consumption might lead to high values of efficiency measures, albeit it is not sufficient to provide momentum for the Lithuanian farmers' graduation in the commodity chain. Noteworthy, the increased activity of animal farming would in turn lead to increase in demand for feed. To conclude, the new Rural Development Programme as well as agricultural policy in general should be focused on support of the farming types which contribute to increase in export.

To cap it all, the farming efficiency was estimated in terms of input and output indicators. The output-oriented data envelopment analysis model was applied for the analysis. Comparison of the selected EU Member States showed that the Latvian agricultural sector was ranked the first (TE=0.7), whereas Estonia (TE=0.67), Lithuania (TE=0.62), and Poland (TE=0.6) remained behind (as of 2009). For Lithuania, the most prospective farming types in terms of international competitiveness are those related to animal farming, namely dairying (milk) and mixed farming. Indeed, this situation is due to low production costs. Accordingly, the new Rural Development Programme as well as the agricultural policy in general should be focused on support of the farming types which contribute to increase in export. The public support could be delivered through income and structural support measures as well as institutional alleviations (establishment of farmers' markets). The current level of intermediate consumption is relatively high in Lithuania if compared to other EU states. However, it still might not be sufficient in absolute terms to modernize the agricultural production and thus successfully compete in the common market. In this context, the pressure on a more reasonable CAP payments' distribution among the EU Member States becomes especially important. The FADN practice can be improved by establishing the uniform estimation of input costs. For instance labour costs and capital depreciation costs remain the most problematic issues. Thereafter, the allocative efficiency of farming could be estimated.

4. 2. Farming Types and their Performance in Lithuania

4. 2. 1. Efficiency Analysis

Reasonable strategic decision making requires an integrated assessment of the regulated sector. The agricultural sector is related to voluminous public support as well as regulations. The application of benchmarking, thus, becomes especially important when fostering sustainable agricultural development. Furthermore, productive efficiency gains might result into lower costs as well as greater profit margins for the producer and better prices for the participants in the agricultural supply chain (Samarajeewa et al., 2012). It is due to Alvarez and Arias (2004) and Gorton and Davidova (2004) that frontier techniques are the most widely applied methods for measuring efficiency in agriculture. Indeed, the frontier methods can be grouped into parametric and non-parametric ones (Bogetoft, Otto, 2011).

The parametric frontier methods rely on assumption that inefficiency can be caused by technical draw-backs as well as random errors. However, the exact production function needs to be specified for these models. On the other side, non-parametric frontier methods do not allow statistical noise and thus the whole distance between the observation and production frontier is explained by inefficiency. In addition, the production frontier (surface) is defined by enveloping linearly independent points (observations) and does not require subjective specification. Therefore non-parametric models are easier to be implemented. Stochastic frontier analysis and data envelopment analysis (DEA) are the two seminal methods for, respectively, parametric and non-parametric analysis.

The Lithuanian agricultural sector was analysed by employing non-parametric methods, DEA and free disposal hull (Vinciūnienė, Rauluškevičienė, 2009; Rimkuvienė et al., 2010; Baležentis, Baležentis, 2011c). These studies, however, paid less attention to efficiency differences across farming types. Thus there is a need to further analyse these issues.

This chapter researches into family farms' efficiency dynamics across different farming types in Lithuania and to define possible managerial improvements leading to its increase. The research covers years 2003–2010. The aggregate FADN indicators describing performance across different farming types were employed for the analysis. The *R* programming language and package *FEAR* (Wilson, 2010) were employed to implement the DEA model.

The research relies on aggregate data. As for benchmarking in agriculture, the FADN is the most elaborated data source. The FADN reports (Ūkių ..., 2011) provide with the relevant data describing performance of family farms with respect to farming type, farm size, and geographic location. This paper focuses on the first option. The farming type assigned to certain farm depends on its output structure in terms of production value. In our case, nine alternatives were considered, namely eight different farming types and one average value

Usually, the following main variables presented in FADN reports are considered when analysing the farming efficiency (Douarin, Latruffe, 2011; Bojnec, Latruffe, 2008): output (Lt), utilized land area (ha), labour (AWU), total assets (Lt), and intermediate consumption (Lt). These four input indicators and one output indicator were thus chosen for further analysis. The data cover the period of 2003–2009. Firstly, the three indicators expressed in monetary terms were deflated by employing respective agricultural input or output price indexes provided by EUROSTAT. Secondly, output was divided by each of the four input indicators. Therefore, the four output indicators were defined for DEA, namely land productivity (Lt/ha), labour productivity (Lt/AWU), return on assets (%), and intermediate consumption productivity (times).

As one can note, the four indicators are measured in different dimensions. The first two indicators were obtained by dividing output by utilized agricultural area and labour input. The third indicator measures return on assets (ROA) and was calculated by dividing output by the total assets. This ratio can be multiplied by 100% and thus expressed as a percentage. The last indicator identifies the efficiency of employment of the working capital, namely seeds, fertilizers, feedstuffs, and farming overheads.

The relative farming efficiency (i. e. technical efficiency) was estimated by DEA method across different faring types during 2003–2010 (Table 4). The *FEAR* package was employed for the analysis (Wilson, 2010).

Table 4. Productive efficiency across farming types in Lithuania, 2003–2010

Period	1. All farms	2. Specialist cereals, oilseeds	3. General field cropping	4. Horticulture, permanent crops	5. Specialist dairying	6. Mixed cropping	7. Mixed livestock, grazing	8. Field crops – grazing livestock	9. Field crops – granivores, pigs
2003	0.871	0.891	0.825	0.983	0.872	0.935	1.000	0.936	0.939
2004	0.867	0.945	0.912	1.000	0.832	0.870	0.965	0.849	1.000
2005	0.765	0.792	0.768	0.796	0.771	0.860	0.835	0.774	0.800
2006	0.853	0.848	0.867	1.000	0.813	0.984	0.922	0.858	1.000
2007	0.859	0.872	0.827	1.000	0.840	1.000	0.955	0.853	0.859
2008	0.884	0.852	0.898	0.950	0.851	1.000	1.000	0.929	0.829
2009	0.883	0.897	0.907	0.817	0.848	0.975	0.961	0.924	0.860
2010	0.922	0.923	0.918	0.942	0.898			0.912	
Average	**0.863**	**0.878**	**0.865**	**0.936**	**0.841**	**0.946**	**0.948**	**0.879**	**0.898**

According to data in Table 4, the efficiency of an average Lithuanian farm fluctuated between 76.5% and 92.2% throughout 2003–2010. In addition, it had been somehow subdued during 2005–2007.

Mixed crop and mixed livestock (mainly grazing) farming was peculiar with the highest TE estimate for the period of 2003–2010. Indeed, the FADN report of 2010 did not cover these two farming types. Horticulture, however, remained the third most efficient farming type throughout the research period. The latter farming type, though, had also been facing the decreasing efficiency since 2008. To be specific, TE decreased by some 4 percentage points. Nevertheless, the mean efficiency placed this farming type in the third place.

Meanwhile, the dairying remained the most inefficient farming type, albeit it managed to improve its efficiency score from 87% in 2003 up to some 90% in 2010. The steepest increase in efficiency was observed for general field cropping (from 82.5% up to 91.8%), whereas mixed field crop – granivore (pig) farms exhibited the most significant decrease in efficiency (from 93.9% down to 86%).

Indeed, the efficiency scores themselves give little information about the underlying causes of inefficiency. The DEA method, however, offers an additional measure for the latter purpose, namely slacks. For the output-oriented DEA model, slack shows how much certain output should be increased—given inputs remain fixed—for a DMU in order to approach a production frontier. The following Tables 5–7 report relative slacks, i. e. percentage of actual outputs, across different periods and farming types.

Table 5. Slacks for long term assets productivity (ROA), 2003–2010

Period	1.	2.	3.	4.	5.	6.	7.	8.	9.	Average
2003	0.0	12.5	2.0	0.0	0.0	0.0	0.0	0.0	0.0	**1.6**
2004	4.2	55.5	60.0	0.0	5.9	0.0	0.0	0.0	0.0	**14.0**
2005	20.5	115.9	89.0	28.1	32.3	0.0	0.0	30.2	2.5	**35.4**
2006	4.9	53.8	40.3	0.0	11.4	0.0	1.3	6.7	0.0	**13.2**
2007	15.0	63.6	19.9	0.0	21.2	0.0	5.8	8.8	0.0	**14.9**
2008	2.6	48.6	17.2	19.1	0.0	0.0	0.0	0.0	0.0	**9.7**
2009	33.7	108.5	50.9	20.9	27.6	4.4	17.3	30.5	21.7	**35.1**
2010	43.8	167.3	83.8	14.9	27.8			37.2		**62.5**
Average	**15.6**	**78.2**	**45.4**	**10.4**	**15.8**	**0.6**	**3.5**	**14.2**	**3.5**	**21.6**

The mean slack for long term assets productivity (ROA) was 21.6% (cf. Table 5). To be specific, the highest mean values of such slacks were observed for specialist cereal farming and general field cropping, 78 and 45%, respectively. It might be related to (i) inappropriate machinery allocation and (ii) accounting discrepancies. The former issue can be tackled by encouraging machinery sharing practices (Раманаускас, 2011), whereas the latter one – by improvement of the methodological basis of financial accounting.

The lowest slacks of ROA were observed for mixed farming, namely cropping, livestock (mainly grazing), and field cropping – granivores (pigs).

Table 6. Slacks for intermediate consumption productivity, 2003–2010

Period	1.	2.	3.	4.	5.	6.	7.	8.	9.	Average
2003	54.6	27.6	12.2	54.5	51.5	45.0	0.0	43.4	27.3	**35.1**
2004	0.0	42.4	30.8	0.0	0.0	0.0	11.9	3.4	0.0	**9.8**
2005	0.0	108.1	58.8	0.0	0.0	10.2	0.0	0.0	59.6	**26.3**
2006	0.0	48.1	2.3	0.0	0.0	0.0	0.0	0.0	0.0	**5.6**
2007	0.0	41.0	0.0	0.0	0.0	0.0	0.0	0.0	43.6	**9.4**
2008	0.0	33.6	0.0	0.0	0.0	0.0	0.0	0.0	28.4	**6.9**
2009	0.0	58.6	8.4	63.5	0.0	0.0	0.0	0.0	55.2	**20.6**
2010	0.0	62.7	4.4	49.8	0.0			0.0		**19.5**
Average	**6.8**	**52.8**	**14.6**	**21.0**	**6.4**	**7.9**	**1.7**	**5.8**	**30.6**	**16.5**

The intermediate consumption productivity slacks were less scattered across farming types if compared to ROA or land productivity slacks (see Table 6). The mean value of 16.5% was observed for all farming types. Indeed, the highest mean slack was estimated for specialist cereal farming (52.8%) and was followed by field cropping – granivores (pigs) and horticulture, permanent crops (30.6% and 21%, respectively). The high slack values for crop farming might be related to underperforming land amelioration system, whereas swine farming suffers from inefficient feeding stuff structure. Thus appropriate scientific research and institutional incentives should be aimed at these issues.

Table 7. Slacks for land productivity, 2003–2010

Period	1.	2.	3.	4.	5.	6.	7.	8.	9.	Average
2003	64.7	205.7	105.6	0.0	42.4	21.6	0.0	45.0	6.5	**54.6**
2004	49.8	211.6	132.2	0.0	32.1	4.6	8.4	31.5	0.0	**52.2**
2005	74.5	361.0	172.6	0.0	42.7	5.8	0.0	65.5	0.0	**80.2**
2006	42.0	250.3	84.1	0.0	18.9	0.0	10.0	32.0	0.0	**48.6**
2007	53.8	222.4	62.7	0.0	15.6	0.0	15.2	40.3	0.0	**45.5**
2008	61.7	235.3	71.8	0.0	9.3	0.0	0.0	47.8	0.0	**47.3**
2009	54.5	228.7	71.4	0.0	12.8	0.0	13.6	50.5	0.0	**47.9**
2010	50.0	271.2	80.2	0.0	12.1			58.9		**78.7**
Average	**56.4**	**248.3**	**97.6**	**0.0**	**23.2**	**4.6**	**6.7**	**46.4**	**0.9**	**56.0**

The labour productivity slacks are not presented here, for only one of observations was attributed with slack of this type. This finding, thus, offers some insights. First, labour plays an insignificant role at the aggregate level. A farm-level analysis, though, might support or reject the hypothesis about labour impact on output and efficiency. Second, FADN practice could be improved in terms of working time estimations.

The analysis showed that the land productivity is the most problematic indicator for the Lithuanian family farming (Table 7). The mean value of some 56% was observed for an average farm. Horticulture and field cropping – granivores (pigs) exhibited zero slacks. This can be explained by production specifics: indeed, these farming types require lesser amounts of land and higher land productivity thus becomes an intrinsic characteristic thereof. At the other end of spectrum, specialist cereals and general field cropping were specific with the highest slack values (averages of 248.3% and 97.6%, respectively). Hence, the incentives for crop structure adjustment should be imposed in order to increase land productivity.

To sum up, efficiency of an average Lithuanian farm fluctuated between 76.5% and 92.2% throughout 2003–2010. In addition, it had been somehow subdued during 2005–2007. Indeed, the mixed crop and mixed livestock (mainly grazing) farming was peculiar with the highest TE estimate for the period of 2003–2010. Meanwhile, dairying remained the most inefficient farming type, albeit it managed to improve its efficiency score. The observed inefficiency might be explained by overcapitalization and low land productivity. The shrinking horticultural efficiency is also affected by low returns on intermediate consumption. The steepest increase in efficiency was observed for general field cropping.

Slack analysis revealed that low land productivity, returns on assets, and intermediate consumption productivity are the most important sources of the inefficiency, in that order. Low land productivity is especially important for specialised cereals and general field cropping. Therefore, the incentives for crop structure adjustment should be imposed in order to increase land productivity. The highest mean values of return on assets slacks were observed for specialist cereal farming and general field cropping. The latter issue can be tackled by increasing technological knowledge on enhanced farming management, by encouraging machinery sharing practices, and by improving the methodological basis of financial accounting. Labour productivity slacks showed that labour plays an insignificant role at the aggregate level analysis. Therefore further studies should employ a farm-level analysis, whereas FADN practice needs to be improved in terms of working time estimations.

4. 2. 2. Estimation of the Total Factor Productivity Change

The measurement and analysis of efficiency and productivity constitutes the fundament of the managerial economics. Indeed, appropriate strategic management decisions should be made with respect to perception of trends in productivity of sector under analysis.

The agricultural sector has always been related to certain governmental regulations and support (OECD and FAO, 2011). It is, therefore, important to design and implement an appropriate agricultural policy. The streamlined agricultural policy, specific with rapid response to changes, should alleviate market distortions and provide with incentives for sustainable initiatives. Thus it is necessary to measure and analyse trends of efficiency and productivity in the agricultural sector.

These issues are of particular importance in Lithuania, which, like other post-communist Central and East European states, is peculiar with relatively high significance of the agricultural sector and to some extent still faces the consequences of collectivization (Gorton, Davidova, 2004). The process of de-collectivization in Lithuania started in 1989 and reached its peak in 1992–1993. Since then the Lithuanian agricultural sector has undergone a serious transformation. Lithuania acceded to the European Union (EU) in 2004 and since the Common Agricultural Policy is implemented there.

One of the most elaborated means for efficiency measurement is DEA, see, for instance, studies by Murillo-Zamorano (2004) and Knežević et al. (2011). Accordingly, various studies employed DEA for efficiency and productivity analysis in agriculture (Alvares, Arias, 2004; Gorton, Davidova, 2004; Douarin, Latruffe, 2011). However, efficiency's estimates are not enough to identify the underlying trends of productivity. Therefore, the Malmquist productivity index is employed to measure changes in the total factor productivity (Mahlberg et al., 2011; Sufian, 2010, 2011). Furthermore, the DEA is suitable for providing distance function estimates which are wherewithal components of the Malmquist productivity index.

This sub-section focuses on the Lithuanian agricultural sector, namely family farms reporting to the FADN. More specifically, the Malmquist productivity index is employed to analyse productivity changes and thus define respective policy implications. The research covers the period of 2003–2009.

The research relies on the aggregate data. As for benchmarking in agriculture, the FADN is the most elaborated data source. The FADN reports (Ūkių ..., 2010) provide with the relevant data describing performance of family farms with respect to farming type, farm size, and geographic location. This paper focuses on the first option. The farming type assigned to certain farm depends on its output structure in terms of production value. In our case, nine alternatives were considered, namely eight different farming types and one average value (Table 8).

Table 8. Farming types and respective notations

Abbreviation	Farming type
CEREAL	Specialist cereals, oilseeds
CROP	General field cropping
HORT	Horticulture, permanent crops
DAIRY	Specialist dairying
MCROP	Mixed cropping
MLGRZ	Mixed livestock, grazing
MCRGRZ	Field crops – grazing livestock
MCRGRN	Field crops – granivores, pigs
ALL	All farms

Usually, the following main variables presented in FADN reports are considered when analyzing the farming efficiency (Rimkuvienė et al., 2010; Bojnec, Latruffe, 2008): output (Lt), utilized land area (ha), labour (AWU), total assets (Lt), and intermediate consumption (Lt). These four input indicators and one output indicator were thus chosen for further analysis. The data cover the period of 2003–2009. Firstly, the three indicators expressed in monetary terms were deflated by employing respective agricultural input or output price indexes provided by EUROSTAT. Secondly, output was divided by each of the four input indicators. Therefore, the four output indicators were defined for DEA, namely land productivity (Lt/ha), labour productivity (Lt/AWU), return on assets (per cent), and intermediate consumption productivity (times).

As one can note, the four indicators are measured in different dimensions. The first two indicators were obtained by dividing output by utilized agricultural area and labour input. The third indicator measures return on assets (ROA) and was calculated by dividing output by the total assets. This ratio can be multiplied by 100 per cent and thus expressed as a percentage. The last indicator identifies the efficiency of employment of the working capital, namely seeds, fertilizers, feedstuffs, and farming overheads.

Considering the average values for 2003–2009, the following findings are valid. The highest land productivity was observed for horticulture and permanent crop farming, whereas the highest labour productivity was reached in general field cropping farms. Meanwhile, the mixed field crop – granivore, pig farms were specific with the maximum ROA. Finally, the utmost intermediate consumption productivity was achieved in horticulture and permanent crop farming. Therefore, there is no single type of farming peculiar with the maximal values of the observed indicators. Accordingly, an application of MCDM method will enable to tackle all the objectives simultaneously.

The relative farming efficiency (i. e. technical efficiency) was estimated by DEA method across different faring types during 2003–2009 (Table 9). The *FEAR* package was employed for the analysis (Wilson, 2010).

Table 9. Technical efficiency across farming types, 2003–2009

Period	CEREAL	CROP	HORT	DAIRY	MCROP	MLGRZ	MCRGRZ	MCRGRN	ALL
2003	1.000	0.926	1.000	0.931	1.000	1.000	1.000	1.000	0.930
2004	0.945	0.912	1.000	0.847	0.932	1.000	0.878	1.000	0.886
2005	1.000	0.972	1.000	0.971	1.000	0.993	0.980	0.991	0.965
2006	0.957	0.978	1.000	0.885	1.000	0.960	0.932	1.000	0.927
2007	0.972	0.916	1.000	0.902	1.000	0.994	0.906	0.882	0.930
2008	0.951	0.989	1.000	0.892	1.000	1.000	0.978	0.897	0.946
2009	0.989	1.000	1.000	0.905	1.000	1.000	0.991	0.917	0.958
Average	**0.973**	**0.955**	**1.000**	**0.904**	**0.990**	**0.992**	**0.951**	**0.954**	**0.934**

As Table 9 suggests, horticultural farms were operating relatively efficiently throughout the whole research period. However, this finding does not imply that these farms were operating truly efficiently; indeed, there was just no any linear combination of other farming types indicating possible output improvement. As of 2008–2009 TFP growth in specialist dairying, mixed cropping, mixed livestock (mainly grazing), and mixed field crops – grazing livestock farms was lower if compared to the average. In general, crop farming was peculiar with higher TE if compared to livestock farming. Dairying farms exhibited the lowest TE. The last columns of Tables 10–12 exhibit TE estimate of an average Lithuanian family farm. This value, hence, can be considered as a yardstick for distinguishing between better performing and underperforming farming types.

The technical efficiency, however, is a static measure and does not provide one with information about productivity changes, Therefore, the DEA-based Malmquist index was employed. Table 10 describes period–wise analysis of TFP changes across different farming types in Lithuania.

Table 10. TFP changes (Malmquist productivity index) for different farming types, 2003–2009

Period	CEREAL	CROP	HORT	DAIRY	MCROP	MLGRZ	MCRGRZ	MCRGRN	ALL
2003–2004	1.061	1.105	1.096	0.962	0.948	0.973	0.933	1.083	1.007
2004–2005	0.837	0.842	0.810	0.928	0.962	0.874	0.922	0.790	0.884
2005–2006	1.072	1.129	1.341	1.027	1.185	1.104	1.071	1.214	1.081
2006–2007	1.028	0.947	0.966	1.031	0.984	1.051	0.985	0.862	1.016
2007–2008	0.978	1.080	0.899	0.990	1.085	1.023	1.079	0.973	1.016
2008–2009	1.052	1.021	0.875	1.002	0.861	0.927	1.006	1.043	1.013
Average	**1.001**	**1.016**	**0.983**	**0.989**	**0.999**	**0.989**	**0.997**	**0.984**	**1.001**

TFP had been increasing for the average Lithuanian farm during 2003–2004 and since 2005. However, the observed growth rate fluctuated around 1 per cent since 2006. Such a trend clearly exhibited a need for technological and institutional innovations in the Lithuanian agricultural sector. Indeed, the changes in TFP varied across farming types. For instance, horticulture—the most technically efficient farming type—exhibited significant TFP growth, namely 34 per cent in 2005–2006 and subsequent decreases of 3.4 to 12.5 per cent. This case exactly illustrated the possibilities of Malmquist index to identify shrinking TFP in spite of stable TE. The highest TFP growth rate was observed for general field cropping. The following Tables 4 and 5 decompose TFP into EC and TC, respectively.

Table 11. Efficiency changes (catch-up) across different farming types, 2003–2009

Period	CEREAL	CROP	HORT	DAIRY	MCROP	MLGRZ	MCRGRZ	MCRGRN	ALL
2003–2004	0.945	0.985	1.000	0.910	0.932	1.000	0.878	1.000	0.953
2004–2005	1.058	1.066	1.000	1.147	1.074	0.993	1.116	0.991	1.090
2005–2006	0.957	1.006	1.000	0.912	1.000	0.967	0.952	1.009	0.961
2006–2007	1.016	0.937	1.000	1.018	1.000	1.035	0.972	0.882	1.003
2007–2008	0.978	1.080	1.000	0.990	1.000	1.006	1.079	1.017	1.016
2008–2009	1.040	1.012	1.000	1.014	1.000	1.000	1.014	1.022	1.013
Average	**0.998**	**1.013**	**1.000**	**0.995**	**1.000**	**1.000**	**0.999**	**0.986**	**1.005**

Table 12. Technical changes across different farming types, 2003–2009

Period	CEREAL	CROP	HORT	DAIRY	MCROP	MLGRZ	MCRGRZ	MCRGRN	ALL
2003–2004	1.122	1.122	1.096	1.058	1.017	0.973	1.063	1.083	1.057
2004–2005	0.791	0.790	0.810	0.810	0.896	0.880	0.826	0.796	0.811
2005–2006	1.120	1.122	1.341	1.126	1.185	1.141	1.125	1.203	1.125
2006–2007	1.012	1.012	0.966	1.013	0.984	1.015	1.013	0.978	1.012
2007–2008	1.000	1.000	0.899	1.000	1.085	1.017	1.000	0.957	1.000
2008–2009	1.011	1.010	0.875	0.988	0.861	0.927	0.992	1.020	1.001
Average	**1.003**	**1.003**	**0.983**	**0.994**	**0.999**	**0.989**	**0.999**	**0.998**	**0.996**

Given the data in Tables 11 and 12, the decreasing TFP in horticulture was mainly linked to technical changes: the frontier moved inwards and hence more inputs are needed to sustain the same level of outputs. Meanwhile, TFP shifts in general field cropping were driven by efficiency changes (catching–up). Furthermore, specialist dairying, mixed cropping, mixed livestock (mainly grazing), mixed field crops – grazing livestock, and mixed field crops – granivores, pigs farming also faced technical changes that reduced their TFP at a higher rate if compared to the average farm.

The analysis therefore showed that the total factor productivity in the Lithuanian family farms had been decreasing throughout 2004–2005, and has been recovering by 1.3–8.1 per cent annually. However, technical change contributed to the increase in the total factor productivity rather insignificantly. Therefore, it might be concluded that the Lithuanian agricultural sector still requires investments which, in turn, could lead to modernization of the production processes. Indeed, the relatively efficient sectors—for instance, horticulture, mixed farming—were specific with diminishing total factor productivity. Therefore, there should be a substantial incentives developed for productivity improvements in these sectors.

Further studies should address each particular sectors and determinants of efficiency therein. Furthermore, such measures as super-efficiency should also be employed for more robust analysis.

5. CONCLUSIONS

The non-parametric deterministic method DEA as well as Malmquist TFP index were employed to assess the efficiency and productivity change of the Lithuanian agricultural sector. Specifically, the agricultural sector was compared to the remaining sectors of the Lithuanian economy, whereas family farm performance was analysed both in the EU and local context.

The DEA-based inter-sectoral analysis indicated that the agricultural sector should expand its output by some 60% in order to approach the efficiency frontier defined by the remaining economic sectors in Lithuania. The EU support had certainly decreased the technical efficiency in the short run thanks to increased capital consumption, which, in turn, was fuelled by inflated prices of machinery and equipment. It is therefore important to further improve the EU support policies and provide farmers and agricultural companies with appropriate decision support tools, which could lead to increasing efficiency in the long run. Anyway, the agricultural sector managed to increase its relative efficiency during 2009–2010 in spite of the economic crisis.

The DEA and multi-criteria decision making method MULTIMOORA were applied under unified framework to facilitate an international comparison of farming efficiency. The agricultural efficiency was assessed with respect to the three ratios, namely crop output (EUR) per ha, livestock output (EUR) per LSU, and farm net value added (EUR) per AWU. Therefore, the land, livestock, and labour productivity were estimated. According to the DEA efficiency scores, Lithuania and Latvia reached the efficiency of 52 and 54%, whereas Estonia and Poland that of 58%. The high value of slacks in crop otput (land productivity) and the net value added per AWU (labour productivity) for the three Baltic States indicated the necessity of qualitative and quantitative changes to be implemented here. The international comparison was carried out by estimating technicall efficiency of the different farming types across the EU Member States. The competitive advantages therefore were identified for the three Baltic States and Poland. The results of analysis showed that for Lithuania, the most prospective farming types in terms of international competitiveness are those related to animal farming, namely dairying (milk) and mixed farming.

Comparison of the selected EU Member States showed that for Lithuania, the most prospective farming types in terms of international competitiveness are those related to animal farming, namely dairying (milk) and mixed farming. Indeed, this situation is due to low production costs. The horticultural sector was also a rather promising one, though these findings need to be reassessed by employing longer time series data. Accordingly, the future Rural Development Programme as well as the agricultural policy in general should be focused on support of the farming types which contribute to increase in export on the one hand and decrease in import of particularly pork and vegetables on the other hand. The public support could be delivered through income and structural support measures as well as institutional alleviations (establishment of farmers' markets) with respect to objective of dynamic efficiency gains. Currently, the ratio of intermediate consumption to the total output is relatively high in Lithuania if compared to the EU average. However, it still might not be sufficient in absolute terms to modernize the agricultural production and thus successfully compete in the common market. In this context, the pressure on a more reasonable CAP payments' distribution among the EU Member States becomes especially important. Furthermore, the FADN practice can be improved by establishing the uniform estimation of input costs. For instance labour costs and capital depreciation costs remain the most problematic methodological issues.

The analysis showed that the efficiency of an average Lithuanian farm fluctuated between 76.5% and 92.2% throughout 2003–2010. In addition, it had been somehow subdued during 2005–2007. Mixed crop and mixed livestock (mainly grazing) farming was peculiar with the highest technical efficiency estimate for the period of 2003–2010. Slack analysis revealed that low land productivity, returns on assets, and intermediate consumption productivity are the most important factors of the inefficiency, in that order.

The TFP analysis therefore showed that the total factor productivity in the Lithuanian family farms had been decreasing throughout 2004–2005, and had been recovering by 1.3–8.1% per annum since then. However, technical change contributed to the increase in the total factor productivity rather insignificantly.

Therefore, it might be concluded that the Lithuanian agricultural sector still requires investments which, in turn, could lead to modernization of the production processes. Indeed, the relatively efficient sectors—for instance, horticulture, mixed farming—were specific with diminishing total factor productivity. Therefore, there should be a substantial incentives developed for productivity improvements in these sectors.

Further longitudinal studies are needed to analyse the patterns of efficiency and productivity within the farming types at the EU level. Especially, the analysis of micro data would enable to identify the underlying causes of inefficiency and thus sources of the economic growth. Application of parametric methods (for instance, stochastic frontier analysis) would enable to tackle measurement errors. The latter problem can also be alleviated by employing bootstrapped DEA. The VRS assumption does also have some implications on the research. Specifically, the DMUs located on the VRS frontier might be remote to the remaining ones in either dimension. Accordingly, the results might be biased due to the shape of the efficient frontier (surface). Accordingly, further studies should assume the CRS technology or employ the Multi-directional Efficiency Analysis (Asmild et al., 2003) to account for suchlike discrepancies.

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