APPLICATION OF THE LUENBERGER INDEX TO ESTIMATING APPLICATION OF THE LUENBERGER INDEX TO ESTIMATING DYNAMICS OF THE TOTAL FACTOR PRODUCTIVITY IN LITHUANIAN FAMILY FARMS

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Abstract

Productivity and efficiency are the two interrelated factors influencing competiveness of a firm, a sector, or a state. It is therefore important to analyse the patterns of changes in productivity and efficiency in various sectors. This study employs the Luenberger productivity index for measuring the total factor productivity in Lithuanian family farms. Specifically, a sample of 200 farms that were operating in 2004–2009 was analyzed. The analyzed farms were classified into crop, livestock, and mixed ones by their output structure. The paper presents a survey on application of frontier techniques in research on the Lithuanian agricultural sector as well as frontier measures of efficiency. Special attention is paid to the Luenberger productivity index and decomposition thereof. The carried out analysis identified the sources of changes in productivity across different farming sectors. Compared to livestock farms both mixed farms and crop farms were characterised by higher efficiency and productivity gains caused by efficiency effect (catch–up) and lower gains from the overall technological change.

Keywords: productivity, efficiency, Luenberger index, data envelopment analysis, family farms.

Introduction

IIt is efficiency that provides a momentum for a non–inflatory economic development and increase in competitiveness. Moreover, as Latruffe (2010) points out, firm– and sector–specific efficiency does influence national competitiveness. Accordingly, the European Commission (2011) launched a flagship initiative under the Europe 2020 Strategy called A resource-efficient Europe. Furthermore, 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.

In order to perform 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 analyzing the actual data, i. e. by the means of benchmarking. Productivity means the ability to convert inputs to outputs. A distinction can be made between total factor productivity (Solow, 1957) and partial (single factor) productivity. Productivity growth is a source of a non-inflatory growth and thus should be encouraged by 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). Lithuanian agricultural sector was analyzed by the means of regression analysis (Kriščiukaitienė et al., 2010), multi-criteria decision making methods (Baležentis, Baležentis, 2011a). Savickienė and Slavickienė (2012) employed correlation analysis and discussed some methodological issues regarding viability of farming business. The frontier measures were also employed (Vinciūnienė, Rauluškevičienė, 2009; Rimkuvienė et al., 2010; Baležentis, Baležentis, 2011b; 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 so far.

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.

The Luenberger index can be employed for assessment of changes in productivity in various areas. For instance, Luenberger index was parameterized and employed to construct a soil quality indicator (Hailu, Chambers, 2012). Epure et al. (2011) extended the Luenberger index to tackle variable returns to scale technology and estimated changes in bank productivity. Boussemart et al. (2003) utilized the Luenberger index to measure total factor productivity changes in OECD countries. Mussard and Peypoch (2006a, 2006b) analyzed the decomposition of the aggregate Luenberger index.

This study aims at employing the Luenberger productivity index as a measure of the total factor productivity in Lithuanian family farms. Specifically, the sample of 200 farms that were operating in 2004–2009 is analyzed.

The paper proceeds as follows. Section 2 presents a survey on application of frontier techniques in research on the Lithuanian agricultural sector. Section 3 discusses the productive technology and frontier measures of efficiency. Section 4 introduces the Luenberger productivity index and decomposition thereof. Finally, Section 5 presents the data employed for the research and results of the analysis.

Manifestations of frontier benchmarking of Lithuanian farming efficiency

Central and Eastern European countries are specific with agricultural sectors contributing a relatively high share to GDP in these countries. Therefore a number of studies have attempted to research into farming efficiency there by employing frontier techniques (Gorton, Davidova, 2004). Lithuanian agricultural sector, however, received less attention in the latter scientific area. Moreover, those few examples employ non-parametric methods, whereas parametric methods (e. g. stochastic frontier analysis) remain underused. This section overviews earlier papers dealing with 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 the FADN aggregates (74 observations in total). The authors employed the following procedure for estimation of technical efficiency: 1) the 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 and Kriščiukaitienė (2012) further analyzed the aggregated FADN data covering the period of 2003–2010. The data envelopment analysis and statistical analysis were applied in the research. The analysis showed that efficiency of an average Lithuanian farm had fluctuated between 76.5% and 92.2% in 2003–2010. In addition, it had been somehow subdued during 2005–2007. Mixed crop and mixed livestock (mainly grazing) farming was characterised by the highest technical efficiency estimate for the period of 2003–2010. Slack analysis revealed that low land productivity and returns on assets, and intermediate consumption productivity are the most important sources of the inefficiency. 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 analyzed by considering multiple criteria. The rank–sum test indicated that the farms expanded in terms of ESU and UAA were characterised by 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 farming efficiency by performing an international comparison on the basis of DEA and free disposal hull – the two non-parametric methods. This study also discussed the differences between the terms efficiency and effectiveness which are often misused in 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, effectiveness of capital and intermediate consumption was observed in Lithuania. Baležentis and Baležentis (2011b) followed the similar framework for international comparison. However, the latter study employed not only DEA but also multi-criteria decision making method MULTIMOORA. The agricultural

efficiency was assessed with respect to 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 output (land productivity) and the net value added per AWU (labour productivity) for the three Baltic States indicated the necessity for qualitative and quantitative changes to be implemented here. Baležentis et al. (2012) furthered the international comparison by estimating technical efficiency of the different farming types across the EU Member States. Competitive advantages were identified for the three Baltic States. The results of the analysis showed that for Lithuania, the most prospective farming types in terms of international competitiveness are those related to animal farming, namely dairy (milk) and mixed farming.

It was Douarin and Latruffe (2011) who offered the single foreign contribution to the DEA-based efficiency analysis of 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, 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 farm. 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 analysis indicates that both Lithuanian and foreign scientists perform analysis of productivity of the Lithuanian agricultural sector. As for 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, productive efficiency is still a promising area for further researches in Lithuania. Micro data analysis is particularly underemployed. Furthermore, the parametric methods should be employed to fit the production functions.

2. Preliminaries of the productive technology

In order to relate the Debreu–Farrel measures to the Koopmans definition of efficiency, and to relate both to the structure of production technology, it is useful to introduce some notation and terminology (Fried et al., 2008). Let producers use inputs $x = (x_1, x_2, ..., x_m) \in \Re_+^m$ to produce outputs $y = (y_1, y_2, ..., y_n) \in \Re_+^n$. Production technology then can be defined in terms of the production set:

$$T = \{(x, y) | x \text{ can produce } y\}. \qquad (1)$$

Thus, Koopmans efficiency holds for an input-output bundle $(x, y) \in T$ if, and only if, $(x', y') \notin T$ for $(-x', y') \geq (-x, y)$.

Technology set can also be represented by input requirement and output correspondence sets, respectively:

$$I(y) = \{x | (x, y) \in T\}, \qquad (2)$$

$$O(x) = \{y | (x, y) \in T\}. \qquad (3)$$

The isoquants or efficient boundaries of the sections of T can be defined in radial terms as follows (Farrel, 1957). Every $y \in \Re_+^n$ has an input isoquant:

$$isoI(y) = \{x | x \in I(y), \lambda x \notin I(y), \lambda < 1\}. \qquad (4)$$

Similarly, every $x \in \Re_+^m$ has an output isoquant:

$$isoO(x) = \{y | y \in O(x), \lambda x \notin O(x), \lambda > 1\}. \qquad (5)$$

In addition, DMUs might be operating on the efficiency frontier defined by Eqs. 4–5, albeit still use more inputs to produce the same output if compared to another efficient DMU. In this case the former DMU experiences a slack in inputs. The following subsets of the boundaries $I(y)$ and $O(x)$ describe Pareto-Koopmans efficient firms:

$$effI(y) = \{x | x \in I(y), x' \notin I(y) \ \forall x' \leq x, x' \neq x\}, \quad (6)$$

$$effO(x) = \{y | y \in O(x), y' \notin O(x) \ \forall y' \geq y, y' \neq y\}. \quad (7)$$

Note that $effI(y) \subseteq isoI(y) \subseteq I(y)$ and $effO(x) \subseteq isoO(x) \subseteq O(x)$.

There are two types of efficiency measures, namely Shepard distance function, and Farrel distance function. These functions yield the distance between an observation and the efficiency frontier. Shepard (1953) defined the following input distance function:

$$D_I(x, y) = \max \{\lambda | (x/\lambda, y) \in I(y)\}. \qquad (8)$$

Here $D_I(x,y) \geq 1$ for all $x \in I(y)$, and $D_I(x,y) = 1$ for $x \in isoI(y)$. The Farrel input-oriented measure of efficiency can be expressed as:

$$TE_I(x,y) = \min\{\theta | (\theta x, y) \in I(y)\}. \quad (9)$$

Comparing Eqs. 8 and 9 we arrive at the following relation:

$$TE_I(x,y) = 1/D_I(x,y), \quad (10)$$

with $TE_I(x,y) \leq 1$ for $x \in I(y)$, and $TE_I(x,y) = 1$ for $x \in isoI(y)$.

Similarly, the following equations hold for the output-oriented measure:

$$D_O(x,y) = \min\{\lambda | (x, y/\lambda) \in O(x)\}, \quad (11)$$

$$TE_O(x,y) = \max\{\phi | (x, \phi y) \in O(x)\}, \quad (12)$$

$$TE_O(x,y) = 1/D_O(x,y), \quad (13)$$

where $TE_O(x,y) \geq 1$ for $y \in O(x)$, and $TE_O(x,y) = 1$ for $y \in isoO(x)$.

The previously discussed Shepard measures of efficiency can be generalized into the directional technology distance function (Färe et al., 2008). In this case direction of improvement can be considered as a vector rather than a scalar (as in case of Shepard and Farrel distance functions). Thus, let $g = (g_x, g_y)$ be a direction vector with $g_x \in \Re_+^m$ and $g_y \in \Re_+^n$ and introduce the excess function:

$$E_{T(t)}(x,y;g_x,g_y) = \max\{\beta \geq 0 | (x - \beta g_x, y + \beta g_y) \in T(t)\}. \quad (14)$$

Technology is denoted by T, whereas the directional vector g is in the fourth quadrant indicating that the inputs are to be contracted and outputs augmented simultaneously. The index t denotes a certain period. To be specific, inputs are scaled down by g_x, whereas outputs are increased by y_x. Thus the directional vector is transformed into $(-g_x, g_y)$ and added to the initial point (x,y). Addition of the two vectors means defining a parallelogram, the vertex whereof is given by $(x - g_x, y + g_y)$. Therefore, one will put the initial point on the efficiency frontier by maximizing β. By setting $(g_x, g_y) = (x,0)$ and $(g_x, g_y) = (0,y)$ we would arrive at the input- and output-oriented distance functions, respectively. In

addition one may choose $(g_x, g_y) = (x,y)$ thus arriving at the proportional distance function, or' $(g_x, g_y) = (\bar{x}, \bar{y})$, $(g_x, g_y) = (1,1)$, or optimize (g_x, g_y) to minimize distance to frontier technology. Specifically, an input-oriented proportional excess function would be related to the Shepard measure (cf. Eq. 8) in the following way:

$$E_{T(t)}^I(x,y;x,0) = \max\{\beta \geq 0 | (x(1-\beta), y) \in T(t)\} = 1 - (1/D_I(x,y)), \quad (15)$$

whereas setting $(g_x, g_y) = (0,y)$ would entail the following relationship:

$$E_{T(t)}^O(x,y;0,y) = \max\{\beta \geq 0 | (x, y(1+\beta)) \in T(t)\} = (1/D_O(x,y)) - 1. \quad (16)$$

The Luenberger productivity index

The Luenberger productivity index was introduced by Chambers et al (1996). Contrary to the multiplicative Malmquist index, the Luenberger index is an additive one. For the two periods, t and $t+1$, the Luenberger index is defined as:

$$L((x^t,y^t),(x^{t+1},y^{t+1})) = \frac{1}{2}(E_{T(t+1)}(x^t,y^t;g_x,g_y) - E_{T(t+1)}(x^{t+1},y^{t+1};g_x,g_y) + E_{T(t)}(x^t,y^t;g_x,g_y) - E_{T(t)}(x^{t+1},y^{t+1};g_x,g_y)), \quad (17)$$

with positive values of the index indicating productivity improvements and negative ones – productivity declines. The input– and output–oriented Luenberger indices can also be obtained by employing efficiency measures of Eqs. 15 and 16, respectively.

As in case of the Malmquist productivity index, the Luenberger index can be decomposed into the two terms, EC and TC, identifying changes in efficiency (catch-up effect) and technology (frontier shift), respectively. The efficiency change, EC, is quantified as:

$$EC = E_{T(t)}(x^t,y^t;g_x,g_y) - E_{T(t+1)}(x^{t+1},y^{t+1};g_x,g_y), \quad (18)$$

and the technology change, TC, is given as:

$$TC = \frac{1}{2}(E_{T(t+1)}(x^{t+1},y^{t+1};g_x,g_y) - E_{T(t)}(x^{t+1},y^{t+1};g_x,g_y) + E_{T(t+1)}(x^t,y^t;g_x,g_y) - E_{T(t)}(x^t,y^t;g_x,g_y)). \quad (19)$$

Obviously, $L = EC + TC$.

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The following Figure 1 depicts a graphical interpretation of the Luenberger index. Say the points a and d denote the two input–output vectors for periods t and $t+1$, respectively. The technology sets for periods t and $t+1$ are, respectively, $T(t)$ and $T(t+1)$. By denoting the directional vector (g_x, g_y) as g we can define the following projections of a and d onto the two production frontiers, $T(t)$ and $T(t+1)$:

$b = a + E_{T(t)}(a,g)g$ and $c = a + E_{T(t+1)}(a,g)g$ are

the respective projections of a, $e = a + E_{T(t)}(b,g)g$

and $f = a + E_{T(t+1)}(b,g)g$ are the respective projections of b. Then, referring to Eq. 18, one can note that the efficiency change, EC, involves the comparisons of points a and b against their projections on the contemporaneous production frontiers viz. $T(t)$ and $T(t+1)$:

$$EC = (b - a) - (f - d) =$$
$$= (E_{T(t)}(a;g) - E_{T(t+1)}(d;g))g . \qquad (20)$$

Similarly, the technological change, TC, is measured by considering the distances between the two production frontiers, $T(t)$ and $T(t+1)$. Specifically, the frontier shift is specified as the average of the distances between the two frontiers:

$$TC = \frac{1}{2}\big((f - e) + (c - b)\big)$$
$$= \frac{1}{2}\Big(E_{T(t+1)}(d;g) - E_{T(t)}(d;g)$$
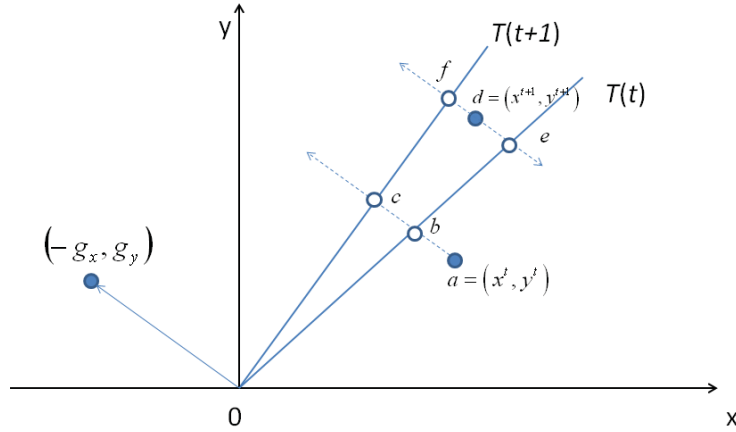$$+ E_{T(t+1)}(a;g) - E_{T(t)}(a;g)\Big) . \qquad (21)$$

Fig. 1. A graphical interpretation of the Luenberger productivity index (Chambers et al., 1996)

By combining assumptions of the constant returns to scale, free (strong) disposability, and convexity the following technology set is obtained:

$$T(t) = \left\{(x_{k,i}^t, y_{k,j}^t) \,\middle|\, \begin{array}{l} x_{k,i}^t \geq \sum_{k=1}^{K}\lambda_k x_{k,i}^t; y_{k,j}^t \leq \sum_{k=1}^{K}\lambda_k y_{k,j}^t; \lambda^k \geq 0; \\ i = 1,2,...,m; j = 1,2,...,n; k = 1,2,...,K \end{array}\right\}, \quad (22)$$

where i and j are indexes denoting certain inputs and outputs, respectively, and k stands for a certain firm. Therefore data envelopment analysis (DEA) can be employed to estimate the distance functions needed for Luenberger index.

The following linear programming model yields the distance between the observation $(x_{k,i}^t, y_{k,j}^t)$ and technology frontier $T(t)$:

$$E_{T(t)}(x_{k,i}^t, y_{k,j}^t; g_x, g_y) = \max_{\beta, \lambda_k} \beta$$

s. t.

$$\sum_{k=1}^{K}\lambda_k x_{k,i}^t \leq x_{k,i}^t - \beta g_x, \quad i = 1,2,...,m;$$

$$\sum_{k=1}^{K}\lambda_k y_{k,j}^t \geq y_{k,j}^t + \beta g_y, \quad j = 1,2,...,n; \qquad (23)$$

$$\lambda_k \geq 0, \quad k = 1,2,...,K;$$

β unrestricted.

Indeed, the inefficiency score, β, belongs to the interval $\beta \in [0; +\infty)$. Efficient decision making units (firms) are attributed with the value of zero, whereas inefficient units are attributed with positive real numbers indicating the extent to which inputs should be scaled down and outputs augmented.

In case an observation is projected onto technology of another period, one has to solve the following model:

$$E_{T(t)}(x_{k,i}^{t+1}, y_{k,j}^{t+1}; g_x, g_y) = \max_{\beta, \lambda_k} \beta$$

s. t.

$$\sum_{k=1}^{K} \lambda_k x_{k,i}^t \leq x_{k,i}^{t+1} - \beta g_x, \quad i = 1, 2, ..., m;$$

$$\sum_{k=1}^{K} \lambda_k y_{k,j}^t \geq y_{k,j}^{t+1} + \beta g_y, \quad j = 1, 2, ..., n; \tag{24}$$

$$\lambda_k \geq 0, \quad k = 1, 2, ..., K;$$

β unrestricted.

The input–oriented proportional distance function (cf. Eq. 15) is a separate case of Eq. 23. Therefore it can be estimated by setting $(g_x, g_y) = (x_{k,i}^t, 0)$ and employing the following model:

$$E_{T(t)}^I(x_{k,i}^t, y_{k,j}^t; g_x, g_y) = \max_{\beta, \lambda_k} \beta$$

s. t.

$$\sum_{k=1}^{K} \lambda_k x_{k,i}^t \leq x_{k,i}^t(1-\beta), \quad i = 1, 2, ..., m$$

$$\sum_{k=1}^{K} \lambda_k y_{k,j}^t \geq y_{k,j}^t, \quad j = 1, 2, ..., n; \tag{23}$$

$$\lambda_k \geq 0, \quad k = 1, 2, ..., K;$$

β unrestricted.

The output–oriented proportional distance function (cf. Eq. 16) is a straightforward generalization and thus not reported here.

Data and results

The technical and scale efficiency was assessed in terms of the input and output indicators commonly employed for agricultural productivity analyses (Bojnec, Latruffe, 2008, 2011; Douarin, Latruffe, 2011). More specifically, the utilized agricultural area (UAA) in hectares was chosen as land input variable, annual work units (AWU) – as labour input variable, intermediate consumption in Litas and total assets in Litas as a capital factor. On the other hand, the three output indicators represent crop, livestock, and other outputs in Litas, respectively. Indeed, the three output indicators enable to tackle the heterogeneity of production technology across different farms.

The cost efficiency was estimated by defining respective prices for each of the four inputs described earlier. The land price was obtained from the Eurostat and assumed to be uniform for all farms during the same period. The labour price is average salary in agricultural sector from Statistics Lithuania. The capital price is depreciation plus interests per one Litas of assets. Meanwhile the intermediate consumption is directly considered as a part of total costs.

The data for 200 farms selected from the FADN sample cover the period of 2004–2009. Thus a balanced panel of 1200 observations is employed for analysis. The analyzed sample covers relatively large farms (mean UAA – 244 ha). As for labour force, the average was 3.6 AWU.

In order to quantify the change in productivity across different farming types, the farms were classified into the three groups in terms of their specialization. Specifically, farms characterised by crop output larger than 2/3 of the total output were considered as specialized crop farms, whereas those characterised by livestock output larger than 2/3 of the total output were classified as specialized livestock farms. The remaining farms fell into the mixed farming category.

The Luenberger index was calculated by employing the input–oriented DEA model (Eq. 23). Indeed, the output–oriented model yielded almost identical results and they are thus omitted here. Figure 2 exhibits dynamics of the total factor productivity (TFP) across the investigated farms during 2004–2009. Results are also given for each farming type as described before. As one can note livestock farming was characterised by rather significant fluctuations in TFP. However, the crop farming did experience a steep decrease in TFP during 2006–2007, which might be explained by unfavourable climatic conditions. Indeed, the latter period was that of decreasing TFP for all types of farming. The subsequent period of 2007–2008 was that of recovery, whereas a more intensive growth in TFP was observed for 2008–2009. It should ne noted that TFP of the mixed farming fluctuated in between growth rates of crop and livestock farming. The latter finding confirms the existing impact of diversification in the Lithuanian family farms.
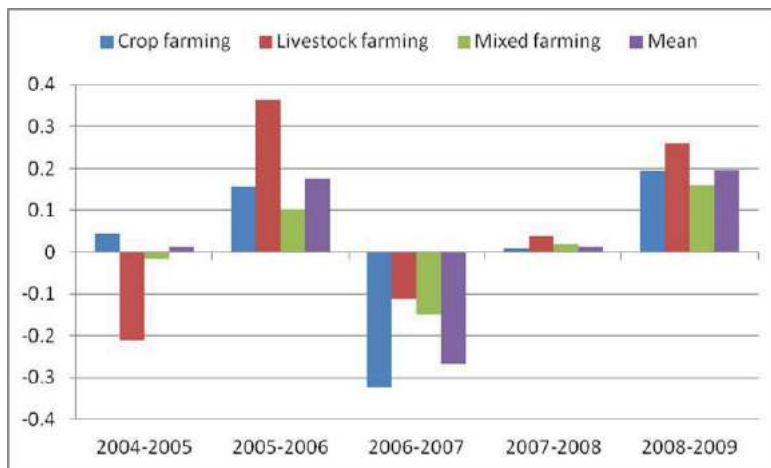
Fig. 2. Mean values of the Luenberger productivity index across different farming types, 2004–2009

The mean change in TFP varied across farming types. During the period of 2004–2009 crop farms experienced mean annual growth in TFP equal to some 1.8%, whereas livestock farms faced annual growth rate of 7.2%. Mixed farms were characterised by mean annual growth in TFP of 2.9%. The livestock farming took lead in terms of cumulative TFP growth (34%). Mixed farms reached the cumulative TFP growth rate of 11.6%. Crop farming was characterised by a modest cumulative growth rate of 8%. The mean cumulative growth for the whole sample was 13%. Thus Lithuanian family farms managed to increase their productivity in spite of certain geo-political effects.

In accordance with Eqs. 18 and 19, the Luenberger productivity index can be decomposed into the two terms describing technological change and efficiency change. The former term measures the overall shift of the production frontier, whereas the latter one measures the firm-specific catch-up effect. Therefore, we have decomposed the Luenbegrer productivity indices for the whole sample as well as for each of the farming types. Figures 3 to 6 present the results.
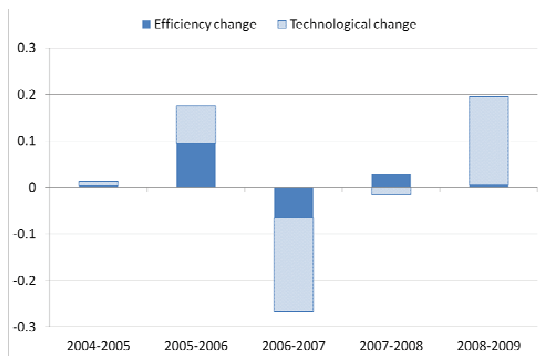

Fig. 3. Mean values of the components of the Luenberger index for the whole sample, 2004–2009
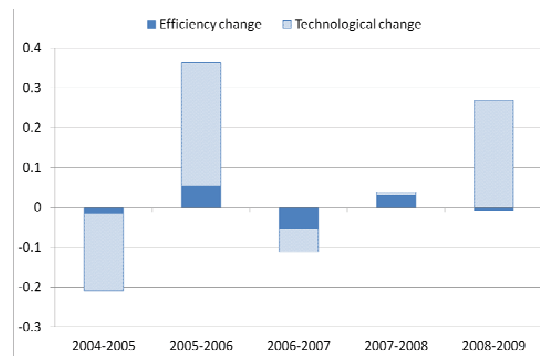

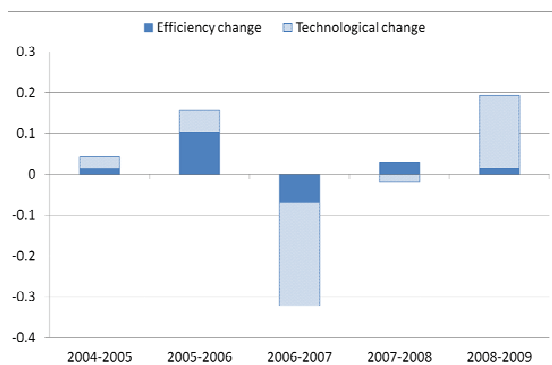**Fig. 5.** Mean values of the components of the Luenberger index for livestock farms, 2004–2009

Fig. 4. Mean values of the components of the Luenberger index for crop farms, 2004–2009
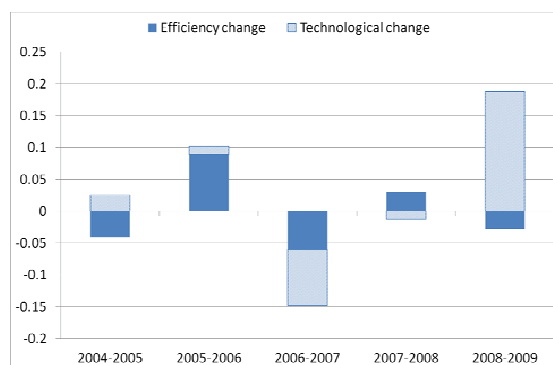

Fig. 6. Mean values of the components of the Luenberger index for mixed farms, 2004–2009

Figure 3 suggests that farm-specific improvements dominated the overall growth in TFP during 2005–2006 and 2007–2008 albeit the absolute contributions differed. The technological frontier moved inwards during 2006–2007 and thus resulted in a negative technological effect. However, the technological frontier expanded during 2008–2009 when virtually the whole productivity change was the outcome of technological change.

The mean values for components of the Luenberger index across different farming types are given in Figures 4 to 6. It is evident that changes in TFP in mixed farms were mainly driven by managerial decisions for efficiency change, which played an important role during the research period (Figure 6). In addition, the range of changes in TFP for mixed farms is lower than for the remaining farming types. Meanwhile livestock farms mostly benefited from overall technology change (Figure 5). It might be explained by fluctuating prices of livestock production. Crop farms exhibited lower TFP gains from efficiency change compared to those of mixed farms, furthermore they experienced steeper decreases and subdued growth in TFP caused by technological change (Figure 4).

What results of the analysis suggest is that the Lithuanian family farms followed a similar pattern of efficiency and productivity change in 2004–2009. Certain differences between farming types, however, became apparent. Both mixed farms and crop farms were characterised by higher efficiency and productivity gains caused by efficiency effect (catch–up) and lower gains from the overall technological change. Therefore certain policies for improving the value–added chains in these farming types should be commenced. At the other end of the spectrum, livestock farming should receive appropriate support for modernization.

Conclusions

This study employed the Luenberger productivity index as a measure of the total factor productivity in Lithuanian family farms. Specifically, a sample of 200 farms that were operating in 2004–2009 was analyzed. The analyzed farms were classified into crop, livestock, and mixed ones by their output structure.

The results indicated that all types of farming did experience a steep decrease in TFP during 2006–2007, which might be explained by unfavourable climatic conditions. The subsequent period of 2007–2008 was that of recovery, whereas a more intensive growth in TFP was observed for 2008–2009. It should be noted that TFP of the mixed farming fluctuated in between growth rates of crop and livestock farming. The latter finding confirms the existing impact of diversification in the Lithuanian family farms. The mean cumulative growth for the whole sample was 13%. Thus Lithuanian family farms managed to increase their productivity in spite of certain geopolitical effects.

What results of the analysis suggest is that the Lithuanian family farms followed a similar pattern of efficiency and productivity change in 2004–2009. Certain differences between farming types, however, became apparent. Both mixed farms and crop farms were characterised by higher efficiency and productivity gains caused by efficiency effect (catch–up) and lower gains from the overall technological change. Therefore certain policies for improving the value–added chains and activities in markets related to these farming types should be commenced. At the other end of spectrum, livestock farming should receive appropriate support for modernization.

This study, however, has some limitations related to the farm sample and the methods employed. Therefore further studies should aim at extending the farm sample or defining it in more strict economic and technological terms. Furthermore, both non-parametric and parametric methods need to be utilized for the analysis. As for non-parametric methods, the bootstrapping procedure is important to test the statistical significance of results. Finally, cost efficiency could be analyzed in further studies.

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Liunbergerio indekso taikymas, vertinant bendrojo produktyvumo pokyčius Lietuvos ūkininkų ūkiuose

Santrauka

Tyrimo aktualumas. Efektyvumo augimas yra infliacijos nesukeliančio, tvaraus ekonominio augimo šaltinis ir vienas iš svarbiausių konkurencingumo veiksnių. Įmonių ir sektorių efektyvumas ir konkurencingumas lemia ir bendrąjį valstybės konkurencingumą. Todėl Europos Komisija paskelbė pavyzdinę iniciatyvą *Tausiai išteklius naudojanti Europa* strategijos *Europa 2020* kontekste. Žemės ūkio sektoriuje efektyvumas taip pat užima svarbią vietą. Henningsen (2009) teigia, kad agroverslo efektyvumas yra susijęs su darbo intensyvumu, ūkių struktūra, technologijomis ir investicijomis, vadybiniais gebėjimais ir pelningumu. Atsižvelgiant į minėtas aplinkybes, svarbu naudoti tinkamus efektyvumo ir produktyvumo vertinimo metodus. Atliekant efektyvumo vertinimą, svarbu suvokti veiksmingumo (angl. *effectiveness*), produktyvumo (angl. *productivity*) ir efektyvumo (angl. *efficiency*) sąvokas. Veiksmingumą įver-

tinti galima žinant tam tikrą naudingumo (tikslo) funkciją. Tačiau iš tikrųjų tai dažniausiai yra neįmanoma ir etaloninė technologija gali būti apibūdinama tik lyginimo būdu. Produktyvumas yra sąnaudų (angl. *inputs*) ir rezultatų (angl. *outputs*) santykis. Lygindami stebimą produktyvumo lygį su etaloniniu, galima įvertinti efektyvumą. Etaloninis produktyviom lygis gali būti nustatomas matematinių (pvz., ribinių) metodų pagalba.

Daugelis veiksnių lemia ypatingą efektyvumo vertinimo svarbą žemės ūkio sektoriuje. Pirma, žemės ūkio produkcijos gamintojai (ūkininkai) dažniausia gyvena savo ūkiuose, esančiuose kaimo vietovėse. Taigi standartinė prielaida, kad rinkoje veikia tik efektyvūs gamintojai, žemės ūkio sektoriuje negalioja, nes ūkio veiklos nutraukimas reikštų gyvenimo šaltinio praradimą. Tokie pokyčiai lemia kaimiškųjų vietovių gyvybingumo praradimą. Antra, žemės ūkio

politikos intervencija (švietimas, mokymas, parama) turėtų skatinti efektyvumo augimą. Trečia, žemės ūkio politikos sąsajos su ūkių struktūra (ypač jų dydžiu) reikalauja atitinkamų efektyvumo tyrimų (Nauges et al., 2011).

Dažniausia žemės ūkio ir kitų sektorių efektyvumo tyrimuose naudojami ribiniai metodai (Murillo-Zamorano, 2004; Coelli et al., 2005; Vinciūnienė, Rauluškevičienė, 2009), kurie gali būti skirstomi į stochastinius ir deterministinius bei į parametrinius ir neparametrinius. Lietuvos žemės ūkio sektoriaus veiklos efektyvumas buvo vertintas ir kitais matematiniais metodais (Baležentis, Baležentis, 2011a; Savickienė, Slavickienė, 2012; Kriščiukaitienė et al., 2010). Iš neparametrinių metodų daugiausia taikomi deterministiniai duomenų apgaubties analizės (angl. *data envelopment analysis*) modeliai. Duomenų apgaubties analizę Lietuvos ūkininkų ūkių veiklos vertinimui taikė Lietuvos ir užsienio autoriai (Baležentis, 2012; Baležentis et al.; 2012; Baležentis, Kriščiukaitienė, 2012; Vinciūnienė, Rauluškevičienė, 2009; Rimkuvienė et al., 2010; Baležentis, Baležentis, 2011b), tačiau produktyvumo indeksai šioje srityje dar nebuvo taikyti.

Dažniausia naudojami šie bendrojo produktyvumo dinamikos vertinimo indeksai: (i) Malmkvisto indeksas, (ii) Hikso–Morsteno indeksas, (iii) Liunbergerio indeksas. Malmkvisto indeksas paprastai orientuotas į sąnaudas arba produkciją (gavą) ir išskaidomas sandauginiu būdu. Hikso–Morsteno indeksas yra Malmkvisto indekso apibendrinimas.

Tyrimo problema. Šiame straipsnyje siekiama ištirti, kokie veiksniai lėmė produktyvumo pokyčius Lietuvos ūkininkų ūkiuose. Tyrimo objektas – Lietuvos ūkininkų ūkiai (imties dydis – 200 ūkių, įtrauktų į Ūkių apskaitos duomenų tinklą). Tyrimo dalykas – ūkininkų ūkių produktyvumo pokyčiai.

Tyrimo tikslas – taikant Liunbergerio produktyvumo indeksą, nustatyti potencialias Lietuvos ūkininkų ūkių plėtros kryptis. Tyrimo periodas – 2004–2009 m.

Tyrimo uždaviniai:

1) apžvelgti literatūrą, susijusią su Lietuvos žemės ūkio sektoriaus efektyvumo vertinimu;

2) apibūdinti efektyvumo vertinimo metodus;

3) aptarti Liunbergerio indekso taikymą;

4) atsižvelgiant į tyrimo rezultatus, pasiūlyti pagrindines žemės ūkio politikos kryptis.

Tyrimo metodai. Tyrimo metu naudojami šie metodai: duomenų apgaubties analizė, Liunbergerio produktyvumo indeksas, statistinė analizė.

Tyrimo rezultatai. Tyrimas parodė, kad didžiausias produktyvumo nuosmukis buvo užfiksuotas 2006–2007 m. dėl nepalankių klimatinių sąlygų. 2007–2008 m. produktyvumo lygis beveik nepadidėjo, o 2008–2009 m. pastebėtas smarkus augimas. Mišraus ūkininkavimo produktyvumo pokyčiai svyravo specializuotų ūkių produktyvumo pokyčių ribose. Taigi diversifikavimas buvo veiksmingas. Vidutinis produktyvumo augimas (visai imčiai) siekė 13 proc., tad Lietuvos ūkininkų ūkiai sugebėjo pasiekti, kad jų produktyvumas augtų nepaisant įvairių geopolitinių veiksnių. Lyginant su gyvulininkystės ūkiais, mišrūs ir augalininkystės ūkiai pasižymėjo didesniu produktyvumo prieaugiu dėl efektyvumo didėjimo ir žemesniu prieaugiu dėl bendro technologinio progreso. Taigi mišriems ir augalininkystės ūkiams turėtų būti sudaromos sąlygos sukurti palankesnes pridėtinės vertės grandines, numatant atitinkamų produktų rinkų vystymo priemones. Gyvulininkystės ūkiams aktualesnis technologinis vystymas (modernizavimas).

Pagrindiniai žodžiai: produktyvumas, efektyvumas, Liunbergerio indeksas, duomenų apgaubties analizė, ūkininkų ūkiai.