ANALYZING THE EFFICIENCY AND PRODUCTIVITY OF SLOVAK FARMS SPECIALIZING IN LIVESTOCK

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ABSTRACT

This paper aims to estimate productivity, efficiency, and especially the estimation of managerial performance among 284 farms specializing in livestock in Slovakia. Data Envelope Analysis (DEA) is used to estimate farm efficiency and related economies of scale. Taking full advantage of the panel structure, changes in farm productivity are provided by the Malmquist index and are divided into technological progress, scale effects, and managerial decision-making. Empirical results show that, on average, a 31% reduction in input use could be achieved, provided that all livestock farms operate efficiently, without further restrictions on this adjustment. In 2012 farms specialized in livestock improved their performance compared to the best farms by 17%, mainly due to improvement of the managerial efficiency by 12% and improvement of scale efficiency by 4%.

Keywords: *productivity, managerial efficiency, Malmquist index, livestock farms, Slovakia*

INTRODUCTION

In livestock production, management practices can be defined as a set of alternative production techniques that can have a significant impact on the economic performance of a farm. According to economic theory, the goal of effective management is the optimal use of inputs to achieve outputs in a way that maximizes economic return. In a rapidly changing environment, the complexity of livestock production systems is accepted. With the growing awareness of overproduction and the associated budgetary burden of the common agricultural policy, the focus of the industry has shifted from production growth to efficient farm management. In 2019, in Slovakia, there was another production performance of the branch focused on animal production by 6.9%, due to the end of the natural production of animals for slaughter [1].

In recent years, several approaches to efficiency and productivity assessment have been developed, which can be divided into two broad categories: parametric and nonparametric boundary models. The first model estimates the production parameters or the cost function. Most nonparametric applications are based on the DEA (Data Envelopment Analysis) methodology, which has become a central technique in the analysis of productivity and efficiency in various aspects of economics and management. A key question arising from the borderline analysis

is whether it is possible to identify common characteristics between units of good practice. The existence of these characteristics means that managerial personal traits may be associated with efficiency levels and their impact on the assessed farm performance. In the literature, numerous empirical studies have attempted to explain variations in farm success by reducing efficiency scores on a set of explanatory variables [2].

Within this context, several empirical studies have focused on combining managerial and economic approaches with animal science. Aspects of operational management practices were explored and who be adapted to day-to-day management to improve farm efficiency. Aspects of management practices were regressed based on the entry efficiency score of the farm-level packaging data analysis (DEA) based on data from Sweden. Changes in husbandry and feeding practices could affect efficiency. Inefficient farms cannot become more efficient by adapting to the veterinary practices of more efficient farms [3]. A significant difference in efficiency change due to different management styles is related to relative management efficiency and efficiency change [4]. The use of DEA that allows for the incorporation of multiple inputs and outputs in determining relative efficiencies can be of value in examining the competitiveness of the chain as a whole [5].

Further analysis of productivity and efficiency in existing meat processing units offers ample opportunities to increase their performance. The change in total factor productivity (TFP) is slight and maintains production in the meat processing industry mainly due to the increased use of inputs and capital investment. The reasons for inefficiency and low changes in TFP were empirically analyzed in terms of input breaks at the optimal level of the production process [6]. Another study using the DEA examines ways to improve the technical, economic, and environmental performance of Dutch pig farms. Compared to currently available technologies, a much higher average technical efficiency of farms has been found. The overall technical performance increases slightly after the introduction of new technologies. Environmental properties, especially ammonia emissions, can be significantly reduced using modern housing techniques [7].

Empirical studies have measured and degraded the overall efficiency of sheep farming in the mountainous areas of Greece. The empirical results suggest that managerial efficiency and scale efficiency of the balance are almost as important in determining the overall efficiency [8]. Within EU countries, another study examined the effectiveness of agriculture through the DEA. Data on inputs such as labour, land, capital, fertilizers, and irrigation, and production-related to the economic value of agricultural production were collected between 1993 and 2013. Most EU countries are experiencing growth or declining economies of scale, highlighting their potential to increase efficiency. by changing the use of inputs. Most EU countries could better rationalize the use of inputs, obtain more outputs and achieve production efficiency. Therefore, when planning policy, but also

when making management decisions, attention should always be paid not only to maximizing agricultural production but also to the excessive use of environmental resources.[9]

Efficiency varies significantly between regions due to differences in the production environment, the ability of individual producers to manage inputs, and the choice of species depending on local environmental conditions [10]. There should be synergies between crop and animal scientists; assistants and agricultural economists to meet the requirements that farmers have for integrating agriculture with livestock farming to achieve optimal levels of efficiency [11].

Regarding existing studies, deficiencies of existing approaches, and availability of data, we assess managerial efficiency change and productivity change on Slovak livestock farms using the DEA approach.

An attempt to explain differences in efficiency based solely on physical or biographical variables may be insufficient; even a farmer with high personal abilities can be inefficient provided that his decision-making process such as planning, implementation, and control of the decision, is bad. In this context, the purpose of this paper is to specify and measure the efficiency of Slovak farms and to focus on certain livestock management practices, and to examine the extent to which a set of different breeding and production practices can affect farm performance.

The study aimed to estimate productivity, efficiency, and possible changes in managerial performance among Slovak farms specializing in livestock. The next section Data Envelope Analysis methodology is devoted, and the applied model is presented. The third part is presented to the methodology, where we estimate the function of rent to identify which factors affect the value of rent in cadastral areas in Slovakia. Next, we present the results and finally we consider the implications of our findings in comparison with other authors.

METHODOLOGY AND DATA

Managerial efficiency is a management system related to the conversion of inputs from various sources to output. Managerial efficiency is a management system related to the conversion of inputs from various sources to output. To Measurement of relative managerial efficiency and efficiency change, we used the DEA approach presents a method by which multiple inputs and outputs of an entity can be objectively combined into the overall effectiveness of an organization [12]. The efficiency, decision-making unit (DMU), can be obtained by solving the output-oriented CCR model

We expressed farm productivity using the Total Factor Productivity (TFP) approach, a suitable methodology for multi-input and output technologies. To estimate the change in TFP, we used the output-oriented Malmquist index, which

uses Shephard's (1970) output-oriented distance function. The Malmquist index (1) can be divided into technical efficiency change (TECH) and technical change (TCH) [13]:

$$M_o(x^t, y^t, x^{t+1}, y^{t+1}) = \frac{D_o^{t+1}(x^{t+1}, y^{t+1})}{D_o^t(x^t, y^t)} \left[\frac{D_o^t(x^{t+1}, y^{t+1})}{D_o^{t+1}(x^{t+1}, y^{t+1})} \cdot \frac{D_o^t(x^t, y^t)}{D_o^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}}$$

$$= TECH(x^t, y^t, x^{t+1}, y^{t+1}) \cdot TCH(x^t, y^t, x^{t+1}, y^{t+1}) \quad (1)$$

where: TECH>1 indicates improvement in technical efficiency and TECH<1 deterioration in technical efficiency. TCH>1 indicates technical progress (evidence of innovation) and TCH<1 technical regress. Both components equal unity are associated with no change. Likewise, Malmquist index of total factor productivity change equal unity means stagnation, index greater that unity indicates growth and index less that unity means deterioration of productivity.

Malmquist index in (1) assumes that technology exhibits constant returns to scale (CRS). If the assumption on returns to scale is relaxed to allow variable returns to scale (VRS), then component of TECH, can be further decomposed to scale efficiency change (SECH) and pure efficiency change (PECH) also known as managerial efficiency [13]. This technical efficiency for the CRS model can additionally be decomposed into a pure technical or management efficiency and scale efficiency. Distance functions $D_o^t(x^t, y^t)$ and $D_o^{t+1}(x^{t+1}, y^{t+1})$ are reciprocal to technical efficiency measures and can be estimated by output-oriented models of Data Envelopment Analysis. As mentioned above, the most notable feature of DEA models is that they allow for comparative evaluations of managerial performance [14].

In our study were used three output variables: total output crops and crop production in EUR; total output livestock and livestock products in EUR; and other output. Base on FADN division of cost, four input variables were used: total specific costs; farming overheads; external factors and depreciation. We used panel data of 284 Slovak agricultural farms. The panel was constructed from the FADN from years 2004-2013. The average annual work units (AWU) and utilised agricultural area (UAA) of the farm in the panel was higher than there was the average value of indicators of the farms provided data to the FADN SK permanently over the period 2004-2008. The average characteristics of the panel farms specializing in livestock according to the specialization confirm that mostly large farms according to their AWU (49) and UAA (1515 ha).

RESULTS

The result obtained by the non-parametric application of the input-oriented DEA model is illustrated in Figure 1 by panel data over the ten-year period. On

average, 11% of farms are the best practice under CRS and 18% under VRS. Average technical efficiency under constant return to scale of the farms in the panel was 0.68 with a standard deviation of 0.15, minimum 0.16, and maximum 1. The interpretation of the scale effectiveness score allows for some interesting mentions. The average scale efficiency is 0.91, which means that the average farm size is not far from the optimal size, although a further increase in productivity of 8.5% could be achieved if they adjust the operation of their farm to the optimum scale. In fact, 67% of livestock farms operate to the most productive scale and the efficiency of the scale is equal to one. The average technical efficiency over ten years implies that only 68% of the possible outputs have been produced by the farms using the current level of inputs. The number of farms producing on the production possibility frontier decreased from 26 (9%) in 2004 to 17 (6%) in 2013.

Farms specialized on livestock production were the most inefficient in 2009. The average yearly technical efficiency of the Slovak farms in the panel decreased from 70% only to 69% over ten years period. The consequences of the global financial and subsequent economic crisis also contributed significantly to this, especially the sharp fall in commodity prices (especially pigs and milk), which were also reflected in Slovak agriculture through market systems and slowed down financial flows. In this year, agriculture achieved a negative economic result after joining the EU. We will achieve the highest efficiency in 2012. Agriculture has achieved a positive economic result mainly due to an increase in revenues from livestock production.

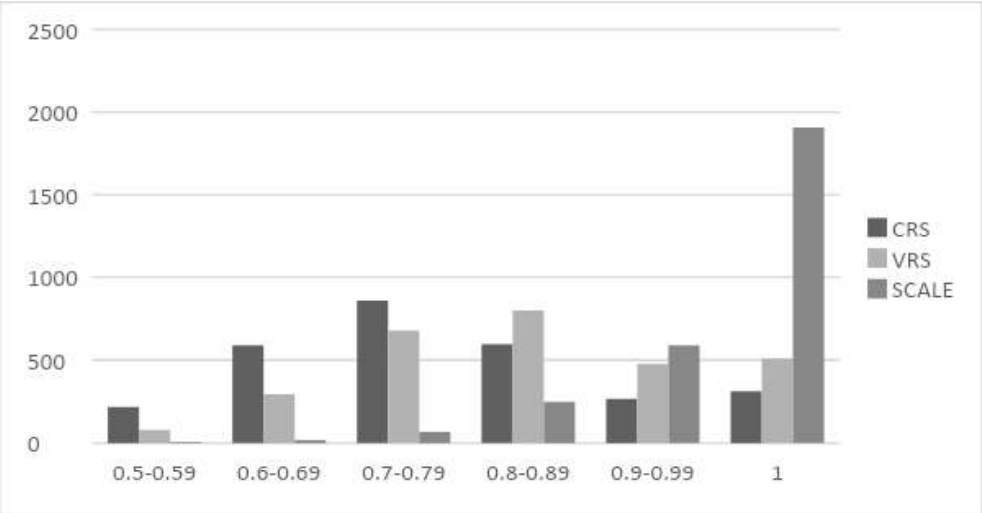

Fig. 1. *Distribution of efficiency*

The total factor productivity change measured by Malmquist indices ranged from 0.97 to 1.11 of livestock farms (Table 1). Although the number of technically efficient farms is not small, the mean radial technical efficiency of the sample is 0.69 under CRS assumptions, respectively. This implies first that on average, farms could reduce their inputs by 31% and still maintain the same output level, and second, that there is considerable variation in the performance of Slovak livestock farms. Total factor productivity increased the most in 2010. The total

factor productivity has declined by 2%, compared to the average productivity level to the beginning of the period.

Table 1. *Decomposition of Malmquist TFP index*

Year	TFP	TECH	TCH	PECH	SECH
2005/2004	0.97	1.11	0.87	1.07	1.04
2006/2005	0.99	0.91	1.08	0.94	0.97
2007/2006	1.03	0.98	1.05	0.96	1.02
2008/2007	0.97	0.91	1.07	1.00	0.91
2009/2008	0.90	0.94	0.96	0.96	0.99
2010/2009	1.09	1.11	0.98	1.00	1.11
2011/2010	1.11	0.98	1.13	1.00	0.99
2012/2011	0.97	1.17	0.83	1.12	1.04
2013/2012	0.97	0.90	1.07	0.93	0.96
Cumulative change	0.98	0.98	1.00	0.97	1.01

Note: TFP = total factor productivity change (Malmquist index), TECH = technical efficiency change, TCH = technological change, PECH = pure technical efficiency change, SECH = scale efficiency change

Source: Calculated from FADN data

The total factor productivity expressed by the Malmquist indices are decomposed into a change in technical efficiency over time as catching up and technological change as a change due to a shift in production boundaries of technologies over time. Technical efficiency change links to how the farms have performed relative to the best farms on the frontier. An efficiency change value greater than one means that the farm is closer to the efficiency threshold at the end of the reference period than at the beginning of the reference period. Changes in the technical efficiency of all groups of farms exceeded 1 and meant that farms lagging at the beginning of the reference period caught up with the best farms. Technological change ultimately represents a shift, influenced by production technologies or innovations. The higher technological progress was in 2011 (13%). This finding means that farms specializing in livestock adopt insufficient extent the innovative technologies. The highest deterioration of TCH was found in (by 10 %). Possible explanation lag of farms specializing in livestock can be exhausted investments in technologies at the end of the programming period.

The technical efficiency change under the variable returns to scale was decomposed into the pure technical efficiency change and the scale efficiency change. Pure technical efficiency is also known as managerial efficiency. A farm exhibits managerial inefficiency when the inputs used to produce a given level of output are more than the required amount. The technical efficiency change is

partitioned into that part that is due to pure or managerial technical efficiency and that part due to scale efficiency.

The model for measuring the change in efficiency is used to examine the change in the managerial efficiency of a livestock farm. The managerial efficiency was achieved in a period, where the value of pure efficiency change was less than 1. On the other side, the highest managerial efficiency was achieved in 2012. The scale efficiency growth in 2010 however, prevailed managerial inefficiency decline, and the farm technical efficiency increased. Cumulative values of indices over the period 2004-2013 show that farms degraded their performance compared to the best farms by 2%, mainly due to deterioration of the managerial efficiency by 3% and improvement of scale efficiency by 1%. Efficient farms increased their technical efficiency mainly due to an increase in managerial efficiency and scale efficiency in livestock and mixed production (2012). The results of the returns to scale estimation indicate that decreasing returns to scale was the predominant form of scale inefficiency of the efficient farms. Low economies of scale mean that farms are too large to take full advantage of scaling. Ultimately, downsizing is the best option for these farms.

CONCLUSION

An input-oriented DEA model under the assumption of CRS and VRS has been applied to investigate the degree of technical and scale efficiency of Slovak livestock farms over the period 2004-2013. Data of 284 farms from the FADN SK were analysed. This procedure makes it possible to identify farms with the best management practices and can also provide them with the necessary knowledge for farm management. By using these farms as benchmarks, inefficient farms can identify which changes in input resource use are needed to increase overall performance.

Total factor productivity (TFP) change was measured by Malmquist indices and decomposed to technical efficiency change and technological change. Further, we identify sources of efficiency changes by decomposition of technical efficiency change to managerial efficiency and scale efficiency changes.

This paper shows that the transformation of all inputs and outputs to average may provide a clearer insight into farm performance as efficiency scores can be more realistic and closer to the actual performance of each farm. Results suggest that on average, a potential 31% reduction in input use could be achieved provided all livestock farms operated efficiently, assuming no other constraints on this adjustment.

These results are important for the livestock sector. To remain profitable, farmers must adapt to the changes associated with the general liberalization of agricultural trade. Reducing waste of input resources and costs may prove to be

the most effective way to increase the viability of livestock farms, as farmers have more control over inputs.

The use of Malmquist indices shows how farmers can benefit from applying operational management tools to assess their performance. Management is identified as one of the main sources of inefficiency. Farms can improve technical efficiency through better management [7]. Improving the technical efficiency of the farm means less use of inputs, lower production costs, and thus affecting the profitability of farms, which is the driving force behind farmers' motivation to adopt new techniques.

We found that the productivity of farms specializing in livestock farming declined over time. The technical efficiency of all livestock farms remains stable over the period under review, with technological changes being negative over time. The negative development of technical efficiency was mainly due to a decrease in managerial efficiency of 3% compared to the average managerial level at the beginning of the period. The findings of a study on the optimal combination of integrated livestock farming in Nigeria revealed declining the average management efficiency by 9%. Farmers therefore can reduce the number of farms, labour, seeds, fertilizers, manure and agrochemical inputs [11].

In order to improve the productivity and efficiency of the industry, these results are useful for management in creating the optimal level of inputs, in streamlining the process of obtaining and using these inputs and in designing an appropriate policy framework to address identified problems in livestock production [6]. Nevertheless, some interesting insights regarding the performance of the Slovak livestock farms along with an indication of the relationship between certain managerial practices and technical efficiency may have been provided.

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