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# EFFICIENCY AND PRODUCTIVITY OF BULGARIAN FARMS

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## Abstract

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In this paper, DEA (Data Envelopment Analysis) is applied to estimate technical, allocative and economic efficiency of Bulgarian farms. The variables used in the model are gross output, land and labour for 2011. DEA results show that there is an extensive use of land and labour inputs, which leads to technical inefficiency. The allocative efficiency exceeds the total economic efficiency, indicating that at the given input prices farms have to decrease the amount of inputs in order to improve their efficiency. The Malmquist TFP Index is employed to analyze productivity changes during the period 2005–2013. The variables are gross output, intermediate consumption, depreciation costs and total costs for labor, land and capital. The analysis reveals that the total factor productivity decreases by 18% on average, mainly due to regression in technical change, but tends to recover. Technical efficiency slightly increases, by 2.2%. The total factor productivity grows by 3%, when annual price indices are used to deflate the value of output and inputs used in the model.

*Key words:* efficiency, productivity, Bulgaria

## Introduction

The efficiency measurement of enterprises is always at the attention of researchers, policy makers and producers. There is a system of different indicators which measure the degree of production factors usage and their impact on the efficiency. The most important common indicator is the rate-of-return (rate of profit), which reflects the capability of enterprises to operate efficiently enough to cover their production costs and earn a return. However, in modern economics is considered that the rate-of-return does not give incentives to enterprises to become more efficient through reducing the costs, to improve production quality in a cost effective way. In order to incentivize the enterprises to increase their efficiency it was introduced approaches, which measure efficiency in terms of innovations and cost minimization. The most commonly used methods are Data Envelopment Analysis (DEA), Stochastic Frontier Analysis (SFA) and Malmqust Index (Malmquist DEA). They evaluate efficiency by comparing enterprises to "the best practice" efficient frontiers formed by the most efficient enterprises in the sample (Anderson, 1996; Coelli, 1996, 1998, 2005).

The frontier efficiency methods have significant implications for the agricultural economics research. Many studies have been conducted, particularly in the new member states that measure the efficiency and productivity of agricultural holdings. There are only few studies estimated the efficiency and productivity of Bulgarian farm. Mathijs et al. (1999) used DEA to measure technical efficiency of 93 crop farms, incl. family farms, producers' cooperatives and companies. The family farms reached an average efficiency of 44%, co-operatives 43% and companies 51%. Kopeva et al. (2012), using a Stochastic Frontier, analysed a sample of 151 crop farms located in four districts (Pleven, V. Turnovo, Vratsa and Montana). They revealed that over 2005 to 2007 the average technical efficiency of cereal, horticulture and wine farms is respectively 91%, 79% and 60%. In our study of 117 field crops family farms and producers' co-operatives technical efficiency was calculated using DEA (Kaneva, 2004). In the solution with two variable inputs, land and labour, family farms reached 31.2% efficiency and co-operatives 32.7%. The efficiency increased to 46.4% and 55.6% respectively, when the value of depreciation and other inputs were employed as variables.

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In the next sections we apply DEA and Malquist-DEA to measure technical, allocative and economics efficiency and total factor productivity of Bulgarian farms, using survey data from the Farm Accountancy *Data* Network (FADN).

## Materials and Methods

**Data envelopment analysis (DEA)**

DEA uses linear programming methods to construct a production frontier. It measures the efficiency of farm performance relative to this frontier, which is the best performance. The core of the DEA is in finding the best virtual farm for each real farm. If the original farm produces less output with the same inputs or produces the same output with more inputs than the virtual farm, then the original farm is *inefficient*. A farm shows complete technical efficiency if it produces on the frontier of the production. Then the efficiency is equal to 1 (100%), while for other less efficient farms the coefficient ranges from 0 to 1 (0 to 100%). The frontier production function is defined assuming constant returns to scale (CRS). The best virtual producer for the real producer consists of the weights of the most efficiently performing other farms from the point of view of the real producer. These best performing farms are peer farms to the real producer (Coeli, 1996; Anderson, 1996).

An input oriented model is applied which seeks to identify technical inefficiency as a proportional reduction in the use of inputs without a reduction in output. The total technical efficiency (TE) is measured under variable returns to scale (VRS) so it is decomposed into *pure* and *scale* efficiency. This allows one to determine how many farms are operating in the area of increasing or decreasing returns to scale.

The allocative efficiency (AE) is calculated using the cost minimization input-oriented DEA model which involves inputs amount and their unit prices. The allocative efficiency reflects the ability of farm to use the inputs in optimal proportion, given their respective prices. The total economic (cost) efficiency (EE) is the product of technical and allocative efficiency (EE = TE* AE). It reflects the ratio between the minimum necessary resources and actually spent to produce a target output.

***Data and sample***

Data are taken from the Farm Accountancy Data Network (FADN) for 2011. The sample consists of 1532 farms, grouped according to the type of farming into: 789 field crops, 173 horticulture, 237 permanent crops, 171 dairy, 129 other grazing livestock (sheep and goats), 33 granivores (pigs and poultry). Farms are also divided according to the legal status into: 900 family farms (natural persons), 605 producers' cooperatives and 27 companies. Allocative and economic efficiency are calculated based on data for 890 farms, those using leased land and hired labour.

***Variables***

Both, the input oriented and the cost minimizing models have the same variables. The dependant variable is the gross output and independent variables are two inputs: utilized land (ha) and labour (annual working units, AWU). In the cost minimizing model, land prices are equal to rents, paid per ha leased land. Labour prices are calculated by dividing labour costs to the labour input (AWU). The entire utilized land (owned and rented) and the total labour input (paid, unpaid and part-time) are used for efficiency estimation. The calculations are made with the computer program DEAP V2.1 (Coelli, 1996).

**Malmquist TFP index**

The Malmquist Index measures the change in total factor productivity (TFP) between two data points by calculating the ratio between the distances of each data point relative to a common technology. The TFP is defined as the index of aggregate output is divided to the index of aggregate inputs. TFP growth refers to the amount of growth in real output that is not due to the growth in inputs.

The Malmquist index is decomposed in two components: efficiency change and technical change. The efficiency change is represented by an index of a farm's efficiency relative to the present and past frontiers, i.e. the efficiency change is equivalent to the ratio of technical efficiency in present period to the technical efficiency in the past (base) period. The technical change is represented by a shift in the production frontier which means the shift in the technology between two periods. The solution of the model provides five indices for each unit (farm) in each year: tfpch **-** total factor productivity change; effch – technical efficiency change; techch – technical change; pech – pure technical efficiency change; sech – scale efficiency change. An index $\geq 1$ implies productivity or efficiency growth and $\leq 1$ implies deterioration or regress.

***Data and sample***

The study uses average per farm data for nine years (2005–2013). Five specialized groups of farms, according to the FADN typology, are analyzed: field crops, horticulture, permanent crops, grazing livestock (cattle and sheep) and granivores (pigs and poultry).

***Variables***

The dependent variable is the gross output and independent variables are costs in BGN for: (1) intermediate consumption; (2) depreciation and (3) labour, land and capital. In order to isolate the effect of inflation, output and input price indices (from Eurostat) are used as deflator. The model is solved in two variants with current and deflated value of output and inputs. The computer program TFPIP V1 is used for index calculations (Coelli, 1996).

## Results and Discussion

### DEA results

***Technical efficiency***

The average technical efficiency is 44% for producers' co-operatives and 31% for family farms. This means that co-operatives could produce their output with 56% less inputs and family farms with 69% less. All co-operative groups, with exception of permanent crops are more efficient than family farms (Figure 1).

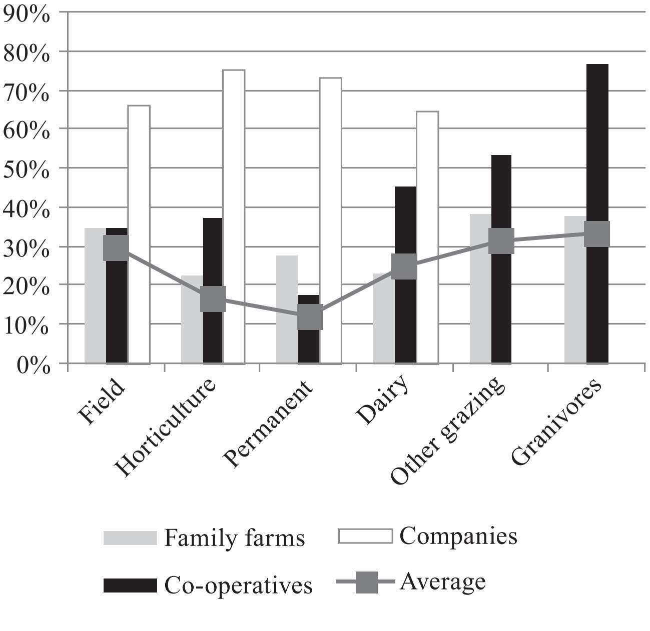


**Fig. 1. Total technical efficiency by type of farms**

Family farms and co-operatives specialized in granivores and other grazing livestock are the most efficient groups. However, the efficiency of the two family farm groups, each reaching 38% is much lower than the efficiency of the corresponding co-operative groups, with 77% and 54% respectively. Permanent crop co-operatives have the lowest efficiency (18%), followed by horticulture family farms (23%). Both, field crop family farms and field crop co-operatives are almost equally efficient with 35% total efficiency. Dairy family farms have 23.4% efficiency, which is almost 2.0 times less than the efficiency of dairy co-operatives. Companies, which are predominantly specialized in field crops, reach the highest efficiency but they have insignificant share in the sample, 1.8%. For this reason they are excluded from the analysis forward.

The results provide evidence that farm's production orientation plays a significant role in terms of its efficiency. As granivores farms have the highest animal density per ha, they exhibit higher efficiency compared to dairy farms, which use more extensively land and show lower efficiency.

***Scale efficiency***

Scale efficiency of most co-operative groups is higher than the efficiency of family farms (Figure 2). Field crop co-operatives are the most efficient group (88%), followed by granivores co-operatives (84%) and field crop family farms (82%). Dairy family farms have the lowest scale efficiency (48%) due to the predominance of very small farms. Permanent crop co-operatives, which have the lowest technical efficiency, also show the lowest scale efficiency out of all co-operative groups, 52%. Most groups of family farms

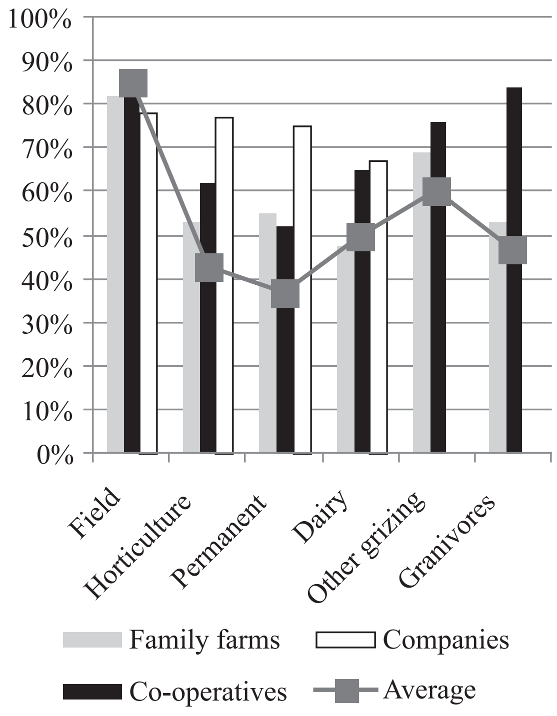


**Fig. 2. Scale efficiency by type of farms**

and co-operatives operate under increasing returns to scale (IRS), i.e. they have no reach their optimum scale and it would be reasonable to increase their size. A greater share of co-operatives than family farms operate at optimum scale, reaching their frontier production function. About 58% of field crop co-operatives and one third of animal (grativores, dairy and other grazing livestock) co-operatives are working under decreasing returns to scale (DRS). They have exceeded the optimal scale and capture diseconomies of scale. In order to reach their optimum, they have to decrease in size. Approximately 21% of field crops and 10% of other grazing livestock family farms are working under DRS. This results implies that not only field crop farms but also animal farms are incentivized under the Single Area Payments Scheme to expand their utilized land.

Input slacks in the model show how much quantity of inputs exceeds the quantity that is necessary for receiving the same output or how much the output must be raised for an efficient use of inputs. Farms have mostly excess land than excess labour. Co-operatives show higher land and labour input slacks than family farms. The granivores co-operatives have the largest amount of excess land (53 ha per farm) and show output slacks (€ 7776), which means that these co-operatives have not only to reduce land input, but to raise output in order to improve their efficiency. Dairy co-operatives exhibit a large amount of excess land (45 ha) and a higher output slack than granivores, € 15 410. The excess land is 10 ha per granivore family farm and 3.3 ha per dairy family farm.

Field crops co-operatives have the highest labour input slacks, almost 1 AWU, while the excess labour in field crop family farms is two times lower, 0.5 AWU. The remaining groups of family farms and co-operatives show slight slacks in land and labour input.

***Allocative efficiency***

It reflects the impact of input prices, is above 80% under DRS for most groups of farms (Figure 3). Co-operatives reach higher average allocative efficiency than family farms. Only field crop and dairy co-operatives show about 1% lower efficiency than the efficiency of the respective family farms. Both, permanent crop family farms and permanent crop co-operatives are the least efficient, reaching efficiency of 63% and 74%, respectively. Horticulture family farms have a similar level of efficiency, 72%. These two farm groups, both horticulture and permanent crops have potential to decrease costs through improving land and labour allocation. The cost-minimizing quantities in the model allow calculating the ratio between the minimum necessary and actually spent inputs. In order to operate at the optimum, horticulture family farms have to expand their utilized land by 10% and to decrease labour inputs by 93%. Family farms, specialized in permanent crops have to decrease the size of land by 5% and labour inputs by more than 2.0 times. The worst performing group, namely permanent crop co-operatives, have to reduce the utilized land 3.3 times and labour inputs 2.4 times.

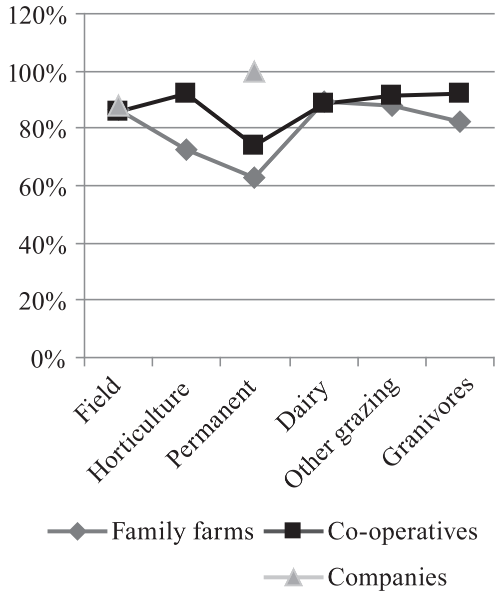


**Fig. 3. Allocative efficiency by type of farms**

***Total economic efficiency***

All groups of farms are less cost (economically) efficient than allocatively efficient, which means that they have low technical efficiency in the cost model. Family farms and co-operatives have almost equal average efficiency (56-58%), ranging from 35% to 80% (Figure 4). The most efficient are granivore and horticulture family farms followed by granivores and horticulture co-operatives. Field crop co-operatives and field crop family farms have the lowest efficiency, about 35–38%.

***Malmquist index results***

Total factor productivity (TFP) has decreased on average by 19.5% during 2005–2013. The rate of annual decline slowed and reached its lowest level of 4.8% in 2011–2012 and subsequently increased by 2.6% in 2012–2013. The decreasing TFR is mainly linked to technical change (change in technology), while technical efficiency raises by 2.2% (Figure 5). The most significant technical change experienced field crop farms with regression of 22.4% (Figure 6). A reason for this is the glut of new machines, which affects the

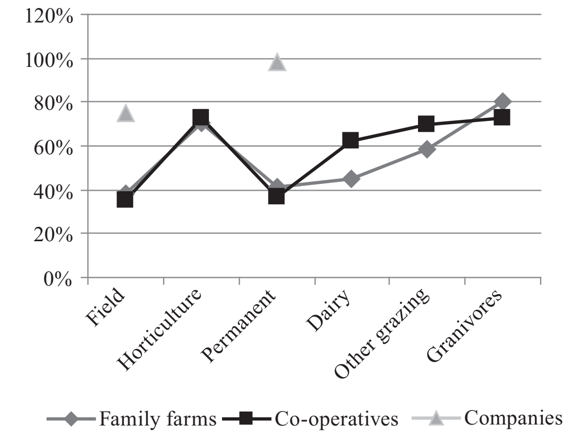


**Fig. 4. Total economic efficiency by type of farms**

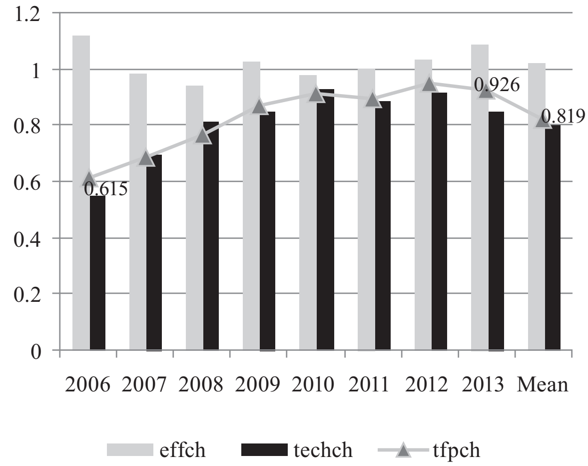


**Fig. 5. Total factor productivity 2005–2013**

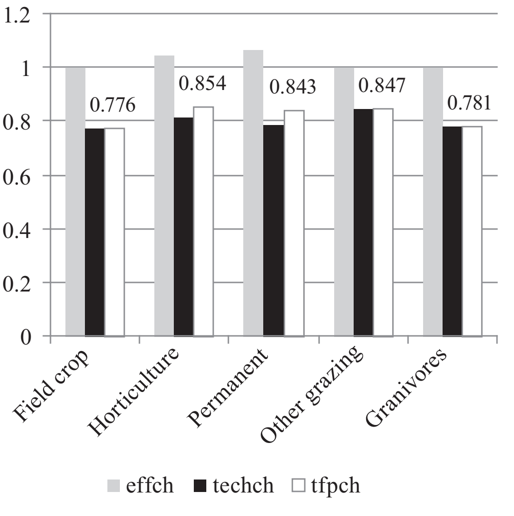


**Fig. 6. Total factor productivity by type of farms**

increase of depreciation, almost 13 times for 2005–2013. As well, rents jump 20 times, while the output goes up only 9.8 times. In 2013, the share of rents in total costs for labour and capital was 71% against 29% costs for wages, while in 2005 the ratio was 38% and 62%, respectively.

Horticulture farms exhibit the least TFP regression (14.3%), due to contribution of technical efficiency, increasing by 4.8%. TPF worsen for permanent crop farms, although there is a raise of technical efficiency. TFP change for both, other grazing livestock and granovores farms is only due to the technical change, while there is no change in technical efficiency.

## Conclusion

In this paper we applied two methods (DEA and Malmquist index) to measure technical, allocative and economic efficiency, and total factor productivity of Bulgarian farms. According to the input minimizing model, technical efficiency of all co-operative groups, with exception of permanent crops, exceeds the efficiency of family farms. Farms specialized in granivores and other grazing livestock are the most efficient groups, while permanent crop co-operaives and horticulture family farms are the least efficient. Scale efficiency of co-operatives, with exception of permanent crops, is higher than the efficiency of family farms. Most groups of both, family farms and co-operatives use extensively land, so they have to reduce their size or to use the land more intensively.

According to the cost minimizing model, co-operatives exhibit higher allocative efficiency than family farms. Both, co-operatives and family farms have lower economic efficiency than allocative efficiency. At a given combination of input prices they have to decrease the amount of inputs in order to perform efficiently.

Total factor productivity decreases for all groups of farms, due to deterioration of technical change, although there is a trend for recovering. In contrast, technical efficiency goes up, mostly after 2010. Such trends indicate a need for technological innovation in Bulgarian farms.

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