DOES GROUP AFFILIATION INCREASE PRODUCTIVITY AND EFFICIENCY IN RUSSIA'S AGRICULTURE?

EVIDENCE FROM AGROHOLDINGS IN THE BELGOROD OBLAST

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Abstract

The impact of group affiliation to agroholdings on enterprise performance in terms of productivity and efficiency is controversially discussed in the literature. However, only few papers evaluate the effects of group membership on the productivity and the efficiency of agricultural enterprises in Russia. The underlying research question of this paper is therefore whether farms that belong to agroholdings perform better than independent farms. We calculate partial land and labor productivity, total factor productivity and technical efficiency scores for the two categories of independent farms and members of agroholdings. In this paper a production function approach is estimated in the framework of stochastic frontier analysis. The results are used to decompose total factor productivity into a scale effect, a technological change effect and a technical efficiency effect. The results show a different trend than observed in previous studies. The growth of agroholdings total factor productivity exceeds by far the development of the independent farms and that group affiliation has a positive impact on the performance of the farm.

Key Words

Agroholding, Stochastic Frontier Analysis, Efficiency, Total Factor Productivity, Russia

1 INTRODUCTION

The agricultural sector in Russia is still facing essential challenges due to the undercapitalization of agricultural enterprises. The appearance of agroholdings may help to bridge the liquidity constraints and thus increases the productivity as well as the efficiency of agricultural enterprises. The impact of group affiliation to agroholdings on enterprise performance in terms of productivity and efficiency is controversially discussed in the literature. However, only few papers evaluate the effects of group membership on the productivity and the efficiency of agricultural enterprises in Russia. This gap can be explained by the fact that Russian agroholdings are a complex and new phenomenon and empirical time-series data is currently not available.

In this paper we contribute to this discussion and analyze whether farms that belong to agroholdings perform better than independent farms. We concentrate on performance indicators (partial productivities), structural indicators (size, specialization), capacity utilization and investigate how these vary with respect to organizational form. Moreover, we will examine how group affiliation affects the production possibilities of agricultural enterprises.

The next section provides an overview of the literature on the performance of agroholdings in comparison with independent farms in Russia. The differences in production using firm level data from the Oblast Belgorod are examined in Section 3. We present structural indicators as well as partial land and labor productivities for the different farm types. In Section 4 a production function is estimated in the framework of stochastic frontier analysis. The results are used to decompose total factor productivity into a scale, a technological change and a technical efficiency effect. These indicators are further examined towards the aim whether group affiliation has an effect on the initial level and their development. Conclusions are presented in Section 5.

2 LITERATURE REVIEW: PERFORMANCE OF FARMS WITH RESPECT TO GROUP AFFILIATION IN RUSSIA

Previous studies on the efficiency of agricultural enterprises in Russia have been done with the main focus on regional development over time, often with a special focus on the period of transition[1]. These studies estimate a production function for different production fields (crop, animal) and/or regions by using either stochastic frontier or data envelopment analysis. The findings of these papers usually proclaim significant technical and allocative inefficiency in agriculture.

Another group of empirical studies deal with differences in farm organization and its impact on production and productivity. Generally Vertical coordination in the agrifood supply chain is an important and growing phenomenon in transition countries of Europe (SWINNEN ET AL. 2005). But in contrast to works on efficiency of corporate farms versus family farms just a few papers concerning the efficiency of agroholdings compared to independent farms exist. One major reason for this could be a lack of information concerning the affiliation of farms to agroholdings. Therefore the consequences of the appearance of agroholdings in the agrifood-sector are still not well understood.

There is evidence that agroholdings diminish their commitment on the farm level and verification for other agroholdings to constantly increase their investments in farming (HOCKMANN 2005). Vertical Integration in the agricultural supply chain generally brings notable investments into the agricultural sector. The flow of capital allows modernization of primary agriculture and infrastructure of the supply chain. This capital is the dynamic cause to purchase modern machinery and farms introduce the most advanced technology (DRIES ET AL. 2009). RYLKO AND JOLLY (2005) showed that the affiliation to an agroholding increases the investments on assets such as machinery as well as the access to input markets and credits. In addition vertical integration brings new management abilities to the farming sector. However, for the Oblast Orel GATAULINA ET AL. (2006) show that efficiency indicators like partial productivities and cost-effectiveness indicate that agroholdings work less efficient than independent farms.

Empirical works about the differences of agroholdings and independent farms can rarely be found. For the Oblast Belgorod HOCKMANN AND KOPSIDIS (2007) made an empirical analysis of agroholdings and independent operating farms. The authors conclude that many agroholdings are less efficient than alternative organizational forms. As one of the reasons for this the authors name the insufficient recognition of economic forces governing integration processes and the requirements for decision making. Efficiency scores of agroholdings calculated in a study by HOCKMANN ET AL. (2007) show for the years from 2001 to 2003 that technological and managerial innovations introduced by agroholdings do not necessarily move agricultural production on an efficient trajectory.

In the above mentioned studies a holistic approach is still not found to explain why agroholdings tend to have a different performance than independent farms. The reasons for the claimed hypothesis that agroholdings have better access to Input markets and higher input quality but a worse performance than independent farms are not ascertained yet. It is questioned whether this issue is related to transaction costs or a needed challenge for

[1] For an overview see Liefert (2007)

Russian agriculture. This limited validity of former studies can be explained in short periods of investigation.

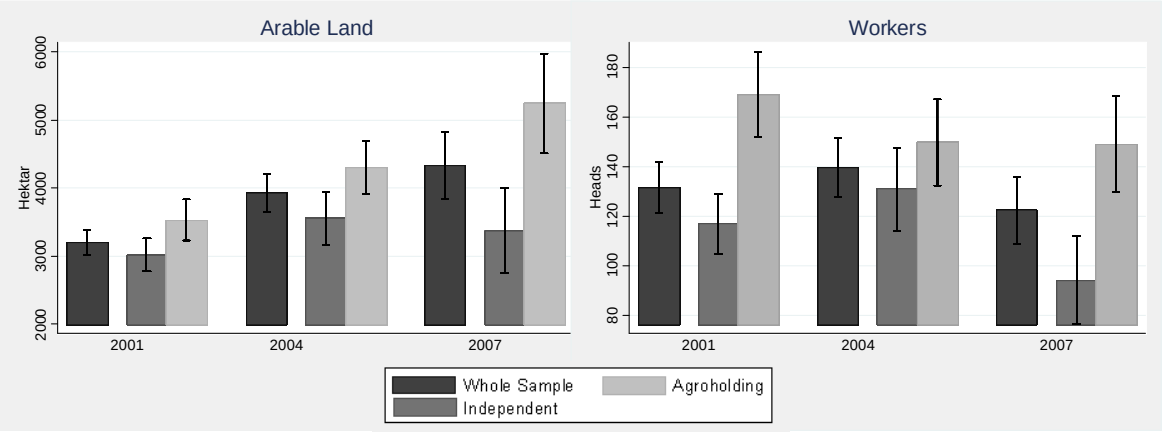
3 AVERAGE DEVELOPMENTS OF THE DIFFERENCES BETWEEN ORGANIZATIONAL STRUCTURES IN THE OBLAST BELGOROD

In this section we are using agricultural firm data from the Goskomstat agricultural registria provided by Golohvastov – Agroconsult. This unbalanced panel of 524 farms located in the oblast Belgorod contains data for the years 2001, 2004, and 2007. Included are 210 indications covering gross production (acreage, yields, average annual livestock and gross volume of production), marketing (sales volumes and sales revenue) and cost structures of the farms. The data are supplemented with regional price indices as well as the FIRA-Database which contains information about the affiliation to agroholdings. In the year 2001 82 Percent of the arable land in Belgorod was controlled by these farms with slight decreasing rate to 2007 (67 Percent of arable land). Due to the high share of arable land cultivated by the farms in the dataset the increasing share of farms that belong to an agroholding the data can be regarded as representative for the corporate farms in the Oblast. This data will be used for the descriptive statistics in Chapter 3.1and 3.2. The relevant indicators will be the use of arable land, Workers in Agriculture, specialization (measured as revenue share in constant prices) and as for partial productivities Labor-Productivity (gross production value per worker) Land Productivity (gross production value in crop production per ha of sown area), land-man-ratio (worker crop per 100 hectare of sown area) and milk per cow (kilogram per cow).

3.1 A First approach

When we look at the whole sample it can clearly be concluded that overall the enterprises increased the amount of arable land by about 1000 ha in the time period from 2001 to 2007 (see figure 1). The increasing confidence interval over time suggests that farms developed heterogeneously with regard to controlled land. This heterogeneity can be observed for independent farms as well as for agroholdings. The land under control of agroholdings increased significantly over the years (in average from 3500 ha up to more than 5000 ha).

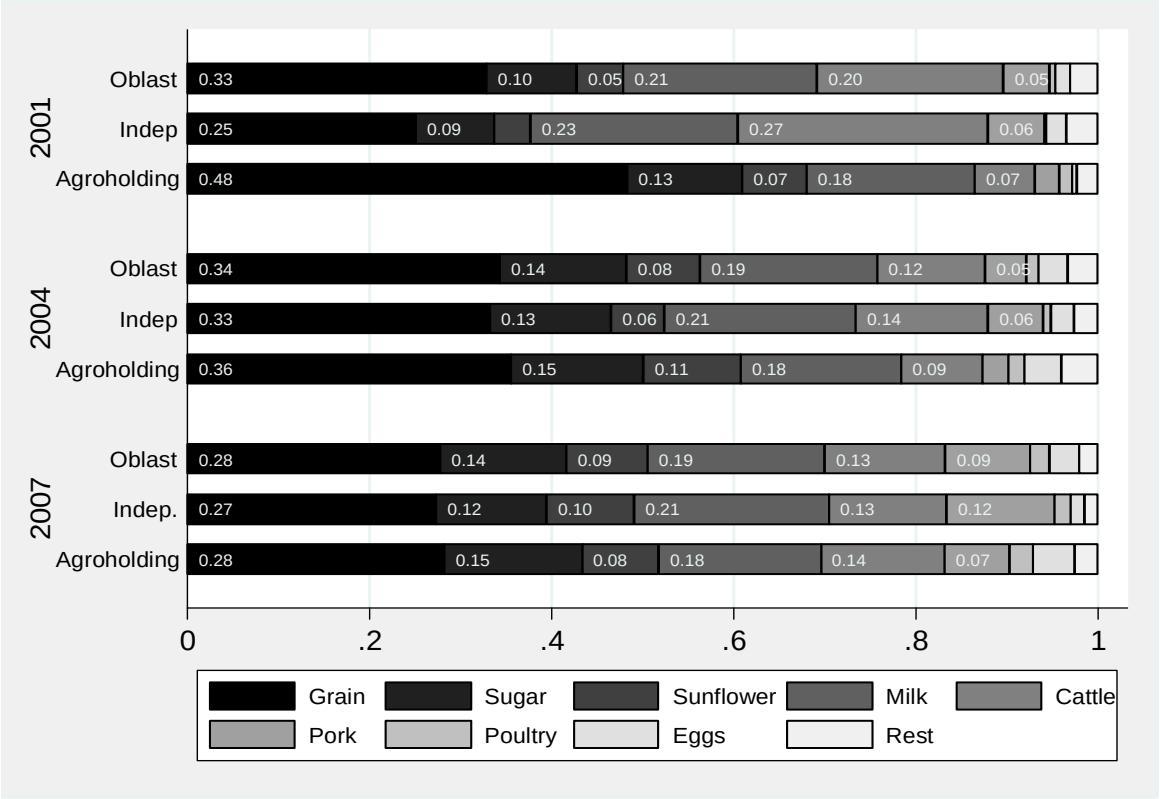
Figure 1: Arable Land and Employed Workers



Agroholdings employ on average more workers than independent farms. This may not be surprising due to the fact that agroholdings cultivate more land than independent farms over time. Concerning the workers employed by enterprise in the whole sample there was a

slight decrease in employment saying that less people in the region were employed in the agricultural production. Surprisingly the independent farms decreased by far the amount of labor (20%), while agroholdings condensed the amount of workers by just 12%.

Figure 2: Specialization (measured in Revenue shares in constant prices)

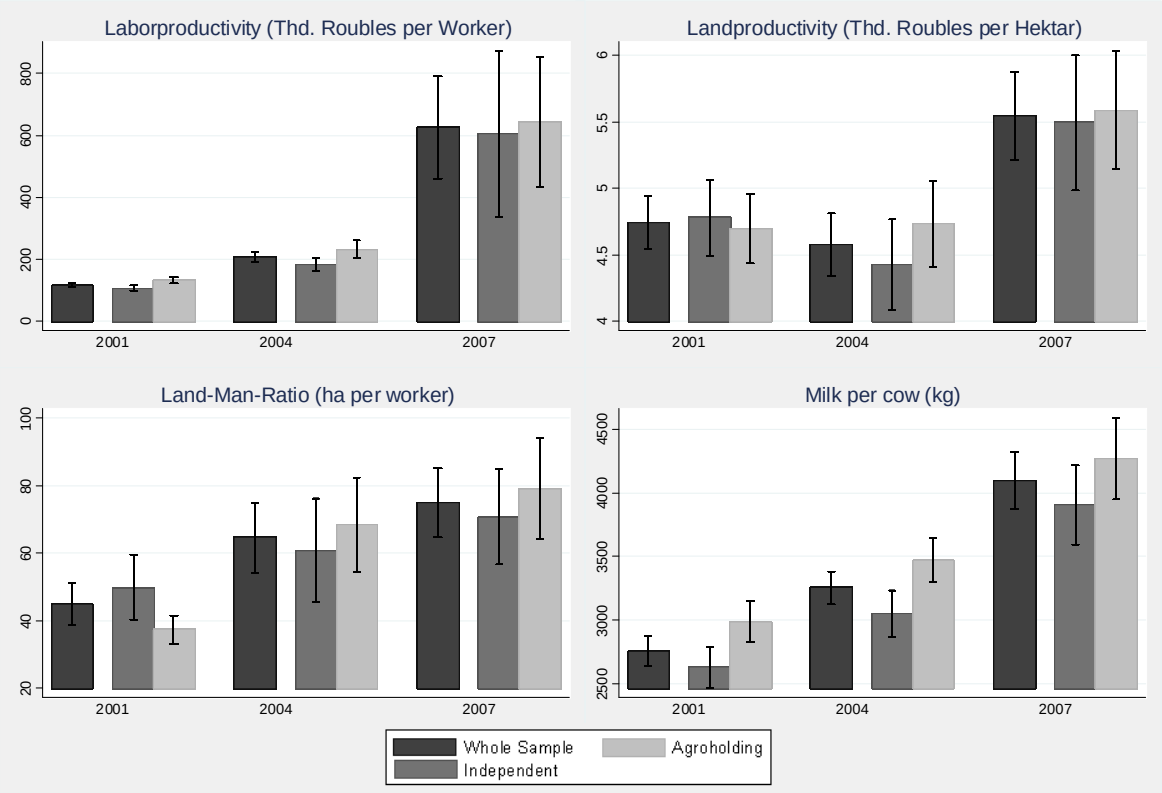


At the oblast level there was a tremendous decrease in the cattle production, contrary pork production increased. Figure 2 shows that both of theses trends are aroused by independent farms. Agroholdings drastically reduced the revenue share of grain production. It decreased from 2001 to 2007 by 20 percentage points. This was to a high extend compensated by revenue shares from cattle (doubled), pork, poultry and eggs. For agroholdings the extent of factory-style specialization (i.e. poultry and hog production) increases whereas the focus of seasonality of production is reduced. This goes in line with the theory of ALLEN AND LUECK (2003) who argued these specializations are less subject to severe transaction cost disadvantages and principle agent problems than other production activities.

3.2 Partial Productivity

Labor productivity increased tremendously over the years. In the Oblast Belgorod this indicator approximately doubled between 2001 and 2004 and tripled as well as between 2004 and 2007 (see figure 3). In this aspect there are no significant differences over time between agroholdings and independent farms. Nonetheless due to the big confidence intervals it can be concluded that there were heterogeneous developments in the complete dataset irrespectively from the type of organisational form.

Figure 3: Partial Productivities



Land Productivity was rather constant over the years but with heterogeneous development in the examined groups. The figure on Land-Man-Ratio shows that farms increased their labor-efficiency due to the fact that one worker was used to farm 40 ha in 2001 and 80 ha in 2007. Largely responsible for this trend was the falling trend of Land-Man-Ratio in agroholdings. While in 2001 one worker was used to control 50 ha of land (where the Land-Man-Ratio was even lower than in independent farms) in 2007 the same worker could control 80 ha. Milk production per cow increased over the period under investigation. In all years agroholdings were more productive than independent farms. On average in agroholdings' milk-production per cow was about 500 Kg higher than in independent farms. For other partial productivity indicators no big differences between agroholdings and independent farms could be found. For instance the differences in grain yields are quite small and changes can be explained to a high extend by climatic conditions.

4 ESTIMATION PROCEDURE

Partial Productivities cannot show a coherent picture of the performance of Agroholdings and independent farms. On the one hand the impact of capital and material inputs such as seed, fertilizer, feeding stuff etc is missing. In addition, partial productivity measures considered in isolation can provide a misleading indication of overall productivity. Therefore in this chapter parameters that add up to the total factor productivity will show the undistorted performance of the respective farms. Reliable conclusions of the development of the different farm types can just be made from a balanced panel. 76 agricultural enterprises in our data set provide information for all the years. This sample comprises holding members and independent enterprises to the same extent.

4.1 Estimation procedure

A stochastic frontier analysis was conducted to estimate farm technical efficiency. We consider a translog stochastic production frontier defined as follows:

$$\ln q_{it} = \beta_0 + \beta_t t + \frac{1}{2}\beta_{tt} t^2 + \sum_{n=1}^{N} \beta_n \ln x_{nit} + \sum_{n=1}^{N} \beta_{tn} t \ln x_{nit} + \frac{1}{2}\sum_{n=1}^{N}\sum_{j=1}^{N} \beta_{nj} \ln x_{nit} \ln x_{jit} + \beta_h h + \beta_{ht} th + \sum_{n=1}^{N} \beta_{tn} h \ln x_{nit} + v_{it} - u_{it} \quad (1)$$

or

$$\ln q_{it} = f(\ln \mathbf{x}_{it}, h, t) + v_{it} - u_{it} \quad (1b)$$

where q_{it} is the output of the *i*th farm in the *t*th time period

x_{nit} are the *n*th input items of the *i*th farm in the *t*th time period

t is a time trend representing technical change

h is a dummy variable which is 1 for holding members and zero otherwise

β s are unknown parameters to be estimated

The v_{it} are random errors, assumed to be i.i.d. and have $N(0, \sigma_v^2)$ distribution, The u_{it} represents the impact of technical inefficiency and are assumed to be log-normally distributed with $N^+(0, \sigma_u^2)$. Moreover, v_{it} and u_{it} are assumed to be statistically independent.

The specification in (1) allows for a rather detailed investigation of the impact of group affiliation on total agricultural production. First, agroholding membership is allowed to shift of the production function. Second, it is accounted for effects on production elasticities, e.g., changes in partial productivities, and different effects of technical change in agroholdings and independent farms.

Due to use of a time invariant variable "*h*" we were not able to apply a fixed affect estimator. A random effect model would have been possible, however, this would have provided time invariant efficiency scores. Given the log time horizon in our data set, this procedure appears to be inappropriate. Thus, despite possible efficiency losses, we opted for a pooled estimation in order to be able to allow for change in firm level technical efficiency and to account for the effects of group affiliation.

4.2 Data

The balanced data set contains 76 agricultural enterprises (39 holding and 37 independent farms). The dependent variable is gross production. This output variable was constructed in three steps. First, farm specific producers' prices for all production activities were calculated using the information on the value and the amount of sold products. Second, gross production was weighted by the individual prices and summed up to total gross production value. This provides values in current prices. In the third step, the values of gross production values were deflated by a Törquist Theil Index. The deflator was constructed from the price information obtained in step 1 and the shares of individual

products on gross production. We used the procedure proposed by (CAVES ET AL 1982) to construct an index which allowed conducting multilateral consistent comparisons. In addition this procedure allows constructing an output variable whose level and development are comparable among enterprises and over time. We used for input: land, labour, capital and material inputs. The land variable comprises the hectares of arable land. Labour is the number of workers in agricultural production. Capital is represented by the costs of fixed assets. Material inputs comprises the information on seed, fertilizer, pesticides and other variable inputs.

Capital and material inputs were only available in current prices. However, we applied the deflation procedure as described for output. The only difference is that we could not use firm but only regional level data calculating the index. This procedure provides enterprise deflators, however, the differences reflect only the firm specific weight of the individual components in the aggregate and the firm specific prices.

For estimation we normalized all variables by their geometric mean. This facilites the interpretation of the estimation results strongly, since the first order terms represents the production elasticities at the sample mean.

Taking into consideration that we just used depreciation as a proxy for the use of capital the probability is high that we underestimate the use of Capital especially with regard to agroholdings. This is due to the fact that the leasing of machinery is a common state of the art in agroholdings (RYLKO AND JOLLY 2005) which could not be calculated from the dataset.

4.3 Estimation results

As can be seen in Table 1 all first order terms are positive and statistically significant. The highest elasticity was estimated for material inputs. This is in concordance with the information in the data set, since this input amounts to about 50% of total production. The coefficient associated with land is second largest. The relatively low elasticity of labor (0.13) goes in line with results of studies from OSBORNE AND TRUEBOLD (2006) or BOKUSHEVA AND HOCKMANN (2006). The sum of the four production elasticities (1,086) is larger than one, suggesting very mild increasing returns to scale at the sample mean.

Group membership significantly affects the production structures. This holds not only for the shift but in addition for the partial productivities and the effect of technical change. Due to the negative coefficient of the variable "member" group affiliation initially affected production negatively. This corresponds to the observation and in beginning of the period under investigation, many bankrupt, e.g., less productive enterprises were forced by the regional government to join agroholdings (WANDEL 2007). In addition, the production elasticity of labor is positively affected by membership, while group affiliation had a negative impact on the other inputs.

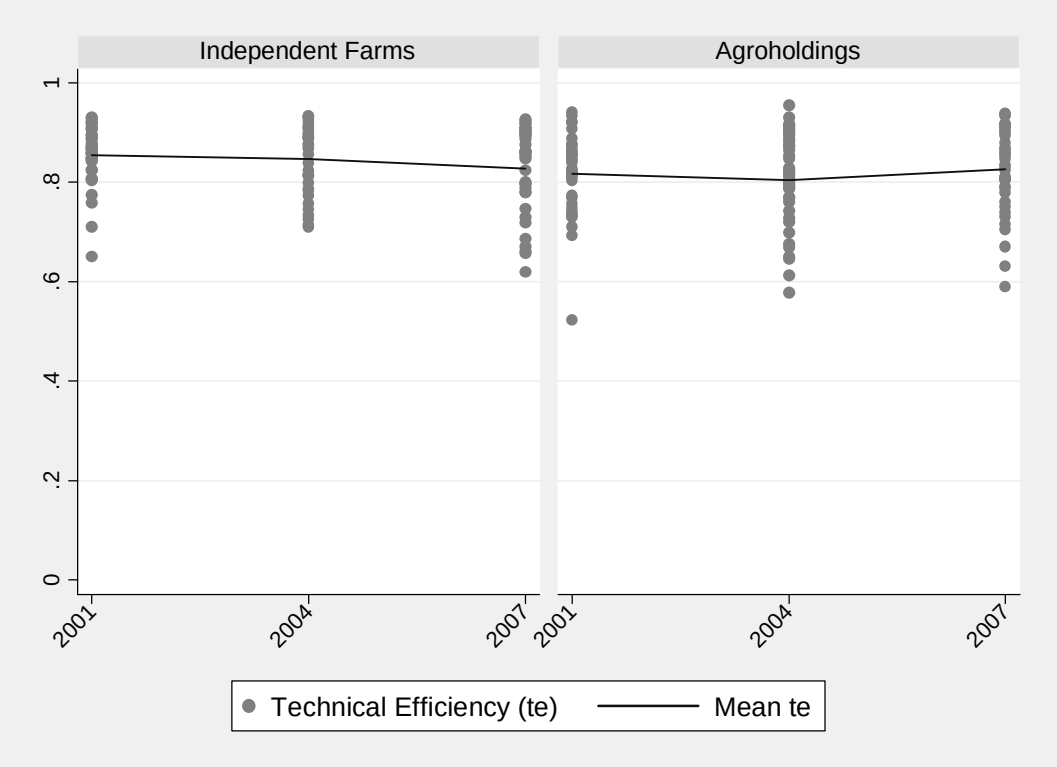
May be most remarkable affect of group affiliation is its impact of technical change (*tm*). The parameter suggest that the productive capacities of agroholding members improved much faster than that of independent farms. This results agrees with the observation that holding members experienced high investments with a corresponding improvement of the production facilities. Moreover, the old management was often substituted by younger, well educated decision makers (HOCKMANN ET AL. 2007).

Table 1: Parameter estimates

	Coef.	Std. Err.	z	P>|z|
ln Labor	0.1267	0.0731	1.7300	0.0830
ln Land	0.3177	0.0817	3.8900	0.0000
ln Capital	0.1319	0.0281	4.7000	0.0000
ln Matrial	0.5102	0.0691	7.3800	0.0000
ln Time	-0.0117	0.0108	-1.0800	0.2780
ln Labor * ln Labor	0.2276	0.1174	1.9400	0.0530
ln Labor * ln Land	0.0057	0.1184	0.0500	0.9620
ln Labor * ln Capital	-0.0218	0.0590	0.3700	0.7120
ln Labor * ln Material	-0.2591	0.1042	-2.4900	0.0130
ln Time * ln Labor	0.0108	0.0208	0.5200	0.6050
ln Land * ln Land	-0.7149	0.1381	-5.1800	0.0000
ln Land * ln Capital	0.0684	0.0636	1.0700	0.2830
ln Land * Ln Material	0.1941	0.1039	1.8700	0.0620
ln Time * ln Material	0.0167	0.0175	0.9600	0.3390
ln Capital * ln Capital	0.0470	0.0317	1.4800	0.1380
ln Capital * ln Material	-0.0675	0.0455	-1.4800	0.1380
ln Time * ln Capital	0.0007	0.0096	0.0700	0.9410
ln Material * ln Material	0.4357	0.1231	3.5400	0.0000
ln Time * ln Material	-0.0195	0.0165	-1.1800	0.2390
ln Time * ln Time	0.0026	0.0073	0.3500	0.7260
ln Holding	-0.0671	0.0325	-2.0600	0.0390
ln Time * ln Holding	0.0452	0.0150	3.0100	0.0030
ln Labor * ln Holding	0.2757	0.0949	2.9100	0.0040
ln Land * ln Holding	-0.1500	0.1146	-1.3100	0.1910
ln Capital * ln Holding	-0.0709	0.0421	-1.6800	0.0920
ln Material * ln Holding	-0.1593	0.0986	-1.6200	0.1060
Constant	0.1499	0.0626	2.3900	0.0170
sigma_v	0.1689	0.0290		
sigma_u	0.1885	0.0736		
sigma2	0.0640	0.0191		
lambda	1.1158	0.1009		

Technical efficiency was estimated by the JONDOW ET AL. (1982) procedure. The development of technical efficiencies by different business structures is shown in Figure 4. Two things can be derived from the graph: 1. Technical efficiency is in general very high. 2. There is no pronounced difference in the efficiency of agroholding members and independent farms. At this point it has to be mentioned that the relatively high Efficiency scores by 0.8 and a small Variance with no farm operating under the 0.5 boarder conflict to efficiency scores of other studies conducted with farm level data (BOKUSHEVA AND HOCKMANN 2006). On average the farms in Belgorod, given the available technology, almost produce on their production frontier. This issue is especially critical concerning conclusions about the agricultural potential of this region. With regard to show the potential of the region and the successive farm structure to reach the potential agroclimatic conditions (i.e. soil quality, growing degrees days and precipitation) in line with a Meta-Production functions as can be found in KIM AND LAU (1994) could be used.

Figure 4: Development of technical efficiency (each observation represents one observation and the line comply with the annual mean)



4.4 Total Factor Productivity (TFP)

As conventionally we define TFP by the relation of the output index and an input index. Since we represented production by a translog functional form, we can apply the quadratic lemma (DIEWERT 1976) and calculate a Törnquist - Theil index for inputs. Because this index gives intransitive results in multilateral comparisons we used a modified version of the index. CAVES ET AL (1982) introduces the modified Törnquist - Theil index which is again exact for the translog function and in addition allows for consistent comparisons among individuals and over time:

$$\ln\left(I^{Input}\right)=\frac{1}{2}\sum_{j\neq 1}\left[\left(s_j+\bar{s}_j\right)\ln\frac{x_j}{\bar{x}_j}-\overline{s_j}\,\overline{\ln x_j}+\overline{s_j\ln x_j}\right], \quad \text{with } s_j=\frac{f(\ln\mathbf{x},h,t)}{\partial\ln x_j}\left(\sum_j\frac{f(\ln\mathbf{x},h,t)}{\partial\ln x_j}\right)^{-1} \quad (2)^2$$

The adjustment provides production elasticities as if the production function would be characterized by constant returns to scale (OREA 2002). This modification allows to identify the productivity effects of input changes, i.e. structural changes in agriculture. In addition, our input index includes also the effect of agroholding membership. We decided for this procedure, in order to be able to identify the affect of group affiliation on the various productivity components consistently.

[2] Due to this transformation, every observation is assessed in relation to the average in the sample.

Applying the same procedure to the output index provides:

$$\ln\left(I^{Output}\right) = \ln\frac{y}{\bar{y}} \tag{B4}$$

Correspondingly, TFP is defined as:

$$\ln(TFP) = \ln\left(I^{Ouput}\right) - \ln\left(I^{Input}\right)$$

This indicator represents all effect on production which result from the exploitation of economies of scale (SE), technology (TC), efficiency (TE), e.g. TFP = SE*TC*TE.

Figure 5: Means of Economies of Scale, Technology Change and Technical Efficiency

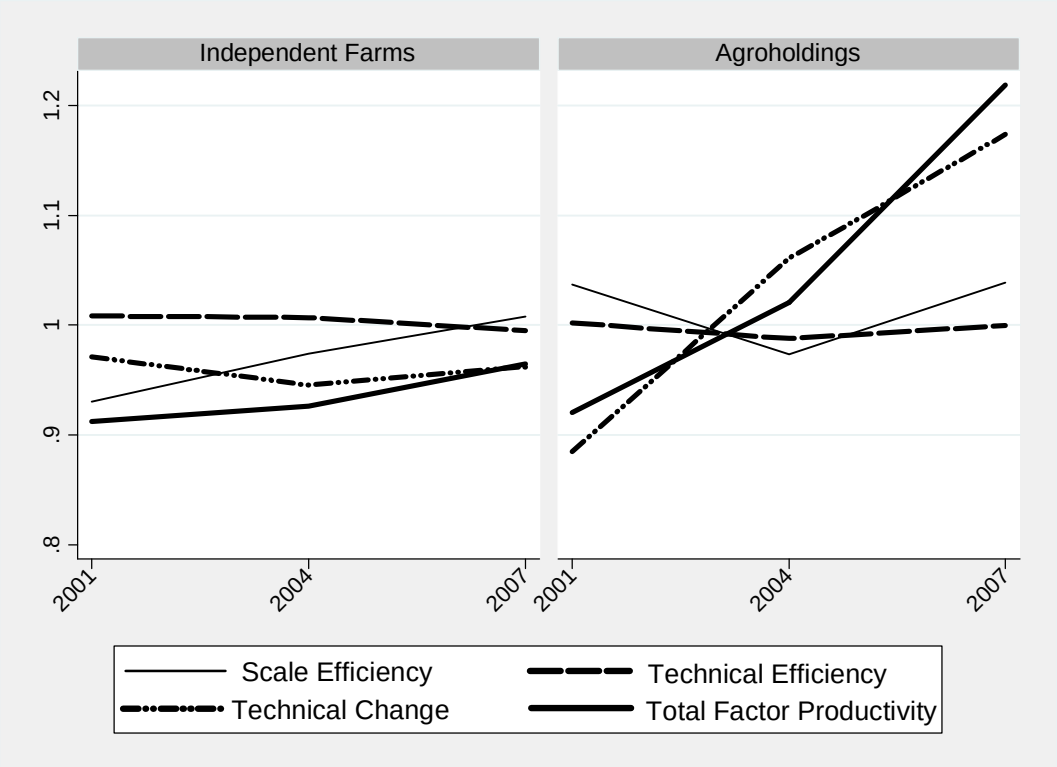


Figure 5 shows the changes over time in total factor productivity and its' subcomponents Scale Efficiency, Technical Efficiency and technical change which add up to the TFP.

Technical efficiency is almost stable in the period under investigation. Moreover, its contribution to TFP on the groups of farms is neglected. However, there are remarkable differences between the organizational form regarding the scale and the efficiency effect. Independent farms benefited especially from improving scale efficiency. This effect was ambiguous for agroholding members. The decreasing scale efficiency of agroholdings may be due to the drastic growth of these companies (see development of land under control in Chapter 3.1) in period from 2001 to 2004. Moreover, holding members on average have higher scale efficiency than independent farms.

The estimates provide further, that in 2001 independent farms appeared to be better equipped with technology. However, they could not keep their favorable position. They suffered from a deterioration of technology until 2004, only in recent years this group benefited from the adoption of technical changes. Contrary, holding members, on average,

were able to improve their technology over the whole period of investigation. Moreover, technical change was the driving force of TFP growth in agroholding members, while independent farms basically benefited mostly from improving their scale efficiency, and thus, changes in the production structures. These developments correspond to the parameter estimates of the production function. In the description of the results, the special role of technical change in agroholdings was already highlighted.

Overall it can be obtained clearly that agroholding members and independent farms start at the same level of TFP, while agroholding members improved significantly only small improvements for independent farms can be observed. This improvement is especially driven by the technical change component. The conclusion can be drawn that holding members show a higher adoption of new technologies than independent farms. Furthermore, this provides that in recent years farms belonging to agroholdings are defining the regional production frontier. This conclusion, at a first glance, is contradictory to HOCKMANN ET AL (2007) who found that agroholdings are lacking behind independent farms. However, their data set captures developments between 1999 to 2003. For this period we were not able to indentify a superior role of holdings, moreover, holding members and independent farms appear to have been similar efficient and productive.

In addition, given the constant variation of technical efficiency among organizational forms and farms it can be concluded that positive developments detected for agroholdings in general, is not a phenomenon which can be observed of all holdings members. On the contrary, the developments detected from our data suggest that agroholding evolve as diverse as other agricultural enterprises. The group on average benefited from individual frontrunners which put the performance indicators ahead. Thus, being a member of a business group is not a guarantee for success per se, but it's the exploitation of the growth potentials which might be higher when being part of an agroholding.

5 CONCLUSIONS

In this paper we contribute to the issue of group affiliation and the intensity of factor use such as capital, land, labor and other production factors as well as the adjustment of new technologies. Generally it can be said that group affiliation has an influence on structure and the performance of the farm. agroholdings tend to focus on factory-style production-units while independent farms tend to focus on seasonal production. By looking at the partial productivities agroholdings overall perform better but the results are not straight forward as well as not comprehensive. Concerning the components of Total Factor Productivity the Findings from HOCKMANN ET AL. (2007) were resumed. The result is twofold: on the one hand the conclusion can be verified that the technological and managerial innovations introduced by agroholdings do not necessarily increase the efficiency of agroholdings. On the other hand we could show that agroholdings are due to technical change the driving force of the shift of the production frontier. Starting with almost the same total factor productivity in 2001 the agroholdings outperformed the Independent farms in the years up to 2007. This is true for the average holding but we doubt that this is true for all. Therefore future research is needed to efficiency and productivity within the group of agrohodlings.

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