Production Risk, Technology and Market Access in Different Organisational Forms: Evidence from Tatarstan and Oryol

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Abstract

This paper examines price and technology differentials between agroholdings and independent farms in two Russian regions: Oryol and Tatarstan. Both organisational forms receive on average the same product prices which indicates that they have the same market access. Moreover, their technologies are also very similar, as estimated by a risk production frontier. However, differences in the factor input between organisational form lead to differences in the shadow prices of the inputs, resulting from the better access of agroholdings to the input markets. The results suggest that production risk, conditions on the product market and inefficiency significantly affect agricultural production. Thus, to improve the conditions, agricultural policy is required to tackle all the issues in parallel using a mix of appropriate policy measures.

Keywords: risk production function, Russia, agroholdings
JEL: Q110, D220, P230

1 Introduction

Several studies have revealed that Russia's agricultural sector is lagging behind the development of other sectors of the economy (VOIGT and HOCKMANN, 2008). The reasons for this divergence are being intensively discussed among economists and politicians. In this paper, we will contribute to this debate and analyse both the significance of price and quantity risks as well as their influence on agricultural development and performance. The analysis will be conducted for two regions of the Russian Federation: the Tatarstan Republic and the Oblast Oryol. In these two regions, agriculture is provided with massive administrative support, with agroholdings particularly benefitting from this aid. Against this background, it seems interesting to investigate how these political interventions may have contributed to the agricultural development in these regions. In this context, we will analyse how prices as well as inputs and outputs have developed regarding organisational forms and how these determinants have influenced performance.

Since the analysis of price variations among farms can provide information about market access, it can also offers insights into the two aspects of whether organisational forms have different access to markets (higher expected price) and whether the market conditions are mode stable (variation of prices). Quantity changes are due to production risk and technical inefficiency. While production risk leads to a variation of agricultural production around the average and essentially results from the variation of natural conditions, e.g. weather, technical inefficiency determines the degree to which producers are able to exploit production possibilities. These indicators will be investigated for two different organisational forms (agroholdings, independent farms) to assess whether productivity differences among agricultural enterprises are determined by the choice of technology or rather by ownership and governance structures in agricultural enterprises. Thus, we will also contribute to the question of whether the occurrence of horizontally and vertically integrated structures (often called agroholdings or business groups) has had a positive effect on agricultural production.[1]

Our analysis is based upon revenue as the central indicator and is conducted in two steps. In the first step, we decompose variation of revenues into the variation of product prices and the variation of production quantities. While the variation of product prices can be directly taken from the data, the contribution of the variation of production with its components technology, production risk and inefficiency has to be estimated using econometric techniques. Therefore, in a second step, we apply stochastic frontier analysis to determine how these individual components affect agricultural production.

The paper is organised in six sections. The next section presents relevant and important indicators for the agricultural sector in the two regions. Section 3 deals with the decomposition of the variance of revenue into the individual contributions of prices and quantities. Differences in the level of production (partial productivities) will also be investigated. Section 4 is reserved for a discussion of the theoretical background of the stochastic frontier analysis and the data used in the analysis. The estimation results are presented in Section 5, together with a critical discussion and the implications arising from the individual contributions of technology, risk and inefficiency to

[1] On this issue, see for instance HOCKMANN et al. (2009), KOLNESNIKOV (2009) and WANDEL (2010).

production. In Section 6, the findings from Section 3 and 5 are consolidated to render a coherent picture of the impact of market access, technology, risk and inefficiency.

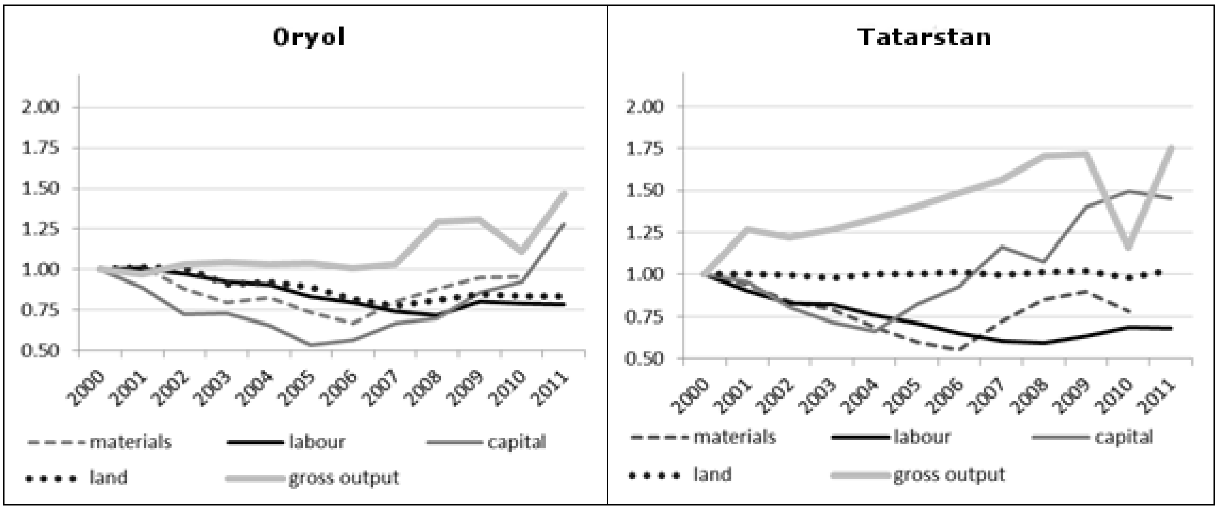
2 Regional Characteristics

The investigated regions both belong to the Russian Federation, with Oryol Oblast located in the southwest of Central Russia, while the autonomous Republic Tatarstan is part of the Volga District. The regions show considerable differences in their geographical size, with Tatarstan stretching across about 67.8 thousand km^2 and thus measuring almost three times the area of Oryol oblast with only 24.7 thousand km^2. This area proportion is reflected in the cultivated area, which amounted to 2.5m ha in Tatarstan in 2008, compared with 0.8m ha in Oryol. Apart from these pronounced differences, both regions have good weather and soil conditions for crop production (grains, potato, sugar beet) and extensive grassland for livestock breeding.

2.1 Agricultural Development

Between 2000 and 2011, both regions experienced a strong increase in agricultural production (Figure 1) with gross agricultural output increasing annually by almost 4% and more than 5% in Oryol and Tatarstan, respectively. However, as is evident from Figure 1, the regions' agriculture did not develop in parallel: in Tatarstan, output growth already started to continuously rise in 2000, whereas in Oryol, it essentially did not start until 2007 and considerably decreased again in 2010, when both regions experienced a sharp decline in output due to a blaze after extreme drought.

Figure 1. Development of production and factor use, 2000-2011 (2000=1)



Source: own calculations based upon Rosstat

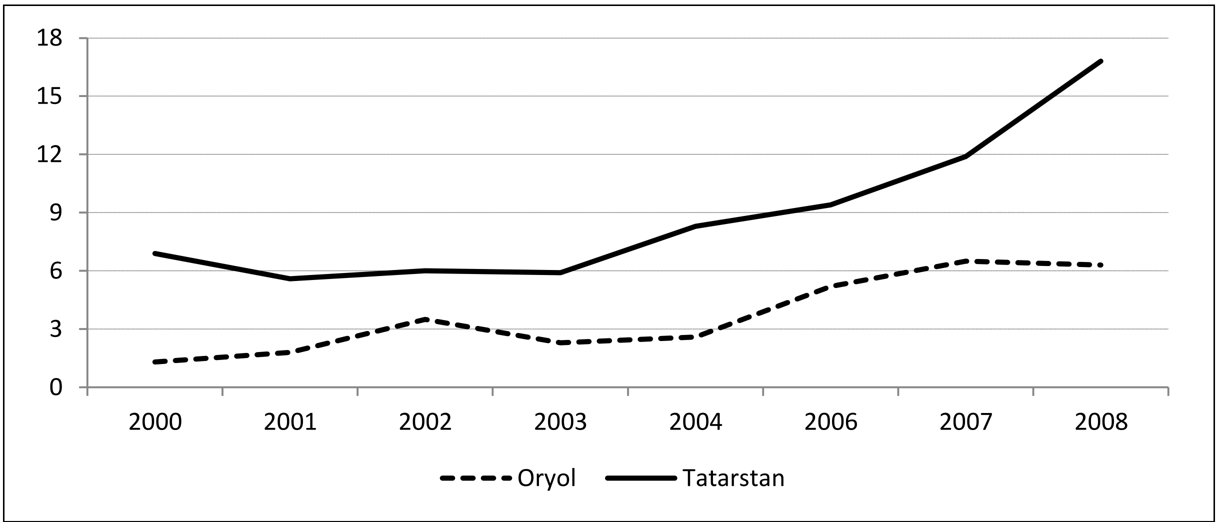
Surprisingly, the change in production was not accompanied by a corresponding development of input use in agriculture. In fact, apart from capital, all inputs showed lower levels in 2011compared to 2000. Regarding industrial inputs such as capital and materials, the lowest level was reached in the middle of the decade, although the use of these inputs has increased in both regions in recent years. Similar to industrial inputs, labour use in agriculture steadily declined until the middle of the decade and stabilized at a level about 25% lower than that of 2000 in both regions after 2008. Finally, the clearest inter-regional difference is revealed for land. While, land use in Oryol steadily declined, it remained stable in Tatarstan over the entire period.

Given that the reasons for these developments, both production-related and inter-regional, are manifold, it would go beyond the scope of this paper to explain all of them in detail, although there are two aspects that should at least be mentioned. First, as the reduced factor use together with increased production output imply that technological and structural change is taking place. It seems appropriate to shed light on the actual role of technical progress in the agriculture of the two regions, which will be taken up in sufficient detail in Section 5. Second, the agricultural sectors are provided with different levels of support from local and federal governments.

2.2 Agricultural Policy

Although it is not possible to put an exact figure on policy intervention from regional and federal governments owing to lacking data, the share of subsidies in the value of production may provide at least a rough estimate of the volume of these expenditures (Figure 2).

Figure 2. Share of subsidies in the value of agricultural production (%), 2000-2008



Source: Rosstat, Russian Ministry of Agriculture

Figure 2 reveals that, on average, public support for agriculture in terms of its share in the value of production was twice as high in Tatarstan compared to Oryol. Moreover, since 2003, Tatarstan farms have experienced a higher increase of subsidies than those in Oryol, which is likely to result from the uneven availability of funds, particularly given that Tatarstan is an oil producing region that could undoubtedly strongly benefit from the increase in crude oil prices between 2000 and 2011. Nevertheless, the scope of the subsidy programmes during the 2000-2008 period were rather similar in both regions, including subsidies for buying fertilizers and feedstuff, subsidies for growing particular crops or grazing livestock, pig or poultry, compensation for interest rates. Additionally, farms in both regions received public support for investment, which led to massive – albeit different in absolute volumes – investments in agriculture (see Figure 1), e.g. in the period from 2006 to 2008, Tatarstan farms invested more the 50 bn Roubles in fixed assets, as compared to only 17 bn Roubles in Oryol.

Both regional governments fostered the creation of agroholdings. Starting in 1990, Oryol was one of the first regions in which the government directly helped to create vertically integrated structures, whereby essentially two highly vertically, horizontally and diagonally integrated structures could emerge, besides structures that would be easily controllable by regional and local governments.[2] The establishment of holdings had closed commodity chains, joint production planning as well as financial administration. Furthermore, since the head companies of the holding have better access to financial markets, it is thought that the liquidity constraints of the agricultural companies were softened. Through their provision of agricultural enterprises with produced farm inputs (materials, capital), the agricultural sector was expected to benefit from a faster modernisation of the production technology, as well as a better mobilisation of the regional production potentials. Altogether, the establishment of holdings was to serve more than the obvious purpose of agricultural development, but additionally a general rural development. However, at the end of the decade, due to lack of effectiveness and profitability, one of the large holdings (Orlovskaya niva) collapsed into several smaller vertically integrated agroholdings, which then specialised in sugar, grain, poultry and/or pork production and processing (WANDEL, 2010).

In the 1990s, Tatarstan belonged among those regions that tried to retain the socialist organisational forms – kolkhoz and sovkhoz – typical for the former Soviet Union. However, the paradigm of agricultural policy changed in the 2000s and with it the rejectionist attitude towards horizontally integrated structures was abandoned. Ultimately, the creation of huge holding structures was strongly supported, bringing about huge farms; for instance, milk producing farms with 800-1,500 cows on average

[2] The main difference from other regions was that in the regions under investigation, the creation of holding structures was initiated by the regional government and not purely privately driven process.

and farms specialising in crop production cultivating about 400 thousand ha per holding. As a result, the four largest agroholdings cultivated 60% of the 2.5m ha available in the region.

In the late 2000s, both regions faced similar problems. First, the companies suffered severely from the financial crises since they were highly indebted. Second, as the regional governors who had once supported the holdings left their positions, some holdings ran the risk of losing state support, which in turn would have worsened their precarious situation as they might have experienced problems in obtaining new credits.

3 Quantity and Price Variation

3.1 Data

We used accountancy data of agricultural enterprises in Tatarstan Republic and Oblast Oryol for the period of 2006-2008 (Rosstat data provided by VIAPI). The original data sets contained about 1,000 observations for Tatarstan and 600 for Oryol. For reasons of quality and reliability, data preparation was necessary and considered two aspects: first, we excluded observations with nonsense partial productivities, e.g. when land productivity or milk production per cows was by more than factor of 10 from average; and second, we excluded farms with only one observation available or even missing data. Including those would have led to large variability in the data of the individual years, while the entering and exiting of farms would have significantly biased the results. After this necessary cleaning, the resulting data sets contained 634 and 352 observations for Tatarstan and Oryol, respectively, with approximately six times as many independent farms as holdings.[3] In detail, the respective numbers amounted to 238 independent farms and 40 holdings for Tatarstan, and 148 and 24 for Oryol.

The prepared data set was ready to provide sufficiently detailed information concerning production structures, specialisation and factor input. Moreover, implicit firm-specific product prices could be calculated from the data in two steps using the quantities and

[3] Given that there is no legal definition of agroholding, holding membership is not defined in official statistics. However, for the sake of practicality, most analyses define the organisation form agroholding according to UŠAČEV (2002), namely as group of companies that are connected via asset and contractual relationships. However, we followed a practical definition of group membership that was developed at VIAPI: a farm is a member of an agroholding when the owner of the farm owns other farms as well. Since this classification considered all agricultural enterprises in the Russian Federation, the identification of owner structures should be quite accurate. However, it captures only asset relationships. The available data only provides information concerning whether or not a farm is a member of a business group but does not identify the business group itself.

sales of marketed products. Since our data allowed conducting comparable analyses for grain and milk, in a first step we took a closer look at production and product prices of the agricultural enterprises. In order to ensure that comparisons were not biased by farm size, gross production was divided by a suitable input unit, i.e. as we concentrated on grain and milk, the area planted with the corresponding crop and the number of cows in milk production. To proceed further, we derived information about different price and partial productivity structures of agroholding members and independent farms. In addition, we decomposed the variance of output-specific revenues to identify whether revenues by organisational form were differently affected by quantity and price variation.

3.2 Prices and Partial Productivities

Table 1 lists information about partial productivities and prices received by farmers. The data show that marked price differences between organisational structures did not exist in either region. Essentially, the same holds true for partial productivites. Altogether, this absence of differences is quite surprising, especially as it is often argued that prices received by holding members are pure transfer prices and thus independent of market prices. Since the information in Table 1 provides no support of this view, it can be ruled out that agroholdings conducted special price strategies, as well as the notion that the result presented here is purely incidental. Of course, the issue of price formation could have been further investigated by comparing prices between different agroholdings, although the available data were too poor to extract or derive the necessary information. Despite not being as informative as holding-specific prices, price variation between independent farms and group members may help to shed some light on this issue instead.

3.3 Variance Decomposition

In the following, we discuss the contribution of the individual variances of prices and quantities to the variance of revenues. For this, we decompose the variance of revenues into the portions explained by prices and quantities; the components using a first-order Taylor approximation:

$$\mathrm{var}(py) = (Ep)^2\,\mathrm{var}(y) + (Ey)^2\,\mathrm{var}(p) + c(y,p) \qquad (1),$$

where *p* and *y* represent output prices and quantities and *c(y, p)* contains the covariance structures between prices and quantities (see Appendix I).

Table 1. Mean prices and production quantities (per hectare or cows), 2006-2008

Region		2006 E(y)	2006 E(p)	2007 E(y)	2007 E(p)	2008 E(y)	2008 E(p)
Tatarstan	**Independent farms**						
	Grain	25.3	2.6	25.7	3.8	33.7	4.4
	Milk	35.9	5.8	37.9	7.0	41.7	8.9
	Holding members						
	Grain	23.8	2.7	23.2	3.8	26.7	4.2
	Milk	33.5	5.9	34.2	7.2	35.2	8.3
Oryol	**Independent farms**						
	Grain	17.6	2.8	18.5	4.4	29.9	3.7
	Milk	29.0	5.9	27.9	7.2	33.4	8.9
	Holding members						
	Grain	17.9	2.6	18.9	4.3	31.7	3.4
	Milk	24.9	5.9	27.2	7.5	29.8	9.1

Notes: E(p) and E(y) denote the mean of prices and production per hectare (per cow), respectively. Quantities are per input unit, i.e. grain production per hectare and milk production per cow. Productivities are in 100kg per hectare or cow; prices are in Rouble per kg or litre.

Source: own calculations

Table 2 suggests that the covariances between prices and quantities are fairly irrelevant in terms of explaining the variance of revenues. Indeed, the price and quantity variances account on average for more than 90 % of the variation of revenues. Moreover, the within-period covariance effects are positive in all cases, thus implying a positive correlation between quantities and prices, which in turn indicates that products are not just sold at prevailing market conditions but rather that farms are to some extent able to negotiate better prices in case they provide higher quantities.[4]

[4] SVETLOV (2009), and SVETLOV and HOCKMANN (2007) investigated the role of external transaction cost in agriculture in Moscow oblast. Following a different approach (DEA), they also found that this cost significantly affects agricultural holdings.

The calculations reveal that by far the dominant share of variation results from quantity, whereas price variance holds minor importance given that it contributes little to the variance of revenues. In addition, despite marked differences in the significance of price variation between members of a business group and independent farms, it is not possible to make an unambiguous statement regarding the shares since the contribution of price variance in the group of independent farms is larger for some products, whereas we observe the opposite for others.

Table 2. Contributions of price and quantity variance to revenue variance (%), 2006-2008

	2006			2007			2008		
	Share explained	Share of prices	Share of quantities	Share explained	Share of prices	Share of quantities	Share explained	Share of prices	Share of quantities
Tatarstan									
Independent farms									
Grain	97.7	6.4	93.6	94.5	4.5	95.5	99.8	9.5	90.5
Milk	89.4	3.9	96.1	87.4	6.7	93.3	91.0	4.0	96.0
Holding members									
Grain	82.7	13.8	86.2	80.5	8.4	91.6	81.3	7.5	92.5
Milk	92.0	4.7	95.3	96.4	5.5	94.5	83.8	6.8	93.2
Oryol									
Independent farms									
Grain	81.3	12.4	87.5	80.0	14.5	85.5	51.6	37.5	62.4
Milk	75.3	8.5	91.5	68.7	13.1	86.9	70.3	12.5	87.4
Holding members									
Grain	60.8	17.4	82.5	82.5	8.0	91.9	42.0	46.4	53.5
Milk	78.2	4.2	95.7	104.8	14.6	85.4	99.9	9.4	90.5

Note: quantities are per input unit, i.e. crop production per hectare and milk production per cow.
Source: own calculations

With output variance playing such a dominant role, taking a more detailed look behind the sources of this variation suggests itself. In principle, the variation arises from the four sources of size, productivity, risk and technical inefficiency. Regarding our main intention to identify the contributions of risk and technical inefficiency to output variance, the next two sections deal with this problem. To this end, we first introduce the theoretical background and the data used in the analysis, before subsequently discussing the results.

4 The Sources of Quantity Variation: Theory

4.1 Methodological Considerations

In the analysis of production structures, we apply an extended version of the conventional production function, i.e. the risk production function. Compared to the conventional procedure, this model is able to consistently identify the separate impacts of individual inputs on risk and inefficiency. This concept was originally introduced by JUST and POPE (1978) and extended by KUMBHAKAR (2002):[5]

$$y = f(\mathbf{x}, m, t; \boldsymbol{\alpha}) + g(\mathbf{x}, m, \mathbf{d}; \boldsymbol{\gamma})v - q(\mathbf{x}, m; \boldsymbol{\theta})u \qquad (2),$$

with

$f(\mathbf{x}, m, t; \boldsymbol{\alpha})$ mean production function,
$g(\mathbf{x}, m, \mathbf{d}; \boldsymbol{\gamma})$ risk function,
$q(\mathbf{x}, m; \boldsymbol{\theta})$ inefficiency function.

In Equation (2), y and **x** denote output and a vector of inputs, respectively. *t* represents time, **d** is a vector of annual dummy variables and *m* denotes the organisational form. $\boldsymbol{\alpha}$, $\boldsymbol{\gamma}$ and $\boldsymbol{\theta}$ are parameters vectors to be estimated.

Thus, output variation in Equation (2) is decomposed into three components. The first component technology is expressed by the mean production function *f* representing the average impacts of inputs (**x**) on production. The second part *g* is assumed to capture the effects of risk on production. Because the actual output can be lower or higher than its average level due to poor or favourable weather conditions, it is reasonable to connect the risk function with a two-sided error component (*v*). The function *q* captures the impact of factor use on the degree of exploitation of production possibilities, and thus generally expresses technical efficiency or – keeping with the terminology of the present analysis – inefficiency. This function transforms a one-sided error term *u*.

For the empirical analysis, we make the following assumption about the functional forms. The natural logarithm of the mean production function is assumed to be translog:

$$\ln f(\mathbf{x}) = a_0 + a_m m + \left(a_t + .\tfrac{1}{2} a_t t + a_{tm} m\right)t + \left(\mathrm{a} + \boldsymbol{\alpha}_t t + \boldsymbol{\alpha}_m m\right)' \ln \mathbf{x} + \tfrac{1}{2} \ln \mathbf{x}' \mathbf{A} \ln \mathbf{x} \qquad \text{(2a)}$$

5 In the following, bold symbols indicate vectors or matrices, whereas all other variables are scalars. Subscripts will be omitted to improve readability.

In this representation, we assume that the constant and the first-order effects may change over time (t) and with organisational structure (m)[6]. The former is supposed to capture the impact of technical change, while the latter is introduced to test whether membership in an agroholding has a significant impact on production structures.

The risk function is assumed to comprise two parts, i.e. a generic and an idiosyncratic component. First, the generic component captures the effects of overall weather conditions and affects all farms equally. In the empirical analysis, we follow BOKUSHEVA and HOCKMANN (2006) and consider this kind of risk by constant and dummy variables for 2006 and 2008 (d_{06}, d_{08}). Second, the idiosyncratic component of g is farm-specific and depends on the intensity and structure of input use. We assume that the idiosyncratic risk can be represented by a Cobb Douglas functional form. Thus, we have:

$$\ln g(\mathbf{x}) = \gamma_0 + \gamma_{06} d_{06} + \gamma_{08} d_{08} + \gamma' \ln \mathbf{x} + \gamma_m m \qquad \text{(2b).}$$

The inefficiency function q is also Cobb Douglas:

$$\ln q(\mathbf{x}) = \boldsymbol{\theta}' \ln \mathbf{x} + \theta_m m \qquad \text{(2c).}$$[7]

4.2 Estimation Procedure

The econometric model comprises Equation (2) and additional assumptions regarding the error terms u and v:[8]

$$y = f(\mathbf{x}, m, t; \boldsymbol{\alpha}) + g(\mathbf{x}, m, \mathbf{d}; \boldsymbol{\gamma}) v - q(\mathbf{x}, m; \boldsymbol{\theta}) u \qquad \text{(3),}$$

with $v \sim N(0,1)$ and $u \sim N^{+}(0, \sigma_u)$.

While the risk production function used in this paper is more flexible than the conventional production function approach, if necessary, it can be transformed to fit the

6 We distinguish between two organizational forms: interdependent farms (m = 0) and holding members (m = 1).

7 Some readers may argue that the model is malspecified since the same variables are used in different functional forms and this specification leads to severe multicollinearity problems. However, it has to be taken into account that the model to be estimated is nonlinear (see Sec. 4.2) and thus all parameters are uniquely identified. The multicollinearity phenomenon leads to identification problems in linear models only. For the specification of the mean production function (translog form) the multicollinearity problem may arise because in inclusion of the cross terms. The estimation results (Table 3) imply we cannot exclude multicollinearity since the significance of the cross terms for the translog function is usually relatively poor.

8 The assumption $v \sim N(0,1)$, i.e. $\sigma_v = 1$, results from the introduction of the idiosyncratic component into the risk function. Without this assumption, the model would not be identified.

requirements of the standard estimation procedure (KUMBHAKAR, 2002). The distribution of the compound error term $\varepsilon = (y - f)/g$ is given by a proportional shift of the skewed normal distribution (AZZALINI, 1985):[9,10]

$$\mathrm{f}(\varepsilon) = \int_0^{\infty} \mathrm{f}(\varepsilon, u)|J|du = \left[\frac{2}{\sigma}\phi\left(\frac{\varepsilon}{\sigma}\right)\Phi\left(-\frac{\varepsilon\lambda}{\sigma}\right)\right]\frac{1}{g(\mathbf{x})}, \text{ with } J = \frac{\partial\varepsilon}{\partial y} = \frac{1}{g(\mathbf{x})} \quad (4),$$

$$\varepsilon = \frac{y - f(\mathbf{x})}{g(\mathbf{x})} = v - h(\mathbf{x})u, \; h(\mathbf{x}) = \frac{q(\mathbf{x})}{g(\mathbf{x})},$$

$$\sigma = \sqrt{1 + h(\mathbf{x})^2 \sigma_u^{\;2}} \quad \text{and} \quad \lambda = h(\mathbf{x})\sigma_u$$

where ϕ and Φ are the density and cumulative distribution functions of a standard normally distributed random variable. Optimal parameter estimates can be computed by maximizing the log likelihood associated with (4). In a second step, the JONDROW et al. (1982) approach is applied to estimate the expected value of *u*:

$$E(u \mid \varepsilon) = \frac{\lambda}{\sigma}\left(\frac{\phi(\varepsilon\lambda/\sigma)}{1 - \Phi(\varepsilon\lambda/\sigma)} - \frac{\varepsilon\lambda}{\sigma}\right) \quad (5).$$

In order to ensure that Equation (2) is an appropriate representation of technology, the function has to be monotonically increasing and quasi-concave in inputs. Since these restrictions can only be locally implemented for the translog function, we have to assure that the regularity conditions hold for a wide range of inputs. In this context, we consider that irregularities most likely occur at the upper or lower end of the input ranges (SAUER et al., 2006) and thus follow a two-step procedure to generate subsamples satisfying the functional requirements. Therefore, for each of the four inputs, all observations deviating more than two standard deviations from the mean of the original sample are identified and assigned to the corresponding new subsamples, each covering the upper or lower tail. Subsequently, in a second step, the mean values for the new subsamples are calculated and the necessary regularity conditions implemented at these new mean values. Although this technique will lead to a large number of monotonicity and curvature restrictions, the estimations show that only a few of this large set of restrictions are binding. In our case, from the a priori set of 32 monotonicity and 32 curvature restrictions, the estimations only identified five of them as binding.[11]

9 λ is called the shape or skewness parameter, σ represents the variance or scale parameter (AZZALINI, 1985, 1986).

10 The proportional shift is given by the Jacobian (*J*). The Jacobian has to be applied due to the transformation from ε to y (DEGROOT, 1989). In the standard workhorse, the Jacobian can be omitted because the differential is equal to one.

11 The estimations were conducted using GAUSS 9.0 with the procedure CML 2.0.

5 The Sources of Quantity Variation: Estimation Results and Further Interpretations

5.1 Data

The analysis in this section is based upon the same data set already used in the variance decomposition analysis, whereby inputs comprised land (Lan), labour (Lab), capital (Cap) and materials (Mat). The first and second variable were given by used agricultural area and the number of workers, respectively. Capital input was approximated by depreciation, in detail, by summing up depreciation of capital use in crop and animal production, each deflated by the corresponding regional price indices for machinery. Materials comprised all expenses for variable inputs. As the database only provided information in current prices, volumes were constructed by (a) weighting the individual components (seed, fertilizer, feedstuff, etc.) by corresponding regional price indices and (b) adding up the individual volumes.

The output variable representing the volume of gross production was constructed in three steps. First, gross production in current prices was estimated by adding up the products of gross production in physical terms and firm-specific product prices. We distinguished between 14 categories in the field of crop and animal production: crop production included cereals, sugar beet, sunflower, potatoes and vegetables, animal production distinguished between beef, pork, lamb, poultry, milk, meat, egg, wool and dairy production. Firm-specific product prices were calculated as the ratio of sales to the amount of products sold. In the second step, we computed firm-specific multilateral consistent price indices using the approach developed by CAVES et al. (1982).[12] To this end, we used firm-specific product prices and firm-specific revenue shares. Finally, in the third step, we deflated gross production in current values by the firm-specific output price indices.

The descriptive statistics are given in the Appendix II of this paper. It is immediately striking that agroholding members are larger than independent farms, e.g. they had a higher factor input. Correspondingly, their output was also larger.

5.2 Estimation Results

Parameter estimates of the risk production function are reported in Table 3. Since most parameters of the three functions (mean production, risk, inefficiency) in Equation (2) were estimated to be highly significant, it can be concluded that the omission of the two functions for risk and inefficiency would have produced biased estimates for the production function. The vast majority of the observations fit the theoretical require-

12 Assuming a translog aggregator function, the result is a Törnquist-Theil Index. Essentially, in this approach, each observation is compared to the average in the sample.

ments (more than 90% in each region), i.e. the monotonicity as well as the whole set of curvature conditions held for most of the observations.

Table 3. Parameter estimates of the risk production function

	Variable		Tatarstan Estimate	Tatarstan t-Value	Oryol Estimate	Oryol t-Value
mean production function	Constant	α_0	0.077	3.137***	-0.031	-1.033
	Tim#	α_t	0.011	0.949	0.069	2.942***
	Tim*Tim	α_{tt}	0.062	1.734**	0.204	3.279***
	Lab	α_1	0.066	2.575***	0.121	2.568***
	Lan	α_2	0.320	10.323***	0.093	3.837***
	Cap	α_3	0.207	14.337***	0.195	9.411***
	Mat	α_4	0.419	17.708***	0.569	19.064***
	Lab*Tim	α_{1t}	0.043	1.698**	0.100	1.782**
	Lan*Tim	α_{2t}	0.037	1.463*	0.134	3.204***
	Cap*Tim	α_{3t}	-0.024	-1.715***	-0.040	-1.588*
	Mat*Tim	α_{4t}	-0.038	-1.421*	-0.089	-2.599***
	Lab*Lab	α_{11}	0.004	0.211	-0.023	-0.209
	Lan*Lan	α_{22}	0.004	0.057	-0.216	-4.468***
	Cap*Cap	α_{33}	0.053	4.974***	0.028	1.549*
	Mat*Mat	α_{44}	0.123	3.157***	0.120	4.590***
	Lan*Lab	α_{12}	0.065	2.208**	-0.008	-0.129
	Lan*Cap	α_{13}	-0.017	-0.973	0.029	0.687
	Lan*Mat	α_{14}	-0.021	-0.714	0.001	0.009
	Lab*Cap	α_{23}	-0.000	-0.006	0.062	2.862***
	Lab*Mat	α_{24}	-0.057	-1.484*	0.052	2.536***
	Cap*Mat	α_{34}	-0.037	-1.751*	-0.082	-3.487***
	Mem	α_m	-0.204	-4.356***	-0.077	-1.256
	Tim*Mem	α_{mt}	-0.053	-1.307	-0.106	-2.423***
	Lab*Mem	α_{m1}	0.048	0.571	0.009	0.055
	Lan*Mem	α_{m2}	-0.005	-0.061	0.115	0.733
	Cap*Mem	α_{m3}	-0.129	-3.243***	0.040	0.786
	Mat*Mem	α_{m4}	0.044	0.570	0.009	0.170
risk function	Constant	γ_0	-1.595	-25.763***	-1.307	-21.976***
	Dum06	γ_{06}	-0.096	-1.267	-0.005	-0.076
	Dum08	γ_{08}	0.078	0.889	0.176	1.742**
	Lab	γ_1	0.473	5.241***	0.343	3.059***
	Lan	γ_2	-0.189	-2.278**	0.038	0.570
	Cap	γ_3	0.025	0.569	0.296	8.043***
	Mat	γ_4	0.476	6.226***	0.197	2.759***
	Mem	γ_m	0.305	3.168***	0.207	1.765**
inefficiency function	Lab	θ_1	0.035	0.223	1.135	1.060
	Lan	θ_2	1.400	4.760***	1.063	0.431
	Cap	θ_3	0.388	2.537***	0.012	0.094
	Mat	θ_4	-0.484	-2.320**	2.096	1.467*
	Mem	θ_m	-5.577	-2.637***	-0.092	-0.047
	Std. Dev.	σ_u	0.310	6.972***	0.020	0.250

Note: *;**;*** denote significance at the 10%, 5% and 1% level, respectively.
Tim is a trend variable that captures the influence of technical change.

Source: own estimations

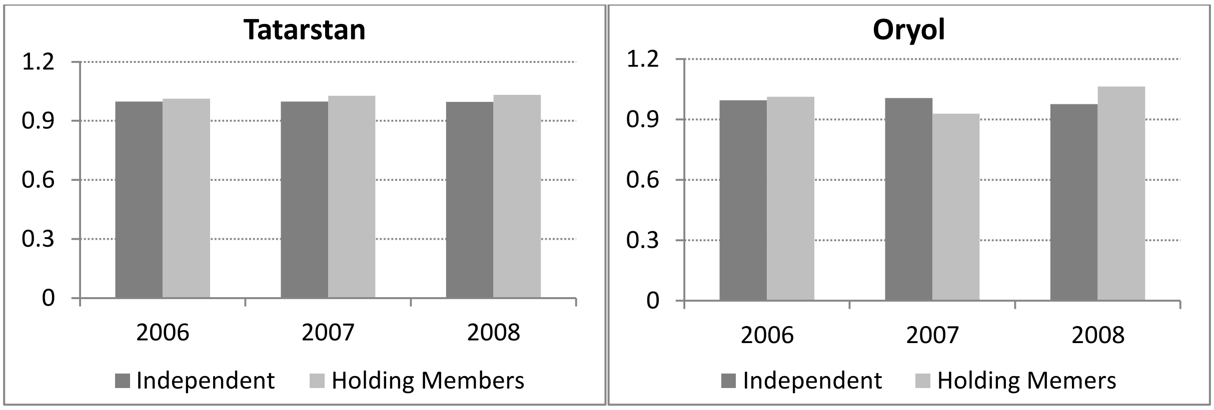
Mean Production Function

Materials (α_4) are the most important input, with the estimates suggesting that about 50 % of revenues in each region are used for the remuneration of variable inputs. Capital receives about 20% of the revenues. These results are consistent with expectations, given the importance of purchased inputs for modern agricultural production. Consistent with the importance of produced inputs, the production elasticity for labour was about 10% in Tatarstan and even lower in Oryol. Besides the high intensity of purchased material inputs, this might be due to many agricultural companies paying considerable attention to their social functions in the area and employing more people than is economically optimal (HOCKMANN et al., 2009).

Both regions experienced a positive and accelerating rate of technical progress. The effect was about 1.1% and 0.69% in Tatarstan and Oryol, respectively (α_t). Moreover, technical change is not Hicks neutral; rather, it is labour and land using and capital and material input saving in both regions. These results are consistent with the theory of induced innovation (HAYAMI and RUTTAN, 1971). Since rural labour is relatively abundant and there is plenty of uncultivated land, these factors might not be scarce factors for most agricultural enterprises. On the other hand, the markets for produced inputs were relatively poorly developed.

Economies of scale are given by the sum of production elasticities. Figure 3 shows the development of this indicator by organisational form and for both regions. Accordingly, in Tatarstan, both organisational forms yielded constant returns to scale and thus can be assumed to have operated at almost optimal farm sizes. In contrast, economies of scale for holding companies were fluctuating over time in Oryol, suggesting that the forces behind farm restructuring were much more influential than in Tatarstan. Indeed, these findings are also well mirrored in the restructuring process taking place in Oryol after breaking up one of the large horizontally and vertically highly integrated structures, as mentioned in Section 2.

Figure 3. Economies of scale by organisational form, 2006-2008



Source: own calculations

The majority of the parameter estimates for holding membership were not statistically significant, implying that the production structures for group members and independent farms were rather similar. However, there is indication that holdings were less able to benefit from technical change than independent farms ($\alpha_{mt} < 0$) and that the production possibilities were lower in holding members ($\alpha_m < 0$). However, these results only concern the parameter estimates and thus the conclusions when comparing the production elasticities by farms may deviate.[13] Moreover, similar elasticities in the groups might not indicate that marginal returns are the same. In order to obtain further information on these issues, we used the definition of elasticities as the ratio of marginal and average effect to take a closer look at the two components (Table 4a and b).

Due to the normalisation of the variables, the means of the production elasticities for independent farms are exactly the same as the parameter estimates for the first-order terms presented in Table 3. Apart from this, the calculations mostly yielded elasticities differing with organisational form. In both regions, holding members showed higher elasticities than independent farms, apart from the production elasticities of capital, which were higher in independent farms. Despite the differences in farms' size (see Section 2), the agricultural enterprises of either organisational form and both regions operated under rather similar production structures, with comparable conditions that find their expression in the mostly insignificant differences between average productivities. However, labour productivity was significantly higher in holding compared to independent farms, which in turn corresponds to the release of labour by the mother company after a farm becomes a holding member.

Significant differences in production elasticities and insignificant results for average productivities offer a first indication that the shadow prices may follow the same pattern and also vary with organisational form. Indeed, this conjecture is confirmed by the calculations. Consistent with the lower labour input in holding members of both regions, the marginal productivity of labour was also higher than in independent farms, which certainly supports the common proposition that agroholdings behave more profit-oriented – or, put differently, they tend to release labour and thus fulfil the traditional social function of farms less satisfactorily than independent agricultural enterprises.

[13] This stems from the fact that the parameter capturing the cross effects has to be considered in the calculation.

Table 4a. Marginal and average productivities by organisational form, Tatarstan

	Production elasticities			
	Labour	Land	Capital	Materials
Independent	0.066 *(0.046)*	0.320 *(0.039)*	0.208 *(0.051)*	0.419 *(0.075)*
Members	0.126 *(0.057)*	0.327 *(0.033)*	0.075 *(0.049)*	0.482 *(0.065)*
t-Value	**-11.789*** **	-1.275	**23.701*** **	**-8.484*** **
	Average productivities			
	Labour	Land	Capital	Materials
Independent	1.132 *(0.616)*	1.129 *(0.572)*	1.434 *(1.945)*	1.135 *(0.606)*
Members	0.913 *(0.428)*	1.155 *(0.604)*	1.121 *(1.139)*	0.877 *(0.462)*
t-Value	**3.386*** **	-0.407	1.552	**4.034*** **
	Marginal productivities			
	Labour	Land	Capital	Materials
Independent	0.076 *(0.080)*	0.361 *(0.188)*	0.236 *(0.146)*	0.441 *(0.126)*
Members	0.124 *(0.082)*	0.373 *(0.193)*	0.046 *(0.079)*	0.412 *(0.161)*
t-Value	**-5.490*** **	-0.565	**12.626*** **	**1.997** **

Note: */**/*** denote significance at the 10%, 5% and 1% level, respectively.
Bracketed numbers indicate standard deviations.

Source: own estimations

The other results regarding the marginal productivities are less conclusive. In Tatarstan, purchased inputs (capital, materials) received a higher remuneration in independent farms than in holding members. This unequal remuneration supports the hypothesis that many independent farms may be subject to credit and/or liquidity constraints, rendering them unable to acquire sufficient purchased inputs. In other words, given the higher financial strength of holdings, members of this organisational form will have better access to purchased inputs and hence a lower shadow price of these inputs. However, this assumption cannot be proved in Oryol, as the opposite effects were observed and holdings actually faced higher shadow prices. The reasons behind this contradiction lie in the economic problems of one of the large holdings, which finally led to a restructuring of this holding (Section 2). Altogether, given this example, it can be assumed that the development and creation of new business relationships is associated with high adjustment and transaction costs, which additionally impede the access of holding members to the markets for purchased inputs.

Table 4b. Marginal and average productivities by organisational form, Oryol

	Production elasticities			
	Labour	Land	Capital	Materials
Independent	0.121 *(0.080)*	0.093 *(0.171)*	0.195 *(0.076)*	0.569 *(0.140)*
Members	0.150 *(0.080)*	0.170 *(0.167)*	0.253 *(0.071)*	0.588 *(0.153)*
t-Value	**-2.649*** **	**-2.757*** **	**4.518*** **	**-1.814** **
	Average productivities			
	Labour	Land	Capital	Materials
Independent	1.136 (*0.701*	1.265 (*0.914)*	1.288 (*1.247)*	1.169 (*0.746)*
Members	1.445 (*1.019*	1.392 (*1.110)*	1.192 (*1.112)*	1.107 (*0.441)*
t-Value	**-2.729*** **	-0.894	0.518	0.580
	Marginal productivities			
	Labour	Land	Capital	Materials
Independent	0.161 (*0.191)*	0.206 (*0.371)*	0.222 (*0.174)*	0.591 (*0.244)*
Members	0.254 (*0.268)*	0.333 (*0.494)*	0.266 (*0.215)*	0.624 (*0.238)*
t-Value	**-3.052*** **	**-2.164*** **	**-1.644* **	-0.912

Note: */**/*** denote significance at the 10%, 5% and 1% level, respectively.
Numbers in parentheses/bracketed numbers indicate standard deviations.

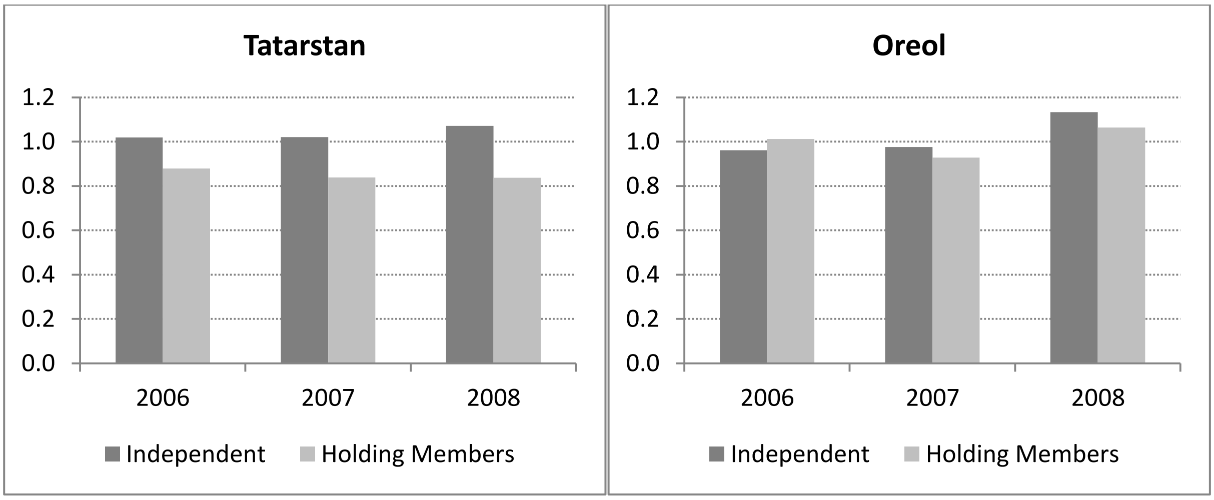
Source: own estimations

The parameter estimates were further used to calculate total factor productivity (TFP) as the main indicator or performance of holding members and independent farms. We proceed by using the extension of the Diewert's (1976) quadratic lemma by CAVES et al. (1982). This procedure allows multilateral consistent comparison of TFP by calculating input and output aggregates in relation to the mean of production and factor use. Given that TFP is defined as the ratio of an output index to an input index, it thus captures the influence of scale adjustment and technical progress. Since the scale effect can be neglected (see Figure 3), it can be assumed that the TFP index only provides information about technical progress.

In Tatarstan, the TFP of independent farms not only grew over the whole period, but was also higher than that of group members. The TFP of business group members decreased, thus implying that agroholding members were falling behind independent farms. Indeed, recalling the introductory remarks on agricultural development in

Section 2, this result is consistent with the observation that Tatarstan holdings encountered severe difficulties in agricultural production (see Section 2). Of course, these adverse production conditions also held for Oryol farms. Here as well, it was the group members that fell behind independent farms, which even experienced an increase in TFP.

Figure 4. TFP level and development by organisational form (mean = 1), 2006-2008



Source: own calculation

Production Risk and Inefficiency

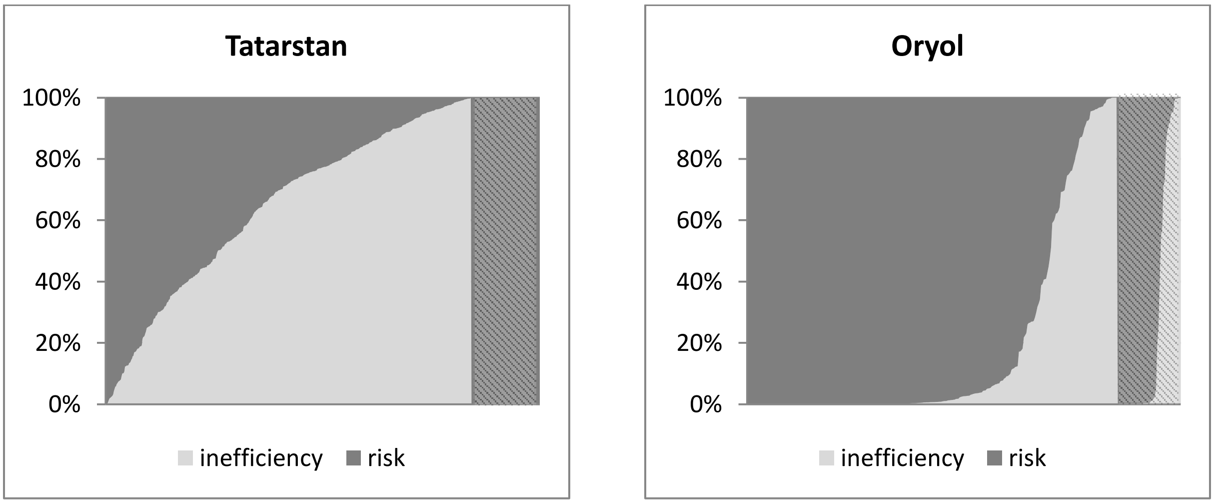
The parameter estimates of the risk function provide that, on average, agricultural enterprises of both regions faced general production conditions that were quite similar over the years. Table 3 show that most of the parameters capturing the impact of input on risk yielded significant and positive values in all but one parameter, i.e. they were risk increasing. The only negative and thus risk reducing impact could be found for land input in Tatarstan. Although the data set did not provide information of sufficient breadth and depth to analyse the impact on risk appropriately, these results provide a strong indication that risk management practices were only poorly developed in both regions. Agroholding membership appeared to be risk increasing, which in turn is in line with the more intense use of purchased inputs in this organisational structure.[14]

[14] A more intense use of material inputs implies lower partial productivity of material inputs in agro-holding members. See Tables 4a, b for more information.

The regression results for the inefficiency functions varied considerably between the two regions (Table 3). In Oryol, inefficiency did not play a role at all, as is revealed by the very small values of σ_u. However, concluding that all farms operated on their production frontier would be too hasty; rather, it simply indicates that there were no noticeable efficiency differences among the farms, while all inter-farm variation was captured by the two-sided error term. By contrast, in Tatarstan, inputs considerably affected efficiency. Land and capital increased efficiency, while materials reduced this effect. Moreover, agroholding membership created a huge negative impact on inefficiency. Given the structure of the inefficiency function, it can be concluded that the holding effect drives the whole inefficiency towards zero. The reasons for this might be twofold and result from the large differences in farm size between agroholding members and independent farms or the relative small number of group members in the sample.

After decomposing total output variance according to $\mathrm{var}(y) = g^2 + q^2\sigma_u^{\ 2}$, the share of risk and inefficiency in total output variance can be seen in Figure 5. Essentially, this figure confirms the implications already derived in the discussion of the parameter estimates, namely that production risk in Oryol carries the most important source of output variation, albeit for both types of farms, whereas in Tatarstan, production risk actually accounts for all of the farms' output variation. In this region, inefficiency contributes almost nothing to output variation for holding members. The reason was explained owing to the large value of θ_m (see Table 3, and the corresponding explanations).

Figure 5. Share of production risk and technical inefficiency in output variance



Note: shaded areas indicate agroholding members.

Source: own calculations

5.3 Variance Decomposition

In this section, we discuss how the parameter estimates affect the individual contributions of production, risk and inefficiency to the variance of output (Table 5).

In both regions, mean production could be identified as the main source of output variance. To draw more detailed conclusions, this indictor was further decomposed into the variance of farm size measured by land and the variance of land productivity. This more detailed look produced rather different results with respect to both regions and organisational forms. Regarding holding members in Tatarstan, almost the whole variation resulted from by farm size, whereas land productivity was only of minor importance. One reason behind this pronounced discrepancy might lie in the special production situation of group members, given that they naturally focussed on crop production due to their size. On the other hand, the independent farms showed a much more balanced contribution scheme between land input and land productivity, which also holds for independent and holding members in Oryol.

Table 5. Contribution of mean production, risk and inefficiency to total output variance (%)

	Tatarstan		Oryol	
	Independent	Holding Members	Independent	Holding Members
Mean production	55.1	66.5	40.5	80.3
Land	71.4	95.3	38.1	56.2
Land productivity	28.6	4.7	61.9	43.8
Risk	24.1	30.2	51.2	12.3
Inefficiency	20.8	3.3	8.4	7.3

Note: Mean production was decomposed using Equations (1). The contributions were calculated in relation to the total variance of production.

Source: own calculations

Moreover, it follows from Table 5 that the variance of the risk function contributes significantly more to output volatility than efficiency; in fact, in both regions and for both organisational forms. Thus, policy measures aiming at increasing productivity of farms might not be the first-best choice since the increase in efficiency might have only a minor, if not negligible, impact on output variability. From this perspective, it would be more beneficial to advise or assist farms in adopting risk management practices, since decreasing production risk, as is widely known, will have a high impact on production volatility. This conclusion is strongly reinforced by the findings in Figure 5, from which it is apparent that, risk matters much more than inefficiency for most farms, particularly given that the parameter estimates in Table 3 revealed the mechanism of risk management to be only poorly developed.

6 Conclusion and Interpretation

First, we investigated product prices and production in terms of average productivities, whereby our data set allowed conducting corresponding analyses for grain and milk. Marked differences between the two organisational structures – agroholdings and independent farms – are not observable, for neither prices nor partial productivities. This absence of differences generally indicates that members of a business group are obliged to use the channels offered by the holding company, although holding members receive a price oriented towards the average price paid in the regions and benefit from a reduction of transaction cost.

Second, the determinants of production variance were estimated using a risk production function with built-in inefficiency term. The parameter estimates confirm that all effects considered are highly important. Moreover, the estimation provides evidence that agroholding membership affects production structures, thus supporting the view that, in Tatarstan, these companies not only have better access to purchased inputs, but also use them more intensively than independent farms. Labour input is lower in the group of holding members, suggesting that this group pays less attention to the traditional social function of farms in rural areas. In addition, both organisational forms seem to operate under constant returns to scale. Technical change hardly renders a uniform picture, with labour and land using on the one hand and capital and material input saving on the other. Looking at Oryol, the described effects are similar yet not exactly the same. Differences may arise from the fact that, at variance with Tatarstan, the Oryol holdings were created under control of the Oblast government, which has never been interested in the economic development of farms alone but also in their social function.

Regarding aspects of risk, almost all inputs except land show risk increasing effects, which in turn offer a strong indication that the farms do not apply management techniques to a significant or sufficient degree. Consistent with the more intense use of inputs, agroholding membership appears to have a higher (generic) production risk. For inefficiency, we find almost opposite results, namely that generic inefficiency in agroholdings is significantly smaller in independent farms.

The estimates further provide that risk holds higher relevance for the variation of production than inefficiency. Moreover, for independent farms, risk and internal transaction costs appear to be much more important than market inefficiencies, since risk and inefficiency is proven to explain about the same amount of production variance as technology differences. This latter conclusion is also relevant for holding members. However, it should be emphasised that these variances remain at a relatively low level compared to independent farms, indicating that differences in technology are more pronounced in this group.

These results suggest that the occurrence of argoholding companies can have positive welfare effects for the agricultural sector. The results imply that many independent agricultural enterprises face a liquidity constraint that hinders the adjustment of produced inputs to their social optimal level. Due to their financial strength or better access to credit markets, the agroholdings' engagement may soften the liquidity constraints, enabling its members to plan the factor input corresponding to the shadow prices. This also helps to develop the production potentials of the agricultural sector. However, this does not imply that the agricultural policy should foster the creation of agroholdings. Agricultural policy should assist in reducing market failures by improving the functioning of the credit market or reducing the liquidity constraints for agricultural enterprises. In addition, the example of Oreol implies that the creation of agroholdings is not a silver bullet that works in any case. The necessary condition is that agroholdings work successfully to generate sufficient means from the credit market.

Moreover, the results show that all three components - production risk, conditions on the product market and inefficiency – significantly affect agricultural production. Thus, to improve the conditions, agricultural policy is required to tackle all the issues in parallel using a mix of appropriate policy measures. However, the focus should be placed upon the adoption of risk management techniques to reduce the volatility of output. This conclusion holds for both organisational forms, given that relatively stable outputs are undeniably a necessary condition for a stable and healthy financial situation, which in turn is a precondition for investment and purchases of material inputs. Thus, such well-tailored political support instruments would induce positive feedback effects, which would straightforwardly lead to sustainable developments in the agricultural sectors of Tatarstan and Oryol alike.

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Appendix I

A first-order Taylor approximation of a product ($p\ y$) around the means of the variables (p_0,y_0) is given by:

$$py = p_0 y_0 + (p - p_0)y + (y - y_0)p$$

Applying the definition of variance provides:

$$\mathrm{var}(py) = \mathrm{E}[py - (py)_0]^2 = \mathrm{E}[p_0 y_0 - (py)_0 + (p - p_0)y_0 + (y - y_0)p_0]^2$$

Expanding the bracket and putting the expectation operator through provides:

$$\begin{aligned}\mathrm{var}(py) = {} & \mathrm{E}(p_0 y_0 - (py)_0)^2 + y_0{}^2\mathrm{E}(p - p_0)^2 + p_0{}^2\mathrm{E}(y - y_0)^2 + \\ & 2 p_0 y_0 \mathrm{E}(p - p_0)(y - y_0) \end{aligned}.$$

In this expression we already simplified by using $\mathrm{E}(p - p_0) = 0$ and $\mathrm{E}(y - y_0) = 0$. Applying the definition of variance and covariance yields:

$$\mathrm{var}(py) = -[\mathrm{cov}(p, y)]^2 + (\mathrm{E}y)^2 \mathrm{var}(p) + (\mathrm{E}p)^2 \mathrm{var}(y) + 2\,\mathrm{E}p\mathrm{E}y\,\mathrm{cov}(p, y).$$

Inserting the terms containing covariances into the function *c(p,y)* provides:

$$\mathrm{var}(py) = (Ep)^2 \mathrm{var}(y) + (Ey)^2 \mathrm{var}(p) + c(y, p).$$

Appendix II

Descriptive statistics

		Variable	Mean	Std. Dev.	Minimum	Maximum
Oryol (352 observations)	Independent farms (148 farms, 300 obs.)	Output[1]	31,100.8	42,726.7	162.9	359,754.0
		Labour[2]	97.4	78.9	5.0	561.0
		Land[3]	4,841.3	4,511.9	90.0	41,139.0
		Capital[4]	4,948.2	9,685.0	6.0	104,922.0
		Materials[5]	29,812.3	208,974.0	103.1	3,633,750.0
	Holding members (24 farms, 52 obs.)	Output[1]	57,458.7	70,684.1	251.0	290,269.0
		Labour[2]	131.7	108.2	8.0	438.0
		Land[3]	6,901.3	4,459.6	540.0	19,571.0
		Capital[4]	7,773.0	8,540.4	66.9	37,265.4
		Materials[5]	27,946.7	33,189.6	122.2	133,344.0
		Variable	**Mean**	**Std. Dev.**	**Minimum**	**Maximum**
Tatarstan (642 observations)	Independent farms (238 farms, 550 obs.).	Output[1]	66,716.7	383,865.0	47.2	5,843,650.0
		Labour[2]	117.9	153.9	1.0	1,934.0
		Land[3]	4,986.3	8,234.8	22.0	165,635. 0
		Capital[4]	5,417.7	9,772.0	3.0	155,701.0
		Materials[5]	26,938.5	65,093.0	10.0	1,084,270.0
	Holding members (40 farms, 92 obs.)	Output[1]	127,158.0	119,113.0	55.6	795,531.0
		Labour[2]	385.6	319.1	2.0	2,047.0
		Land[3]	14,888.5	11,910.3	85.0	56,527.0
		Capital[4]	17,349.6	24,419.2	4.1	211,014.0
		Materials[5]	79,448.6	71,586.9	152.0	389,676.0

[1] in m Rouble, deflated, [2] persons employed, [3] in hectare, [4], in m Rouble, deflated [5] in m Rouble, deflated