THE SIGNIFICANCE OF MARKET TRANSACTION COSTS, TECHNICAL EFFICIENCY AND RISK IN AGRICULTURE: AN EMPIRICAL ANALYSIS FOR TATARSTAN REPUBLIC

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ABSTRACT

The paper investigates the significance of risk, external and internal transaction costs in the agriculture of the Tatarstan Republic. The analysis is conducted for two categories of organisational forms, independent farms and members of agroholdings. Although average prices do not differ among organisational forms, the results indicate that external transaction costs are more pronounced in independent farms, whereas agroholding membership entails higher internal transaction costs, thereby making agroholdings more vulnerable to inefficiency than independent farms. In addition, the estimation suggests that this higher inefficiency results from the more enhanced risk management in agroholding members. Since this strategy leads to a more intensive factor use, members of business groups are able to allocate inputs so as to increase production at the same time.

Keywords: Risk production function, internal and external transaction costs

JEL Classification: 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 discrepancy have been intensively discussed among economists and politicians. In this paper we contribute to this debate by analysing the significance of risk and of external and internal transaction costs as well as their influence on agricultural development and production growth. The analysis is conducted for the Tatarstan Republic. Since agriculture in this republic is subject to massive and sustained administrative support, it is reasonable to evaluate the impact of political intervention in agricultural development in this region by surmounting the obstacles to economic growth.

The analysis focuses on the factors transaction costs, both external and internal, and risk. External transaction costs result in allocative inefficiency and find their expression in the variation of prices among agricultural enterprises. Internal transaction costs determine the degree to which producers are able to exploit production possibilities. In this view, technical inefficiency can be regarded as indicator of internal transaction costs. Risk leading to a variation of agricultural production around the average and basically results from the variation of natural conditions, primarily weather. These three indicators are investigated for different organisational forms in order to assess whether productivity differences among agricultural enterprises are determined by the choice of technology or basically by ownership and governance structures in the enterprises. In so doing, we also contribute to answering the question whether the occurrence of horizontally and vertically integrated structures (often called agroholdings or business groups) has had a positive effect on agricultural production.[1] Additionally, we identify the key arguments for independent farms to enter into an agroholding or, put otherwise, which kinds of economic obstacles are likely to be removed by becoming a member of an agroholding.

To achieve our research goal we base our analysis on revenue as a representative economic key indicator that can serve as starting point for further, necessary operations. In a first step we decompose the variation of revenue into the variation of its two main components, i.e. the

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[1] On this issue see for instance Kolnesnikov (2009), Wandel (2010) and Hockmann et al. (2009)

variation of product prices, and the (composite) variation of production (technology, risk, inefficiency). While the variation of product prices can be directly taken from the data, the contribution of the composite component has to be estimated using econometric techniques. To determine how technology, risk and inefficiency affect agricultural production, we therefore apply stochastic frontier analysis in the second step.

The paper is organised as follows. The next section deals with the decomposition of the variance of revenues into the partial contributions of prices and quantities. Here, differences in the level of production (or productivity) and prices are also investigated. Section 3 discusses the theoretical background necessary to conduct the stochastic frontier analysis. The ensuing Section 4 presents all relevant results, i.e. we discuss estimation results, especially in view of the implications of how technology, risk and inefficiency affect production. Finally, in Section 5, the findings from Section 2 and 4 are put together so as to shape a coherent picture of the influence of the investigated factors on the Tatarstan agriculture.

2 REVENEUE, QUANTITIY AND PRICE VARIATION

2.1 Data

We used accountancy data of agricultural enterprises in the Tatarstan Republic for the period of 2006-2008 (Rosstat data provided by VIAPI). To ensure good estimation, the original data set containing more than 1000 observations had to be checked to remove incorrect, misleading and incomplete observations. In this respect, to avoid significantly biased results due to large changes in individual years, we first excluded those farms with only one observation available. Second, we purged observations with inconsistent partial productivities, e. g. when land productivity or milk production per cows was 100 times larger than average. This second cleaning left a data set of 277 farms and 636 observations. The set included 41 members of agroholdings, which accounted for 101 observations.

The resulting data set fit our purpose threefold: it contained detailed information on production structures, specialisation and factor input; it also allowed for calculation of implicit firm specific product prices using the quantities and sales of marketed products; in addition, it provided information on organisational forms and thus governance structures.

To ensure comparability, the remaining data set had to be adjusted applying standard manipulations. So, we standardized data on relevant products (various crops and milk production) by appropriate input units. In detail, the gross production of grain, sugar beet and potatoes was standardized by area planted, and the number of cows in milk production. To proceed further, some descriptive statistics were calculated so as to obtain a first and preliminary indication about the significance of external transaction costs in both organisational forms, and to answer the question whether agroholding members are better positioned to reduce or even avoid these costs. We therefore extracted information about different price and partial productivity structures of both agroholding members and independent farms from the data, and calculated the corresponding mean values and variations for each organisational form, respectively. Additionally, we decomposed the variance of output-specific revenues in order to analyse whether revenues by organisational form are affected by quantity and price variation in different ways.

2.2 Prices and partial productivities

Table 1 provides information about partial productivities and prices received by farmers, expressed as expected values per area. The data show no marked price differences between organisational structures. Basically, the same holds true for quantities. However, there is indication of higher yields per hectare for products with special support by the business group as is the case with sugar beet. As regards prices, the results are rather surprising, all the more so because it is often argued that prices received by agroholdings are merely transfer prices and thus independent of market prices. In fact, the information in Table 1 fails to prove this view, since both groups receive, on average, the same prices. In other words, descriptive figures at first glance contradict that agroholdings conduct special price strategies. and the result presented in Table 1 is incidental only. Trying to finally prove this preliminary hypothesis by comparing prices between agroholdings was doomed to fail due to missing data, however, it should be noticed, that according to experts the price paid to the holding members was often related to the average price achieved in the regions.. Although not as informative as agroholding-specific prices, price variation between independent farms and group members may help to shed some light on this issue.

Table 1: Expected prices and quantities (per hectare)

	Independent farms					
	2006		2007		2008	
	E(y)	E(p)	E(y)	E(p)	E(y)	E(p)
Grain	25.3	0.26	25.7	0.38	33.7	0.44
Sugar beet	175.7	0.09	166.7	0.10	170.1	0.11
Potatoes	111.1	0.33	117.6	0.41	137.3	0.54
Milk	35.9	0.58	37.9	0.70	41.7	0.89
	Agroholding members					
	2006		2007		2008	
	E(y)	E(p)	E(y)	E(p)	E(y)	E(p)
Grain	23.8	0.27	23.2	0.38	26.7	0.42
Sugar beet	226.8	0.10	175.4	0.09	240.2	0.09
Potatoes	73.6	0.27	118.8	0.33	143.8	0.47
Milk	33.5	0.59	34.2	0.72	35.2	0.83

Notes: E(y) and E(p) denote the mean of production and prices, respectively.
Quantities are per input unit, i.e. crop production per hectare and milk production per cow.
Quantities are in 100kg and prices in 1000 Rouble per kg

Source: Own calculations.

Table 2, reporting the coefficients of variation (CV) of prices, shows considerable differences between the two groups of farms. Generally, the indicator is smaller for members of a business group than for independent farms, which is why prices obtained by agroholding members are more homogeneous than the prices independent farms are facing. Interpreted in terms of market possibilities, this suggests that agroholding members might be less flexible in using different marketing channels. Indeed, recalling the results from Table 1, the higher homogeneity of prices points to the fact that members of a business group are are committed to using the channels offered by the agroholding. Altogether, this pricing strategy can be assumed to help reduce transaction costs resulting from engaging in the (free) product market. On the other hand, the higher CV of prices as calculated for independent farms implies that market transaction costs constitute a serious problem for this group. In addition, despite given differences in the CV for various prices, market transaction costs may differ among the product markets.

Table 2: Coefficients of variation of prices and quantities by organisational form

	Independent farms					
	2006		2007		2008	
	CV(y)	CV(p)	CV(y)	CV(p)	CV(y)	CV(p)
Grain	35.6 %	9.3 %	36.1 %	7.8 %	28.6 %	9.2 %
Sugar Beet	28.1 %	17.5 %	29.7 %	8.7 %	28.5 %	4.0 %
Potatoes	37.1 %	10.5 %	39.3 %	9.5 %	34.6 %	9.9 %
Milk	33.4 %	6.7 %	31.3 %	8.3 %	27.9 %	5.7 %
	Agroholding members					
	2006		2007		2008	
	CV(y)	CV(p)	CV(y)	CV(p)	CV(y)	CV(p)
Grain	36.8 %	14.7 %	35.4 %	0.9 %	28.8 %	8.2 %
Sugar Beet	15.4 %	4.4 %	47.7 %	0.0 %	6.0 %	3.1 %
Potatoes	32.8 %	16.2 %	23.6 %	0.0 %	27.6 %	2.0 %
Milk	28.0 %	6.2 %	32.4 %	0.6 %	25.8 %	6.9 %

Notes: CV(y) and CV(p) denote the coefficient of variation of production and prices, respectively. Quantities are per input unit, i.e. crop production per hectare and milk production per cow.

Source: Own calculations.

However, the extent to which transaction costs affect revenues may be rather marginal as compared to the effect of the variation of quantities; a conjecture that cannot be denied ex ante, since the coefficient of variation of quantities is considerably higher than the CV for prices.

2.3 Variance decomposition

In the following, we discuss the contribution of the variance of prices and quantities to the variance of revenues. To do so, we decomposed the variance of revenues into the individual contribution of prices and quantities applying a first order Taylor approximation:

(1) $$\mathrm{var}(py) = \left(\mathrm{E}(p)\right)^2 \mathrm{var}(y) + \left(\mathrm{E}(y)\right)^2 \mathrm{var}(p) + \mathrm{c}(y, p),$$

where p and y represent output prices and quantities, respectively, and c*(y, p)* the covariance structures between prices and quantities as derived in the Appendix.

The results of this decomposition, as reported in Table 3, suggest that the covariances between prices and quantities largely fail to explain the variance of prices. Indeed, on average, the price and quantity variances account for about more than 90 % of the variation of revenues. Moreover, the covariance effects in most cases show positive signs, and hence a positive correlation between quantities and prices. From this it follows that products not only can be sold at prevailing market conditions but, what is more, that farms may even be able to negotiate better prices for selling larger quantities, at least to some extent. This again emphasises how relevant market transactions costs are for the agricultural markets in Tatarstan.[2]

Turning to the shares of prices and quantities contributing to the variance of revenues, the calculations provide that the lion's share results from quantity, whereas price variance is of minor importance. In addition, there are considerable differences of price variation between members of a business group and independent farms, though without revealing consistent differences both between and within the two organisational forms with respect to products. While the contribution of price variance within independent farms is greater for some products, for others the opposite is true.

[2] Svetlov (2009) and Svetlov and Hockmann (2007) investigated the role of external transaction costs in agriculture in Moscow oblast. Using a different approach (DEA), they also proved the significant impact of these costs on agricultural holdings.

Table 3: Contribution of price and quantity variance to revenue variance

	Independent farms								
	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
Grain	97.7 %	6.4 %	93.6 %	94.5 %	4.5 %	95.5 %	99.8 %	9.5 %	90.5 %
Sugar Beet	85.5 %	28.0 %	72.0 %	102.8 %	7.9 %	92.1 %	91.1 %	2.0 %	98.0 %
Potatoes	122.1 %	7.5 %	92.5 %	100.3 %	5.6 %	94.4 %	134.8 %	7.6 %	92.4 %
Milk	89.4 %	3.9 %	96.1 %	87.4 %	6.7 %	93.3 %	91.0 %	4.0 %	96.0 %
	Agroholding members								
	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
Grain	82.7 %	13.8 %	86.2 %	80.5 %	8.4 %	91.6 %	81.3 %	7.5 %	92.5 %
Sugar Beet	110.4 %	7.7 %	92.3 %	102.5 %	2.8 %	97.2 %	54.6 %	21.6 %	78.4 %
Potatoes	79.8 %	19.7 %	80.3 %	150.7 %	7.4 %	92.6 %	109.7 %	0.5 %	99.5 %
Milk	92.0 %	4.7 %	95.3 %	96.4 %	5.5 %	94.5 %	83.8 %	6.8 %	93.2 %

Note: Quantities are given per input unit, i.e. crop production per hectare and milk production per cow

Source: Own calculations.

The dominant role of product variation deserves a more detailed look at the sources of its variation, which, in principle, are size, productivity, risk and technical efficiency. However, according to our main intention to determine a reliable indicator of internal transaction costs, it was reasonable to restrict further considerations to the contribution of risk and technical inefficiency to output variance. The next two sections therefore introduce the necessary theoretical background and then present the estimation results..

3 The Sources of Quantity Variation: Theory

3.1 Methodological considerations

In the analysis of the production structures we applied an extended version of the conventional production function, the risk production function. Compared to the conventional procedure, this model is able to consistently indentify the impact of individual inputs on risk and efficiency separately. This concept, originally introduced by Just and Pope (1978), was extended by Kumbhakar (2002):[3]

(2) $y = f(\mathbf{x}) + g(\mathbf{x})v - q(\mathbf{x})u$, with $v \sim N(0,1)$ and $u \sim N^+(0,\sigma_u)$.

$f(\mathbf{x})$ mean production function

$g(\mathbf{x})$ risk function

$q(\mathbf{x})$ inefficiency function

According to equation (2), we decompose the variation of production into the three additive components technology, risk and inefficiency. Technology effects are expressed as the mean production function *f* of average impacts of inputs ($\mathbf{x}$) on production (y). The function $g(\mathbf{x})$ reflects risks to production, i.e. external and thus hardly controllable effects on production;

[3] In the following equations, the notation is as usual: bold non-italic symbols indicate vectors or matrices; all other italic variables are scalars. Subscripts are omitted in order to improve readability.

e.g. due to varying weather conditions - poor or favourable - actual output may yield lower or higher than average level. Thus, it is reasonable to connect the risk function with a two-sided error component (*v*) which captures this effect and which is normally distributed with zero mean and unit variance. Finally, the function $q(\mathbf{x})$ reflecting the efficiency of production captures the impact of factor use on the exploitation of the production possibilities. This function transforms the one-sided error term *u*.

For the empirical analysis we approximated the natural logarithmic of $f(\mathbf{x})$ by a translog function:

(2a) $$\ln f(\mathbf{x}) = a_0 + a_m m + \left(\mathbf{a}_t + \frac{1}{2}\mathbf{a}_t t + \mathbf{a}_{tm} m \right) t + (\mathbf{a} + \mathbf{a}_t t + \mathbf{a}_m m)' \ln \mathbf{x} + \frac{1}{2} \ln \mathbf{x}' \mathbf{A} \ln \mathbf{x}$$

In this representation we assume that the constant and the first order effects may change over time (*t*) and with organisational structure (*m*). The former is supposed to account for the impact of technical change, while the latter is introduced in order to empirically test the significance of membership in agroholdings on production structures.

The risk function $g(\mathbf{x})$ is assumed to consist of two parts, a generic and an ideosyncratic one. The generic risk takes the effects of overall weather conditions, thereby affecting all farms similarly. In the empirical analysis we followed Bokusheva and Hockmann (2006) and specified this kind of risk by a constant and dummy variables for the years 2006 and 2008 (d_{06}, d_{08}) The farm-specific or idiosyncratic part of risk depends on the intensity and structure of input use. We assume that the idiosyncratic component is best represented by a Cobb-Douglas functional form. Thus we have

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

For the inefficiency function $q(\mathbf{x})$ we also suppose a Cobb-Douglas functional form:

(2c) $$\ln q(\mathbf{x}) = \boldsymbol{\theta}' \ln \mathbf{x} + \theta_m m$$

3.2 Estimation procedure

The following considerations represent the workhorse of conventional stochastic frontier analysis: A production function *f* is given by

(3) $$y = f(\mathbf{x}) + \varepsilon^*, \text{ with}$$

$$\varepsilon^* = v^* - u^*,\ v^* \sim N(0, \sigma_v) \text{ and } u^* \sim N^+(0, \sigma_u).$$

The error terms have the same properties as those in (2). Kumbhakar and Lovell (2000) showed that the density function (f) corresponding to (2) is given by:

(4) $$\mathrm{f}(\varepsilon^*) = \int_0^\infty \mathrm{f}(\varepsilon^*, u^*) du^* = \frac{2}{\sigma} \phi\left(\frac{\varepsilon^*}{\sigma}\right) \Phi\left(-\frac{\varepsilon^* \lambda}{\sigma}\right)$$

$$\text{with } \sigma = \sqrt{\sigma_u{}^2 + \sigma_u{}^2} \text{ and } \lambda = \frac{\sigma_u}{\sigma_v}$$

where ϕ and Φ are the standard normal density and cumulative distribution functions. Optimal parameter estimates can be computed by maximizing the log-likelihood associated with equation (4). Moreover, besides parameter estimates, estimates of expected efficiency can be obtained. According to Jondrow et al. (1982) the expected value of u^* is:

(5) $$E(u^* | \varepsilon^*) = \frac{\sigma_u{}^2 \sigma_v{}^2}{\sigma^2} \left(\frac{\phi(\varepsilon^* \lambda / \sigma)}{1 - \Phi(\varepsilon^* \lambda / \sigma)} - \frac{\varepsilon^* \lambda}{\sigma} \right)$$

The risk production function as used in this analysis is more flexible than the conventional production function approach; however, it can be transformed to fit the requirements of the standard estimation procedure:

(6) $$y = f(\mathbf{x}) + g(\mathbf{x})v - q(\mathbf{x})u$$

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

and $v \sim N(0,1)$ and $u \sim N(0,\sigma_u)$.

The assumption $\sigma_v = 1$ results from the introduction of the idiosyncratic component into the risk function. This assumption is necessary, for without it the model could not be identified.

The density of ε in (6) is given by:

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

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

which implies the following log-likelihood function:

(7) $$\ln L = \text{constant} - \sum_{t=1}^{T}\sum_{n=1}^{N} \ln\left(\sigma_{it}\, g(\mathbf{x_{it}})\right) + \sum_{t=1}^{T}\sum_{n=1}^{N} \ln\left[\Phi\left(-\frac{\varepsilon_{it}\lambda_{it}}{\sigma_{it}}\right)\right] - \frac{1}{2}\sum_{t=1}^{T}\sum_{n=1}^{N}\left(\frac{\varepsilon_{it}}{\sigma_{it}}\right)^2$$

Similar to (4), the expected value of u can be computed by:

(8) $$E(u_{it} \mid \varepsilon_{it}) = \frac{h(\mathbf{x_{it}})^2 \sigma_u{}^2}{\sigma_{it}{}^2}\left(\frac{\phi(\varepsilon_{it}\lambda_{it}/\sigma_{it})}{1 - \Phi(\varepsilon_{it}\lambda_{it}/\sigma_{it})} - \frac{\varepsilon_{it}\lambda_{it}}{\sigma_{it}}\right)$$

4 THE SOURCES OF QUANTITY VARIATION: ESTIMATION RESULTS AND FURTHER INTERPREATIONS

4.1 Data

We applied the same data set as in section 2. Inputs comprised land, labour, capital and materials. Land and labour were defined as agricultural area in use (L) and the number of workers (A), respectively. Capital input (C) was approximated by depreciation in crop and animal production, each deflated by the corresponding regional price indices for machinery. Materials comprised (V) all variable input expenses. Since the data base only provided information in nominal prices, volumes were constructed by first weighting the individual components (seed, fertilizer, feedstuff, etc.) by corresponding regional price indices and then adding up the individual volumes.

The output variable representing the volume of gross production (y) was constructed in three steps. First, value of gross production in nominal prices was compiled by multiplying gross production in physical terms by firm-specific product prices. Production considered the following categories: crop production including cereals, sugar beet, sunflower, potatoes and vegetables, and animal production with pork, lamb, poultry, milk, meat, egg, wool and dairy production. Firm-specific product prices were obtained from the data set by determining the relation between sales and the amount of marketed products. In the second step, we calculated

[4] J is the Jacobian. The Jacobian has to be applied because of the transformation from ε to y (DeGroot 1989). In the standard procedure the Jacobian can be omitted because the differential is equal to one.

firm-specific multi-lateral consistent price indices applying the approach developed by Caves et al. (1982).[5] Therefore, we used firm-specific product prices and firm-specific revenue shares. Finally, in the last and third step, we deflated gross production in nominal values by the derived firm specific output price indices.

For convenience, all variables were normalized by their geometric mean. In so doing, the parameter estimates for the first order terms can be directly interpreted as production elasticities at the sample mean.

4.2 Estimation results

Parameter estimates of the risk production function *y* are given in Table 4. Most parameters of its components (mean production *f*(**x**), risk *g*(**x**), inefficiency function *q*(**x**)) are highly significant. Altogether, a result that proves the chosen specification or, put otherwise, omitting the components risk and inefficiency would have produced biased estimates for the mean production function.

The mean production function fulfils the monotonicity requirement for all inputs (α_i, for i = A, L, C, V) and regardless of the organisational form. An increase in input use therefore results in an increase of production in both independent farms and members of agroholdings. The mean production function does not exhibit quasi-concave requirements in all inputs. We found that capital and materials follow the "law" of diminishing returns ($\alpha_{ii} + \alpha_i^2 - \alpha_i < 0$, for i = C, V) for independent farms, though labour and land showed increasing returns ($\alpha_{ii} + \alpha_i^2 - \alpha_i > 0$, for i = A, L) at the sample mean. It should be noticed here that without considering the risk component, the just mentioned results could hardly be explained. Nonetheless the estimates indicate that the implementation of management techniques cannot be denied. Indeed, these techniques may be primarily responsible for the unexpected results.

Among all inputs, materials (α_V) appeared to be the most important input. The estimates suggest that about 49 % of revenues are used for the remuneration of variable inputs a result that, given the importance of purchased material inputs for modern agricultural production, is consistent with expectations. Production elasticity of labour (α_L) turned out rather low and significant only at the 10 % level, whereas land and capital accounted for about 32 % and 18 % of total factor renumeration, respectively. Turning to agroholding membership, estimates clearly support that this organisational form affects production structures. However, regarding significance levels, this result could only be confirmed for labour and materials (α_{AM}, α_{VM}). The impact on land is positive, while its effect on material input is negative.

Recalling the definition of elasticity as relation of marginal and average productivities, the estimated values offer further insights regarding differences of marginal productivities and factor use by organisational form. Due to normalisation as mentioned in the data section, average productivities at the sample mean are equal to one; hence the estimated values provide direct information about the marginal products. Thus, the low estimate of labour suggests that, on average, independent farms might operate with a suboptimal and high labour input, which in turn implies that, on average, these farms attach a relatively high weight to their social function in rural areas.[6] Agroholding membership increases the marginal product of labour significantly. Since the "law" of diminishing returns holds for agroholdings, labour input here is (assumed to be) considerably lower in agroholdings than in independent farms; a finding that supports the often expressed view that agroholdings seek to maximize profits on the basis of economic reasoning alone and not with an eye to social aspects: they tend to release under-

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

6 See Koester (2005) for more details on this issue.

employed labour while independent farms tend to retain them to satisfy the social function ascribed to them

There are further differences between the two forms. The results also support the view that agroholdings have a better access to material inputs. Marginal products in agroholdings are significantly lower. Again, the “law” of diminishing returns implies that agroholding members apply material inputs more intensively than independent farms. Similar conclusions can be deduced for land and capital input, though the corresponding estimates failed to be significant.

Table 4: Parameter estimates of the risk production function

	Variable	Symbol	Estimate	Std.-Error	t-ratio
mean production function	Constant	α_o	0.0369	0.0255	1.4470
	Time	α_T	-0.0046	0.0138	-0.3309
	Time*Time	α_{tT}	0.0362	0.0374	0.9675
	Labour	α_A	0.0438	0.0272	1.6138
	Land	α_L	0.3222	0.0313	10.3110
	Capital	α_C	0.1812	0.0157	11.5320
	Material	α_M	0.4886	0.0268	18.2150
	Labour*Time	α_{AT}	0.0410	0.0241	1.7048
	Land*Time	α_{LT}	0.0639	0.0288	2.2164
	Capital*Time	α_{CT}	-0.0263	0.0149	-1.7698
	Material*Timi	α_{VT}	-0.0450	0.0271	-1.6585
	Labour*Labour	α_{AA}	0.0713	0.0146	4.8701
	Land*Land	α_{LL}	0.2714	0.0758	3.5811
	Capital*Capital	α_{CC}	0.0755	0.0128	5.9138
	Material*Material	α_{VV}	0.2035	0.0557	3.6543
	Land*Labour	α_{AL}	0.0787	0.0299	2.6367
	Land*Capital	α_{AC}	-0.0300	0.0116	-2.5796
	Land*Material	α_{AM}	-0.0693	0.0242	-2.8669
	Labour*Capital	α_{LC}	-0.0720	0.0303	-2.3741
	Labour*Material	α_{LV}	-0.1867	0.0487	-3.8343
	Capital*Material	α_{CV}	0.0037	0.0194	0.1892
	Membership	α_M	-0.2024	0.0530	-3.8169
	Time*Membership	α_{TM}	-0.0452	0.0421	-1.0752
	Labour*Membership	α_{AM}	0.1736	0.0401	4.3343
	Land*Membership	α_{LM}	-0.0096	0.0894	-0.1078
	Capital*Membership	α_{CM}	-0.0456	0.0386	-1.1809
	Material*Membership	α_{VM}	-0.1413	0.0675	-2.0952
risk function	Constant	γ_0	-1.6110	0.0657	-24.5220
	D06	γ_{06}	0.0536	0.0795	0.6735
	D08	γ_{08}	-0.0209	0.0897	-0.2331
	Labour	γ_A	0.1977	0.0846	2.3383
	Land	γ_L	-0.7574	0.0943	-8.0357
	Capital	γ_C	0.2073	0.0653	3.1736
	Material	γ_V	0.9579	0.0744	12.8820
	Membership	γ_M	0.2622	0.1123	2.3341
inefficiency function	Labour	θ_A	0.2043	0.1978	0.0335
	Land	θ_L	1.7257	0.2383	10.4220
	Capital	θ_C	-0.0150	0.1596	-1.3932
	Materials	θ_V	-0.3667	0.2068	-6.4048
	Membership	θ_M	-0.7275	0.5624	-1.7597
	Sigma_U	σ_u	0.1118	0.0254	4.4082

Note: t-ratios of 1.66, 2.04, and 2.72 are the critical values for the 1 %, 5 % and 10 % levels of significance, respectively.

Source: Own estimations.

Average economies of scale are given by the sum of production elasticities. The results show that both independent farms as well as agroholdings operate at almost constant returns to scale. In addition, in the period under investigation, we could neither find a significant impact of neutral technical change (α_T and α_{TT}) nor a special impact of agroholding membership on technical change (α_{TM}). However, the estimates indicate that technical change was strongly biased (α_{iT}, i = A, L, C, M). It was labour and land using and capital and material input saving.

Table 4 reports all relevant estimates as highly significant and reveals risk increasing effects (denoted by positive signs) for all inputs except land. Moreover, these different signs suggest that the farms apply some kind of risk management technique, the information we had, however, did not allow going into deeper detail, so that further statements must remain a matter of conjecture. With respect to organisational form, agroholding membership appears to be associated with an increase of production risk, a finding consistent with the more intense use of purchased inputs as compared to independent farms. In addition, the results concerning generic risk imply that overall weather conditions in the investigation period actually did not differ significantly in the period under investigation.

According to the estimated constant, farms are more affected by generic risk than generic inefficiency (σ_u). As regards significance, the estimate of -1.611 implies a standard deviation of the two-sided error term of about 0.2,[7] which is almost two times higher than the standard deviation of the efficiency distribution. According to our estimates, efficiency is significantly affected by all inputs except capital. Labour and land input increase efficiency while materials tend to decrease it. In this context, it is worth mentioning that the labour-related effects of this estimation support the conclusion derived for the mean production function where differences in labour input has been explained with the different perception of the social function independent farms and agroholding members.

In addition, the results suggest that group members were better positioned to exploit production possibilities than independent farms a result that is in line with the findings of Hockmann et al. (2009) who pointed out that agroholdings usually change the managerial structure and adopt modern management structures that offer better monitoring of production processes.

4.3 Variance decomposition

In this section we discuss how the parameter estimates affect the contribution of production, risk and efficiency to the variance of inputs, and whether there are differences between organisational forms. First, an overview of the expected values and the relative importance of the variances of the three sources of variation are provided in Table 5.

From the expected values of mean production in Table 5, it is apparent that agroholdings are considerably larger in size than independent farms. Unlike this almost natural finding, the more pronounced inefficiency is somewhat surprising. At first glance, this may contradict the insights derived from Table 4, certainly; but the information in this table only refers to the generic part of inefficiency while the idiosyncratic component is additionally considered in Table 5. To resolve this contradiction, the following reasoning will be helpful. Since inefficiency affected by the intensity of factor use. Moreover, the coefficients of inefficeincy increasing inputs are higher than the coefficient of inefficiency reducing input. Thus the level of inefficiency will increase with farm size. Following this chain of reasoning and given the larger size of agroholdings, the higher average level of inefficiency follows immediately.

Referring back to Table 5, the coefficients of variation of mean production are quite similar between the two organisational forms. Consequently both groups can be treated as either homogeneous or heterogeneous depending on the magnitude of this CV which yields slightly below one in all cases except one. Turning to inefficiency, the table reveals a different result. Now, the CVs vary, both within and between the two groups with higher values and a wider

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7 The assumptions in (6) together with the functional forms in (2) provide $\sigma_v = e^{\gamma_0}$.

range in independent farms than among agroholding members. Moreover, since the coefficient of variation for inefficiency is more marked than for mean production, inefficiency is likely to influence average total production stronger than differences in the structure of inputs. In contrast to the results mentioned so far, the risk-related coefficients of variation turned out clearly different, namely with the highest absolute value across all farms and functions. The reason for this is twofold: On the one hand, this result follows from the definition of the two-sided error term, which determines both organisational forms to have a mean risk of about zero. On the other hand, the values indicate that production risk is a too important feature of production to be neglected when analysing production structures.

Table 5: Statistical indicators for mean production, risk, and efficiency

	Coefficient of variation CV(.)			Expected value E(.)		
	Independent farms					
	2006	2007	2008	2006	2007	2008
Mean production	0.96	1.02	0.97	1.09	1.20	2.04
Risk	29.50	-48.13	94.97	0.01	-0.00	0.00
Inefficiency	1.60	2.48	2.14	0.11	0.12	0.23
	Agroholding members					
	2006	2007	2008	2006	2007	2008
Mean production	0.99	0.97	0.83	3.09	3.66	4.27
Risk	199.58	-69.18	5.46	0.00	-0.01	0.21
Inefficiency	1.51	1.35	1.15	0.31	0.32	0.35

Source: Own estimations.

Table 6: Decomposition of the variance of total production

	Independent farms		
	2006	2007	2008
Share explained	128.9 %	134.8 %	153.4 %
Mean production	83.3 %	116.1 %	133.7 %
Land productivity	*32 %*	*23 %*	*18 %*
Size (hectare)	*79 %*	*73 %*	*108 %*
Risk	19.9 %	10.3 %	11.0 %
Inefficiency	25.3 %	7.5 %	8.4 %
	Agroholding members		
	2006	2007	2008
Share explained	136.7 %	119.8 %	121.9 %
Mean production	128.0 %	111.2 %	108.1 %
Land productivity	*26 %*	*20 %*	*19 %*
Size (hectare)	*95 %*	*82 %*	*92 %*
Risk	5.5 %	6.9 %	12.3 %
Inefficiency	3.1 %	1.6 %	1.4 %

Note: Mean production was decomposed using equation (1). The contributions are calculated in relation to the total variance of mean production.
Source: Own estimations.

Table 6 contains the results of the variance decomposition of total production. In describing the results, we concentrate - as we did with revenues - on the variances and ignore the covariance structures. The line entitled "share explained" for each organisational form provides information on the portion of the variance of production explained by the variance of the individual factors. However, neglecting covariances bears consequences: First, the given shares, clearly amounting above 100 %, indicate that considering variances alone tends to overestimate the variance of total production in most years. If, in addition, account is taken of the variance of the mean production function exceeding the variance of production, it strongly points to the homogenizing effect of the covariances between mean production, risk and inefficiency on the variation of total production. Second, as distinct from decomposition of revenues, covariances appear to play a much more important role, because on average, they account for about 30 % of the production variance. However, there is still more to say. Third, Table 6 also reveals what matters most for total production: mean production. Not surprisingly, by far the major portion of production variance stems from mean production. This result simply underlines the importance of farm size and the implied effects on specialisation and input intensities. The size effect accounts, on average, for more than 80 % of the variance of mean production. By way of contrast, the differences in productivity play only a minor role, as they explain only about one fourth of the variance of mean production. However, the variation of partial productivities is far more important than the variation of risk and inefficiency.

Compared to inefficiency, production risk is far more crucial for the variance of production. Interestingly, the impact of risk in agroholdings is lower than in independent farms. At first glance this is surprising since we know from Table 4 that agroholding membership has a positive impact on risk (γ_M) due to higher intensity of input use, in particular, purchased inputs. Now, Table 6 implies that this intensity effect on risk was overcompensated by employing risk management techniques. So, the successful adoption of such techniques leads to a considerable reduction of uncertainty in production. However, it appears that this benefit was bought at the cost of higher input use which, in turn, induces a lower level of efficiency (see Table 5) which, again in turn, countervails the positive influence of agroholding membership effects on the generic impact of inefficiency as discussed in the context of Table 4.

5 CONCLUSION AND INTERPRETATION

In this paper we analysed the significance of risk, and external and internal transaction costs on agricultural development and production growth with respect to the organisational forms of independent farms and agroholdings. The analysis was conducted for the Tatarstan Republic on the basis of accountancy data of agricultural enterprises for the period of 2006-2008. The data set contained 277 farms and 636 observations, 41 farms of which were members of agroholdings accounting for 101 observations.

First, we investigated production and product prices on the basis of individual crops and dairy production. The data basis enabled corresponding analyses for grain, sugar beet, potatoes and milk. In this stage, marked differences between organisational structures were not observable, neither for prices nor for quantities. However, prices received by agroholding members appeared to be more homogeneous than those obtained by independent farms. Although this indicates that members of a business group are obliged to use the channels offered by the holding company, in fact, they were paid a price based on the average prices paid in the regions. In this way, agroholding memebrs do benefit from a reduction of transaction costs.

Second, the sources of production variance were estimated using a risk production function with inefficiency component. The parameter estimates confirm that all effects are highly significant. Moreover, as compared to the first part of the analysis, there is evidence for differences between organisational forms because agroholding membership significantly affects production structures, thus supporting the view that these companies, for one thing, have better access to purchased inputs, and for another, use these more intensively than independent farms. Labour input is lower in holding members suggesting that this group is less committed to fulfilling attention to the social function of farms in rural areas. In addition, both organisational forms seem to operate under constant returns to scale. The effects of technical change turned out strongly biased, neutral technical change failed to be significant.

All inputs except land hadproduced a risk increasing effect. The different signs associated with the inputs indicate that the farms apply some kind of risk management techniques in production. Consistent with the more intense use of inputs, agroholding members appear to face a higher (generic) production risk. However, the idiosyncratic effects imply that agroholdings apply risk management techniques more intensively than independent farms, which, in turn, results in a lower agroholding-related contribution of the risk component to total production variance; a result that corroborates findings from earlier studies which highlighted the change in management and the adoption of modern management strategies observed for agroholdings.

For inefficiency, we found almost opposite results: while the generic inefficiency produces significantly smaller effects in agroholdings than in independent farms, the idiosyncratic component shifts the relation towards higher inefficiency for group members. The reason for this shift according to the estimation results, may lie in the more intense risk management in agroholdings, which, at the same time, allows using inputs more intensively, and thus helps to increase production. It should be stressed, however, that the intensified input use is due to the managerial goal of reducing uncertainty rather than increasing production, which, in fact, may be seen as side benefit.

As regards relative importance, the estimates provide evidence that risk is of higher relevance for the variation of production than inefficiency, as is reflected not only in the generic but also in the idiosyncratic component. Moreover, since for independent farms, risk and inefficiency explain about the same amount of production variance than technology differences, risk and internal transaction costs appear to be much more important than external transaction costs. Undoubtedly, the latter conclusion is also true for holding members. However, it has to be emphasised that, compared to independent farms, these variances remain at a relatively low level indicating that differences in technology are more pronounced in this group.

In sum, the results corroborate that all three components - risk, external and internal transaction - significantly affect agricultural production. Thus, seeking to improve the conditions for production, this insight has to be translated from farm to policy level. Agricultural policy therefore is required to tackle the mentioned obstacles to production implementing a mix of appropriate policy measures. One option would be to actively support agroholding membership, because according to the data, this would reduce the cost-incurring side effects of “free” market participation and volatile production, even if these benefits would clearly be be at the expensive of higher inefficiency or higher external transaction costs. However, in this context, it should go without saying that policy “support” points to appropriate measures taken to pave the way, so that agriculture is able to provide what is needed to feed the country and the farmer – agroholding member and independent farmer alike. Granted, membership in an agroholding is favourable. But farms should not be forced be become a member of an agroholding, nor should agroholdings be forced to accommodate more members. Both types of famers should be free to decide about their strategies. Finally, since risk, inefficiency, and technology are not necessarily substitutes, a system of measures needs to be defined and implemented which improves all three indicators at the same time. In this sense, encouraging and facilitating membership in agroholdings might only be a second best solution.

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APPENDIX

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 the variance provides:

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

Expanding the bracket and passing the expectation operator through provides:

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

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

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

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

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